MODEL OF ELECTRONIC WASTE MANAGEMENT FOR EASTERN ECONOMIC CORRIDOR

Chalida Nieobubpa

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Chalida Nieobubpa

The Graduate School of Environmental Development Administration

..... Major Advisor
(Professor Wisakha Phoochinda, Ph.D.)

..... Co-Advisor
(Professor Tawadchai Suppadit, Ph.D.)

The Examining Committee Approved This Dissertation Submitted in Partial Fulfillment of Requirements for the Degree of Doctor of Philosophy (Environmental Management).

..... Committee Chairperson
(Associate Professor Kraichat Tantrakarnapa, Ph.D.)

..... Committee
(Professor Wisakha Phoochinda, Ph.D.)

..... Committee
(Professor Tawadchai Suppadit, Ph.D.)

..... Committee
(Assistant Professor Karika Kunta, Dr.sc.ETH Zurich)

..... Committee
(Professor Chamlong Poboon, Ph.D.)

..... Dean
(Professor Wisakha Phoochinda, Ph.D.)

_____/_____/_____

ABSTRACT

Title of Dissertation MODEL OF ELECTRONIC WASTE MANAGEMENT FOR EASTERN ECONOMIC CORRIDOR
Author Chalida Nieobubpa
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This research aimed to evaluate the household electronic waste (e-waste) management in Eastern Economic Corridor (EEC) in Chachoengsao, Chonburi, and Rayong provinces, and recommend the appropriate model of household e-waste management for EEC, notably at the policy level. This research was qualitative research by analyzing situations, problems, and impacts from household e-waste management in the three provinces between 2016-2019, with the concept of Pressure-State-Response (PSR). After that, evaluate the household e-waste management in the three provinces with the CIPP-I Model, documentary research, request information, non-participant observation, and in-depth interview by semi-structured interview with 27 key informants by purposive sampling. They were executives, policymakers, e-waste experts, state enterprises in electrical and electronic manufacturing companies, and e-waste sorting or recycling plants in industrial estates. Data analysis used the content and grouping analysis. The evaluation results were used for SWOT Analysis and TOW Matrix to acquire the factors impacting the management and guidelines of household e-waste in the three provinces and use them to develop the model of household e-waste management for EEC. The evaluation form conducted the draft model testing with 55 assessors covering the former interviewees and residents in EEC.

The findings revealed that only Rayong provincial administrative organization collected household e-waste from local administrative organizations (LAOs) at the Rayong Integrated Solid Waste Management Center and sent e-waste to the private disposal site outside the EEC areas. People thought that the e-waste sorting was the responsibility of LAOs. LAOs motivated people to realize the importance of sorting e-waste by collaborating with the relevant local government

agencies and the private sector in the collection process, namely installing drop-off points in private establishments. The drop-off points were installed in all communities. However, e-waste was discarded and mixed with general solid waste, contamination of heavy metals in soil, surface water, and groundwater, foul smell from sorting and recycling factories operating with improper methods, causing dizziness to the people living near the factories. Some could not bear the smell and had to move out, especially in Chachoengsao and Chonburi. Natural Resources and Environmental Protection Volunteers (NEV) were established. Employment and income were generated for local junk shops.

The appropriate model of household e-waste management in the three provinces of EEC for LAOs and relevant agencies according to the CIPP-I framework consisted of Context: submit the comprehensive plan on household e-waste management in EEC to the Eastern Economic Corridor Office of Thailand (EECO), set up a center for services and repair learning of household electrical and electric equipment. Input: provide services to collect large-sized e-waste at people's homes, prepare the list of e-waste disposal companies in EEC, and provide enough personnel and budget for household e-waste management in each LAO. Process: the construct of community model, improve public relations to attract interest for people. Product: add the appropriate drop-off points with a sign at all areas, send collected household e-waste for disposal plants in EEC at priority. Impact: promote new e-waste disposal plants in industrial estates in EEC, support the local networks to monitor e-waste management situations, such as NEV-Net or Local Environmental Volunteer Network (LEV-Net), and support junk shops to receive a permit for health-hazardous operation.

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ABBREVIATIONS

Abbreviations	Equivalence
BFR	Brominated Flame Retardants
BMA	Bangkok Metropolitan Administration
CRT	Cathode Ray Tube
DEQP	Department of Environmental Quality Promotion
DOLA	Department of Local Administration
EEC	Eastern Economic Corridor
EECa	Eastern Airport City
EECd	Digital Park Thailand
EECh	Eastern Economic Corridor of High-Speed Rail Linking Three Airports
EECi	Eastern Economic Corridor of Innovation
EECmd	Eastern Economic Corridor of Medical Hub
EECO	Eastern Economic Corridor Office of Thailand
EEE	Electrical and Electronic Equipment
EPR	Extended Producer Responsibility
ESDZ	Eastern Special Development Zone
ESDZPO	Eastern Special Development Zone Policy Committee
E-Waste	Electronic Waste
GSEDA	Graduate School of Environmental Development Administration
HDD	Hard Disk Drives
HHW	Household Hazardous Waste
HW	Hazardous Waste
IC	Integrated Circuit
IEAT	Industrial Estate Authority of Thailand
IT	Information Technology
LAO	Local Administrative Organization
LCD	Liquid Crystal Display

LED	Light Emitting Diode
M-Industry	Ministry of Industry
MNRE	Ministry of Natural Resources and Environment
MOI	Ministry of Interior
MOPH	Ministry of Public Health
NESDB	Office of the National Economic and Social Development Board
NESDC	Office of the National Economic and Social Development Council
NEV	Natural Resources and Environmental Protection Volunteers
NIDA	National Institute of Development Administration
OECD	Organization for Economic Co-operation and Development
PAO	Provincial Administrative Organization
PC	Personal Computer
PCB	Polychlorinated Biphenyls
PCBA	Print Circuit Broad Assembly
PCD	Pollution Control Department
PONRE	Provincial Offices for Natural Resources and Environment
PPP	Polluter Pays Principle
PPPs	Public-Private Partnerships
PRO	Producer Responsibility Organization
PSR	Pressure -State-Response
REO	Regional Environment Office
SAO	Subdistrict Administrative Organization
TIS	Thai Industrial Standard
WEEE	Waste (from) Electrical and Electronic Equipment

CHAPTER 1

INTRODUCTION

1.1 Background and Significance of the Study

At present, many countries worldwide, including Thailand, face the problems of the management of electronic waste (e-waste) or waste from electrical and electronic equipment (WEEE) with increasing severity. The reason derived from the increased and continuous growth of the electrical and electronics industries. According to the Office of Industrial Economics, in 2016-2018, Thailand's production of electronic products included Tablet, Notebook, Personal Computer (PC), and Smart Phone, such as Semiconductor, Hard Disk Drives (HDD), Integrated Circuit (IC), Print Circuit Broad Assembly (PCBA) increased 1.5%, 7.5%, and 4.5% respectively from the previous year. In 2019, the production declined 6.3% from the previous year due to the global demand for electronic goods. In 2020, the production rebounded 1.6% compared to the previous year due to the less severe global economy (Office of Industrial Economics, 2016, 2017, 2018, 2019). One other reason was the increased consumption of electronic goods, especially mobile phones, where consumers tended to change their mobile phones even before they wore out. According to the National Statistical Office (2018), in Thailand, the mobile phones of the population over six years of age during the three years between 2016-2018 increased. In 2018, mobile phones increased from 81.4% (population of 51.1 million) to 89.6% (population of 56.7 million) compared to 2016. Moreover, it is forecast that in 2021, the amount of global e-waste will reach approximately 52.2 million tons, up from 44.7 million tons in 2016 (Baldé, Forti, Gray, Kuehr, & Stegmann, 2017). Most developing countries have not enforced laws one-waste or set up a correct e-waste system. It expects that by 2030 the amount of e-waste in developing countries will be two times more than in developed countries (Yu, Williams, Ju, & Yang, 2010).

In Thailand, e-waste comes from 3 primary sources: the production process in factories, households, or shops, and import of e-waste (Nicha Buranasing, 2016). Most e-waste originates from the community due to households' consumption and increases every year. Between 2016-2019, household e-waste constituted 393,070 tons, 401,387 tons, 414,655 tons, and 421,335 tons, respectively, or the average increase of 2.3% a year. Household e-waste of television, air conditioner, washing machine, refrigerator, computer, telephone, VCD/DVD player, and digital camera or 65% of the total amount of HHW (Pollution Control Department, 2020d) or the average of 1.37% of the amount of municipal solid waste in Thailand between 2016-2019 (amount of municipal solid waste generated between 2016-2019 equaled 27.06 million tons, 27.37 million tons, 27.93 million tons, and 28.71 million tons respectively) (Pollution Control Department, 2019b, 2020e). It was by the forecast of the amount of e-waste from consumption and the survey of the amount of e-waste from industrial sources conducted by the Department of Industrial Works. It found that in 2017, the amount of e-waste totaled 359,048 tons, mostly or 81% came from households and establishments (290,288 tons), and the rest of 19% was an industrial waste (68,760 tons) (Center of Excellence on Hazardous Substance Management, 2019b)

Thailand's Eastern Economic Corridor (EEC) in Chachoengsao, Chonburi, Rayong, and Special Economic Promotional Zone has announced 29 zones of 6 Promoted Zones for Specific Industries and 23 Promoted Zones for Targeted Industries. Examples of Promoted Zones for Specific Industries are Eastern Economic Corridor of Innovation (EECi) at Wang Chan District in Rayong and Digital Park Thailand (EECd) at Si Racha District in Chonburi. Promoted Zones for Targeted Industries divided into two types, namely 1) Zones to develop areas to accommodate the targeted industries in 2 zones at Ban Pho District and Bang Pakong District both in Chachoengsao and 2) Industrial Estates in 21 zones. Most belong to the private sector in the old industrial estates with 1 zone in Chachoengsao, 12 zones in Chonburi, and 8 zones in Rayong such as TFD Industrial Estate 2 in Chachoengsao, Amata Nakorn Industrial Estate, and Pinthong Industrial Estate (Phase 4) in Chonburi, Amata City Industrial Estate and WHA Eastern Seaboard Industrial Estate 4 in Rayong. The EEC zone develops into ASEAN's leading economic zone to promote all

or partial 12 targeted industries. The five industries (First S–Curve) such as Next-Generation Automotive, Smart Electronics and five industries of the future to upgrade the industrial value (New S – Curve) such as Robotics, Digital, and two industries for particular purposes namely Defense and Human Resource Development and Education as the New Engine of Growth to drive the country towards Thailand 4.0 according to the Cabinet resolutions on 28 June 2016. It was considered Thailand's first area for systematic economic and social development with laws, operating agencies, and transparent development guidelines under the overall plan for the development of EEC between 2017-2022 (Eastern Economic Corridor Office of Thailand, 2018, 2019c). At the same time, some targeted industries are developed, such as the electrical and electronic industry, telecommunication equipment industry, intelligent electronics industry, digital industry, and next-generation automotive industry. These industries will produce electrical and electronic equipment and telecommunication equipment such as computer and screen parts, mobile phones, television, intelligent electrical appliances connected to internet networks (Internet of Things: IoT), portable electronic system equipment (e.g., fit bits), and microelectronic chip, as well as automotive battery, hardware, and digital part (Office of Industrial Economics, 2017).

Consequently, the amount of household e-waste in Chachoengsao, Chonburi, and Rayong tended to increase in the EEC areas. That is in line with the forecast that the amount of household e-waste in EEC would reach approximately 43,851 tons per year in 2027 and 50,199 tons per year in 2032 that estimated from the amount of municipal solid waste, including household hazardous waste in EEC in 2027 (1,993,221 tons per year) and in 2032 (2,281,786 tons per year). That estimated household e-waste in EEC consisted of lamps, batteries, electrical and electronic equipment such as mobile phones, television, computer. (Center of Excellence on Hazardous Substance Management, 2018, 2019a) In 2050, the amount of 10 types of e-waste from household consumption consisting of television, washing machine, air conditioner, refrigerator, notebook, tablet, telephone, fluorescent bulb, LED bulb and batteries in Thailand will reach approximately 600,000 tons a year. The e-waste from a computer and mobile phone will change into products with lighter weight such as from computer with CRT screen (Round screen) to computer with LDC/LED screen

(Flat screen), notebook, tablet. So, there will be an increase in the e-waste of the computer with LDC/LED screen, notebook, and tablet. The 50-78% four types of e-waste in large size (Big 4), namely television, air conditioner, washing machine, and refrigerator, will be sold to junk shops. In contrast, the e-waste from the lightbulb, mobile phones, and small equipment such as the automotive battery and the battery may find to mix with municipal solid waste (Center of Excellence on Hazardous Substance Management, 2019b). Therefore, the researcher was interested in studying e-waste from household consumption or household e-waste in the EEC areas in Chachoengsao, Chonburi, and Rayong.

The household e-waste in this research means three types of household hazardous waste (HHW), namely 1) Lamps, 2) Battery and dry battery, and 3) Electrical and electronic appliances in daily lives at the end of life or no longer of use in 3 main types namely telephone and mobile phone, computer, and television, in total five types. Lamps, batteries, and dry batteries are the targets of the Integrated Waste Electrical and Electronic Equipment Management Strategy 2014-2021 (Pollution Control Department, 2017a). Telephone and wireless telephone, computer, and television are e-waste with small size under the Draft of the Waste from Electrical and Electronic Equipment Management Act B.E. ...., there is a tendency to change often and with lighter weight (Center of Excellence on Hazardous Substance Management, 2019b). At present, it finds that most e-waste from the battery and dry battery, telephone, and wireless telephone is managed as part of HHW by local administrative organizations (LAOs) in Chachoengsao, Chonburi, and Rayong. Each LAO collects e-waste from drop-off points in every community in its area. As of March 2021, there is still no system to collect e-waste in each LAO for disposal in Chonburi and Chachoengsao. The e-waste will be kept at each LAO office while waiting for disposal. In Rayong, there is an HHW collection center situated in the Rayong Integrated Solid Waste Management Center. It receives household e-waste from LAO in Rayong areas for collection and disposal. However, e-waste is still mixed with general waste as the public still lacks knowledge, understanding, and cooperation in sorting e-waste and disposal at the drop-off point. (Regional Environment Office 13 (Chonburi), 2021a). The computer and television are mostly sold to junk shops, donated, or sold to repair shops as secondhand products (Center of

Excellence on Hazardous Substance Management, 2019b). Suppose the five types of household e-waste in this study do not have correct and appropriate management. In that case, they may affect human health from the leak of a hazardous substance in e-waste, impact the environment from the contamination of heavy metals into soil and water, and impact the economy with economic loss from the budget to solve the problems in the future (Janejira Jannuwat, 2019).

E-waste is hazardous and non-biodegradable. The toxic substance is also found in e-waste, primarily heavy metals such as lead, mercury, cadmium. Brominated Flame Retardants (BFRs) found. Once they are released into the environment through the disposal by burning of e-waste with BFRs as composition, they will affect human health differently. For example, palpitation, destruction of the nervous system, cancer, and probably death may occur if accumulated in the body in large quantities. Those at risk of health impact from e-waste include those working in the industrial sector, those sorting waste for recycling, and users of electronic equipment. Those who work in the industrial sector, sort waste for recycling, and users of electronic equipment can receive toxic substances and impact health differently. For example, those who work in the industrial sector producing electronic equipment risk touching heavy metals during production and having lung cancer, Nasopharynx cancer, and brain cancer. Users of electronic equipment risk receiving BFR contaminated from dust on the computer, which will disturb the functioning of the nervous system (Orawan Phuphisut & Suleeporn Sangrajang, 2010). Those who incorrectly sort waste for recycling such as burning and acid used to separate valuable metals from e-waste risk receiving heavy metals lead accumulated in the body through the respiratory system and contamination of lead in the soil in sorting and burning e-waste (Seelawut Damrongsiri, 2015). If lead accumulated in large quantities, it will affect the development of the brain and central nervous system leading to memory loss (World Health Organization, 2019). For example, the impact on the environment and health in China takes place in academically incorrect sorting or recycling of e-waste through burning at Guiyu and Langtang in Guangdong Province and Taizhou in Zhejiang Province. These areas contaminated heavy metals in the soil, such as cadmium, zinc, nickel, chromium, and copper, exceeding soil quality standards for agriculture and dwelling in China. The Intervention Value

indicated that the concentration of heavy metals in the soil was severed and required treatment (Li, Duan, & Shi, 2011; Zhang, Ye, Chen, Xu, Wang, & Zhao, 2014). The level of cadmium found in the children's blood in the areas of e-waste recycling at Guiyu in Guangdong Province and Taizhou in Zhejiang Province exceeded the standards and was higher than the controlled group in Chendian (Song & Li, 2015). In Thailand, the areas of sorting of e-waste include 1) Sua Yai Uthit community, Chatuchak District, Bangkok 2) Khok Sa-At Subdistrict, Khong Chi District, Kalasin 3) Daeng Yai Subdistrict, Ban Mai Chaiyaphot District, Buri Ram and 4) Ban Pao Subdistrict, Phutthaisong District, Buriram. In 2014, contamination of some heavy metals found in the soil such as lead, arsenic, copper exceeding the standards of quality of soil for agriculture and dwelling in Thailand according to the Notification of the National Environmental Board No. 25 (2004). The Intervention Value indicated that the concentration of heavy metals in the soil was at a deep level and required treatment (Saijai Withaya-Anumas, 2017; Seelawut Damrongsiri, 2015; Sujitra Vassanadumrongdee, 2015).

At present, the direction is set for the household e-waste management in the EEC in Chachoengsao, Chonburi, and Rayong by formulating policies, plans, and measures to serve as the framework of more concrete implementation, incorporated in the solutions to the problems of HHW management such as the Action Plan “Clean Province” of Department of Local Administration (DOLA), Ministry of Interior (MOI). The framework of the operation consists of 3 processes in planning and formulating of measures, namely 1) Upstream involves reduction of the amount of waste and sorting of waste 2) Midstream involves the increase of efficient transport of waste by LAOs, and 3) Downstream involves waste that is managed based on correct, academic principles by using the principles of 3 Rs: Reduce, Reuse, and Recycle and cooperation among public sector, private sector, academic sector, religion sector, civil society sector, and people sector to solve the problems by adhering to the goals of the National Solid Waste Management Master Plan (2016-2021) such as HHW is collected and sent for disposal based on correct, academic principles not less than 30% by 2021, and LAOs sort hazardous waste at the upstream not less than 50% by 2021 to enable provinces and LAOs to adapt in line with the area context and to efficiently manage e-waste management (Ministry of Interior, 2020). Also, it is in line

with the 20-Year National Strategy (2018-2037), the Twelfth National Economic and Social Development Plan (2017-2021), and other relevant plans or guidelines such as the 20-Year Master Plan on the Prevention and Management of Pollution caused by Solid and Hazardous Waste (2018-2037), Environmental Plan in Eastern Economic Corridor (2018-2021), and the Integrated Waste Electrical and Electronic Equipment Management Strategy 2014-2021, as well as relevant laws such as the Act of Maintaining Cleanliness and Tidiness of the City (No. 2) 2017, Notification of Ministry of Interior on Solid Waste Management 2017, and the Draft of the Waste from Electrical and Electronic Equipment Management Act B.E. ....

Based on the above information, it can see that in the future, the EEC areas in Chachoengsao, Chonburi, and Rayong will face the problems of increasing household e-waste and possible impact on the environment and human health in the areas. Lack of correct household e-waste management system, people's knowledge, understanding, cooperation separation and disposal of e-waste, laws on e-waste management are the main reasons that make e-waste management in Thailand fail (Sasiwimon Mudju, 2019). Literature review reveals that there is yet no research on the model of household e-waste management in the EEC areas in Chachoengsao, Chonburi, and Rayong. However, there is research on HHW management in Chonburi using CIPP Model (Anan Photikul, 2018) and Phatthalung (Somsiri Decharat, 2018), as well as a study on e-waste management in other provinces such as Prachin Buri (Pachanit Naovapun & Anusara Chaodorn, 2020), Ubon Ratchathani (Mok Tuntipalaku, 2016), and Bangkok (Sasiwimon Mudju, 2018; Walanna Wattanahemmakorn, 2017). Therefore, the researcher was interested in studying an appropriate model of household e-waste management for EEC in Chachoengsao, Chonburi, and Rayong. The study results will benefit the solutions to problems of household e-waste management in EEC for success, efficiency, and sustainability. The integration guidelines between LAOs, mainly provincial administrative organizations (PAOs) and municipalities, government agencies, private sector, and people sector in EEC for appropriate adaptation in each area. Also, the proper operation of household e-waste management will provide household e-waste reduction upstream, midstream efficiently, and downstream, including reducing

environmental and health impact in the community, increasing value from household e-waste management, and creating the circular economy in the EEC.

1.2 Research Questions

1.2.1 At present, how is the household e-waste management in Thailand and the EEC in Chachoengsao, Chonburi, and Rayong? What are the problems and obstacles? What is the impact?

1.2.2 What should be the appropriate model of e-waste management in the EEC in Chachoengsao, Chonburi, and Rayong?

1.3 Research Objectives

1.3.1 Study the situations, problems, and impacts of household e-waste management in EEC in Chachoengsao, Chonburi, and Rayong, including strategies, policies, and laws related to e-waste management

1.3.2 Evaluate the household e-waste management in EEC in Chachoengsao, Chonburi, and Rayong

1.3.3 Present the appropriate model of household e-waste management for EEC in Chachoengsao, Chonburi, and Rayong

1.4 Expected Benefits

1.4.1 Situations, problems, and impacts of household e-waste management in EEC in Chachoengsao, Chonburi, and Rayong

1.4.2 Factors and obstacles impacting household e-waste management of PAOs in EEC in Chachoengsao, Chonburi, and Rayong

1.4.3 Model of household e-waste management for EEC in Chachoengsao, Chonburi, and Rayong

1.4.4 The government sector, LAOs, and relevant agencies can use the model of household e-waste management to devise the guideline of household e-waste management for EEC in Chachoengsao, Chonburi, and Rayong

1.4.5 More efficient household e-waste management for EEC in Chachoengsao, Chonburi, and Rayong

1.5 Scope of Research

1.5.1 Content

This study investigated the model of household e-waste management for EEC in Chachoengsao, Chonburi, and Rayong mainly at the policy level. The study overviewed household e-waste management in EEC in Chachoengsao, Chonburi, and Rayong during 2016-2019 and the present. There were strategies, policies, plans, and laws relevant to household e-waste management, the amount of e-waste, problems and impact of household e-waste management, and guidelines of solutions to problems of household e-waste management. The conceptual framework of Pressure-State-Response (PSR) and the CIPP-I Model analyzed and evaluated household e-waste management in EEC in Chachoengsao, Chonburi, and Rayong. After that, the draft model of household e-waste management in the three provinces was developed by SWOT Analysis and TOWS Matrix Analysis. Finally, the appropriate model of household e-waste management for EEC was presented after the draft model testing to be more implemented and efficient.

1.5.2 Population

There were 27 key informants classified into four groups, namely:

1.5.2.1 Executives and government officials of the central government who formulate the policy and plan on the management of the country's electronic waste and HHW such as Pollution Control Department (PCD) and Department of Environmental Quality Promotion (DEQP), Ministry of Natural Resources and Environment (MNRE), Department of Local Administration (DOLA), Ministry of Interior (MOI), Department of Industrial Works, Ministry of Industry (M-Industry), and Department of Health, Ministry of Public Health (MOPH), in total five persons namely:

1) Environmentalist, Professional Level, Waste and Hazardous Substance Management Bureau, PCD, MNRE

2) Dissemination Technical Officer, Professional Level, DEQP, MNRE

3) Director, Local Environment Subdivision, Local Environment Division, DOLA, MOI

4) Chief, responsible for waste, Bureau of Environmental Health, Department of Health, MOPH

5) Scientist, Industrial Waste Management Division, Department of Industrial Works, M-Industry

1.5.2.2 Executives and officers in central and regional state enterprises who formulate policies, manage, and develop the EEC and involve in e-waste management in industrial estates in the EEC such as EECO, Industrial Estate Authority of Thailand (IEAT), Offices of Industrial Estate in Chachoengsao, Chonburi, and Rayong, in total six persons namely:

1) Deputy Director and Assistant Director, Overall Planning Bureau, EECO total two persons

2) Scientist, IEAT

3) Director, Office of Gateway City Industrial Estate, Gateway City Industrial Estate, Chachoengsao

4) Director, Office of Pinthong Industrial Estate, Pinthong Industrial Estate 2, Chonburi

5) Scientist, Office of Amata City Chonburi Industrial Estate, Amata City Chonburi Industrial Estate

1.5.2.3 Executives and government officials in local administration and provincial administrative organizations who supervise, support, and monitor the management of household e-waste in Chachoengsao, Chonburi, and Rayong such as Regional Environment Office 13 (Chonburi) or REO 13 (Chonburi), Provincial Offices for Natural Resources and Environment (PONRE), Provincial Industry Offices, provincial administrative organizations (PAOs), and Provincial Office for Local Administration, in total eleven persons namely:

1) Environmentalist, Professional Level, Environmental Quality Control Subdivision, REO 13 (Chonburi), MNRE

2) Director, Environment Subdivision, Provincial Office for Natural Resources and Environment Chonburi, MNRE

3) Environmentalist, Professional Level, Provincial Office for Natural Resources and Environment Chachoengsao, MNRE

4) Environmentalist, Practitioner Level, Provincial Office for Natural Resources and Environment Rayong, MNRE

5) Engineer, Professional Level, Provincial Industry Office Chonburi, M-Industry

6) Engineer, Professional Level, Provincial Industry Office Chachoengsao, M-Industry

7) Chief, Industrial Factory Group, Engineer, Professional Level, Provincial Industry Office Rayong, M-Industry

8) Chief, Waste and Environment Management Group, Chonburi Provincial Administrative Organization

9) Chief, Environment Group, Rayong Provincial Administrative Organization

10) Chief, Environment Group, Chachoengsao Provincial Administrative Organization

11) Chief, Environment Group, Local Administrative Development Subdivision, Chonburi Provincial Office for Local Administration

1.5.2.4 Managers and private sector employees in companies of electrical and electronic equipment manufacturing, e-waste sorting/recycling/disposing companies in Industrial Estates in Chachoengsao, Chonburi, and Rayong, in total five persons namely:

1) Environmental employee at a company producing radio and CD player, telephone, and camera in Amata City Chonburi Industrial Estate

2) Environmental and safety employee at a company producing electronic parts at Amata City Chonburi Industrial Estate, and Senior Environmental Engineer at a power plant from industrial waste in WHA Chonburi Industrial Estate 1

3) Senior Director at a recycling company of fluorescent lamps and crushing of unused electrical and electronic equipment (EEE) in WHA Chonburi Industrial Estate 1

4) General Manager at a crushing company of electrical and electronic parts in Pinthong Industrial Estate 1 in Chonburi

1.5.3 Areas

EEC in Chachoengsao, Chonburi, and Rayong provinces and industrial estates that is household hazardous waste and e-waste management by LAOs, PAOs, and municipalities**.**

1.5.4 Duration

Study and compile academic data through documentary study and field data, using in-depth interviews, information requests and compilation from local relevant agencies, and non-participant observation in the EEC of the three provinces between March 2019 and March 2021.

1.6 Definitions

Household Hazardous Waste means hazardous waste from households managed by Chachoengsao, Chonburi, and Rayong Provincial Administrative Organizations, classified into four groups namely 1) Battery and dry battery such as the battery, mobile phone battery, digital camera battery 2) Lamps such as straight fluorescent lamp 3) Electrical and electronic equipment such as mobile phone, computer, television, and 4) Utensil containing chemicals such as spray can paint and thinner cans, pesticide bottle, expired medicine bottle, a bottle of household cleaners.

Electronic Waste (E-Waste) means household hazardous waste classified into three groups, namely 1) Lamps 2) Battery and dry battery and 3) Electrical and electronic equipment used in daily lives at the end of life or no longer of use with at least three types as stipulated in the Draft of the Waste from Electrical and Electronic Equipment Management Act B.E. .... namely (1) Computer (2) Telephone and wireless phone and (3) Television.

Household Electronic Waste Management means the operation of local administrative organizations in household e-waste reduction at origin, repeated use, and reuse based on the principle of 3Rs (Reduce, Reuse and Recycle), sorting, collection, transportation, and correct disposal. Local administrative organizations are mainly provincial administrative organizations, municipalities, relevant agencies in Chachoengsao, Chonburi, and Rayong.

Model of Household Electronic Waste Management means the model, the significant components, and the factors, the relations between the model, the components, and the factors, as well as the guidelines of academically correct and more efficient household e-waste management appropriate to economic, social, and environmental conditions of Chachoengsao, Chonburi, and Rayong. It reduces household e-waste at origin, encourages more e-waste at drop-off points, collects household e-waste for proper disposal. Moreover, it reduces impacts on the environment and local people, relying on cooperation between local administrative organizations, relevant central, regional, and local government agencies, the private sector, and local people.

Eastern Economic Corridor (EEC) means the areas in Chachoengsao, Chonburi, and Rayong according to Section 6 and Promoted Zones for Targeted Industries in the form of the industrial estate in 21 zones. Most are old industrial estates in 21 zones divided into Chachoengsao 1 zone, Chonburi 12 zones, and Rayong 8 zones according to Section 39 of Eastern Special Development Zone Act B.E. 2561 (2018) and considered outstanding areas and significant foundations for the industrial sector, especially industries generating e-waste such as intelligent electronics industry, digital industry.

Local Administrative Organization (LAO) means a local administrative organization with potential for management of household hazardous waste, e-waste, and operation of the overall management of household hazardous waste, and e-waste in Chachoengsao, Chonburi, and Rayong such as provincial administrative organization, city municipality, town municipality, and subdistrict municipality.

CHAPTER 2

RELEVANT DOCUMENTS AND RESEARCH WORKS

To research the Model of Electronic Waste Management for the Eastern Economic Corridor, the researcher conducted research and compiled the relevant concepts, principles, and theories. Research works for the study are as follows:

2.1 Concepts on electronic waste management

2.2 Strategies, policies, plans, and laws relevant to electronic waste management

2.3 Situations and electronic waste management in Eastern Economic Corridor in Thailand

2.4 Conceptual framework of Pressure-State-Response

2.5 Principles of SWOT Analysis and TOWS Matrix

2.6 Concept of evaluation according to the CIPP-I Model

2.7 Relevant research works

2.1 Concepts on E-Waste Management

2.1.1 Definition and Types of E-Waste

Electronic waste (e-waste) is the definition that is widely in the Asia Pacific. Waste from Electrical and Electronic Equipment (WEEE) is the European Union (EU) and Pollution Control Department (Sujitra Vassanadumrongdee & Panate Manomaiwiboon, 2012). United Nations defines E-waste in the Solving the E-Waste Problem: STEP Project. It means all types of Electrical and Electronic Equipment (EEE) and other components of the equipment that is discarded or unused, which the owner of the equipment does not intend to reuse (United Nations University, 2014). The EU Directive on Waste of Electrical and Electronic Equipment No. 2012/19/EU Article 3(1) defines Waste from Electrical and Electronic Equipment as electrical and electronic equipment. Under the definition of EU Directive on waste No. 2008/98/EC

(Article 3(1) of Directive 2008/98/EC), it covers all components, sub-assemblies, and consumables which form parts of the product when discarded (European Parliament and Council, 2012). The definition of "waste" according to the EU Directive on waste 2008/98/EC Article 3(1) means any substance or object that the owner discards or intends to discard or needs to discard (European Parliament and Council, 2008). Therefore, e-waste, according to the definition of EU means waste from electrical and electronic equipment (WEEE), which covers all components, sub-assemblies, and consumables which all form parts of WEEE that the owner discards or intends to discard or needs to discard the EEE.

According to the EU Directive on Waste from Electrical and Electronic Equipment No. 2012/19/EU in Annex I and Annex II according to Article 2(1)(a), EEE is divided into ten groups as follows:

1) Large household appliances such as refrigerator, cooler, air conditioner, washing machine, dishwasher, microwave.

2) Small household appliances such as vacuum cleaners, iron, toaster, coffee maker, electric razor.

3) IT and telecommunications equipment such as computer, notebook, printer, smartphone, scanner, facsimile.

4) Consumer equipment and photovoltaic panels such as television, audio set.

5) Lighting equipment such as Straight fluorescent lamps and Compact fluorescent lamps

6) Electrical and electronic tools such as drill, electric saw

7) Toys, leisure, and sports equipment such as game players, coin slot machines

8) Medical devices such as radiation machines, electrocardiographs

9) Monitoring and control instruments such as smoke detector, thermostat

10) Automatic dispensers such as drink vending machines, ATM booths

Moreover, the EU Directive on Waste from Electrical and Electronic Equipment No. 2012/19/EU in Annex III and Annex IV according to Article 2(1)(b) divides EEE into six groups as follows:

1) Temperature exchange equipment such as refrigerator, air conditioner

2) Screens and monitors such as television, Laptops, Notebooks, Tablets

3) Lamps such as a fluorescent lamp, LED lamp

4) Large equipment such as washing machine, large printer, large photocopier, washing machine, dryer

5) Small equipment such as radio, vacuum cleaner, iron, camera, microwave, electric razor

6) Small IT and telecommunication equipment such as computers, smartphones, Global Positioning Systems (GPS), small photocopiers, calculators

In summary, the EU classified electrical and electronic equipment (EEE) into ten groups and six groups as in Table 2.1.

Table 2.1 Classification of EU's Electrical and Electronic Equipment

Product categories	**Annex I and Annex II-EU10**	**Annex III and Annex IV-EU6**
Large household appliance	1	1,4,5
Small household appliances	2	5
IT and telecommunications equipment	3	2,4,6
Consumer equipment and photovoltaic panels	4	2,5
Lighting equipment	5	3,5
Electrical and electronic tools	6	4,5
Toys, leisure, and sports equipment	7	4,5,6
Medical devices	8	4,5
Monitoring and control instruments	9	4,5
Automatic dispensers	10	1,4

In Thailand, the definitions of e-waste or WEEE are as follows:

Department of Health (2 0 1 5) defines E-waste as electrical and electronic equipment (EEE) that is expired or that the owner no longer wants to use. Due to advancements in technology, consumers change EEE often, generating e-waste that requires academically correct management. The equipment parts are toxic and non-biodegradable such as smartphones, computers, telephones, photocopiers, printers, refrigerators, washing machines.

The Integrated Waste Electrical and Electronic Equipment Management Strategy B.E. 2557-2564 (2014-2021) determines ten types of the target electrical and electronic waste that large local administrative organizations (LAOs), all city municipalities, Bangkok, and Pattaya must have the mechanism of efficient return and collection, and transfer for correct recycling, treatment or disposal namely 1) Fluorescent lamp 2) Dry battery 3) Refrigerator 4) Television 5) Air conditioner 6) Camera/video camera 7) Portable video/audio device 8) Printer 9) Telephone and 10) Personal computer (Pollution Control Department, 2017a).

Draft Article 4 of the Draft of the Waste from Electrical and Electronic Equipment Management B. E. . . . . (Draft version in 2019) defines waste from electrical and electronic equipment as the electrical and electronic equipment (EEE). They are 1) Device or equipment that relies on the electric current or electromagnetic field to function 2) Device or equipment that produces, transmits, or measures electric current and 3) Related tools with components of 1) and 2) that are damaged or deteriorated until they can no longer function or are no longer wanted. In the Draft Act, five types of electrical equipment posing major problems include 1) Computer 2) Telephone and wireless phone 3) Air conditioner 4) Television and 5) Refrigerator. Minister of Natural Resources and Environment (MNRE) was empowered to issue the Ministerial Regulation to determine additional EEE under this Act. However, EEE used as military weapons are not applied.

Pollution Control Department (2020b) defines e-waste as an electrical and electronic product including parts or any part of the expired product or no longer wanted and classified as HHW. E-waste is also classified as household toxic or hazardous solid waste according to the Ministerial Regulation on Communal Toxic, or Hazardous Solid Waste Management B.E.2563 (2020) Section 8 (5) as the contamination of toxic substances or other substances may cause risks to people,

animals, plants, or environment. Therefore, the Regulation will provide the common benefit of e-waste management and HHW management to operating officers, people, and those involved in sorting, preparation of containers, collection, and storage before treatment or disposal.

Therefore, based on the definition and types of e-waste, the researcher defines E-waste or WEEE as electrical and electronic waste, including components of EEE that are expired or degenerated or damaged so that it is no longer usable or no longer wanted. It is HHW due to hazardous compounds to health and the environment and non-biodegradable. Therefore, it requires academically correct management from sorting, collection, transport, treatment, or disposal such as fluorescent lamps, dry batteries, refrigerators, televisions, air conditioners, telephone, computers.

2.1.2 Origins of E-Waste

The origins of e-waste in Thailand are industrial waste, household e-waste, and e-waste from import. Industrial waste is from the production of goods within domestic industrial factories, and household e-waste is from use in domestic households, companies, or shops. (Department of Health, 2015; Nicha Buranasing, 2016). The details are as follows:

2.1.2.1 Industrial factories

Industrial factories producing EEE are the source of EEE production. Each year, a lot of produced EEE enters the market. There is found residue from the production process of goods or products not meeting the standard. Some will be recycled or destroyed or become e-waste. EEE will then become e-waste in the future after expiration. According to the statistics of production of electronic goods in Thailand between 2016-2020, the production of parts and components of the computer, Tablet, Notebook, Personal Computer, and Smart Phone such as Semiconductor, Hard Disk Drives Integrated Circuit, Print Circuit Broad Assembly (PCBA)) increased from the previous year by 1 . 5 %, 7.5%, and 4.5% in 2016-2018, respectively. In 2019, the production of electronic goods decreased by 6.3% from the previous year due to a slowdown of global demand. Similarly, in 2020, the production was down 1 . 1 % compared with the previous year due to economic

slowdown and the spread of COVID-19 (Office of Industrial Economics, 2016, 2017, 2018, 2019, 2020b).

At present (2021), the Ministry of Industry issues the Ministerial Notification on Specifying the Type and Origin of Raw Materials used in the Factory, B.E.2563(2020), and published it in the Royal Gazette May 28, 2020. The content of the law prohibits factories based on the Factory Act to use electrical and electronic parts or scraps (excluding scraps from the electric generator) with the components of the capacitor and other batteries, switch with mercury, a capacitor with Polychlorinated Biphenyls (PCBs) or contaminated with cadmium, mercury, lead, PCBs. That is according to the List 52 ranked 2.18 of Notification of Ministry of Industry on the List of Hazardous Substances B.E. 2556 (2013) under the Hazardous Substance Act B.E. 2535 (1992), as well as contaminated with hazardous substances as stipulated by the Ministry of Industry imported to be used as raw materials in factories (Notification of Ministry of Commerce on Electronic Waste is Prohibited from Importing into the Kingdom, 2020, 14 September).

2.1.2.2 Communities

At present, EEE is considered an essential part of people's daily lives and in households. The advancement of production technology that is fast developed and changed causes products to have shorter working life (Pollution Control Department, 2008, 2017a), as shown in Table 2.2. Products with lower prices and easy access to consumers result in the increased use or consumption of EEE due to convenience, speed, and modernity, including mobile phones, computers, television, air conditioner, refrigerator. Therefore, when EEE expires or can no longer function or is old, outdated, or no longer wanted by consumers, it will become e-waste. Household e-waste from household consumption in Thailand rises every year. Between 2016-2019, the generated household e-waste amounted to 393,070, 401,387, 414,655, and 421,335 tons, respectively, or the average increase rate of 2.3% a year. The household e-waste came from eight types of goods: television, air conditioner, washing machine, refrigerator, computer, telephone, VCD/DVD player, digital camera, or 65% of the total amount of HHW (Pollution Control Department, 2020d).

Compared to the e-waste generated from the domestic sources of e-waste, the generation source of most e-waste was from communities rather than industrial factories. From the survey of the amount of e-waste from household consumption and industrial sources by the Department of Industrial Works, the estimated amount of the ten types of e-waste, namely television, air conditioner, washing machine, refrigerator, computer, notebook, tablet, telephone, fluorescent lamp, and LED lamp, and battery in 2017 was 359,048 tons, mostly or 81% from households and establishments (290,288 tons). The minority of 19% was industrial waste (68,760 tons) (Center of Excellence on Hazardous Substance Management, 2019b).

Table 2.2 Average Working Life of Electrical and Electronic Equipment

Electrical and electronic equipment	**Approximate working life (years)**	
	2004[1]	**2012[2]**
1. Temperature exchange equipment		
Refrigerator	14	6-7
Air conditioner	10	5
2. Screens and monitors		
Personal computer/Notebook	7	3-4
Television with CRT monitor	18	6-7
Television with LCD/Plasma monitor		3-4
3. Lamps		
Fluorescent lamp	1	
4. Large equipment		
Washing machine	12	
5. Small equipment		
Portable video/audio device		3-4
Camera/video camera		3-4
6. Small IT and telecommunication equipment		
Smartphone		3
House phone		6
Printer		3
Fax machine		3-4
Smartphone battery	1	

Sources: 1 Pollution Control Department, 2004 as cited in Pollution Control Department, 2008

2 Adapted from Pollution Control Department, 2017a

2.1.2.3 Import

Between 2016-2018, importing electrical and electronic parts and using EEE as e-waste was mainly from developed countries for repair or sold at low prices or disassembling valuable metals used as raw materials in the next production. In 2017, Thailand significantly increased import of e-waste with an import volume of 54,260 tons compared with 2016 with an import volume of 1,986 tons and in 2018 with an import volume of 38,404 tons. (“MNRE shift measures,” 2020). In 2017, China announced the ban of imported waste effective in 2018. As a result, Hong Kong, Australia, the US, New Zealand, Japan, and the EU had to find new sources to accommodate e-waste. Thailand is one of the target countries for exporting e-waste from those developed countries, including China. To avoid e-waste disposal in their own countries, they would export to Thailand and engage the recycling factories, which were their affiliated companies set up in Thailand to sort valuable metals in the e-waste based on academically incorrect methods. Then, they re-export the valuable metals back to their countries as raw materials in production (Sasiwimon Mudju, 2019).

At present (2021), the Ministry of Commerce has issued a Notification that Electronic Waste is Prohibited from Importing into the Kingdom, B.E.2563 (2020), and published it in the Royal Gazette on September 14, 2020. The banned e-waste from import was the HS Code chapter 84 and Chapter 85, precisely statistical code number 899. The e-waste was under the Basel Convention with 428 lists of products and effective since September 15, 2020 (Notification of Ministry of Commerce on Electronic Waste is Prohibited from Importing into the Kingdom, 2020, 14 September). Most LED lamps, electric current control boards, integrated circuits, and heaters were imported from China (81% of the total import value of e-waste), followed by the EU and Japan with 7% and 5% of the total import value of e-waste, respectively. The e-waste had no use and could not contribute to value-added through recycling and discharged toxic substances ("Do not let Thailand it is second hand e-waste.," 2020). However, the Notification prevented the e-waste import from being disposed of in Thailand, contribute to environmental conservation, public health, protect people's safety, and drive entrepreneurs and relevant agencies to

accelerate the management of domestic e-waste based on correct and appropriate methods.

In summary, the generation sources of e-waste in Thailand came from two sources: factories producing EEE and communities (e.g., households, companies, and shops) that were not industrial factories. E-waste was generated from communities (81% of the generated e-waste) than industrial factories (19% of the generated e-waste). The generation sources of e-waste from abroad included importing parts of EEE and used EEE from developed countries such as China, EU, and Japan.

2.1.3 Hazardous Substances in E-Waste and Impacts

2.1.3.1 Hazardous Substances in E-Waste

In the parts of e-waste, there were over 20 types of hazardous substances (Robinson, 2009). Most were heavy metals such as Lead, Mercury, Cadmium, Chromium, Beryllium, Antimony, and other substances that could be found such as Brominated Flame Retardants (BFR). This substance was widely used in the mixture in electronic equipment to delay flame and other toxic substances such as Polyvinyl Chloride (PVC), Polychlorinated Biphenyls (PCBs), Triphenyl Phosphate, Nonylphenol, and Polychlorinated Naphthalene (PCNs). Moreover, dioxins and furans were discharged into the environment when there was burning to destroy e-waste with the composition of BFR (Orawan Phuphisut & Suleeporn Sangrajang, 2010).

2.1.3.2 Health, Environmental, and Economic Impact

The danger from e-waste came from academically incorrect management, lack of modern technology for disposal. As a result, hazardous substances that were electronic equipment components and were heavy, primarily metals such as Lead, Mercury, Cadmium, and Brominated Flame Retardants (BFR), were leaked into the environment (Orawan Phuphisut & Suleeporn Sangrajang, 2010). The contamination with hazardous waste such as heavy metals into the environment and as residue in the soil, surface water sources, and groundwater sources might cause danger to living creatures and people living in the area as follows:

(1) Health impact: Each type of hazardous substance in e-waste would impact people's health differently, such as palpitation, destroyed the

nervous system, could cause cancer and death if accumulated in the body in large quantities. Those at risk of health impact from e-waste included those who worked in the industrial sector, those who sorted waste for recycling, and users of electronic equipment. As these people can be exposed to toxic substances with different health impacts, those who worked in the industrial sector producing electronic equipment would be prone to contact heavy metals during production, risking lung cancer, Nasopharynx cancer, and brain cancer. The users of electronic equipment risked exposure to BFR contaminated from the dust on the computer, which could disturb the function of the nervous system (Orawan Phuphisut & Suleeporn Sangrajang, 2010). Those who incorrectly sorted waste for recycling, such as burning and using acid with e-waste to separate valuable metals, risked accumulation of lead in the body through the respiratory system and contamination of lead in the soil in the area of dismantling and burning of e-waste (Seelawut Damrongsiri, 2015). If accumulated in large quantities, the lead would impact the development of the brain and central nervous system, causing amnesia (World Health Organization, 2019). Based on the study of Health Risk Assessment of E-Waste Dismantling Workers Exposed to Heavy Metals via Dermal Absorption at Dang Yai Subdistrict, Ban Mai Chai Poj district, Buri Ram of Kakanan Konjanawan, Nitaree Satrabhan, Kamonthip Khunchalee, and Tassanee Prueksasi (2020), it was found that the average concentrations of the six heavy metals on the hands of the workers during the dismantling of e-waste from high to low concentrations were as follows: zinc (2,592.91-40,722.91 mg/kg), copper (785.43-49,899.31 mg/kg), lead (81.50-6,038.26 mg/kg), nickel (81.50-188.36 mg/kg), cadmium (2.00-63.25 mg/kg), and arsenic (0.02-8.44 mg/kg), respectively. The evaluation result of non-cancer risk, hazard quotients (HQ) revealed that the ratio of the hazardous risk of all types of metals was lower than 1 . It was showed that exposure to heavy metals through contact by hand did not provide the opportunity to increase health risk. The workers had more chances to contact heavy metals through other parts of their bodies, such as arm, leg, knee, sole, face. The heavy metals' abilities for skin permeation were different as well. Arsenic was not good at skin permeation, so it had a good chance of sticking on workers' hands. Copper interacted well with the skin tissue of living creatures. Lead could also absorb well on the skin.

People's health impact from heavy metals and hazardous substances is as shown in Table 2.3.

Table 2.3 Health Impact from Some Heavy Metals and Hazardous Substances from E-Waste

Hazardous substances	**Parts of e-waste [1,2]**	**Health impact [3,4]**
Lead	Television screen, computer screen, circuit board, car battery	- Affect the central nervous system and brain, causing irritability, restlessness, dizziness, and amnesia. In severe case, tremor might occur when moving, seizure, loss of consciousness, and possible death. Affect peripheral nervous system, digestive system, circulatory system - For children younger than six years old, the accumulated lead may affect the development of the brain causing low IQ, slow development, and growth
Mercury	Fluorescent lamp, switch, LCD monitor (Liquid Crystal Display Monitor)	- Destroy the nervous system, affecting learning, memory, concentration, physical communication. If received in a large quantity, it will affect kidneys, respiratory system, and possible death - Can receive toxic mercury through the food chain by consuming fish with accumulated mercury. For pregnant women, the consumption of fish with mercury may affect the development of the fetus and mercury will accumulate in mother’s milk as well
Mercury (continued)		
Cadmium	Semiconductor, circuit board, CRT monitor (Cathode Ray Tube Monitor), battery	If received in large quantity in a short time, it will cause fever, headache, vomit as long as 20 hours. In the long run, it will cause osteoporosis (Itai-Itai disease) causing brittle and easily broken bone, bone pain all over the body, and danger to kidneys.
Beryllium	Circuit board, electric wire	Cause irritation in respiratory mucosa, coughing, and difficulty breathing, causing pneumonia and carcinogen in human being especially lung cancer
Antimony	Circuit board, CRT monitor, LCD monitor, parts in computer, television, and smartphone	Acute toxicity causing irritation, nausea, vomit, and diarrhea. Chronic toxicity causing fatigue, no appetite, nausea, destroy the liver and may experience skin problem with rough, swollen skin. May cause skin cancer.
Copper	Circuit board, CRT monitor	Vomit, diarrhea, inflammation in abdomen and muscles, arrhythmia. If accumulated in large quantity, it may cause the body to shake all the time, muscular rigidity, and difficulty in

Hazardous substances	Parts of e-waste [1,2]	Health impact [3,4]
		controlling speech.
Lithium	Battery	Severely destroy tissues of mucous membranes of various organs, respiratory organs, eyes, skin. In case of inhalation, it may cause seizure, bronchitis, headache, vomit, and may cause pneumonia from chemicals and pulmonary edema.
Arsenic	Circuit board, CRT monitor, LCD monitor, Plasma Display	Destroy the nervous system, skin, and digestive system. If received in large quantity, it may cause death and affect the fetus
Brominated Flame Retardants	Circuit board, plastic-wrapped electronic equipment	Disturb functioning of the nervous system, brain, ductless gland, and hormone, affecting the development of the fetus and increasing risk of gastric cancer and lymphoma

Sources: 1 Robinson, 2009

2 Townsend, 2011

3 Orawan Phuphisut & Suleeporn Sangrajang, 2010

4 Sopana Jirawongnusone, Nattawadee Chitmanasak, Sarin Littisan, & Puangpaka Phooyada, 2018

(2) Environmental impact: Hazardous substances from e-waste could contaminate the soil, water, air and destroy the ozone layer. Incorrect methods of managing electronic equipment parts by buyers of used items and small entrepreneurs who were villagers and not part of registered factories or the Informal sector abroad. The burning of electronic equipment caused heavy metals (e.g., lead, cadmium, and mercury) to become residue and spread to the environment, such as pouring acid from car batteries onto the soil, disposal of glass scraps from television screens caused lead to spread in the soil and water. In aquatic animals, mercury would accumulate in the human body if the aquatic animals for food. The burning of compressors in the refrigerator and air conditioner would cause refrigerants such as Chlorofluorocarbon (CFCs) to evaporate in the air and destroy the ozone layer (Saijai Withaya-Anumas, 2017; Seelawut Damrongsiri, 2015). Moreover, the use of the machine in melting parts of plastic waste in e-waste caused a loud noise and foul smell from chemicals that disturbed and affected people living in the vicinity of the e-waste sorting and recycling factories (Narakorn Nuntatripob, 2018).

The examples of environmental and health impact from hazardous substances in e-waste took place in China in the areas using academically incorrect e-waste sorting or recycling methods through burning in Guiyu, Guangdong Province, and Taizhou, Zhejiang Province. Subsequently, there was heavy metal contamination in the soil, such as cadmium, zinc, nickel, chromium, copper. Their concentration of heavy metals was exceeded the soil quality standard for agriculture and habitation in China which determined at 0.3 milligram/kilogram (mg/kg), 200 mg/kg, 40 mg/kg, 200 mg/kg, and 50 mg/kg respectively and the Intervention Value determined at 13 mg/kg, 720 mg/kg, 100 mg/kg, 78 mg/kg, and 190 mg/kg respectively. It signified that the concentration of heavy metals in soil was serious and required treatment, as shown in Table 2.4 (Li et al., 2011; Zhang et al., 2014). It was also found that the level of cadmium in children's blood in the areas of e-waste recycling in Guiyu, Guangdong Province, and Taizhou, Zhejiang Province exceeded the standards and higher than the controlled Chendian (Song & Li, 2015).

The significant sorting sources of e-waste in the northeast of Thailand and Bangkok were 1) Sua Yai Uthit Community, Chatuchak District, Bangkok 2) Khok Sa-At Subdistrict, Khong Chai District, Kalasin 3) Daeng Yai Subdistrict, Ban Mai Chaiyaphot District, Buriram and 4) Ban Pao Subdistrict, Phutthaisong District, Buriram. The survey results of heavy metal contamination in soil between 2014-2017 around the areas with activities of disassembling and crushing parts of e-waste and the landfill sites of e-waste. The areas were Sua Yai Uthit Community, Chatuchak District, Bangkok, Khok Sa-At Subdistrict, Khong Chai District, Kalasin, and four southern provinces, namely Nakhon Si Thammarat, Songkhla, Phatthalung, and Trang. The concentration of lead in soil exceeded the soil quality standard for agriculture and habitation in Thailand according to the Notification of National Environment Board No. 25 B.E. 2547 (2004), which stipulated 400 mg/kg and the Intervention Value 530 mg/kg. It signified that the concentrations of heavy metals in soil was severe and required treatment, as shown in Table 2.4 (Peeranat Kiddee & Somsiri Decharat, 2017; Pornpilai Thanomsangad, Ratchuda Junsong, & Lamyai Neeratanaphan, 2018; Saijai Withaya-Anumas, 2017; Seelawut Damrongsiri, 2015; Sujitra Vassanadumrongdee, 2015). The concentrations of lead and cadmium in workers' blood in e-waste recycling shops in Nakhon Si Thammarat, Songkhla, Phatthalung, and Trang with value ranges between 1-17 microgram/deciliter (µg/dl) and 0.3-2.6 microgram/liter (µg/l), respectively. All workers who had their blood tested (71

workers) had the concentrations of lead and cadmium in blood within the standard criteria according to the Notification of Department of Disease Control on the Biological Exposure Indicies (Thai BEIs), which stipulated at 30 µg/dl and five µg/l respectively. Among the 71 workers, the workers experienced headache and acute dizziness (17 workers or 23.9%), acute blurred vision and rashes (19 workers or 26.8%), acute skin inflammation (19 workers or 26.8%), and acute numbness of hands and feet (18 workers or 25.4%) (Peeranat Kiddee & Somsiri Decharat, 2017). Pornpilai Thanomsangad, Ratchuda Junsong, and Lamyai Neeratanaphan (2018) studied the heavy metal contamination in surface water sources around the e-waste landfill area at Khok Sa-At Subdistrict, Kong Chai District, Kalasin with six water sources Pornpilai Thanomsangad et al. (2018), concentrations of copper (Cu), lead (Pb), cadmium (Cd), and manganese (Mn) in three water sources were exceeded the standard of surface water quality class 3 (for agriculture). The concentrations of nickel (Ni) and zinc (Zn) in two water sources and chromium (Cr) in a water source have exceeded the standard. The water sources with the concentrations of heavy metals exceeding the standard were in the e-waste landfill site (Sites of water sampling No. 2, 3, and 5), which directly impacted leachate. Mn in the water in paddy fields (Site of water sampling No. 1) exceeded the standard. The landfill was more elevated than the paddy fields. There was a flow of leachate down to the paddy fields, the details in Table 2.5.

Table 2.4 Concentrations of Heavy Metals in Soil in the Areas of Landfill, Areas of Sorting and Recycling of E-Waste in China and Thailand

Areas (year of the survey)	**Results of the concentration of heavy metals in soil (mg/kg)**								**Source**
	Cu	Pb	Zn	Cd	Ni	Cr	As	Mn	
1. Area of the burning of e-waste in Guiyu, Guangdong Province, China (2009)	12,700	480	3,500	10.0	1,100	320	52	500	Li et al., 2011
2. Area used to be the location of metal melting from e-waste in Guiyu, Guangdong Province, China (2009)	4,800	150	330	1.2	480	2,600	26	300	Li et al., 2011
3.Deserted area of sorting of e-waste in Taizhou, Zhejiang Province, China (n.d.)	157	167	276	2.2	-	69.5	5.3	-	Zhang et al., 2014
4. Deserted location of recycling of e-waste in Taizhou, Zhejiang Province, China (n.d.)	2,364	6,038	5,996	42.3	-	771.5	36.6	-	Zhang et al., 2014
5. Areas of houses that bought back and disassembled parts of e-waste at Khok Sa-At Subdistrict, Khong Chai District, Kalasin (2014)	9,267	1,383	5,80	3.3	27	18	6	-	Sujitra Vassanadumrongdee, 2015
6. Areas of landfills of e-waste (6 locations) and distance of 100 meters from the landfills (17 locations) at Khok Sa-At Subdistrict, Khong Chai District, Kalasin in total 23 locations (2017)	3.45-6,431	3.21-7,719.16	57.39-2,104.47	0.37-16.55	1.93-77.98	8.11-35.75	0.74-12.09	11.08-223.64	Pornpilai Thanomsangad et al., 2018
7. Disassembling area of e-waste, Soi Sua Yai Uthit, Chatuchak District, Bangkok (2014)	4,828	1,058	1,874	< 2	74	88	-	511	Seelawut Damrongsiri, 2015
8. Area outside the disassembling of e-waste, Soi Sua Yai Uthit, Chatuchak, Bangkok (2014)	90	67	237	< 2	16	37	-	374	Seelawut Damrongsiri, 2015

Areas (year of the survey)	Results of the concentration of heavy metals in soil (mg/kg)								Source
	Cu	Pb	Zn	Cd	Ni	Cr	As	Mn	
9. E-waste recycling shops in the four southern provinces of Thailand namely Nakhon Si Thammarat, Songkhla, Phatthalung, and Trang in total 20 shops (2016)	-	< 1.15-2,886.97	-	< 0.18-< 0.20	-	-	-	-	Peeranat Kiddee & Somsiri Decharat, 2017
Standard of soil quality for agriculture and habitation in China	50	250	200	0.3	40	200	30	-	Ministry of Environmental Protection, 1996
Intervention Value	190	530	720	13	100	78	76	-	Ministry of Housing Spatial Planning and the Environment, 2009
Standard of soil quality for habitation and agriculture according to the Notification of National Environment Board No. 25 B.E. 2547 (2004) on the standard of soil quality	-	400	-	37	1,600	300	3.9	1,800	Announcement of National Environment Board Issue 25, 2004

Table 2.5 Concentrations of Heavy Metals Contaminated in Water Sources around the E-Waste Landfill at Khok Sa-At Subdistrict, Kong Chai District, Kalasin

Sites of sample collection	Concentration of heavy metals in water sources (mg/kg)							
	Cu	**Pb**	**Zn**	**Cd**	**Ni**	**Cr**	**As**	**Mn**
Landfill of e-waste								
Site 2	0.647*	0.206*	4.289*	0.040*	0.335*	0.001	0.009	2.780*
Site 5	1.083*	0.183*	0.543	0.007*	0.054	0.001	0.008	0.211
Site 6	69.759*	2.106*	19.008*	0.179*	1.394*	0.061	0.008	11.585*
Distance of 100 meters from the landfill of e-waste								
Site 1	0.051	0.009	0.272	0.002	0.018	0.001	0.007	3.268*
Site 3	0.063	0.007	0.264	0.001	0.015	0.004	0.007	0.567
Site 4	0.018	0.002	0.233	0.001	0.011	0.001	0.006	0.852
Standards of water quality[1]	**0.1**	**0.05**	**1.0**	**0.005**	**0.1**	**0.05**	**0.1**	**1.0**

Source: Adapted from Pornpilai Thanomsangad et al., 2018

Note: 1 Surface Water Quality Standard in Class 3: Surface water resources used for consumption, but passing through an ordinary treatment process before using, and for agriculture according to the Enhancement and Conservation of National Environmental Quality Act B.E. 2535 (1992) on Surface Water Quality Standard in Surface Water Sources

* Exceeding the Surface Water Quality Standard in Class 3

(3) Economic impact: E-waste could generate value-added and create a positive economic impact if e-waste recycling is the academically correct process. The study of Kasikorn Research Center (2017) found that in 2016 the e-waste recycling market in Thailand was valued at approximately 4,770 million baht. One ton of e-waste could create a value of approximately 67,100 baht, generating employment and income for Thai entrepreneurs who operated an e-waste recycling business. Because in e-waste, there were many types of valuable metals such as gold, silver, copper, aluminum. The recycling and modification of old or damaged EEE would create value-added. Afterward, the usable EEE would be sold as secondhand goods or donated to the poor in the rural areas, generating income for the sales and assistance

to the underprivileged in society (Sasiwimon Mudju, 2018). As for valuable e-waste that sold, such as television, refrigerator, air conditioner. People would sell them to those who bought old items or recycled waste. They were sidecar buyers of used items, peddlers, or local junk shops. So, people earned income from the sale of these waste products as a whole. Local junk shops would like employed local people in the community to sort and disassemble components and valuable materials from e-waste to resell at reasonable prices or send e-waste for industrial factories to recycle. Therefore, it generated employment and income for residents in the communities and junk shops. Moreover, it would reduce production costs of industrial factories as well (Thitichai Athikomkulchai & Viroj Jadesalug, 2015).

As for negative economic impact, in case of a large quantity of e-waste, without systematic and efficient management planning, it would cause economic loss. When the amount of e-waste increased, without good management, e-waste with the potential of reuse would be mixed with general solid waste and caused contamination with environmental quality and impacted people's health. It would also be damaged and no reused. It would cause the loss of natural resources and the environment. It could not reduce the amount of e-waste. It would create an economic impact as the government must lose a big budget to improve and rehabilitate environmental quality and people’s health (Janejira Jannuwat, 2019).

2.1.4 Concepts and Principles of E-Waste Management

The concept and principles of solid waste management and HHW management adapted for household e-waste management in this study consisted of six principles. They were 3 Rs, Polluter Pays Principles (PPP), Extended Producer Responsibility (EPR), Public-Private Partnerships (PPPs), Circular Economy, and Reverse Logistics Management. The details are as follows:

2.1.4.1 Principles of 3 Rs consisting of the following:

1) Reduce means reduce unnecessary consumption, avoid luxurious use to reduce loss and amount of waste as much as possible. If necessary, consideration should be to buy energy-saving goods with environmental-friendly labels or industrial standard labels (TIS) (Chompoonut Promprak, 2012; Pollution Control Department, 2018b).

2) Reuse means reuse packaging waste or residue without going through processing, extending the working life of the products such as Rechargeable batteries, donation of EEE, secondhand EEE(Pollution Control Department, 2018b).

3) Recycle means packaging waste, residue as raw material in the production process, or product into new products (Pollution Control Department, 2018b). For example, recycle valuable metals of e-waste (copper, silver, gold) as raw materials for the jewelry industry or electronic industry through proper extraction or sorting of e-waste (Pavittra Lerkbangphlat, 2017).

Apart from the principles of 3Rs, there were also the principles of 5Rs with two additional R, namely Repair and Reject (Department of Labour Protection and Welfare, 2011), which added people's changed behavior into the e-waste management as follows:

4) Repair means repairing damaged materials or tools for reuse, such as repairing electrical devices.

5) Reject means avoid or reject the use of goods that may cause danger.

2.1.4.2 Polluter Pays Principle

The Polluter Pays Principle (PPP) in terms of economic concept means the Environmental costs or Externality as part of production costs of goods and services. They impacted the environment, caused production costs and goods and services to go up, and caused producers and consumers to change their behaviors, which would benefit environmental conservation (Mingsarn Kaosa-ard & Kobkul Rayanakorn, 2009). Legally, it was the concept that wanted those who generated pollution to be responsible for the pollution. Generally, these are principles used in the production or control of pollution emissions of the industrial sector. It proposes using the economic tool in the management of natural resources and the environment, creating incentives, and determining the responsibilities to reduce pollution generation such as e-waste recycling fee, and tax reduction for repair or donation of EEE (Amnat Wongbandit, 2014)

The e-waste recycling fee stipulated the generator of pollution to be responsible for ensued environmental costs. For example, in California, US, a

recycling fee was imposed on consumers who bought new EEE. The retailer would collect 3% of the fee at the time of purchase as operational expenses. The rest were sent to the government (Bergner, 2004). In Japan, the law determined that consumers would pay household electrical waste recycling fees to producers or retailers by which the producers or retailers determined the fee rate collected under the supervision of the competent minister. The determined household electrical appliances consisted of four types: television (CRT TVs, LCD, and plasma TVs) , air conditioners, refrigerators and freezers, clothes washers, and dryers (Ministry of Economy Trade and Industry, 2018). Tax reduction for repair and donation of EEE would motivate taxpayers to take EEE for repair or donation. It would also reduce e-waste. For example, in Sweden, half of the labor wages from repair of EEE could be tax-deductible for personal income tax (Margolis, 2017). In the United States (US), the donation of EEE would be tax-deductible if the donation was for the agencies as stipulated by law (Pandika, 2013).

For Thailand, based on Chutima Keereeruttapisal (2020) study, no tax measure was used to solve the problems of e-waste specifically. It proposed the guideline to use tax measures to motivate people to reduce e-waste. The developed countries used tax measures in parallel with legal measures and succeeded in solving the problems of e-waste, such as California, the US, Japan, and Sweden. The researcher suggested that Thailand should determine the tax deduction for the donation of used EEE and collected value-added tax at the rate of 0% for the repair of EEE. There is a law on the specific management of e-waste by collecting recycling fees to ensure that the generator of pollution would be responsible for the environmental costs.

2.1.4.3 Extended Producer Responsibility

The principle of Extended Producer Responsibility (EPR) was the principle of policy approach that expanded the responsibilities of producers to the phases of the life cycle of products, especially the phase of return, recycling, and disposal of product waste to improve the environment of the product. In practice, the principle of EPR was the foundation to select the set of policy tools, including management tools, economic tools, or IT tools. The primary goals of the principle of EPR consisted of the following: 1) Create the system of collection and transport of

product waste to reduce incorrect disposal of waste 2) Increase the ratio of reuse of materials from product waste through Reuse, Recycle, and Energy recovery and 3) Motivate changes in the design of more environmental-friendly products in the product's entire life cycle (Lindhqvist, 2000).

Generally, the EPR system would involve the public sector, producers, and service providers collecting and managing product waste. It would be different in terms of the number of the central organization or "Producer Responsibility Organization (PRO)," the agency that collected and distributed funds. This agency monitored and enforced the law and responsibilities of the agencies that joined the system. The EPR has two types, namely Full EPR and Government's fund. Full EPR was the format that producers and importers were fully responsible for e-waste management from sorting, collection, treatment, and reuse. Mostly found in Europe, including one PRO and many PROs. The government's fund was the format that the government managed the fund by which producers and importers. They were responsible for financial matters in e-waste disposal only by paying the product fee into the government's fund, such as China and Taiwan (Organization for Economic Co-operation and Development, 2016).

For the past 30 years, many countries worldwide have used the EPR system to manage various types of waste, especially e-waste, packaging waste, and car tires. The EPR reduced the amount of waste sent for disposal, increased the recycling rate, and reduced the local budget for solid waste management. The EPR system would encourage the development of the waste management industry, especially the recycling industry. However, the major weakness of the EPR system was that the EPR system could not motivate producers to change into environmental-friendly product design (Eco-design). The weaknesses were 1) Reduce the amount of used material such as the development of product for lighter weight or reduce the use of packaging 2) Develop the products to reduce environmental impacts such as avoid the use of hazardous substances or the use of more recycled material for the production 3) Extend the working life of products by increasing resistance and reusing parts and 4) Reduce impact during waste management, such as design for easy disassembling of parts or using the same type of material. The EPR system opened to producers to jointly manage through producer responsibility organization (PRO) and

many countries. The local government still supported the costs of collection of some parts and lacked close communication between recycling entrepreneurs and producers. Therefore, up till now, EPR had not quite reached the goal of Eco-design (Organization for Economic Co-operation and Development, 2016).

2.1.4.4 Public-Private Partnerships

The principle of Public-Private Partnership (PPPs) means the mechanism of the public sector in preparing basic infrastructure or public service through the use of resources and knowledge and expertise of the private sector. If the public sector encountered the problem of inefficiency of the basic infrastructure or quality of public service, the risks and responsibilities between the sectors would be allocated and shared to enable the public sector to thoroughly perform the main tasks of other parts of the public sector. The tasks included formulation of policy, planning, law enactment, and routine work (World Bank Group, 2021).

From the 20-Year Master Plan on the Prevention and Management of Pollution Caused by Solid and Hazardous Waste (2018-2037) for Thailand, PCD used the Public-Private Partnership and Polluter Pays Principle for promoting and supporting the private sector to invest or jointly invest in the waste management system because the private sector would be ready and have the potential for long-term system management. At the same time, the public sector and the local administration had limited budgets, machines, equipment, and personnel with knowledge and expertise in supervising waste management systems (Pollution Control Department, 2018a).

2.1.4.5 Circular Economy

A Circular Economy is the concept of the economic system that wants to circulate the comprehensive use of resources for maximum benefit into a cycle from production, consumption, Reuse, Recycle, and Re-material. The optimal use of resources and the reduction of environmental pollution are the issues that the economic sector must consider. Moreover, it may have to revolutionize the business model to the circular economy by using resources to enter production for reuse to solve the shortage of resources (Geissdoerfer, Savaget, Bocken, & Hultink, 2017; Kalmykova, Sadagopan, & Rosado, 2018). Thailand Institute of Scientific and Technological Research (2019) stated that circular economy is the concept to process the used resources for reuse for maximum efficiency, reduce waste problems, and use natural

resources when necessary. However, the circular economy is not about the repetitive use of material but to find business management by using various tools such as 3Rs (Reduce, Reuse, Recycle) in operation and management to make a profit and is environmental-friendly in the long run. The countries that initiated the use of circular economy were countries in the EU. At present, many countries around the world adapted themselves to enter the system of the circular economy. Many countries succeeded in driving the legal system in countries to support a circular economy. Consequently, the circular economy assumed a role in business operations that negatively impacted the environment, such as Denmark, the Netherlands, Germany, and the United Kingdom, who were considered circular economy leaders. Moreover, the countries in Asia included China and Japan (Phanlob Chankachang, 2020).

Thailand used a circular economy for national development in Thailand's industrial sector and the prevention and solutions to pollution problems from waste and HW. For example, PCD used the concept of circular economy in the management of waste and HW (including e-waste) to formulate the 20-Year Master Plan on the Prevention and Management of Pollution Caused by Solid and Hazardous Waste (2018-2037) (Pollution Control Department, 2018a). The circular economy has developed guidelines in four areas, namely production, consumption, waste management, and secondary raw materials (cited according to the prototype of development policy of Circular Economy of European Commission in four Key Action Areas, namely production, consumption, waste management, and secondary raw material). It focuses on the optimal and comprehensive use of resources, reduces environmental problems, reduces waste, and create economic value added to the country at the same time (Office of Industrial Economics, 2020a; Thailand Institute of Scientific and Technological Research, 2019) as follows:

1) Production: Production will promote the improvement of the production process using degradable raw materials such as bio raw materials, support the “Design for Circular Economy." It designs to extend the working life of environmentally friendly products, easily repaired, and can conveniently return unused products to be reused as raw materials in production. Moreover, it focuses on promoting technology, innovation, and research and development to improve the production process.

2) Consumption: Consumption starts from raising awareness, promotion of marketing to stimulate more consumption of goods and services based on the Circular concept. It provides information to consumers on environmental quality through product labels and determines the guideline for consumers to return products after expiration conveniently.

3) Waste Management: Waste management consists of developing a waste management system of the industrial sector for more efficiency, driving the determination of measures to foster responsibilities of producers in product waste management, strict supervision of waste management of the industrial sector, and promotion of recycled household waste.

4) Secondary Raw Material: Secondary raw material consists of promoting the use of raw materials already produced and consumed into the new production process, promoting the processing of waste/unused goods as raw materials in the industrial sector, development of standards for recycled raw materials, and development of laws or formulation of policies specifically for materials/waste as raw materials. Their materials are plastic, construction material, iron, glass, e-waste.

2.1.4.6 Reverse Logistics Management

Reverse Logistics Management is the concept of management that focuses on the reverse process of products or raw materials and dramatically contributes to business sustainability. It focuses on maximum and environmental-friendly efficiency in parallel (Punyapon Tepprasit, Thirawan Sakulwongsirichok, & Natsapan Paopan, 2021). Gao (2019) defined reverse logistics management as the process relevant to planning, implementation, and control with the objectives to create value and process of getting rid of objects in the flow of reverse logistics (Return flow) through management of Raw Materials, In-process Inventory, Finished Goods, and information relevant to efficient consumption to origin. Reverse logistics management consists of three main components, namely 1) Return policy and procedure, 2) Remanufacturing or refurbishment, and 3) Waste management. It is crucial for executives of an organization or responsible persons to place importance on and design it as appropriate to the guideline of their operation (Punyapon Tepprasit et al., 2021).

The management of reverse logistics in e-waste management means planning, operation, application, and control of product waste management that is no used, expired from the point of consumption initially to bring out the value of goods through various processes. The processes are Resale, Reuse, Repair, Refurbishing, Remanufacturing, and Recycling through the methods of Collection, Inspection, Selection, Sorting, Recovery, and Disposal with efficiency (Arrieta, 2015; Kannan, Diabat, Alrefaei, Govindan, & Yong, 2012; Saringkhan Khlaikhaek, 2018). For Thailand, the concept of e-waste with reverse logistics has attracted broader interest. Most scholars were interested in studying the factors impacting e-waste management (Ampol Navavongsathian, Yuth Plermpirom, Chayada Plermpirom, Jaruwan Songsang, Kongsak Lolertrattana, & Thanitsak Pudtipatkosit, 2017; Saringkhan Khlaikhaek, 2018), costs of e-waste management such as the alkaline battery, fluorescent lamp, design of the reverse logistic system with e-waste management, and measures and guideline of appropriate e-waste management (Chetphanat Leelasrisiri & Chutimaporn Mhonyai, 2018). The details of the study are under item 2.7, Relevant research works.

2.2 Strategies, Policies, Plans, and Laws Relevant to E-Waste Management

2.2.1 Strategies, Policies, Plans Relevant to E-Waste Management in Thailand and EEC

The guideline of e-waste management in Thailand took into account the requirement of the 17 United Nations' Sustainable Development Goals (SDGs) with many SDGs, such as SDG 3 on good health and well-being, SDG 6 on clean water and sanitation, SDG 8 on decent work and economic growth, SDG 9 on industry innovation and infrastructure, SDG 11 on sustainable cities and communities, and SDG 12 on responsible consumption and production. In particular, SDG 3 Target 3.9: By 2030, reduce the illnesses and deaths due to hazardous chemicals and air, soil, and water pollution and contamination, SDG 6 Target 6.3: By 2030, reduce pollution, eliminate dumping, and minimize release of hazardous chemicals and material, SDG 8 Target 8.3: By 2030, Promote development-oriented policies that support productive activities, decent job creation, entrepreneurship, creativity and innovation, and

encourage the formalization and growth of micro-, small- and medium-sized enterprises, including through access to financial services, SDG 9 Target 9.4: By 2030, upgrade infrastructure and retrofit industries to make them sustainable, with increased resource-use efficiency and greater adoption of clean and environmentally sound technologies and industrial processes, SDG Target 11.6: By 2030, reduce the adverse impact of cities on environment per capita, including special attention given to air quality and municipal and other waste management; and SDG 12 Target 12.5: By 2030, substantially reduce waste generation through prevention, reduction, recycle, and reuse (Baldé et al., 2017; Bhaskar & Kumar, 2019; Forti, Balde, Kuehr, & Bel, 2020; United Nations, 2021) The SDGs relevant to e-waste management was summarized in Figure 2.1.

Thailand placed importance on solid waste and HW management problems by determining it as national agenda in 2014. It approved the Roadmap of Thailand on solid waste management and HW management by PCD, MNRE on August 26, 2014. Afterward, relevant agencies formulated plans at various levels to ensure that solid waste and HW management, including e-waste, in areas around Thailand were efficient, could reduce the impact on people and environmental damage in Thailand based on concreteness and sustainability (Pollution Control Department, 2014). Plan level 1, meaning strategy, Plan level 2, meaning master plan under the strategy and national reform plan, and Plan level 3, meaning plan formulated to support Plan level 1 and Plan level 2 such as action plan, integrated plan. (Office of the National Economic and Social Development Council, 2018b).

The content of HW and e-waste management from the policies, strategies, and plans relevant to Thailand's e-waste management is as follows:

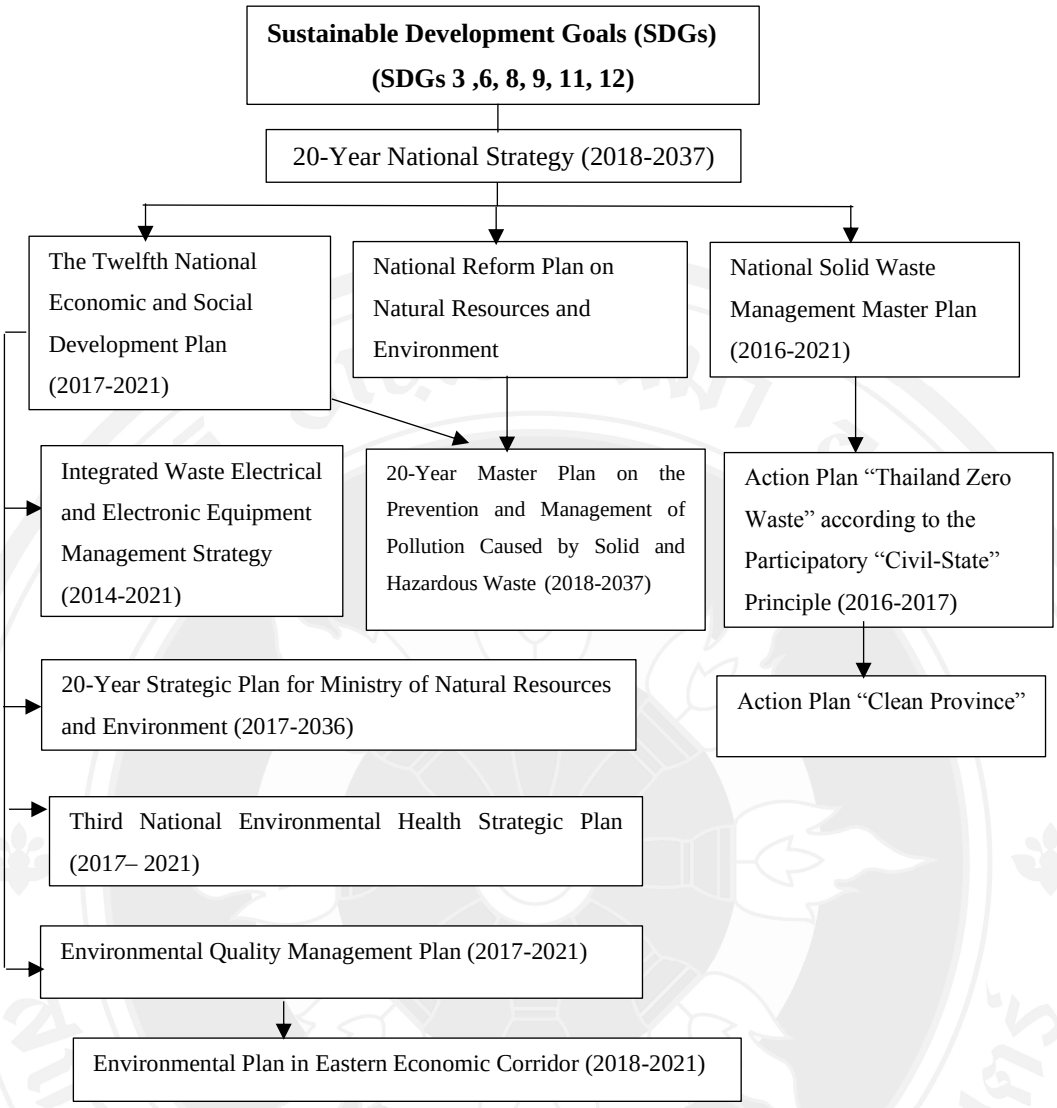


Figure 2.1 Linkage of SDGs, Policies, Strategies, and Plans relevant to E-Waste Management in Thailand

2.2.1.1 20-Year National Strategy B.E. 2561-2580 (2018-2037) was Thailand's first strategy according to the Constitution of the Kingdom of Thailand. It determined the framework and guideline of development to ensure the compliance of all government agencies to upgrade the level of development and the vision of Thailand to become "a developed country with security, prosperity, and sustainability by the Sufficiency Economy Philosophy." It consisted of six strategies. Strategy 5 Eco-friendly development and growth determined with measures to solve HHW and household e-waste management problems. This strategy included the transport and disposal system of household solid waste based on sanitary principles, zero waste, 3R

(Reduce, Reuse, Recycle), and sustainable waste management. (National Strategy Secretariat Office & Office of the National Economic and Social Development Council, 2018).

2.2.1.2 The Twelfth National Economic and Social Development Plan (2017-2021) was the main master plan of national development with the SDGs parallel with the national restructuring towards Thailand 4 . 0 . It consisted of ten strategies. The strategy relevant to HW management and e-waste management was Strategy 4 Environmental-friendly growth for sustainable development Goal 3 . The goal aimed to good environmental quality, reduced pollution, and reduced impact on people's health and eco-system, focusing on solid waste management and HW management as a priority. The indicators were as follows:

1) Not less than 75% of household solid waste is correctly managed and utilized by 2021.

2) Not less than 30% of HHW is correctly managed by 2021

The guideline of operation relevant to HW management and e-waste management included the following: drive the plans on waste management at provincial and local levels, drive the enactment of laws and measures on HHW management, provide locations for collection and disposal of HHW across the country, and promote the use of economic tools for waste management (Office of the National Economic and Social Development Council, 2016).

2.2.1.3 5-Year National Reform Plan on Natural Resources and Environment (2018-2022). The issue of reform relevant to solid waste management and HW management was in Reform issue 5: Environment as follows:

1) Reform issue 5 . 1 : Promote efficient management of pollution at the origin. The sub reform issues on HW management and e-waste management included Sub reform issue 5 . 1 . 1 : Reduce solid waste at origin through the motivation of sorting and reuse as much as possible, Sub reform issue 5 . 1 . 2 : Encourage the private sector to support LAOs in management of all types of waste with completely and academically correct methods from household till destination and Sub reform issue 5 . 1 . 4 : Expand the role, duty, and responsibility of the private sector in HW management since origin.

2) Reform issue 5.2: Improve the system and mechanism of monitoring, follow-up, investigation, and pollution control. The sub-reform issues on HW management and e-waste management included Sub-reform issue 5.2.1: Assign leading responsible agencies to set up standards, provide advice, follow up, and inspect the management of all types of waste based on clear and academic principles.

The examples of the significant reform as mentioned earlier and relevant to e-waste management included (1) Consider budget allocation to support LAOs to manage and sort waste at origin as the priority of the budget related to waste management (2) Accelerate the enactment of the Act on the Management of Waste Electrical and Electronic Equipment by 2020 and follow up on the operation of the system continuously developed from 2021-2022 and (3) Study the guideline of integration of laws relevant to waste management such as the enactment of national waste management act, as well as drive for concrete results (Office of the National Economic and Social Development Council, 2016).

2.2.1.4 National Solid Waste Management Master Plan (2016 - 2021). This Master Plan was approved by the cabinet resolution on May 3, 2016, on the national solid waste management and HW management with the conceptual framework based on the principles of 3Rs (Reduce, Reuse, Recycle). They consisted of integrated solid waste management and HW management, processing to produce energy, under the responsibilities and participation of all sectors, including public, private, people, and LAOs. The goals related to HW management and e-waste management according to the Master Plan were as follows:

1) Not less than 75% of household solid waste is managed based on academically correct methods by 2021.

2) Not less than 30% of HHW is collected and sent to disposal based on academically correct methods by 2021.

3) Not less than 50% of LAOs of the LAOs nationwide sort solid waste and HHW at origin by 2021.

There were three main measures for solid waste management and HHW management under the Master Plan as follows:

1) Measures to reduce solid waste and HW at the origin with the operational guideline relevant to the management of HHW and e-waste: The

measures included (1) Support people, academic institutions, government offices, establishments, and facilities to reduce and sort HW for reuse (2) Support people to use environmental-friendly goods that can be reused or recycled and (3) Promote the production sector to design/produce environmental-friendly products and packaging to extend their working life and can be reused several times, and promote the reusing of materials.

2) Measures to enhance the potential of solid waste management and HW management: The operational guidelines relevant to HHW and e-waste management included (1) LAOs sort, collect HHW by separating the types or schedule the time of collection of each type of solid waste (2) Provide the return system of product waste after an expiration from the collection, recycling, and treatment that are safe for the environment and (3) Support the increase of sorting and recycling plants for waste from electrical and electronic equipment.

3) Measures to promote solid waste management and HW management: The operational guidelines relevant to HHW and e-waste management included (1) Develop database system and report on HW management (2) Develop LAO personnel to have capability HW management (3) Construct network/center for the exchange of learning on HW management at the regional level (4) Create mechanism and network to monitor and inspect HW management with people's participation (5) Support the investment in the construction of factories for HW disposal, recycling plants of the private sector such as tax deduction on machinery, soft loans, and (6) Honor the entrepreneurs or communities or LAO executives with good performance on HW management (Pollution Control Department, 2016a).

2.2.1.5 The 20-Year National Master Plan on the Prevention and Management of Pollution Caused by Solid and Hazardous Waste B.E. 2561-2580 (2018-2037). The main goal of this Master Plan includes waste and HW are correctly managed and not impacting the environment and people's health and hygiene. The indicators relevant to HHW and e-waste are determined. HHW is academically managed (the amount of HW management to recycled at legal factories category 105 and 106, together with the HW sent to disposal site with legal factories category 101) for not less than 30%, 35%, 75%, and 100% by 2021, 2022, 2027, and 2032-2037

respectively. The Master Plan consists of three main measures with short-term measures (2018-2022) and long-term measures (2023-2037) as follows:

1) Measure to prevent and reduce pollution from waste and HW: The operational guidelines relevant to HHW and e-waste management with short-term measures included (1) Use economic measures or legal measures to design products and packaging for the environment (Design for Environment) such as reduce the size and weight of products for reuse and easy recycling, reduce the use of dangerous materials, reduce the addition of hazardous substances in products and (2) Determine the signs or symbols representing recycle and disposal methods on packaging/products to ensure consumers' understanding, sorting for reuse and, efficient disposal.

2) Measures to increase efficiency in pollution management from treatment and disposal of waste and HW: The operational guidelines relevant to HHW management and e-waste management, which are short-term measures, include accelerating the enactment of the Act on the Management of WEE and subordinate legislation under the Act on the Management of WEEE in line with the above guideline to ensure the Act's immediate enforcement.

3) Measures to support pollution management from waste and HW with the operational guideline relevant to HHW management and e-waste management. The short-term measures included (1) Public relations to provide knowledge and raise awareness to the youth and people to participate in solid waste management from origin until final disposal (2) Integrate the content of solid waste management in the courses at all levels to create knowledge and understanding of HW management (3) Determine special economic zone and adjacent areas to have comprehensive HW management and not posing problems to LAOs in neighboring areas and (4) Monitor and inspect import of e-waste based on the strict customs control system. The long-term measures included national waste management legislation as general law covering all types of waste and environmental management fee collection for products and packaging that were difficult to dispose of (Pollution Control Department, 2018a).

2.2.1.6 The 20-Year Strategic Plan for the Ministry of Natural Resources and Environment B.E. 2560-2579 (2017-2036) and 20-Year Guideline on

Management of Solid Waste and Household Hazardous Waste at the area level B.E. 2560-2579 (2017-2036) under Strategy 3 Solid waste management and environment. The strategic plan aimed to academically correct HHW management (including e-waste) for 30%, 50%, and 100% by 2021, 2026, 2031, respectively. It consisted of four sub-strategies. Sub-strategies 1 and 3 provide the guideline relevant to the management of HW and e-waste as follows:

1) Sub strategy 1 Academically correct solid waste management such as (1) Formulation of Action Plan on Provincial Household Hazardous Waste Management (2) Promote community's participation in reducing and sorting of solid waste at origin (3Rs) through the motivation of sorting and reuse for maximum benefit and (3) Create national discipline in reducing waste and sorting waste at the origin.

2) Sub strategy 3 Academically correct HHW management such as promote correct HHW management and increase efficiency in centralized HHW management and expand the role and duty of the private sector in HW management at origin (Ministry of Natural Resources and Environment, 2018).

2.2.1.7 Integrated Waste Electrical and Electronic Equipment Management Strategy B.E. 2557-2564 (2014-2021) by MNRE with six strategies and 20 measures as follows:

1) System of sorting and collection of target electrical and electronic waste with ten types namely (1) Fluorescent lamp (2) Dry battery (3) Refrigerator (4) Television (5) Air conditioner (6) Camera/video camera (7) Portable video/audio devices (8) Printer and fax machine (9) Telephone and (10) Personal computer that is efficient using academically correct methods in extensive LAOs, all city municipalities, Bangkok, and Pattaya with the average collection rate of the target product waste of not less than 5 % of the amount of the generated product waste expected in the target areas by 2021.

2) The four types of the target electrical and electronic waste, namely (1) Fluorescent lamp (2) Dry battery (3) Refrigerator and (4) Television or others collected from various origins or sellers or LAOs for correct treatment and disposal by producers and importers of no less than 5 % of the average sales of the products by 2021.

3) Sorting and recycling plants of target electrical and electronic waste according to 2) for one type with the comprehensive process appropriate to the type of the products for at least one plant by 2021 (Pollution Control Department, 2017a).

2.2.1.8 Thailand Environmental Quality Management Plan 2017-2021. The practical guideline related to HW management and e-waste management was stipulated in Strategy 2 . 1 Prevent, reduce, eradicate pollution of Strategy 2 Management of good environmental quality with the prevention, treatment, and rehabilitation. The determination of the indicators by which HHW was collected and sent to academically correct disposal is not less than 30% by 2021. The practical guideline of management of HW and e-waste in the relevant action plans included the following:

1) Action plan to develop tools and mechanism of management with the following practical guideline consisted of first, accelerate the drive of the legislation on solid waste management especially Draft Ministerial Regulation on Hygienic Conditions for Management of General Solid Waste B.E….., Draft Act on National Waste Management B.E. …., Draft of the Waste from Electrical and Electronic Equipment Management B. E.. . S e c o n d , Promote the application of economic tools and mechanisms in fee collection of products generating high pollution, collection of deposit-money return for packaging, and promote the principle of 3Rs (Reduce, Recycle, Reuse).

2) Action plan on the management of household solid waste and HW with the practical guideline such as (1) Producers and sellers of products to support entrepreneurs operating the sorting of product waste, packaging waste, and HHW based on correct methods, not dangerous to the health of the sorters and not causing pollution in the environment (2) Increase responsibilities to producers in comprehensive management of product waste from design of product, production of product, collection of product waste, arrangement for storing location, transport, correct, appropriate, safe management, not having environmental impact (3) Promote setting up of center of learning for WEEE management and support the private sector to participate in the setting up and operation (4) Support producers to be responsible for management based on correct methods and drive the technology transfer of HHW management of producing countries and (5) Support research and development on

WEEE for optimal reuse or academically correct management, etc. (Ministry of Natural Resources and Environment, 2016).

2.2.1.9 Third National Environmental Health Strategic Plan 2017-2021. It consisted of four strategies. The strategies relevant to HHW and e-waste management included Strategy 2: Create multisectoral cooperation among relevant partners and local government organizations, using the Pracharat (Civil-State) approach in Measure 1 and Strategy 3: Strengthen the environmental health management system in Measure 1 and Measure 2. The practical guideline relevant to HHW management and e-waste management are as follows:

1) Strategy 2 Measure 1: Promote the community's potential to monitor and manage environmental health problems. The practical guideline included the provision of budget sources to support communities in monitoring, easy risk evaluation, prevention, and management of environmental health problems such as health prevention from air pollution, HHW in risk-prone areas

2) Strategy 3 Measure 1: Develop, promote, and support law enactment. The practical guideline included project development and amendment laws such as the Draft Ministerial Regulation on service fees for collection, transport, and disposal of household toxic or hazardous waste B.E. ….

3) Strategy 3 Measure 2 : Promote the study and research in response to environmental health management. The practical guideline included a research program, assessment of exposure to toxic substances, and health effects in the population living in the e-waste recycling sites (Ministry of Public Health & Ministry of Natural Resources and Environment, 2017)

2.2.1.10 Environmental Plan in Eastern Economic Corridor 2018-2021 consisted of four strategies and 11 sections. The strategies relevant to HHW management and e-waste management included Strategy 1 Management of good environmental quality in Measure 1 . 1 and Strategy 3 Promotion of participation and CSR in Measure 3 . 1 and Measure 3 . 2 . The practical guideline relevant to HHW management and e-waste management was as follows:

1) Measure 1 . 1 : Treatment and disposal of waste, control of pollution since origin with the following practical guideline: (1) Provide drop off points and disposal locations of HHW and WEEE based on standards and (2) Support joint

investment with the private sector in solid waste management, selection of technology appropriate to problems, and public hearing with people to reduce conflicts and protests from people.

2) Measure 3.1: Promote environmental-friendly production, service, and consumption. The practical guideline included promoting all sectors to realize the importance and change behavior in consuming environmental-friendly services and goods. In addition, it supports the choice to purchase goods with environment labels, labels showing efficient use of energy or resources of the goods, and labels showing the emission of carbon dioxide into the atmosphere.

3) Measure 3.2: Promote economic measures for CSR. The practical guideline included motivation to reduce emission at the origin. It consisted of tax imposed on pollution emission, fee on the use of products highly generating pollution, deposit-cash return of product packages, and promote the principles of 3Rs (Reduce, Recycle, Reuse) for application and concrete implementation (Ministry of Natural Resources and Environment, 2019).

2.2.1.11 Action Plan "Thailand Zero Waste" according to the Participatory "Civil-State" Principle Phase 1 (2016-2017). The Cabinet approved this Action Plan on September 20, 2016. It was a short-term action plan on solid waste management focusing on the first 2 phases from a total of 3 phases. The phases were Origin phase: reduce the amount of waste and promote sorting of waste at origin based on the concept of 3Rs (Reduce, Reuse, Recycle) and Intermediate phase: set up a good and efficient collection/transport system. Local waste situations led to efficient waste management at the destination phase (Phase 3: Phase of academically correct and efficient waste management). This Action Plan consisted of five strategies. The strategies relevant to HHW and e-waste management included Strategy 2: Efficient HW management and Strategy 5: Support management to enhance efficiency. This Action Plan ended on September 30, 2017. (Department of Local Administration and Pollution Control Department, 2016).

2.2.1.12 Action Plan "Clean Province" was the action plan formulated by the Ministry of Interior to drive and solve the problems of household solid waste management for continuity after the end of the Action Plan "Thailand Zero Waste" according to the Participatory "Civil-State" Principle Phase 1 (2016-2017) on

September 30, 2017. Therefore, the Action Plan “Clean Province” in 2018 was the Action Plan in its first year (Ministry of Interior, 2018). Until the present (April 2021), the Action Plan "Clean Province" for 2021 was formulated. The Action Plan “Clean Province” for each year had different indicators of goals and practical guidelines. The same framework of operation and principles consisted of three processes of planning and determination of measures. The process was at the origin: reduce and sort waste, at intermediate point: increase efficiency in waste collection of LAOs, and at destination: waste was managed based on academically correct methods. The principles of 3 Rs: Reduce, Reuse and Recycle, and partnership between public, private, academic, religious, civil society, and people sectors used to solve the problems of solid waste management (Ministry of Interior, 2019, 2020).

As for the Action Plan “Clean Province” in this study, they have mainly involved the Action Plan "Clean Province" in 2019 and 2020. The goals and main activities relevant to HHW management and e-waste management are in Table 2.6.

Table 2.6 Examples of Goals, Activities, and Results of the Operation of HHW Management and E-Waste Management under The Action Plan "Clean Province" 2019 and 2020

Measures	Action Plan "Clean Province"	
	2019[1,2]	**2020[2,3]**
Waste management at origin		
Goal (Results of operation of 76 provinces)	100% of LAOs organized activities to concretely campaign for 3R: Reduce, Reuse, Recycle with the output of at least one project per LAO (99.09%).	60% of households joined the network "Local Environment Volunteers" to promote solid waste management (45.1%).
Main activities	LAOs organized activities to raise people's awareness of the value of waste before useless disposal such as the offering of recycled waste, green shops buying back used items, community recycling bank, community recycle center, second hand flea market.	LAOs recruited "Local Environment Volunteers" and provided training, set up as a network of voluntary cooperation with sacrifice and dedication to waste management, protection, and conservation of natural resources and environment in their local areas.
Waste management at midstream		
Goal (Results of operation of 76 provinces)	100% of villages/communities set up "Drop-off points of HHW" (98.83%).	100% of villages/communities set up "Drop-off points of HHW" (100%).
Main activities	- Provide drop-off points or bins for HW at least one per village/community. - Report on the setting up of drop-off points of HHW through the IT system of Department of Local Administration.	- Provide drop-off points or bins for HW at least one per village/community. - Report on the setting up of drop-off points of HHW through the IT system of the Department of Local Administration.
Goal (Results of operation of 76 provinces)	100% of HHW collected and sent for academically correct disposal (100%).	100% of Clusters of solid waste management of LAOs in each province formulated solid waste management plan through the consideration of the Provincial Sewage and Solid Waste Management Committee (86.5%).

Measures	Action Plan "Clean Province"	
	2019[1,2]	2020[2,3]
Waste management at downstream		
Main activities	- LAOs conducted public relations on the types of HW. - LAOs announced drop-off points of HHW and dates scheduled for collection. - Municipalities/subdistrict administrative organizations (SAOs) coordinated with PAOs for academically correct collection and disposal.	- Formulate a plan on solid waste management of the Clusters. - Provincial Sewage and Solid Waste Management Committee made recommendations of the plan of the Clusters.

Sources: 1 Ministry of Interior, 2019
2 Ministry of Interior, 2020
3 Ministry of Interior, 2021

In summary, the policies or strategies and plans relevant to e-waste management at the EEC areas in Chachoengsao, Chonburi, and Rayong provinces consisted of 1) 20-Year Guideline on Management of Solid Waste and Household Hazardous Waste Management at the Area Level (2017-2036), 2) Integrated Waste Electrical and Electronic Equipment Management Strategy (2014-2021), 3) Third National Environmental Health Strategic Plan 2017-2021, 4) Action Plan "Clean Province" and 5) Environmental Plan in Eastern Economic Corridor 2018-2021. The guideline of solutions to the problems of e-waste management in EEC according to the relevant policies, strategies, and plans was determined and integrated with the measures of HW management. Most focused on enhancing potential and measures to promote HW and e-waste management to ensure that e-waste was managed based on academically correct methods. E-waste would be collected to the HW provincial collection center at or LAO level or cluster of solid waste disposal and then sent to recycling at factories category 105 (sorting factories and landfills), category 106 (recycling factories), or for disposal at factories category 101 (common waste treatment plants or incinerators). The overview of the linkage of SDGs, policies, strategies, and plans relevant to e-waste management in Thailand summarize in Figure 2.1.

2.2.2 Laws Relevant to E-Waste Management in Thailand and EEC

At present (June 2021), Thailand did not have specific legislation for e-waste management that could supervise and control the life cycle of e-waste from production, sales, consumption, collection, disposal, and reuse (Siriluk Subongkot, 2019). No measure or requirement forced people to reuse e-waste (Weerayut Sukhoyachai, 2018). On October 22, 2020, the Ministry of Public Health (MOPH) issued "Ministerial Regulation on Communal toxic or hazardous solid waste management B.E. 2563 (2020)." It determined criteria, methods, and measures to control and supervise household toxic or hazardous solid waste management, including e-waste, such as collection, transport, and disposal. LAOs must comply with this Ministerial Regulation. However, efficient e-waste management required laws that had provisions for HW and industrial operation management, including environmental laws to apply with the Ministerial Regulation on Communal Toxic or Hazardous Solid Waste Management B.E. 2 5 6 3 (2020). These laws are two groups, namely 1) Laws that controlled and managed hazardous waste and e-waste and 2) Laws that controlled the operation that generated pollution from hazardous waste and e-waste. The significant laws relevant to household e-waste management in EEC in Chachoengsao, Chonburi, and Rayong could be summarized as follows:

2.2.2.1 Laws Relevant to Control and Management of HW and E-Waste

1) Ministerial Regulation on Communal toxic or hazardous solid waste management B.E. 2563 (2020) by the MOPH determines the criteria, methods, and measures to control and supervise household toxic or hazardous solid waste management. It consists of 4 Chapters and 24 Sections, namely, Chapter 1 General, Chapter 2 Collection of toxic or household hazardous solid waste, Chapter 3 Transfer of toxic or household hazardous solid waste, and Chapter 4 Disposal of toxic or household hazardous solid waste. It assigns local administration or those assigned to comply with the criteria and sanitation in this Ministerial Regulation. Chapter 1 concerns the responsible officials and the operating personnel for collecting, transferring, and disposal of communal toxic or hazardous solid waste. Chapter 2 concerns collecting communal toxic or hazardous solid waste such as light bulbs, dry cell, and battery, EEE, consisting of sorting, drop-off points, containers, and storage

sites. Chapter 3 concerns the transfer of communal toxic or hazardous solid waste consisting of measures to control the transfer and the vehicles transporting toxic or hazardous solid waste. Chapter 4 concerns the disposal of communal toxic or hazardous solid waste consisting of the disassembly of toxic parts. It includes s secure landfill, incinerator, and others stipulated by the Minister and published in the Royal Gazette. The measures to control the disposal in each method to protect people's health and hygiene and environmental impact.

2) Public Health Act B.E. 2535 (1992) and amended Act (2nd revision) B.E. 2550 (2007) and amended Act (3rd revision) B.E. 2560 (2017) by the MOPH is the law relevant to the solid waste management of LAOs. It covers household toxic or HW (including e-waste) based on Section 4 of this Act. It consists of 16 Chapters and 90 Sections. It focuses on collecting, transporting, and disposing waste in local administration such as PAO, Municipality, Subdistrict Administrative Organization, and Pattaya with three methods according to Section 18 and Section 19, Chapter 3 : Management of Sewage and Waste. The methods consist of 1) Local administration operates by itself, 2) Local administration assigns others to operate, and 3) Local administration allows others to operate in its place. Operators of factories with HW and the companies to collect, transport, or dispose of HW must submit a written paper to local authorities, namely Chief Executive of PAO, Mayor in Municipality, Chief Executive of SAO, and Mayor of Pattaya. In Section 20 Chapter 3: Management of Sewage and Waste, Assignment to the local administration have the authority to issue local legislation such as prohibition to dispose of waste in public areas except as determined by the local administration, determination of garbage bins in public places or private places, and determination of fees for hygienic disposal of waste as stipulated by Ministerial Regulations.

3) Act of the Maintaining Cleanliness and Tidiness of the City B.E. 2535 (1992) and 2nd revision B.E. 2560 (2017) by Ministry of Interior is the law related to prohibition of dumping of sewage and solid waste in public places and public buildings. Sewage and solid waste Management includes collection, transport, and disposal of sewage and solid waste, and penalty for those who operate management of sewage and solid waste without a license. Those who fail to comply with the local legislation are subject to a penalty of imprisonment not exceeding six

months or fine not exceeding 50,000 baht, or both imprisonment and fine. It consists of six Chapters, one Transitory Provision, and 62 Sections. The parts related to e-waste are Section 34/1 Clause 6 under Chapter 3/1 Management of sewage and solid waste as follows:

According to the factory law, section 34/1 Clause 6, hazardous and non-hazardous waste management must comply with the factory law. Except when the hazardous and non-hazardous waste mixed with the local administration's sewage and solid waste. Assignment of local administration or government agencies or other local administration units, including PAOs or the private sector assigned to collect the waste and notify officials responsible for factory law to proceed according to the factory law. The officials must start within three days after the date of receiving the notification. After the expired period, if the officials do not take action, local administration or government agencies or other local administration and PAOs, or the private sector, are assigned to collect and handle sewage and solid waste as appropriate. It assumes that the officials responsible for factory laws deliberately restrain from performing their duties to cause damage to any person.

4) Notification of Ministry of Interior on Solid Waste Management B.E. 2560 (2017) stipulates the criteria, methods, and conditions that local administration assigns government agencies or local administration, including PAOs, or the private sector as operators or working with the local administration. They included collection, transfer, disposal of waste, and exploitation and utilization of the collected waste. The criteria and methods of collection, transfer, and disposal of waste were four sections, namely Section 1 General, Chapter 2 Collection, Transfer, and Disposal of Waste, Section 3 Assignment for collection, transfer, or disposal of waste, Chapter 4 Exploitation and utilization and One Transitory Provision in total 24 items. As for the container of toxic waste or HHW in orange follows Item 8 Chapter 2 Part 2 Collection and transfer of waste. Provinces assign PAOs to serve as hosts to HHW management (including e-waste) relevant to Item 13 Chapter 3 Part 1: Assignment of government agencies or local administration for collection, transfer, and disposal of waste as follows:

Item 1 3 If the local administration works with government agencies or other local administrative agencies, it will benefit local people more

instead of the operation by the local administration itself. The local administration may work with the government agencies or other local administrative agencies to collect, transport, or dispose of solid waste. It complies with the guideline as announced by the Committee on Decentralization to LAOs on the agreement to cooperate in providing public services of LAOs.

5) Notification of Pollution Control Department on Guideline of household hazardous waste management for local administrative organizations B.E. 2560 (2017) dated May 19, 2017. It enables LAOs to use the guideline for HHW and e-waste management in battery and car battery and fluorescent lamps of all types from preparation, separation, collection, transport, and monitoring and assessment.

6) Draft of the Waste from Electrical and Electronic Equipment Management B. E. .... (2019 version) is the law on the management of the e-waste through the principle of EP R to ensure an efficient system of buy-back, collection, storage, transport, and disposal of e-waste. National Legislative Assembly already accepted in principle the 1st reading of the Draft on January 1 1 , 2019. At present, (April 2021) , the Draft is pending consideration by National Legislative Assembly. The Draft consists of 5 Draft Chapters and 36 Draft Sections, namely Chapter 1 Disposal of product waste (Sections 7-14) , Chapter 2 Duties and responsibilities (Sections 15-18) , Chapter 3 Dissemination of knowledge and information on product waste management (Sections 19-20), Chapter 4 Investigation and control (Sections 21-23) , Chapter 5 Penalty (Sections 24-35), and Transitory Provision Section 36 with the following:

(1) Section 5 The electrical and electronic product waste enforced under this Act includes 1) Computer 2) Telephone and wireless telephone 3) Air conditioner 4) Television 5) Refrigerator and 6) Electrical and electronic equipment as stipulated by the Ministerial Regulation, excluding electrical and electronic equipment which are weapons used in the military according to Section 3.

(2) Section 7 prohibits the disposal of the product waste in deserted public areas or mixed with solid waste. Upon violation, the penalty is imprisonment not exceeding six months or a fine not exceeding 50,000 baht or both imprisonment and acceptable according to Section 24.

(3) Section 9 Prohibition to those to buy back, store, or collect product waste except by Product Waste Buy-Back Center established and registered according to the criteria, people, or agencies with legal permits only to separate the waste send to or coordinate with the center.

(4) Section 10 Establishment of Product Waste Buy-Back Center by producers or between producers in agreement with LAOs to work in their place

(5) Section 15 Producers are enforced to have a responsibility to buy back, store, and collect product waste of the same type belonging to any producer, as well as product waste imported or without brand or trademark or producers no longer in business. Upon violation, the producers are subject to a penalty of imprisonment not exceeding two years or a fine not exceeding 200,000 baht or both imprisonment or fine according to Section 29. The producers cannot refuse or stipulate any criteria that burden those who bring back the product waste.

(6) Section 16 and Section 17 Producers are enforced to formulate the plan responsible for product waste management and present the responsibilities to PCD by March 31 every year. They collect e-waste for recycling, treatment, or disposal at factories with factory permits from relevant agencies. Upon violation, producers are liable to imprisonment for a term of not exceeding six months or to a fine of not exceeding 50,000 baht or to both, according to Section 30.

(7) Section 19 and Section 20 assign PCD to prepare and disseminate knowledge and information on correct methods of product waste management. PCD set up the Center of Coordination and Dissemination of Knowledge and Information of Product Waste to disseminate information on product waste management and the location of the Product Waste Buy-back Center for people, entrepreneurs, or relevant people.

7) Notification of Ministry of Industry Re: Industrial Waste Management and Disposal, B.E.2548 (2005) and (No. 2) B.E. 2560 (2017) determine the classification, code, and type of sewage or unused material, role and duty of waste generator, waste collector and transporter, waste processor, and criteria and methods of management of sewage or unused materials. It consists of four Chapters and 26 items, namely Chapter 1 Waste codes, Chapter 2 Duty of waste generator Chapter 3

Collection and transport of HW, Chapter 4 Duty of waste processor, and Chapter 5 Provisional chapter.

8) Hazardous Substance Act B.E. 2535 (1992) and amended (No. 2) B.E. 2544 (2001), (No. 3) B.E. 2551 (2008), (No. 4) B.E. 2562 (2019) by the Ministry of Industry (MOI) controls and supervises business in hazardous substances. E-waste is hazardous substance category three according to Section 18, which requires a permit from the authorities before production, import, export, or in possession according to the duties and responsibilities of producers (Section 59), importers (Section 60), transporters (Section 61), and those in possession that are not factories (Section 62).

9) Enhancement and Conservation of National Environmental Quality Act B.E. 2535 (1992) and amended (No. 2) B.E. 2561 (2018) by the MNRE. It consists of 7 Chapters and 1 Transitory Provision. It is the law on the study and reporting of environmental impact assessment from projects or activities or any operation by the government or licensed by the government in Section 46, Part 4 Providing Environmental Impact Assessment Reports of Chapter 3 Reporting of environmental impact assessment. As for solid waste and HW in Sections 78 and 79, Part 6, Other pollution and HW of Chapter 4, Pollution control, collection, transport, and treatment and disposal of e-waste combined in Section 78. Household e-waste may impact environmental quality as it has components of HW and causes danger to people's health if it is not correctly managed. This law is enforced only when there is no specific law on e-waste management by the power of Section 79 in issuing the Ministerial Regulation.

2.2.2.2 Laws that Control Operations Generating Pollution from HW and E-Waste

1) Factory Act B.E. 2535 (1992) and amended (No. 2) and (No. 3) B.E. 2562 (2019) by the MOI is the law that controls factory operation and discharge of waste, sewage, and unused materials from the production process of factories for factory operators and LAOs. It consists of 68 sections. The definition of the factory in Section 5 is building, premises, or vehicle using machine or machines with total power or an equivalent of fifty horsepower or more, or which employs fifty workers or more with or without machinery for factory operation. The factories of all sizes category 105 (sorting factory or landfill), category 106 (recycling factory), and

category 101 (central treatment plant/waste incinerator) are classified as category three factories according to Section 7, which requires a permit before establishment according to Section 12. According to Section 50, establishing factories before obtaining the license shall be liable to imprisonment or a fine.

Moreover, in Section 37 (1), the competent official finds out that any factory operator violates or declines to comply with this Act or engages in factory operation in such a manner as to cause harm, injuries, or distress to people or property in the factory or its vicinity. The competent official shall have the power to order such a person to stop such violating Act or rectify or improve the same or comply accordingly or appropriately within a specified time. The competent official shall have the power in Section 39 (1) to order the factory operator who deliberately violates the order of the competent official according to Section 37 without a valid reason. Any factory operation may cause harm, injuries, or distress to people or property in the factory or its vicinity; the competent official shall have the power to order the person to temporarily stop all or some operations and rectify or improve the factory or comply appropriately.

2) Industrial Estate Authority of Thailand Act B.E. 2522 (1979) and amended (No. 2) B.E. 2534 (1991), (No. 3) B.E. 2539 (1996), (No. 4) B.E. 2550 (2007), and (No. 5) B.E. 2562 (2019) is the law on licensing, supervision of factory operation and suspension of factory operation of entrepreneurs in industrial estates both the general industrial zone or free operation zone of Industrial Estate Authority of Thailand and entrepreneurs in industrial estates. It consists of 4 Chapters and 80 Sections, namely Chapter 1 Industrial Estate Authority of Thailand, Chapter 2 Industrial Estate, Chapter 3 Competent officer, Chapter 4 Supervision, Chapter 5 Penal Provisions, and 1 Transitory Provision.

In summary, there is yet no specific law on e-waste management or the Draft of the Waste from Electrical and Electronic Equipment Management B. E. …. In terms of management of HHW and household e-waste, LAOs in EEC in Chachoengsao, Chonburi, and Rayong prepare containers, sort, collect, transfer, and dispose of HHW and household e-waste. Moreover, they operate notably according to the criteria, methods, and measures stipulated in Ministerial Regulation on Communal toxic or hazardous solid waste management B.E. 2563

(2020) to prevent people's health, hygiene, and environmental impact. It is jointly enforced with other relevant laws such as Public Health Act B.E. 2 5 3 5 (1992) and amended, Act of the Maintaining Cleanliness and Tidiness of the City (2nd Revision) B.E. 2 5 6 0 (2017), Notification of Ministry of Interior on Solid Waste Management B.E. 2560 (2017), and Notification of Pollution Control Department on the guideline of household hazardous waste management for local administrative organizations B.E. 2560 (2017). As for industrial factories, e-waste treatment, and disposal plants in industrial estates, other laws could control the amount of generated e-waste and impact the environment and people's health that might arise from incorrect e-waste management. These laws are Factory Act B.E. 2535 (1992) and amended, Hazardous Substance Act B.E. 2 5 3 5 (1992) and amended, Enhancement and Conservation of National Environmental Quality Act B.E. 2535 (1992) and amended, and Industrial Estate Authority of Thailand B.E. 2522 (1979) and amended. As for people, they need to cooperate with LAOs and conduct good behavior of e-waste management by strictly sorting and collecting e-waste in containers for HHW or the channels designated by the government. Moreover, people are not discarding e-waste mixed with general solid waste or in public places or abandoned places for LAOs' easy collection and disposal.

Many countries in Western Europe (Sweden, US, Canada, Switzerland, and Australia), EU (Germany), Asia (Japan, China, South Korea, India, Vietnam, and Cambodia) had the legislation and enforcement on e-waste management with the principle of Extended Producer Responsibility (EPR) as in Table 2.7. The enactment of laws in those countries stipulated those producers, importers, or consumer must participate in financial responsibilities and system of e-waste management from origin until destination. They consist of the determination of product design, types of products requiring control, collection of product waste, reuse, and the cooperation of all sectors. However, each country had different formats to determine responsibilities according to past waste management measures, strengths of the public sector, and awareness of the people. However, the same goal was to stipulate those producers and seller must be responsible in whatever means for their products (Paphada Pramanpon, Supol Engprasan, & Winai Lamlerd, 2016; Paphada Pramanpon, Suwit Nimnoi, & Ruangrai Suwandamrongchai, 2019; Ratchaphong

Klinsrisuk & Wassana Jangprajak, 2016). Japan was successful in specific laws on e-waste management due to the precise structure of specific laws on e-waste management and good enforcement, and a comprehensive basic structure system in management such as storing locations and recycling plants (Ratchaphong Klinsrisuk & Wassana Jangprajak, 2016). However, many countries in Asia were enacting laws to support e-waste management, such as Malaysia, Indonesia, Laos, including Thailand (Paphada Pramanpon et al., 2019).

Table 2.7 Examples of Laws on E-Waste Management in Some Countries in Asia

Countries	**Laws on e-waste management (Year of enforcement)**	**Format and controlled products**	**Sources**
Japan	Law for the Recycling of Specified Kinds of Home Appliances: LRHA (2001)	Full EPR Controlled products: 4 types of household electrical appliances namely 1) Air conditioners 2) TVs Cathode Ray Tube (CRT), liquid crystal, and plasma TVs 3) Refrigerators and freezers and 4) Washing machines and clothes dryers	Ministry of Environment, 2013b
	Act on Promotion of Recycling of Small Waste Electrical and Electronic Equipment (2013)	Full EPR Controlled products: Waste of over 100 items of small electrical appliances and electronic equipment such as smartphones, tablets, radio, cameras, small video device, etc.	Ministry of Environment, 2013a
China	Regulations for the Administration of the recovery and disposal of waste electric and electronic products 2009 (2011)	Government fund Controlled products: television, refrigerator, air conditioner, computer (including tablet and personal computer (PC)	Ministry of Environmental Protection of the People's Republic of China, 2009
India	The e-waste (Management and Handling) rules (2012)	Full EPR Controlled products: 1) Information technology and telecommunication equipment such as computer, printer including cartridges, telephones and 2) consumers electrical and electronics such as television sets, refrigerator, washing machine, and air-conditioners	Ministry of Environment and Forest, 2011

Countries	Laws on e-waste management (Year of enforcement)	Format and controlled products	Sources
Vietnam	The Prime Minister's Decision No. 16/2015/QD-TTg dated 22 May, 2015 on Prescribing Retrieval and Disposal of Discarded Products (2016)	Full EPR Controlled products: 6 product groups among which 2 product groups are relevant to e-waste namely 1) Accumulator and battery and 2) EEE such as fluorescent light/compact light, television; refrigerator, desktop or laptop; computer monitor; air conditioner, DVD, VCD, CD recorder.	Prime Ministry of Vietnam, 2015

2.3 Situations and E-Waste Management in EEC in Thailand

2.3.1 Eastern Economic Corridor

2.3.1.1 Areas in Eastern Economic Corridor

Eastern Special Development Zone Act B.E. 2561 (2018), according to Section 4 and Section 6 defined "Eastern Economic Corridor (EEC)" as the areas in Chachoengsao, Chonburi, and Rayong, with other areas in the east as additionally determined by the Royal Decree as Eastern Economic Corridor. The definitions of EEC areas are following objectives 1) Develop modern and environmental-friendly economic activities to enhance national competitiveness 2) Provide comprehensive public services to reduce obstacles and costs in business operation 3) Establish efficient, continuous basic infrastructure and public utilities for people's easy access and complete, and systematic linkage 4) Determine land use appropriate to the situations and potential of the areas following the principles of sustainable development and 5) Modern urban development at international level and appropriate to convenient and safe habitation with accessibility and quality business operation.

Sections 3 9 -4 2 of Eastern Special Development Zone Act B.E. 2 5 6 1 (2018) determined the establishment of the "Special Economic Promotional Zone." It means the three provinces in the east, namely Chachoengsao, Chonburi, and Rayong, or other areas as additionally determined according to Section 6 that Eastern Special Development Zone Policy Committee (ESDZPO) announced and determined. The special economic promotional zone develops and promotes at least ten targeted

industries according to Section 39 Clause 2 consisting of the First 5 S-Curve Industries (Categories 1 -5). The target industries are namely 1) Next-Generation Automotive Industry 2) Intelligent Electronics Industry 3) High-Value and Medical Tourism Industry 4) Advance Agriculture and Biotechnology Industry 5) Food Processing Industry, and the 5 New S-Curve Industries (Categories 6-10) namely 6) Automation and Robotics Industry 7) Aviation and Logistics Industri e s 8) Biofuel and Biochemical Industry 9) Digital Industry and 1 0) Medical and Comprehensive Healthcare Industry (Eastern Economic Corridor Office of Thailand, 2019b, 2019c) as shown in Figure 2.2.

Figure 2.2 Eastern Economic Corridor in Chachoengsao, Chonburi, and Rayong
Source: Eastern Economic Corridor Office of Thailand, 2019b

At present (per June 2021), ESDZPO resolved to announce 29 special economic promotional zones, divided into two types namely six promoted zones for specific industries and 23 promoted zones for targeted industries as follows:

1) Promoted Zones for Specific Industries established for efficient, continuous basic infrastructure and public utilities with complete and systematic linkage to develop six modern areas. They consist of (1) Eastern Airport City (EECa) with the area of approximately 6,500 rais around the U-Tapao International Airport in Rayong (2) Eastern Economic Corridor of Innovation Platform (EECi) with the area of approximately 3,454 rais in Wang Chan District, Rayong (3) Digital Park Thailand (EECd) with the area of approximately 830 rais in Si Racha District, Chonburi (4) Eastern Economic Corridor of High Speed Rail Linking Three Airports (EECh) the area along the high speed rail link connecting Don Mueang International Airport, Suvarnabhumi Airport, and U-Tapao International Airport with the distance of approximately 220 kms (5) Eastern Economic Corridor of Medical Hub (EECmd) with the area of approximately 566 rais in the area of Thammasat University, Pattaya Campus, in Bang La Mung District, Chonburi and (6) Genomics Thailand with the area of approximately 3.69 rais at Faculty of Pharmaceutical Sciences, Burapha University, Mueang Chonburi District, Chonburi (Eastern Economic Corridor Office of Thailand, 2018, 2019a, 2019c) as shown in Figure 2.3.

Figure 2.3 Promoted Zones for Specific Industries
Source: Eastern Economic Corridor Office of Thailand, 2019a

2) Promoted Zones for Targeted Industries are the areas to support targeted industries with public utilities, accommodations, and services necessary to industrial operation in 23 areas. They consist of two types namely area development to support specifically targeted industries and industrial estates (Eastern Economic Corridor Office of Thailand, 2019c) as follows:

(1) Area development to support specifically targeted industries consists of two areas. They are a unique economic promotional zone for the next-generation automotive industry in Ban Pho District, Chachoengsao, with approximately 1,694 rais and a special economic promotional zone for e-commerce in Bang Pakong District, Chachoengsao, with an area of approximately 232 rais.

(2) Industrial estates are mostly with areas of the private sector in the old industrial estates and the areas for the promotional zone with approximately 8 6 ,7 7 5 rais in 2 1 areas. They are one in Chachoengsao, 12 in Chonburi, and 8 in Rayong such as TFD Industrial Estate 2 in Chachoengsao, Amata Nakorn Industrial Estate, and Pinthong Industrial Estate (Projects 3 ,4 , and 5) in Chonburi, Amata City Industrial Estate, and WHA Eastern Seaboard Industrial Estate 4 in Rayong. The 21 promoted zones for targeted industries in industrial estates support and promote all targeted industries or partly to be the new Engine of Growth and drive the country towards Thailand 4.0.

In summary, EEC was established by the government in the east through special legislation due to high economic growth. Continuous, systematic development, primarily developing and promoting the country's targeted industries towards advanced and environmental-friendly technology and innovation, will benefit local people and national economic development. It covers the three provinces of Chachoengsao, Chonburi, and Rayong and the six Promoted Zones for Specific Industries, namely EECa, EECi, EECd EECh, EECmd, and Genomics Thailand, and 23 Promoted Zones for Targeted Industries. The Promoted Zones for Targeted Industries consists of 21 areas in the old industrial estates (one in Chachoengsao, 12 in Chonburi, and eight in Rayong), as well as a special economic promotional zone for the next-generation automotive industry in Ban Pho District in Chachoengsao, and e-commerce in Bang Pakong District in Chachoengsao.

2.3.1.2 Operating Agencies in Eastern Economic Corridor

Eastern Special Development Zone Act B.E. 2561 (2018) Section 10 determined Eastern Special Development Zone Policy Committee (ESDZPO). ESDZPO consists of 1) Prime Minister as the Chairman 2) Deputy Prime Minister assigned by the Prime Minister, as the Vice-Chairman 3) Ministers of 14 Ministries namely Minister of Defence, Minister of Finance, Minister of Agriculture and Cooperatives, Minister of Transport, Minister of Digital Economy and Society, Minister of Natural Resources and Environment, Minister of Energy, Minister of Commerce, Minister of Interior, Minister of Labour, Minister of Science and Technology, Minister of Education, Minister of Public Health, and Minister of Industry, as members 4) Director of the Bureau of the Budget, Secretary-General of the National Economic and Social Development Board, Secretary-General of the Board of Investment, as members 5) Chairman of the Board of Trade of Thailand, Chairman of the Board of the Federation of Thai Industries, and Chairman of the Thai Bankers' Association as members 6) No more than five qualified persons and 7) The Secretary-General of the Eastern Economic Corridor Office of Thailand (EECO) as the Secretary.

Section 11 of Eastern Special Development Zone Act B.E. 2561 (2018) stipulated that the ESDZPO had the following duties and responsibilities: 1) Formulate policies for the development of the Eastern Special Development Zone (ESDZ); 2) Consent to the overall plan for the development of the ESDZ, the overall land use plan, the development plan of infrastructure and public utilities, the implementation plan, and the plan to provide comprehensive and integrated government services in the ESDZ; 3) Approve the action plans, projects, and budgets in the development of the ESDZ; 4) Monitor and evaluate the results of the development of the ESDZ, as well as to resolve any issues and obstacles arising in the course of implementation.

Section 29 of Eastern Special Development Zone Act B.E. 2561 (2018) stipulated that the Eastern Economic Corridor Office of Thailand or EECO formulate a policy and a plan providing an overview of the development of the ESDZ, a plan for land use, a plan for the development of infrastructure and public utilities, a plan for implementation, and a plan for integrated government services. They are conveniently

accessible and responsive to obtain maximum benefits to the local community and ensure effective land use. The office shall appoint a State Agency responsible for proposing such policy and plan to the Policy Committee for approval. Upon being approved by the Policy Committee, the implementation shall become the agency's responsibility above unless specified otherwise by the Policy Committee. The EECO shall be a juristic person. It is a State Agency but not a government agency or state enterprise and serves as Secretariat to the ESDZPO according to Section 14 and Section 15. The EECO shall have the duties and authorities such as 1) Responsible for the administrative and academic affairs of the Policy Committee 2) Supervise, monitor, and report the progress on the development of the ESDZ to the Policy Committee at least every three months and 3) Coordinate with the relevant State Agencies to ensure that the development of the ESDZ is under the policies, plans, and measures specified by the Policy Committee.

In summary, the supervisory agencies in ESDZ consisted of 1) Eastern Special Development Zone Policy Committee (ESDZPO) with the Prime Minister as Chairman and 14 Ministers and 2) The EECO. ESDZPO formulate policies for the development of the ESDZ, approve the action plans, projects, and budgets in the development of the ESDZ. Moreover, ESDZPO monitors and evaluates the development of the ESDZ and resolves any issues and obstacles arising in implementation. The EECO served as Secretariat to ESDZPO and under the supervision of ESDZPO with the duties and authority to supervise, monitor, and report the progress of ESDZ to ESDZPO, coordinate with the relevant State Agencies to ensure that the development of the ESDZ is under the policies, plans, and measures specified by the Policy Committee.

2.3.2 States and E-Waste Management in EEC in Thailand

2.3.2.1 Global and Thailand's Situations of E-Waste

At present, many countries worldwide are encountering E-waste or WEEE problems with a more severe tendency. According to the Global E-waste Monitor 2020, in 2020, the e-waste worldwide totaled 53.6 million tons, or the rate of generated e-waste worldwide equaled 7.3 kgs per capita per year. Asia mainly contributed to the generated amount of e-waste (24.9 million tons or the rate of

generated e-waste 5.6 kgs per capita per year), followed by America, Europe, Africa, and Oceania. The generated e-waste in America, Europe, Africa, and Oceania were 13.1, 12, 2.9, and 0.7 million tons, with the rate of e-waste generation 13.3, 16.2, 2.5, and 16.1 kgs per capita per year, respectively. The reasons came from the higher consumption rate of EEE, the short life cycle of EEE, and few repair options for EEE (Forti et al., 2020). Moreover, it was forecast that in 2021 the amount of generated e-waste around the world would reach approximately 52.2 million tons or 44.7 million tons up from 2016 (Baldé et al., 2017). By 2030, the amount of computer waste in developing countries would surpass that in developed countries two times. Most developing countries still did not have legislation and correct e-waste management system (Yu et al., 2010).

Similarly, Thailand is facing the problems of the management of the increased amount of e-waste. The reason is the growth of the electrical and electronic industry in Thailand. In 2019, electrical appliances such as air conditioners and refrigerators increased compared to 2018 at the rate of 15.0% and 8.0%. In 2020, the domestic sales of electrical products such as refrigerators, air conditioners, and fans increased from 2019 at the rate of 7.8%, 6.71%, and 1.8%, respectively. Similarly, in 2018, the production of fans, air conditioners, and the microwave increased from the previous year at the rate of 12.2%, 3.5%, and 3.2% respectively due to increased domestic sale. However, in 2019 and 2020, the production of electronic products such as components and tools for computers (Tablet, Notebook, Personal Computer (PC)) and Smart Phone such as Semiconductor, Hard Disk Drives (HDD), Integrated Circuit (IC), Print Circuit Broad Assembly (PCBA) tended to decrease compared to 2018. The reason was that, in 2019, there was an economic slowdown, and in 2020 there was the spread of the pandemic COVID-19, causing global economic slowdown as well (Office of Industrial Economics, 2019, 2020b). The other reason was people's increased consumption of electronic products, especially smartphones, with consumers' attitude to change the products before they were expired. According to National Statistical Office (2018), the use of smartphones of the population aged over six years old for the past three years between 2016-2018 in Thailand tended to rise. In 2018, smartphones increased from 81.4% (51.1 million persons) to 89.6% (56.7 million persons) compared to 2016.

Household e-waste is considered household hazardous waste (HHW). Forecast the generated HHW in Thailand in 2016-2019; the average rate of generated HHW in Thailand between 2018-2019 equaled 7.39 kgs per capita per year or approximately 65% of all generated HHW. Eight e-waste products ranked from most to found least are television, air conditioner, refrigerator, washing machine, computer, VCD/DVD player, telephone, and camera, with the tendency to increase every year at the average increased rate of 2.3% a year. The ratio of 35% of the amount of all generated household e-waste constituted other types of HW such as lamps, battery, dry cell, the container of chemicals, and spray can and tended to increase every year (Pollution Control Department, 2020d), the details as in Table 2.8. In this study, the researcher was interested in five types of household e-waste, namely lamps, dry cell and dry battery, telephone and wireless telephone, computer, and television, the detail as mentioned in Chapter 1. Therefore, the five types of household e-waste generated in Thailand constituted both the amount of generated product waste and the number of other types of HHW, which in 2019 equaled 172,074.42 tons and 226,873 tons, respectively (Table 2.8). The forecast amount of household e-waste from the Center of Excellence on Hazardous Substance Management (2019b), in 2050, the amount of household e-waste would generate approximately 600,000 tons a year. Those are ten types: television, air conditioner, washing machine, refrigerator, computer, notebook, tablet, telephone, fluorescent lamp, LED lamp, and battery. The e-waste of computers and smartphone would change to lighter weight products such as from computers with CRT monitors (round monitors) to computers with LDC/LED monitors (flat monitors), notebooks, and tablets. Consequently, the amount of computer e-waste with LDC/LED monitors, notebooks, and tablets would increase. At the same time, the four types of large-sized e-waste (Big 4), namely television, air conditioner, washing machine, and refrigerator, would be sold to junk shops as much as 50-78%. In contrast, the e-waste of lamps, smartphones, and small devices such as the battery and dry cell stood the chance of being mixed with general municipal solid waste.

Table 2.8 Situations of HHW between 2016-2019

Amount of HHW (tons/year)	2016	2017	2018	2019
1) Amount of product waste	**393,070**	**401,387.21**	**414,654.49**	**421,335.00**
1.1 Television**	108,781	98,369.71	98,612.65	99,447.71
1.2 Air conditioner	76,519	75,419.61	76,653.41	77,653.41
1.3 Refrigerator	67,287	63,884.71	64,970.07	65,995.07
1.4 Washing machine	61,883	60,851.64	61,927.60	62,807.60
1.5 Computer**	58,370	56,087.54	58,261.41	59,711.41
1.6 VCD/DVD player	18,324	30,436.42	32,630.77	32,830.77
1.7 Telephone**	1,721	8,797.58	11,824.85	12,915.30
1.8 Camera	194	7,539.99	9,773.73	9,973.73
2) Amount of other types of HHW*,**	**213,249**	**216,639**	**223,275**	**226,873**
Total amount of HHW 1) + 2)	**606,319**	**618,749**	**637,930**	**648,208**

Source: Pollution Control Department, 2020d

Note: * Other types of HHW such as lamps, battery, dry cell, the container for chemicals, and spray can, etc.

**Amount of the types of e-waste that the researcher was interested in this research

2.3.2.2 Situations of the Amount of E-Waste in EEC

The situations of the e-waste in EEC in Chachoengsao, Chonburi, and Rayong were similar to the situations of e-waste in other provinces in Thailand. E-waste is discarded and mixed with general solid waste, so it is impossible to know the exact amount of e-waste. Therefore, the researcher reviewed the information on the amount of municipal solid waste generated in Chachoengsao, Chonburi, and Rayong for the past five years between 2016-2020 as well. Regional Environment Office 13 (Chonburi) (2021b) revealed that the amount of municipal solid waste generated in the three provinces in 2020 was 4,899.38 tons/day of 233 LAOs (Table 2.9) with correct disposal. That was engineer landfill, sanitary landfill, and incinerator for 2,291.69 tons/day or 4 6 . 7 8 % of the amount of waste generated in the three provinces. Compared to the amount of municipal solid waste during the past five years, the amount of generated sold waste tended to increase every year, as shown in

Table 2.10. Because of the growth of urban communities, increased population every year, many hidden populations in many areas, and the areas of ESDZ with the promotion of investment in industries and tourism that increased consumption and solid waste in many areas accordingly. In 2020 in the three provinces, 33 stations were open for municipal solid waste disposal. There were 18 stations with correct disposal with the accumulated municipal solid waste totaled 302,984.14 tons. Chonburi had most of the amount of accumulated waste, followed by Chachoengsao, and Rayong, respectively, as in Table 2.9. The clusters in Chachoengsao consisted of Chachoengsao PAO, Bang Khla Subdistrict Municipality, and Chachoengsao Town Municipality. Chonburi consisted of five clusters: Pattaya, Si Racha Town Municipality, Saen Suk Town Municipality, Ban Bueng Town Municipality, and Koh Sichang Subdistrict Municipality. With one cluster of Rayong PAO serving as host of the cluster, Rayong ensures efficient solid waste management of all LAOs.

According to the Center of Excellence on Hazardous Substance Management (2019a), the estimated amount of municipal solid waste, including household hazardous waste in EEC, would be 1,993,221 tons per year in 2027 2,281,786 tons per year in 2032. The researcher forecasted that the amount of 5 types of household e-waste in this study in EEC would reach approximately 43,851 tons per year in 2027 and 50,199 tons per year in 2032. (Calculation data included 1) the amount of household hazardous waste in Thailand was 0.3 % of the amount of municipal solid waste 2) household hazardous waste of BMA in 2018 consisted of the light bulb, batteries, electrical and electronic equipment (e.g., mobile phones, television, computer), and containers of chemicals and others at the rate of 40.1%, 17.1%, 15.4%, and 27.4% respectively, and 3) the calculated amount of household e-waste in this study was about 2.2 % of the amount of municipal solid waste) (Center of Excellence on Hazardous Substance Management, 2018).

Table 2.9 Number of LAOs and Situations of Municipal Solid Waste Disposal Sites of Chachoengsao, Chonburi, and Rayong in 2020

Information (unit)	Chachoengsao	Chonburi	Rayong	In total three provinces
Number of LAOs[1]				
Provincial administrative organization (number)	1	2 (including Pattaya)	1	**4**
City municipality (number)	-	2	1	**3**
Town municipality (number)	1	10	2	**13**
Subdistrict municipality (number)	33	36	27	**96**
Subdistrict administrative organization (number)	74	49	37	**160**
Total (number)	109	99	68	**276**
Number of LAOs and services of collection of waste for disposal[2]				
Services provided for collection of waste for disposal (number)	75	92	66	**233**
No services provided for collection of waste for disposal (number)	34	7	2	**43**
Situations of solid waste disposal sites and amount of accumulated waste[2]				
Disposal sites for operation (number)	7	21	5	**33**
Proper disposal sites	4	11	3	**18**
Improper disposal sites (number)	3	10	2	**15**
Assessment of the amount of accumulated waste from the information in 2015 (tons)	59,501.46	224,710.23	18,772.45	**302,984.14**

Sources: 1 Department of Provincial Administration, 2020

2 Regional Environment Office 13 (Chonburi), 2021b

Table 2.10 Amount and Management of Municipal Solid Waste Management in Chachoengsao, Chonburi, and Rayong between 2016-2020

Year	Provinces	Number of population[1] (persons)	Amount of generated waste [2,3] (tons/day)	Rate of solid waste generation (kg/person/day)	Correct disposal[2]	
					Amount[2,3] (tons/day)	%
2016	Chachoengsao	704,399	751.12	1.07	18.41	2.45
	Chonburi and Pattaya	1,483,049	2,619.72	1.77	1,261.40	48.15
	Rayong	700,223	896.88	1.28	547.04	60.99
	Total	**2,887,671**	**4,267.72**	**1.48**	**3,106.20**	**72.78**
2017	Chachoengsao	709,889	751.12	1.06	420.00	55.92
	Chonburi and Pattaya	1,509,125	2,580.66	1.71	2,327.45	90.19
	Rayong	711,236	953.70	1.34	953.70	100.00
	Total	**2,930,250**	**4,285.48**	1.46	**3,701.15**	**86.36**
2018	Chachoengsao	715,009	709.24	0.99	367.42	51.80
	Chonburi and Pattaya	1,535,445	2,591.03	**1.69**	1,435.58	55.41
	Rayong	723,316	967.80	1.34	744.77	76.95
	Total	**2,973,700**	**4,268.07**	**1.44**	**2,547.77**	**59.69**
2019	Chachoengsao	720,113	733.14	1.02	8.81	1.20
	Chonburi and Pattaya	1,558,301	2,909.86	1.87	1,531.78	52.64
	Rayong	734,753	969.76	1.32	815.86	84.13
	Total	**3,013,167**	**4,612.76**	**1.53**	**2,356.45**	**51.09**
2020	Chachoengsao	720,718	891.99	1.24	389.81	43.70
	Chonburi and Pattaya	1,566,885	3,017.98	1.93	1,605.44	53.20
	Rayong	741,524	989.41	1.33	296.44	29.96
	Total	**3,029,127**	**4,899.38**	**1.62**	**2,291.69**	**46.78**

Sources: 1 Department of Provincial Administration, 2020

2 Regional Environment Office 13 (Chonburi), 2017, 2018b, 2021b

3 Pollution Control Department, 2019a; 2020e

The HHW that the LAOs in Chachoengsao, Chonburi, and Rayong prepared the containers for academically correct collection and disposal consisted of four groups. They were 1) Light bulb such as fluorescent lamp 2) Dry cell and dry battery such as dry cell, alkaline battery, mobile phone battery, digital camera battery, and car battery, 3) Containers of chemicals such as spray cans, bottles for chemicals and pesticides, paint cans, bottles for household cleaners, and 4) EEE for daily lives that were expired or not wanted for usage, with relatively small size such as waste of smartphone and peripheral device (Pollution Control Department, 2017b). Based on the latest information in 2020, the amount of HHW (including e-waste) collected from the three provinces totaled 47.718 tons (Regional Environment Office 13 (Chonburi), 2021b). Compared to the past five years, in 2019, the amount of HHW (including e-waste) collected from the three provinces totaled 843.19 tons and could be disposed of for 4.54 tons or only 0.54% of the amount of HHW collected from the three provinces. In 2017, Rayong could collect and send all to dispose of HHW (including e-waste) due to Rayong Provincial Administrative Organization as a host of HHW management (Pollution Control Department, 2016b, 2017c, 2020d). The detail is in Table 2.11.

Table 2.11 Situations of Management and Amount of HHW Collected and Sent to Disposal in Chachoengsao, Chonburi, and Rayong provinces

Year	Province (Responsible agency)	Amount of HHW (including e-waste) (tons)		Situations of HHW management (Including e-waste)
		Collection	Disposal	
2016[1]	Chachoengsao (Chachoengsal PAO)	No information	No information	- PAO in the process of constructing Integrated Solid Waste Management Center but collected and sorted HHW for disposal - PAO did not venture into operating the activities of collection and disposal of HHW due to the absence of written regulations and orders. But many LAOs collected and sorted HHW for disposal.

Year	Province (Responsible agency)	Amount of HHW (including e-waste) (tons)		Situations of HHW management (Including e-waste)
		Collection	Disposal	
2016[1]	Rayong (Rayong PAO)	No information	No information	- PAO in the process of preparing the project to construct Integrated Solid Waste Management Center in Rayong.
	Total	**0**	**0**	
2017[1]	Chachoengsao (Chachoengsal PAO)	0.10	Not sent for disposal	- No operation yet to collect HHW for disposal. The only collection of HHW that was mixed with solid waste and already sorted from LAO that brought the waste to the Integrated Solid Waste Management Center of Chachoengsao PAO.
	Chonburi (Chonburi Town Municipality)	No information	No information	- No main host yet to set up a center for collection of HHW and LAOs in the province provided for drop-off points of HHW in their areas.
	Rayong (Rayong PAO)	10.04	10.04	- Center for collection of HHW was located in Rayong Integrated Solid Waste Management Center ready to receive HW from LAOs in Rayong.
	Total	**10.14**	**10.04**	
2018[1]	Chachoengsao (Chachoengsao PAO)	No information	No information	Each LAO collected waste in own area.
	Chonburi (Chonburi Town Municipality)	No information	No information	Each LAO collected waste in own area.
	Rayong (Rayong PAO)	No information	No information	Each LAO collected waste in own area.
	Total	**0**	**0**	

Year	Province (Responsible agency)	Amount of HHW (including e-waste) (tons)		Situations of HHW management (Including e-waste)
		Collection	**Disposal**	
2019[1]	Chachoengsao (Chachoengsao PAO)	806.65	Not sent for disposal	- No host. Each LAO collected waste in own area**.**
	Chonburi (Chonburi Town Municipality)	32.00	Not sent for disposal	- Each Lao collected waste in own area - Chonburi PAO in the process of preparing a "Memorandum of Understanding on the cooperation of HHW" with municipalities and subdistrict administrative organizations in the province.
	Rayong (Rayong PAO)	4.54	4.54	- Center for collection of HHW situated in Rayong Integrated Solid Waste Management Center ready to receive HW from LAO in Rayong.
	Total	**843.19**	**4.54**	
2020[2]	Chachoengsao	25.135	No information	- No host. Each Lao collected waste in own area**.**
	Chonburi (Chonburi PAO)	**22.170**	No information	- Each Lao collected waste in own area - Chonburi PAO and 95 local government agencies signed the MOU on HHW management on September 24, 2020**.**
	Rayong (Rayong PAO)	**0.413**	No information	- Center for collection of HHW situated in Rayong Integrated Solid Waste Management Center ready to receive HW from LAO in Rayong.
	Total	**47.718**	**No information**	

Sources: 1 Pollution Control Department, 2016b, 2017c, 2020d
2 Regional Environment Office 13 (Chonburi), 2021b

2.3.2.3 Situations of HHW Management and E-Waste Management of LAOs in Chachoengsao, Chonburi, and Rayong

According to the Department of Provincial Administration (2020), in 2020, there were 276 LAOs, namely in Chachoengsao (109 LAOs), Chonburi (99 LAOs), and Rayong (68 LAOs). Among the 276 LAOs, there were 233 LAOs with

services provided for the transfer of solid waste for disposal (Regional Environment Office 13 (Chonburi), 2021b), the detail in Table 2.10.

For the overview of the HHW (including e-waste) of LAOs in Chachoengsao, Chonburi, and Rayong from 2018-2021, the Action Plan “Clean Province” 2018-2020 by the Ministry of Interior were operation. Each LAO provided drop-off points of HHW (including household e-waste) within communities or villages, at least one per community or village. Each LAO collected HHW in its area. When the amount was appropriate for transport, it would be sent to the provincial center to collect HHW (Ministry of Interior, 2019, 2020). There was a guideline for PAOs to take responsibility as host of HHW management (including household e-waste) and send the waste for academically correct disposal, the detail in Table 2.11 (Regional Environment Office 13 (Chonburi), 2018b, 2019b, 2020b).

The situation of household e-waste management in 2020 (as per September 2020), Chachoengsao, Chonburi, and Rayong could implement the order of the Ministry of Interior on the Action Plan "Clean Province." They set up drop-off points of HW in all communities, collected HHW amounted to 25.135 tons, 22.170 tons, and 0.413 tons respectively, totaled 47.718 tons in the three provinces. In Rayong, Rayong PAO was the host of collection and transfer of HHW for disposal at Rayong Integrated Solid Waste Management Center. The center was ready to receive HW from LAOs in Rayong for collection and further disposal. In Chonburi, Chonburi PAO was the host of collection and transfer of HHW from each LAO for disposal. Chonburi PAO signed the "Memorandum of Understanding on the cooperation of HHW management” with 95 municipalities and SAOs in the province on September 24, 2020. However, there was no provincial center for the collection of HHW. Whereas in Chachoengsao, there was Chachoengsao Integrated Solid Waste Disposal Center of Chachoengsao PAO, but Chachoengsao PAO was not ready to operate the collection of HHW for disposal. Thus, Chachoengsao had no host to operate the collection and transfer of HHW from each LAO for disposal, the detail in Table 2.11 (Regional Environment Office 13 (Chonburi), 2021b).

As e-waste of mobile phones and peripheral at present, in 2021, REO 13 (Chonburi) participated in the public relations of the "Thais without E-Waste" project of MNRE in collaboration with Advanced Wireless Network Co., Ltd. by inviting

people to donate old, unused mobile phones with a peripheral device such as the battery, charger, circuit board, and plastic in a donation box located at the office, Ban Suan Subdistrict, Mueang District, Chonburi for environmental-friendly management (Regional Environment Office 13 (Chonburi), 2021a)

2.3.2.4 Problems and Obstacles of HHW Management and Household E-Waste Management in EEC

In summary, the problems and obstacles of operation of HHW management and household e-waste management in EEC in Chachoengsao, Chonburi, and Rayong during the past five years between 2016-2020 (Pollution Control Department, 2016b, 2017c, 2020d; Regional Environment Office 13 (Chonburi), 2019b, 2020b, 2021b) could be divided into the following areas:

1) Policy and laws

(1) Thailand's e-waste law or the Draft of the Waste Electrical and Electronic Equipment Management Act B.E. …. (Draft version in 2019) was not enacted and enforced. Therefore, e-waste could not be properly managed, and there was no system for the efficient return of e-waste for proper and safe disposal (Paphada Pramanpon et al., 2019).

(2) There was still no legislation that determined a specific agency in LAO to take responsibility in the supervision of e-waste management, so that other agencies with other main tasks must take responsibility for e-waste as well (Weerayut Sukhoyachai, 2018). However, LAOs must prepare containers, operate sorting, collection, transport, and dispose of HHW and household e-waste based on the criteria, methods, and measures stipulated in the Ministerial Regulation on Communal Toxic or Hazardous Solid Waste Management B.E. 2563 (2020) of the MOPH.

2) Local management

(1) Household e-waste management at origin did not duly attract people's interest due to a lack of motivation in the buying prices of the old items. The spread of COVID-19 since 2019 made it difficult to campaign and support people's participation in reducing waste and sorting waste at the origin.

(2) Guideline of HHW management (including household e-waste) in some provinces was not clear. Consequently, LAOs, which were the

agencies responsible for management from collection and transport, did not perform their tasks based on academically correct methods despite the installation of drop-off points of HHW in the areas according to the policy of the MOI.

(3) Many LAOs were not ready in terms of containers for each type of HHW, and there was no location for the collection of HW and e-waste. Alternatively, if there was such a location, it did not operate with academically correct methods.

(4) Most personnel in LAOs still lacked knowledge on HW management and e-waste management, and the technology of management.

3) Budgets such as some PAOs were limited by budget in constructing the storage center of HHW.

4) Cooperation from people and the private sector

(1) People still lacked awareness and cooperation in sorting HHW and e-waste from general solid waste. Although people had already sorted the waste by type, most local agencies still collected HHW and e-waste. They mixed them with general solid waste due to the limitation of the trucks transporting the waste and the budget.

(2) Clandestine dumping of e-waste in public places or abandoned places or landfills of general solid waste.

(3) Recycling, treatment, or disposal factories of e-waste, which were illegal and did not meet the standards in EEC, used the process of disassembling and recycling HHW and household e-waste, which was not academically correct and had an impact on the environment and health.

2.3.2.5 Guideline to Solve Problems and Support HHW Management and Household E-Waste Management in EEC

There were guidelines to solve problems and support HHW management, and household e-waste management in EEC included Chachoengsao, Chonburi, and Rayong by relevant government agencies. The government agencies were the MNRE (PCD, REO, PONRE), Ministry of Interior (D O L A), Ministry of Industry (Department of Industrial Works), and Ministry of Commerce for the past five years between 2016-2020 (Pollution Control Department, 2016b, 2017c, 2020d, 2020e; Regional Environment Office 13 (Chonburi), 2020b, 2021b) as follows:

1) Policy and laws

(1) Drive the legislation of the Draft of the Waste Electrical and Electronic Equipment Management Act B.E. …. as specific law.

(2) Notification of the Ministry of Industry on Specifying the Type and Origin of Raw Materials that will be Used in The Factory, B.E.2563 (2020) prohibits factories according to Factory Act from using imported waste from EEE raw materials in factories

(3) Notification of Ministry of Commerce on the Electronic Waste is Prohibited from Importing into the Kingdom, B.E.2563 (2020) of which the e-waste banned from import consisted of 428 items according to HS Code Chapter 84 and Chapter 85 especially statistical code number 899 which was e-waste under the Basel Convention (Notification of Ministry of Industry on Specifying the Type and Origin of Raw Materials Used in the Factory, 28 May 2020).

2) Local management

(1) Promote the reduction and sorting of HHW (including household e-waste) at origin through the campaign of acknowledgment and understanding to raise people's awareness of participation to reduce waste and sort HHW for reuse.

(2) LAOs set up drop-off points of HHW in all villages/communities/department stores.

(3) Support LAOs by advising on HHW management (including household e-waste) for academically correct operation.

(4) Prepare handbooks and guidelines on HHW management and e-waste management for LAOs and disseminate them to the public such as work manual of LAO personnel in the collection, transport, and disposal of HHW, handbook on the WEEE management, etc., by PCD.

3) Cooperation

(1) All government agencies as a role model to campaign for the private sector and people to reduce and sort HW and household e-waste.

(2) Support the private sector by offering locations to set up drop-off points and send them to LAO for academically correct treatment and disposal such as department stores, convenience stores, gas stations. The private sector can

cooperate with LAOs, REO, PONRE, and PCD (Pollution Control Department, 2020a).

2.4 Pressure-State-Response Framework

The Pressure-State-Response (PSR) Framework consisted of the concept of causality and development on Organization for Economic Co-operation and Development (OECD). It is the conceptual framework that is widely recognized and used to develop natural resources and environmental indicators. Natural resources and environment indicators analyze the overview of natural resources and environment situations at domestic and international levels to evaluate the operation and solve the problems, leading to sustainable development. It involves the activities of people as the driving force which creates pressure on the environment (Pressure: P), such as communication, transport, industry/agriculture, the pattern of energy consumption, the expansion rate of income, population density, which result in the changed conditions or status of natural resources and environment (State: S) such as water quality, air quality, forest land, erosion of soil surface, the richness of the ecosystem. The conditions of the problems and changed information of environmental quality are therefore used for decision-making to formulate policy or measures to respond to the demand of the particular society to solve problems, reduce impact, and prevent potential problems in the future. (Response: R) response from the public sector, private sector/organization, and people sector through the relationship of Pressure-State-Response as shown in Figure 2.4 (Linster, 2003).

In this research, the researcher applied the Pressure-State-Response (PSR) Framework to analyze household e-waste in EEC and recommend the guidelines and measures for efficient household e-waste in EEC.

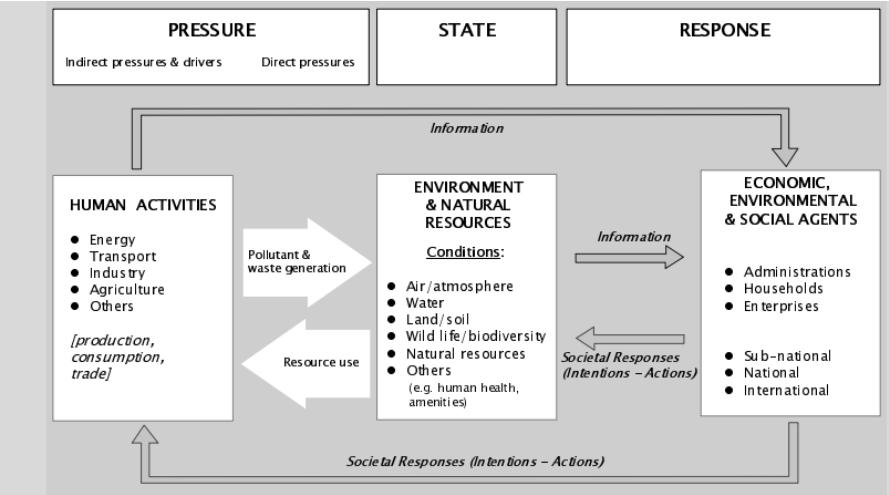


Figure 2.4 The OECD Pressure-State-Response Model
Source: Linster, 2003

2.5 Principles of SWOT Analysis and TOWS Matrix

2.5.1 Principles of SWOT Analysis

SWOT Analysis is the tool used to determine the strategy by evaluating and analyzing the internal and external environment or situation. The analysis of the internal environment or situation conduct on the Strengths (S) and Weaknesses (W), whereas the analysis of the external environment or situation conduct on Opportunities (O) and Threats (T) (Chamlong Poboon, 2018). SWOT Analysis was first used in 1960 up till the present in 2021 or over six decades. Applying SWOT Analysis is wide, such as application in planning strategy to analyze the alternative situations in urban development, assess projects, formulate plans and projects both at local and international levels, and evaluate sustainable development results with many different factors. As SWOT Analysis facilitates the systematic decision-making with direction and formulation of a possible alternative strategy, the determination of any framework of SWOT Analysis depends on the type of work or business and the nature of the organization. The models that wide used include External Environment Analysis and Internal Environment Analysis (Comino & Ferretti, 2016) as follows:

2.5.1.1 External Environment Analysis

External Environment Analysis is used to evaluate the external factors or environment that impact the organization's roles. The organization's operation must change according to the environment and find external opportunities and threats. The external environment outside the organization can be considered from various factors. They are Political and Legal Factors (e.g., stability of government, the policy of political parties, laws), Economic Factors (e.g., economic situations, employment, interest rate, trade barrier), Sociocultural Factors (e.g., the structure of the population, education, profession, value, behavior, the trend of foreign culture), Technological Factors (e.g., innovation and advancement of technology), and Environmental Factors (e.g., topography, natural disasters, green marketing or marketing for the environment). The external environment analysis from the factors is to ensure that the organization can create opportunities and reduce threats in work and formulate strategies appropriate to situations and realities (Arthit Wongsanga, 2015; Chamlong Poboon, 2018; Utai Parinyasutinun, 2016) as follows:

Opportunities (O) analyzes the external factors that can, directly and indirectly, impact or benefit the organization's operation at the macro level and if the organization can take the opportunities to strengthen itself.

Threats (T) analyzes the external factors that can impact the organization at the macro level, cause direct and indirect damage, which the organization must avoid or reorganize to ensure its robustness with readiness to face the impact.

PESTLE Analysis is one of the widely used models to analyze the external factors or environment updated from PEST Analysis. It is an excellent tool to find the efficient external factors in SWOT Analysis to classify opportunities and threats. It consists of six factors, namely Political Factors (P), Economic Factors (E), Sociocultural Factors (S), Technological Factors (T), Legal Factors (L), and Environmental Factors (E). The Technological and Legal Factors are added on from the PEST Analysis (Team FME, 2013). Many research works on waste management apply PESTLE Analysis to analyze the external factors or environment to find opportunities and threats (Jackkrit Kanjanakrit, 2013; Panuwatt Ontes, 2020;

Saowalak Saksit, 2016; Sirima Pokpong, 2018; Walanna Wattanahemmakorn, 2017) as summarized in Table 2.12.

2.5.1.2 Internal Environment Analysis

Internal Environment Analysis evaluates an organization's internal factors or environment on resources and internal capabilities to find the strengths and weaknesses. The internal environment analysis of the organization should consider various factors such as Structure and Policy, People, Marketing, Finance, Management, Resources, Innovation and Ideas, Processes, Operations, and Products and Services. The internal environment analysis based on the factors is to ensure that the organization can create strengths and reduce weaknesses in work, as well as formulate appropriate strategies (Chamlong Poboon, 2018; Ekachai Boonyathithan, 2010; Utai Parinyasutinun, 2016) as follows:

Strengths (S) analyzes the internal factors from the perspective of the persons in the organization to see the strengths that the organization should use in organizational development and maintain them to strengthen the organization.

Weaknesses (W) analyzes the internal factors from the perspective of the persons in the organization themselves to see the weaknesses that the organization should improve or eradicate for its benefit.

For internal environment analysis, the widely used models include PRIMO-F Analysis, 4P Analysis, Seven-S Framework of McKinsey, and MMPF. ***PRIMO-F Analysis*** consists of five factors, namely 1) People such as knowledge, ability, behavior 2) Resources such as location, image, reputation 3) Innovation and Ideas such as technology, research, and development on tools, equipment 4) Operations such as procedure, process and 5) Finance such as return, debt burden. ***4P Analysis*** consists of four factors, namely 1) People such as personnel and skills 2) Properties such as building, machinery 3) Processes such as management, communication and 4) Products and Services such as customers, products. ***Seven-S Framework of McKinsey*** consists of seven factors, namely 1) Strategy means plan formulated to create or maintain competitive advantage or find other channels 2) Structure means method or guideline of how an organization is arranged to show who is the supervisor and whom to report to 3) System means activities or process of routine work that the employees in the organization need to accomplish 4) Shared Value means organizational culture or attitude or feelings and thoughts of

personnel in the same direction 5) Style means the form of leadership of executives 6) Staff means employees or temporary employees, including ability or competency and 7) Skill means knowledge, the expertise of employees or temporary employees to accomplish work according to the objectives. ***MMPF*** consists of four issues: Marketing, Management, Production, and Finance (Ekachai Boonyathithan, 2010).

However, the internal environment analysis of many researches works on waste management applies the models of 4 M (4 M Management Resources) and PDCA (PDCA Cycle). The ***4 M*** consists of four factors, namely Man, Money, Material, Management. The ***PDCA (PDCA Cycle)*** consists of Plan, Do, Check, and Act (Jackkrit Kanjanakrit, 2013; Panuwatt Ontes, 2020; Saowalak Saksit, 2016; Sirima Pokpong, 2018; Walanna Wattanahemmakorn, 2017). The factors are in Table 2.12.

The principles of 4 M and PDCA Cycle are as follows:

1) Principles of 4 M (4 M Management Resources)

4 M Management Resources or 4 M's is the vital factor or resource of management and one model that is widely used in management development. It consists of 4 M, or Man means personnel, Money means budget, Material means tools and equipment, and Management means administration, management. The 4 M is the basic foundation for work management to reach the targets of an organization. Successful management requires sufficient qualified personnel, a sufficient budget for operation, tools, equipment appropriate to plans and projects' requirements, and a sound and efficient management system (Drucker, 2011; Siriwan Serirat & Somchai Hirankitti, 2002).

2) Principles of PDCA or Deming Wheel

PDCA or Deming Wheel is the cycle of quality work management. Dr. William Edwards Deming introduced the principles in Japan and met with success and widespread recognition. The activities of the four processes to ensure correct, efficient, and reliable work consists of P (Plan), D (Do), C (Check), and A (Act). Plan (P) means planning to choose problems, set targets, solve problems, and solve problems. Do (D) means to solve the problems following the set guideline and implement the plan. Check © means to inspect the results of work and compare the results. Act (A) means solving the problems that hinder accomplishing set objectives, establishing the standards, and improving better operations. PDCA Cycle

or Deming Wheel as in Figure 2.5. The complete PDCA Cycle requires the results of the appropriate operational process (A) to operate appropriately in the planning process again (P), and thus the unending cycle until the cycle is usually used with all similar activities (Suthasinee Bodhichan, 2015; Tool, 2016).

Figure 2.5 The Plan-Do-Check-Act Cycle or Deming Wheel
Source: Mind Tool, 2016

2.5.2 Analysis of TOWS Matrix

TOWS Matrix is the tool used to create new strategies based on the current environment of an organization. The strategy that the organization can implement should be a good strategy through analysis. It must also be a feasible strategy for implementation in the organization. The acquired strategy requires a SWOT Analysis. After evaluating an organization's external and internal environment acquired from the SWOT Analysis by analyzing strengths, weaknesses, opportunities, and threats or limitations, all the information would be analyzed in the form of a relationship between matrix using the TOWS Matrix. TOWS Matrix is the analysis matrix by analyzing and determining the information acquired from analyzing strengths, weaknesses, opportunities, and obstacles into various strategies. TOWS Matrix (Threats-Opportunities-Weaknesses-Strengths) is used to formulate the strategies, as shown in Figure 2.6. The two main operational processes (Theppasak Boonyarataphan, 2010; Weihrich, 1982) are as follows:

2.5.2.1 The strengths, weaknesses, opportunities, and threats or limitations are identified based on the evaluation of the environment of the SWOT Analysis. The effectiveness of strategy formulation using the TOWS Matrix technique depends on all dimensions of the SWOT Analysis.

2.5.2.2 The analysis is conducted on the relationship between Strengths and Opportunities, Strengths and Threats, Weaknesses and Opportunities, and Weaknesses and Threats. The analysis of the relationship of each pair will be used to analyze the strategies of an organization. The strategies can be divided into four types as follows:

1) SO Strategy or Maxi-Maxi Strategy is the strategy acquired from evaluating Strengths and Opportunities for joint consideration to construct the guideline to develop strengths from available opportunities.

2) ST Strategy or Maxi-Mini Strategy is the strategy acquired from evaluating Strengths and Threats or limitations for joint consideration. An organization has both strengths and threats that are out of control from external factors. Nevertheless, the organization can use its strengths to prevent threats to the organization.

3) WO Strategy or Mini-Maxi Strategy is the strategy acquired from evaluating Weaknesses and Opportunities for joint consideration. An organization has the opportunities to bring good things to rectify the problems or weaknesses in the organization.

4) WT Strategy or Mini-Mini Strategy is the strategy acquired from evaluating Weaknesses and Threats for joint consideration. When an organization faces both weaknesses and threats, the solution is to create a strategy or guideline to solve the out-of-control problems.

Internal factors / **External factors**	**Strengths (S)** List 5-10 internal strengths here	**Weaknesses (W)** List 5-10 internal weaknesses here
Opportunities (O) List 5-10 external opportunities here	**SO (maxi-maxi) Strategies** Generate strategies here that use strengths to take advantage of opportunities.	**WO (mini-maxi) Strategies** Generate strategies here that take advantage of opportunities by overcoming weaknesses.
Threats (T) List 5-10 external threats here	**ST (maxi-mini) Strategies** Generate strategies here that use strengths to avoid threats.	**WT (mini-mini) Strategies** Generate strategies here that minimize weaknesses and avoid threats.

Figure 2.6 TOWS Matrix
Source: Adapted from Heniz, 1982

In summary, SWOT Analysis is the process of the analysis of the internal and external environment. The internal environment analysis includes Strengths, and Weaknesses and the external environment analysis includes Opportunities and Threats. A good SWOT Analysis requires detail. The complete and efficient acquirement of information leads to the development of strategies by the TOWS Matrix. It is the technique to analyze the relationship to develop the strategies and acquire the strategies able to be used for organizational development in four types, namely SO Strategy, WO Strategy, ST Strategy, and WT Strategy.

In this study, the researcher applied the concept of SWOT Analysis of the factors impacting the success of household e-waste management in EEC. The internal factors used the 4 M's consisting of Man, Money, Material, and Management, and applied the PDCA Model consisting of Plan, Do, Check, and Act. The external factors used in the PESTLE Analysis consisting of policies, economic conditions, social conditions, technology, law, and environment. Then, TOWS Matrix was established by pairing the external and internal factors acquired from the SWOT Analysis. These resulted in four pairs: Strengths and Opportunities, Weaknesses and Opportunities, Strengths and Threats, and Weaknesses and Threats. The analysis acquires the strategies of household e-waste management in EEC in four forms, namely SO Strategy, WO Strategy, ST Strategy, and WT Strategy, and recommendations of the guideline of household e-waste management in EEC in Chachoengsao, Chonburi, and Rayong. Then, the model of household e-waste management was developed for the three provinces of EEC based on the CIPP-I Model consisting of Context, Input, Process, Product, and Impact.

2.6 Concept of Evaluation according to the CIPP-I Model

A CIPP-I Model is a form of evaluation applied from the CIPP Model by Daniel L. Stufflebeam (Chamlong Poboon, 2018). The CIPP Model was developed in 1971 to evaluate the overall plans and projects and is widely used to evaluate projects especially study projects. The strengths of the CIPP evaluation include Formative evaluation, which evaluates the projects during their operation, and Summative evaluation, which evaluates the projects at their termination, consisting of four areas

of evaluation, namely Context, Input, Process, and Product (Stufflebeam & Shinkfield, 2007). The CIPP-I Model evaluates the results of the projects, consisting of four areas based on the main compositions of the former CIPP Model, namely Context, Input, Process, Product, with the addition of Environmental Impact Assessment (EIA) (Chamlong Poboon, 2017, 2018) with the following evaluation guideline:

1) Context: Evaluation evaluates the external factors impacting the results of plans/projects but is out of control of plans/projects such as economic, social, political, environmental, technological factors. The context evaluation inspects if the external factors impact the success or failure of the plans/projects or if the plans/projects are under the context of external factors.

2) Input: Evaluation evaluates the input factors or resources used in the operation of the plans/projects in terms of sufficiency, quality, and efficient use. The primary input factors include personnel, budget, raw materials, tools, and equipment. The input evaluation shows the scope of success or failure of the plans/projects from the input factors.

3) Process: Evaluation evaluates to inspect the activities of process and methods of operation of the plans/projects if they follow the set plans. In case of evaluation during operation, the process evaluation shows strengths and weaknesses of operation in the processes, problems, and obstacles and the appropriateness of the activities and processes of operation whether they reach the objectives or not. At the end of the plans/projects, the evaluation case shows the scope of success or failure of the plans/projects from the operational process

4) Product: Evaluation compares the output of plans/projects with the objectives, targets, or set criteria in Quantity and Quality. The evaluation can conduct during operation in the periodical output of plans/projects or the end of the plans/projects to see the overview of the output from the plans/projects.

5) Impact: Evaluation evaluates to inspect the positive and negative impacts on the plans/projects for target groups (those directly impacted from the operation of the projects), non-targeted groups (those indirectly impacted from the operation of the projects), and other groups such as community, economy, society, and environment which can be evaluated during operation or at the end of the plans/projects. The

impact evaluation can also find the guideline to rectify and improve the projects to ensure acceptance of each group, which will significantly impact the success of the projects.

The factors and sub-factors used in evaluating waste management according to the CIPP-I Model from the relevant research works are in Table 2.12. In this study, the researcher chose the CIPP-I Model consisting of Context (C), Input (I), Process (P), Product (P), and Impact (I) to evaluate the household e-waste management in Chachoengsao, Chonburi, and Rayong provinces. Moreover, the CIPP-I Model showed the evaluation of the entire system, identifying strengths, weaknesses, and expected positive and negative impacts on communities, economy, society, and environment.

Table 2.12 Factors and Model used in the Evaluation of Waste Management according to the CIPP-I Model

Issues	Factors	Sub-Factors	Sources
Context Evaluation			
PESTLE Analysis			
Policy and plan	Policy and plan/political	- Government's national policy and plan on waste management	Jackkrit Kanjanakrit, 2013; Panuwatt Ontes, 2020; Saowalak Saksit, 2016; Sirima Pokpong, 2018
		- Policy and plan of waste management at provincial and local levels	Jackkrit Kanjanakrit, 2013; Panuwatt Ontes, 2020; Sirima Pokpong, 2018
		- Continuity of policy	Sirima Pokpong, 2018
Economic	Economic conditions	- Economic structure, profession, income	Saowalak Saksit, 2016; Sirima Pokpong, 2018
		- Economic growth	Jackkrit Kanjanakrit, 2013; Panuwatt Ontes, 2020
Social	Social conditions	- Public participation/demand of people	Panuwatt Ontes, 2020; Saowalak Saksit, 2016; Sirima Pokpong, 2018
		- Number of population/migrations	Jackkrit Kanjanakrit, 2013
Technology	Technology	- Efficient, sufficient, and modern technology of waste management	Saowalak Saksit, 2016; Sirima Pokpong, 2018; Walanna Wattanahemmakorn, 2017
Law	Law	- Laws relevant to waste management/local regulations	Jackkrit Kanjanakrit, 2013; Panuwatt Ontes, 2020; Sirima Pokpong, 2018; Walanna Wattanahemmakorn, 2017
		- Enforcement and penalty	Sirima Pokpong, 2018

Issues	Factors	Sub-Factors	Sources
Environment	Environment	- Environmental conditions of the province, terrain, land use	Jackkrit Kanjanakrit, 2013; Panuwatt Ontes, 2020; Saowalak Saksit, 2016
		- Local environmental problems/problems of waste/environmental impact from waste management	Saowalak Saksit, 2016; Sirima Pokpong, 2018; Walanna Wattanahemmakorn, 2017
		- People's awareness	Sirima Pokpong, 2018
Input Evaluation			
4 M's			
Man	Personnel	- Sufficient personnel	Jackkrit Kanjanakrit, 2013; Panuwatt Ontes, 2020; Saowalak Saksit, 2016
		- Knowledge and understanding Expertise	Jackkrit Kanjanakrit, 2013; Sirima Pokpong, 2018; Walanna Wattanahemmakorn, 2017
		- Appropriate use of personnel in their line of work	Jackkrit Kanjanakrit, 2013
		- Cooperation, awareness	Sirima Pokpong, 2018
		- Personnel development and Personnel assignment	Panuwatt Ontes, 2020
Money	Budget	- Budget for management/sufficient and continuous budget	Anan Photikul, 2018; Jackkrit Kanjanakrit, 2013; Saowalak Saksit, 2016; Sirima Pokpong, 2018; Walanna Wattanahemmakorn, 2017
		- Efficient and optimal use/appropriate use	Jackkrit Kanjanakrit, 2013; Panuwatt Ontes, 2020; Sirima Pokpong, 2018

Issues	Factors	Sub-Factors	Sources
Input Evaluation			
Material	Tools/equipment/locations	- Efficient, correct, and sufficient use	Jackkrit Kanjanakrit, 2013; Panuwatt Ontes, 2020; Saowalak Saksit, 2016; Sirima Pokpong, 2018
		- Sufficient tools/equipment/locations that readily facilitate work	Jackkrit Kanjanakrit, 2013
Management	Management/administration	- Plan, procedure, process, monitor, inspect	Saowalak Saksit, 2016; Sirima Pokpong, 2018; Walanna Wattanahemmakorn, 2017
	Rules/regulations	- Rules/regulations/requirements of performing work	Sirima Pokpong, 2018
Process Evaluation			
PDCA			
Plan	Planning	- Policies/plans/action plans/projects	Jackkrit Kanjanakrit, 2013; Panuwatt Ontes, 2020; Saowalak Saksit, 2016; Sirima Pokpong, 2018
Do	Plan implementation	- Implementation of policies/plans/projects	Jackkrit Kanjanakrit, 2013; Saowalak Saksit, 2016
		- Process and procedure of operation/collection/reuse/disposal	Jackkrit Kanjanakrit, 2013; Panuwatt Ontes, 2020; Sirima Pokpong, 2018
		- Public participation	Panuwatt Ontes, 2020; Saowalak Saksit, 2016
Check	Monitor and inspect the results of the implementation of policies/plans/projects	- Monitor and inspect the set plans and goals	Sirima Pokpong, 2018
		- Monitor and inspect/evaluate	Jackkrit Kanjanakrit, 2013; Panuwatt Ontes, 2020; Saowalak Saksit, 2016

Issues	Factors	Sub-Factors	Sources
Process Evaluation			
PDCA			
Act	Improve and rectify for appropriate operation	- Improve and develop plans/action plans - Rectification and improvement procedure - Improve and solve problems and obstacles - Forge cooperation	Panuwatt Ontes, 2020 Saowalak Saksit , 2016 Sirima Pokpong, 2018 Jackkrit Kanjanakrit, 2013
Product Evaluation			
Product	Waste separation or collection	- Amount of sorted waste/collected waste/residue	Jackkrit Kanjanakrit, 2013; Panuwatt Ontes, 2020; Saowalak Saksit, 2016
	Waste utilization	- Amount of waste for recycle /reuse /use	Jackkrit Kanjanakrit, 2013; Panuwatt Ontes, 2020
	Waste disposal	- Amount of disposed waste	Panuwatt Ontes, 2020
	Public participation	- Number of cooperating communities /cooperation received from people	Panuwatt Ontes, 2020
Impact Evaluation			
Environment and people's health	Impact on environment and health	- Problems of pollution from waste such as wastewater, foul smell, incineration	Jackkrit Kanjanakrit, 2013; Saowalak Saksit, 2016
Society	Social impact	- Waste management network	Jackkrit Kanjanakrit, 2013
		- People's satisfaction	Jackkrit Kanjanakrit, 2013
		- People's participation	Panuwatt Ontes, 2020
		- The conflict between residents and the public sector	Saowalak Saksit, 2016)
Economy	Economic impact	- Income from waste or recycling	Jackkrit Kanjanakrit, 2013; Saowalak Saksit, 2016
		- Economic growth	Saowalak Saksit, 2016
		- Collection and disposal costs	Panuwatt Ontes, 2020

2.7 Relevant Research Works

For the study of the Model of Electronic Waste Management for Eastern Economic Corridor, the researcher conducted studies and research works similar or relevant to this study as follows:

Ampol Navavongsathian et al. (2017) studied Electronic waste management with reverse logistics from foreign and domestic literature reviews. The product design, producers' responsibilities to protect the environment, traceability of products for reuse, reduced production loss as much as possible, and setting up locations for treatment and disposal of e-waste were essential factors of e-waste management with reverse logistics. Moreover, producers must be legally responsible, recall of waste and return own's product, and design products for a long working life that was easy to repair and reuse, recyclable, and easy disassembling of parts.

Bovea, Ibáñez-Forés, and Pérez-Belis (2020) studied Repair vs. replacement: Selection of the best end-of-life scenario for small household electric and electronic equipment (EEE) based on life cycle assessment. This study aimed to evaluate two different end-of-life scenarios: repair & reuse and replacement for nine types of small household EEE in Span. These types were vacuum cleaners, hand blenders, coffee makers, heaters, juicers, iron, hairdryer, sandwich maker, and toaster. The life span for each small household EEE was in the range of 6-9 years. The results showed that the repair & reuse option generally verified environmentally better than the replacement because the repair & reuse had a lower environmental impact than the replacement for any failure in the first three years of the life span of small household EEE. For some failures of EEE types related to the printed circuit boards or motors, the replacement option was better than repair & reuse because the environmental impact from their repair activities was not offset by the environmental benefits of increasing the useful life obtained.

Chatralada Kanchanasuttisang, Wichet Jiranurak, and Jariya Namtubtim (2015) studied the Health impact assessment of the enterprises that are harmful to health: A case study of recyclable scrap accumulation enterprises in Chiengraknoy subdistrict municipality, Phra Nakhon Sri Ayutthaya province in 2013 in three types of business operation namely Wooden Pallets, recycled waste, and e-waste.

Compilation data using a questionnaire with 550 samples consisted of entrepreneurs dealing in used objects, staff, and people living in a radius not exceeding 3 km from the establishment (6 villages). The study findings revealed that e-waste business mainly caused troubles from foul smell from chemicals (61.30%), followed by dizziness of operators mostly found during work or after work (29.0%), and residents in neighboring communities mainly were dissatisfied with the sorting of parts of e-waste (64.50%).

Chetphanat Leelasrisiri and Chutimaporn Mhonyai (2018) conducted reverse logistics to manage hazardous waste (HW) in Thailand effectively. The case studies of alkaline batteries and fluorescent lamps included factors impacting reverse logistic management for HW, costs of reverse logistics for HW, and measures to motivate reverse logistic management for HW. In-depth interviews were conducted with experts in ten organizations and 400 consumers in Bangkok and adjacent six provinces, namely Nakhon Pathom, Nonthaburi, Pathum Thani, Samut Prakan, Samut Sakhon, and Samut Songkhram. The study results revealed that the external factors impacting reverse logistic management for alkaline battery and fluorescent lamps included 1) Policy and political: The government should promote the improvement of efficient collection and dismantle with the participation of local administrative organizations in operation 2) Economical: Consideration should be on the number of waste-buying shops, competition of buying/selling prices, motivation, and welfare impacting waste disposal 3) Social: Focus on cooperation with the network of stakeholders from suppliers of raw materials to consumers 4) Technology: Should support the use of technology for disposal 5) Environment: Should determine the types of environmental-friendly products, showing how to dispose of with easy dismantling to motivate producers and 6) Law: Success of legislation to enforce the management of HW. It included 1) Process of participation from all sectors 2) System to report monitoring and inspection of information 3) Sufficient drop-off points of collection and sorting HW covering all areas. The reverse logistics costs consisted of collecting, transporting, and recycling alkaline batteries of 40 satangs per piece and the fluorescent lamp of all sizes at an average of one baht. Primary motivation measures were formulated, including activities organized to collect product waste that the market would not buy. The determination of drop-off points to be in short distance

(distance between the house and the nearest retail shop was 0 . 5 -3 km such as convenience stores Seven-Eleven, Big C Mini, Lotus Express) with convenience for consumers' disposal. Furthermore, producers arranged for Trade-in with old for new products. In this case, the collection of product waste would be in larger quantity and worth taking it to the recycling plant and stimulate sales.

Janejira Jannuwat (2019) studied the Measures to promote electronic waste recycling: A comparative study of Thai law and European union and Japanese laws. The research results found that the problems of e-waste in Thailand included continuously increased amount of e-waste, problems of toxic substances which were components in the waste, and problems of the guideline of waste management. Without proper e-waste management, the potentially recycled e-waste would be mixed with general solid waste, contaminated in environmental quality, and impacted people's health, causing contamination or damage. The e-waste could not be recycled, losing natural resources and the environment and not reducing the amount of generated e-waste. It would have an economic impact as the government must lose an enormous budget in improving and rehabilitating environmental quality and people's health. As for the guideline of e-waste management appropriate to Thailand, the focus should be on the guideline to promote the recycling of e-waste such as 1) The government should forge knowledge and understanding of the necessity to sort e-waste and danger of e-waste to the environment and people's health and hygiene via various media 2) The government conducts public relations on the knowledge of the methods to make choices in buying and using EEE and knowledge on recycle and e-waste management to people via various media including documents and public relation media 3) Use tax deduction measures relevant to e-waste to motivate consumers to take an interest in new products with some parts of components coming from recycling or goods or products with less impact on the environment and 4) Promote business of e-waste recycling such as financial or technical support for those interested to invest in the business of e-waste recycling and should determine that all factories type hazardous waste disposal (factories category 101, 105, and 106) must be located in industrial estates to facilitate control and supervision of environment.

Kumar and Dixit (2018) studied Evaluating critical barriers to implementation of WEEE management using the DEMATEL approach. This study aimed to identify the crucial barriers to successfully implementing WEEE management in India from 18 experts. They were electronic manufacturers, WEEE recyclers, electronic retailers, policymakers of the central pollution control board, an academic expert, and a non-government organization. The earlier adopted seven criteria of barriers were financial barriers (F), infrastructural barriers (I), knowledge barriers (K), policy and regulatory barriers (PR), socio-cultural barriers (SC), socio-economic barriers (SE), and technological barriers (T). The analysis results revealed that PR and T barriers were the most critical barriers to effective WEEE management implementation. Further, the barriers I, PR, SC, and SE were the significant barriers to drive the overall system. The first ranking of sub barriers associated with I, PR, SC, SE, and T barriers was lack of infrastructural facilities such as storage, transportation, and treatment technology (I1), delay in extended producer responsibility approaches (PR1), low public environmental consciousness (SC1), low recycling penetration and supply of domestic WEEE (SE7), and limited skill workforce (T2).

Mok Tuntipalaku (2016) studied E-waste management in Bangkok: The government and citizen aspect on the in-depth interviews with three government agencies, namely the Pollution Control Department, Electrical and Electronics Institute, and Department of Industrial Works in 2015. The study findings revealed that the government still lacked knowledge and understanding of e-waste, unclear law, lenient penalty, and lack of concrete law enforcement. The solutions to the problems included a campaign on e-waste and IT on the Cloud to reduce the use of electronic equipment. However, the research results through the questionnaire of 400 residents in Bangkok showed that people knew e-waste management at a relatively high level (4 7 %). Most people (9 0 %) viewed that the sorting of e-waste was necessary before disposal and would facilitate the government's waste management. Nevertheless, people's disposing of waste was still not correct because disposing of e-waste was not widespread. In practice, most people would sell all types of e-waste due to compensation, repair, or recycle, except lighting equipment which would mostly be put in separate bags.

Pachanit Naovapun and Anusara Chaodorn (2020) studied the Electronic waste management in the ecosystem by junk shops case study: CPU waste management of Sahaphankarnkha, Prachinburi province. The study was on 50 CPUs with the average weight of CPUs at 12 kgs per one CPU. The study results revealed that Trade Federation at Na Mueang Subdistrict, Muang Prachinburi District, Prachin Buri, was licensed to operate trade in old items and could disassemble parts from the CPU of old computers. They were bought in five types: plastic, iron, aluminum, copper, and circuit board. The number of separated types of waste equaled 5 kgs, 6 kgs, 0.6 kg, 0.3 kg, and 0.1 kg. Each piece could be sold per kg at 12 baht, 9 baht, 28 baht, 156 baht, and 3,000 baht, respectively. The costs were 13,916.47 baht and could create value from the sales of different parts, all of which were sold with an income of 23,880 baht. The average monthly profit was 9,963.53 baht or 41.72% of income which was a good profit.

Paphada Pramanpon et al. (2019) studied the Legal measures for waste electrical and electronic equipment (WEEE) management in Thailand. The study findings revealed that the WEEE problems in Thailand required legal measures for the solutions. The government must accelerate the Draft of the Waste Electrical and Electronic Equipment Management Act B.E. …. or e-waste law. That is required cooperation from the business sector by which producers and importers must accept return of product waste for correct and safe disposal of the e-waste and cooperation from the people sector to return product waste. Even with the actual law enforcement, if people did not understand the logic of the law, it would lead to the problems of lack of cooperation in returning the product waste.

Park, Ahn, Lee, Choi, Song, Choi, and Han (2019) studied Analysis on public perception, user-satisfaction, and publicity for WEEE collecting system in South Korea: A case study for Door-to-Door (D-to-D) Service. The D-to-D service was one of the WEEE collection channels managed by the Ministry of Environment of Korea (MOE) and the Korea Electronics Recycling Cooperative (KERC). The survey questionnaires of 1,200-2,000 interviewees were conducted by the computer-assisted telephone interviewing (CATI) method for three years in 2015-2017. The survey results in 2017 revealed that 48 % of respondents were aware of the operation of the service, with the highest awareness level in the two previous years. The effective routes of D-to-D recognition were mass media such as radio and television (24%),

promotional literature (19%), inquiries to local authorities (19%), acquaintances (15 %), internet (14%), and online paths (4%) such as blog and Social Network Service (SNS). Most of the D-to-D service users were satisfied with the service, with 91% expressing very satisfied or satisfied opinions. The perceived advantages of the service were free of charge (44%), direct contact system between customers and visiting engineers (27%), provision of speedy customer service (9 %), the ability to adjust the visiting schedules (8%), convenience (nearly 8%), and kindness (5%). These results indicated that raising awareness of consumers and additional public relation activities for the D-to-D service to the public via all media types were necessary.

Saringkhan Khlaikhaek (2018) studied the Factors affecting reverse logistics network operations for electrical and electronic equipment waste in Thailand. The qualitative research conducted in-depth interviews with nine specialists, experts, and entrepreneurs. The quantitative research used a questionnaire with entrepreneurs or executives of factories category 105 and category 106 operating in e-waste in a total of 150 factories. Rules and regulations were essential factors in the reverse logistic management of e-waste. It determines the goals of recovery, reuse, recycle, to make maximum recycle of the valuable materials, which would impact financial operation, increasing sales and profit, reducing the use of natural resources, reducing useless waste, and reducing pollution on the environment. The problems and obstacles in operating the reverse logistic network of e-waste in Thailand included 1) Thailand had no specific law relevant to e-waste management 2) Government officials were not strict in law enforcement and failed to perform their duties 3) Local administrative organizations and relevant agencies lacked stringency in law enforcement and in solving practical problems 4) Entrepreneurs in households did not sort waste based on academically correct methods. They disposed of waste by incineration and landfill that were not academically correct, and 5) Lack of proactive measures to promote the access of information and news.

Sasiwimon Mudju (2018) studied Bangkok Metropolitan Administration's electronic waste management through in-depth interviews with 20 experts with knowledge and expertise in e-waste. There were five public sector representatives, two companies from the private sector, and ten representatives from the people sector.

The study findings revealed that Bangkok Metropolitan Administration (BMA) sought cooperation from people living in the 50 districts in Bangkok to sort e-waste from general waste and schedule the collection of e-waste on the 1st day and 15th day of the month. The collected e-waste would be sent to BMA's waste transfer stations (Saimai station, Onnut station, and Nongkham station) to send to private companies for disposal. There were four methods of e-waste management for people in households, namely, sell to junk shops, discard and mix it with general waste, keep it at home, and donate to others for repair. Most people chose to sell e-waste to junk shops and discard non-valuable e-waste mixed with general solid waste. People did not know about correct e-waste management and thought it was the public sector's duty to sort types of waste, they thrust upon BMA to manage in their place by discarding e-waste mixed with general waste. The guideline of e-waste management for BMA included 1) Accelerate the enactment of the law on WEEE management, which stipulated that producers must be responsible for disposal of WEEE based on correct methods 2) Determine the role of producers to be responsible for their products from the production process, collection of product waste, and disposal 3) Add more channels to collect the WEEE and 4) Promote creation of awareness and good behavior toward e-waste management to the people. The public sector must create advertising media that attracted people's interest and integrate knowledge on e-waste management based on correct methods. Advertising media was important and influential to people in society. It affected people's good behavior towards more e-waste management with correct methods such as sorting, repairing for reuse

Somsiri Decharat (2018) studied People's participation in hazardous waste management in Pa-payom District, Phattalung Province, using a questionnaire with a sample consisting of 13 representatives responsible for the environment from four local administrative organizations in Pa Phayom District and 253 people. They were Village health volunteers in Pa Phayom. Most people (53%) understood that once the household hazardous waste (HHW) such as dry cell, mobile phone battery, mobile phone, the container of pesticides was sorted and collected and separated from general waste, LAOs must be responsible for the HW management. The participation of people was still at a low level. The three priorities of guidelines for HHW management promoting people's participation included, firstly, constructing the model to promote sorting of hazardous waste

in households (91.30%), secondly increasing public relations of news and activities related to HHW (82.61%). Thirdly local government agencies must be active and focus on HHW management (77.87%).

United Nations Development Program (2019) studied E-waste management in Korea focusing on Seoul. The studying finding revealed that the Government of Korea changed the Extended Producer Responsibility (EPR) system in 2008 to the Electrical and Electronic Product Eco-Guarantee system. This new system broadened the responsibility of producers or manufacturers from simple e-waste recycling to utilizing more environmentally-friendly production processes. In 2014, the Ministry of Environment of Korea (MOE) started free collection services for large household appliances (i.e., refrigerators, washing machines, air conditioners, and televisions) under the Korea Electronics Recycling Cooperative (KERC) as a partner. The KERC managed and coordinated a free-of-charge collection service network. As for another partner, the Korea Environment Corporation (K-eco) monitored the implementation of recycling programs and ran management training programs for improving resources efficiency in e-waste management. The MOE installed recycling bins for batteries and other e-waste such as cell phones and fluorescent light bulbs in various public places. These places were subway stations, community centers, parks, roads, and apartment complexes. As of 2019, the average number of recycling bins for batteries in Seoul was 15 bins per administrative sub-unit (6,577 bins). These easily accessible recycling bins led to an increase in the collection and recycling of batteries. The "Seoul Recycling Centre" was established by Seoul Metropolitan Government (SMG) and operated by "Eco City Seoul." The center recycled mobile phones and small-scale appliances such as rice cookers, computers, electric fans, heaters. The products were classified and disassembled by material types and then sold to secondary processing companies through bidding processes. Furthermore, the Korean government continuously introduced new legislation and revised their existing laws related to e-waste management. For example, the Act on Resource Circulation of Electrical and Electronic Equipment and Vehicles and the Act on Saving and Recycling of Resources were revised in 2015 and 2017, respectively.

Weerayut Sukhoyachai (2018) studied the Legal measures concerning electronic waste management in local administrative organizations (LAOs) by comparing them with

foreign laws in Japan and the US. The law in Thailand stipulated that LAOs had the duty to manage waste. LAOs might assign other persons to work in their place but under their supervision, and LAOs did not have an internal unit with the specific responsibility of e-waste management. Subsequently, e-waste was neither correctly managed nor efficient. Therefore, in defining legal measures on e-waste management in LAOs, the content of the law must determine the specific agency with the responsibility of the e-waste management system and measures or requirements for people to have the role in reusing e-waste.

CHAPTER 3

RESEARCH METHODOLOGY

The research for the model of electronic waste management for Eastern Economic Corridor (EEC) aimed to study the situations, problems, and impacts from household e-waste management in EEC in Chachoengsao, Chonburi, and Rayong provinces between 2016-2019 and at present. Including the strategies, policies, and laws related to e-waste management in Thailand and EEC, evaluate household e-waste management in the three provinces of EEC and present the appropriate model of household e-waste management in the three provinces of EEC. The researcher conducted relevant literature reviews, concepts, and theories used to design the methodology. The details are as follows:

3.1 Research Conceptual Framework

For this research, the researcher was interested in the model of household e-waste management in Chachoengsao, Chonburi, and Rayong consisting of three main groups, namely 1) Lamps, 2) Battery and dry battery, and 3) Electrical and electronic appliances in daily lives at the end of life or no longer of using them namely telephone and wireless phone, computer, and television. In total, the household e-waste in the study consisted of five types, namely 1) Lamps such as a straight fluorescent lamp, compact fluorescent lamp 2) Battery and dry battery such as a battery, mobile phone battery, digital camera battery, automotive battery 3) Telephone and wireless telephone 4) Computer such as desktop computer, notebook, and tablet 5) Television. The source of e-waste in Thailand mostly came from households 82%, followed by office buildings 14%, and hotels/apartments 3% (Pollution Control Department, 2020c). The five types of household e-waste studied in this research were figured in the goals of the Integrated Waste Electrical and Electronic Equipment Management Strategies B.E. 2557-2564 (2011-2021). It must

be efficiently sorted, collected, and sent to academically correct recycling, treatment, or disposal in big LAOs, all city municipalities, and Pattaya (Pollution Control Department, 2 0 1 7 a). Telephone and wireless telephone, computer, and television were small to medium e-waste with a tendency to change often for the lighter weight (Center of Excellence on Hazardous Substance Management, 2019b), including three out of five types in the Draft of the Waste from Electrical and Electronic Equipment Management Act B.E. .....

This study was qualitative research from documentary research through academic literature reviews, academic documents, related research works, and electronic data sources. The data included population and household, electrical and electronic equipment factory and worker, amount of HHW and household e-waste, policies, plans, and laws on e-waste management in Thailand and EEC, situations of HHW and household e-waste management, problems and obstacles of the operation of HHW and household e-waste management in EEC in Chachoengsao, Chonburi, and Rayong between 2016-2019. The analysis on e-waste management in EEC in the past using the Pressure-State-Response (PSR) framework of the Organization for Economic Co-operation and Development (OECD) (Linster, 2003). It identified the Pressures (P) of the growth of the electrical and electronic industry, rising use of electrical and electronic devices, and household e-waste disposal behavior of people, the resulting Pressures (P) causing changes in the State (S). The state (S) included situations, problems, and obstacles of the operation of household e-waste management in the three provinces of EEC, including Response (R) as policies, plans, guidelines, and measures for household e-waste management in EEC. The results of the PSR analysis framework used in evaluating household e-waste management for EEC in the three provinces according to the CIPP-I model of Chamlong Poboon (2018). It led to the search for the model of household e-waste management for EEC through the study and compilation of data from documents and field surveys in Chachoengsao, Chonburi, and Rayong provinces. The data consisted of documents, memos, official letters, and operation reports of household e-waste management from relevant agencies in EEC. Moreover, interviews and observation were through consideration of five dimensions, namely Context, Input, Process, Product, and Impact, as follows:

1) Context: The PESTLE analysis consisted of policies, strategies, and plans of e-waste management (Policy), economic conditions of the east (Economic), social conditions of the east (Social), technology of sorting, recycling, and disposal of e-waste (Technology), laws related to e-waste management (Legal), environmental conditions of the east (Environment)

2) Input: Use of 4 M consisting of personnel, responsible agencies, and public (Man), Money, Material and Machine, and Management

3) Process: Use of the principle of PDCA, namely planning/project (Plan), operation of project and activity (Do), monitoring (Check), and improvement for appropriate operation (Act)

4) Product: Results of household e-waste management in line with the goal of the Action Plan "Clean Province" 2020, such as installation of drop-off points for HHW in all communities, e-waste sorted and disposed of at the drop-off points as determined by LAOs, and the amount of e-waste collected and disposed of that was more academically correct

5) Impact: It was both positive and negative impacts from e-waste management consisting of impact on the environment and local people's health, society, and economy.

Afterward, the results of the CIPP-I model determined the significant issues impacting the success of household e-waste management in EEC in Chachoengsao, Chonburi, and Rayong provinces. The analysis of internal and external factors used SWOT Analysis and TOWS Matrix to recommend the guideline to develop household e-waste management, construct and select the model for e-waste management in EEC. Then, the researcher tested it with the model evaluation form of e-waste management in EEC via New Normal communication or meeting through the set Line to reduce the risks of COVID-19. The meeting could be held anywhere without spending time on transport. These Line members consisted of experts, executives, government officials, employees related to e-waste management of public agencies and state enterprises, the private sector, and related community leaders in Chachoengsao, Chonburi, and Rayong. The Line members responded to the evaluation form and provided comments and recommendations of the e-waste management model for EEC via Line or e-mail, or google form. Then, the researcher used the opinions and recommendations to

improve the model appropriate to e-waste management in EEC. The conceptual research framework summarizes in Figure 3.1.

3.2 Key Informants

The twenty-seven selected key informants were used in the research by purposive sampling of those involved in e-waste and HHW management in EEC and industrial estates in the Promoted Zones for Targets Industries of the EEC in Chachoengsao, Chonburi, and Rayong provinces. They divided into four groups, namely:

3.2.1 Executives and government officials of the central government who formulate the policy and plan on the management of the country's electronic waste and HHW such as PCD and DEQP of MNRE, DOLA of MOI, Department of Industrial Works of M-Industry, and MOPH, in total five persons namely:

1) Environmentalist, Professional Level, Waste and Hazardous Substance Management Bureau, PCD, MNRE, here under the assumed name of Government official of the central government No. 1

2) Dissemination Technical Officer, Professional Level, DEQP, MNRE, here under the assumed name of Government official of the central government No.2

3) Director, Local Environment Subdivision, Local Environment Division, DOLA, MOI, here under the assumed name of Government official of the central government No. 3

4) Chief, responsible for waste, Bureau of Environmental Health, Department of Health, MOPH, here under the assumed name of Government official of the central government No. 4

5) Scientist, Industrial Waste Management Division, Department of Industrial Works, M-Industry, here under the assumed name of Government official of the central government No. 5

3.2.2 Executives and officers of central and regional state enterprises formulate policies, develop the EEC areas, and operate in e-waste management in industrial estates. They were EECO, IEAT, Offices of Industrial Estate in Chachoengsao, Chonburi, and Rayong, in total six persons namely:

1) Deputy Director and Assistant Director, Overall Planning Bureau, EECO in total two persons, here under the assumed name of Officers of EECO No. 1 and No. 2

2) Scientist, IEAT, here under the assumed name of Officer of IEAT No. 1

3) Director, Office of Gateway City Industrial Estate, Gateway City Industrial Estate, Chachoengsao, here under the assumed name of Officer of IEAT No. 2

4) Director, Office of Pinthong Industrial Estate, Pinthong Industrial Estate 2, Chonburi, here under the assumed name of Officer of IEAT No. 3

5) Scientist, Office of Amata City Chonburi Industrial Estate, Amata City Chonburi Industrial Estate, here under the assumed name of Officer of IEAT No. 4

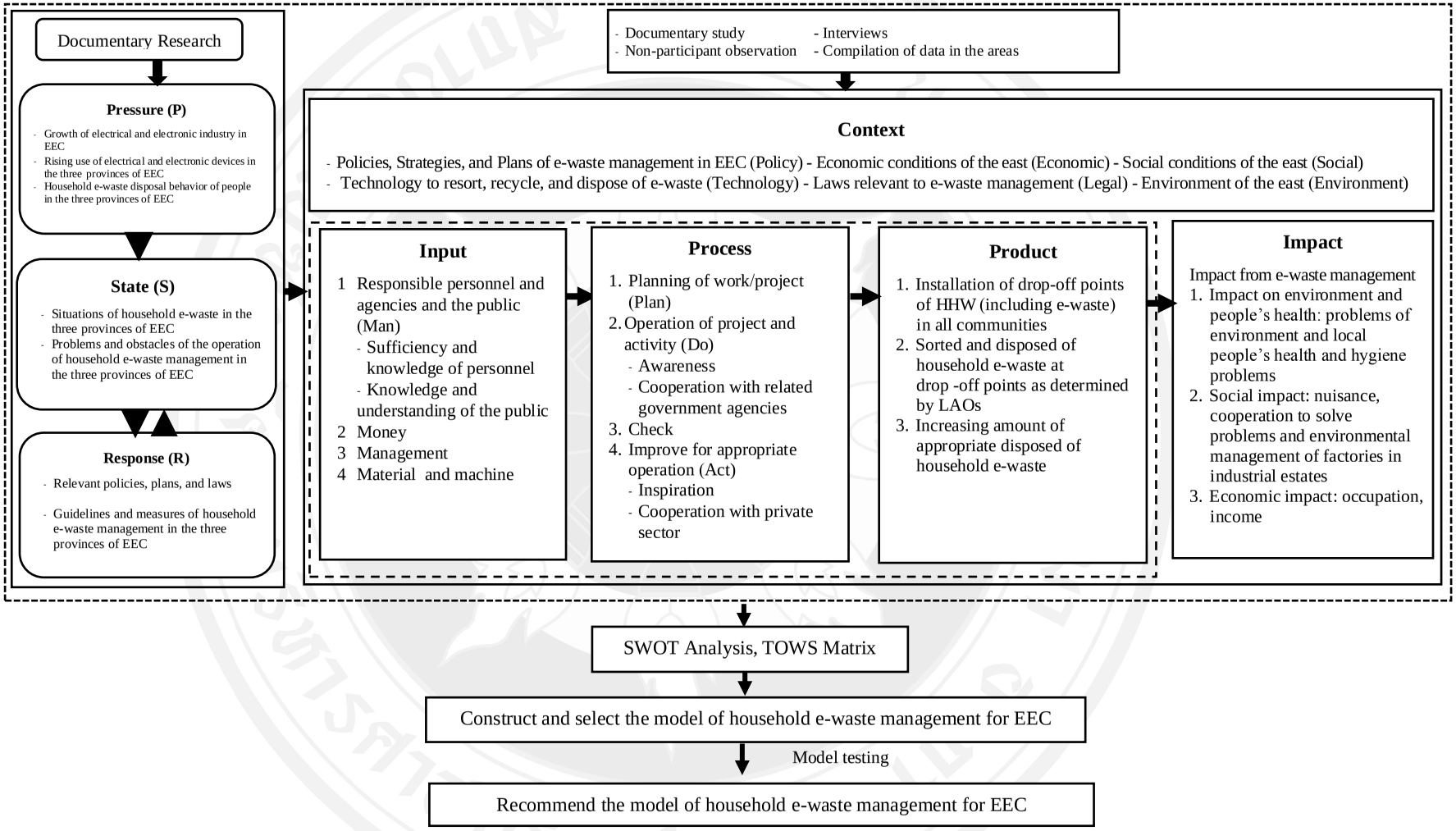


Figure 3.1 Research Conceptual Framework

3.2.3 Executives and government officials in local administration and provincial administrative organizations who supervise, support, and monitor the management of household e-waste in Chachoengsao, Chonburi, and Rayong such as REO 13 (Chonburi), PONRE, PAOs, and Provincial Office for Local Administration, in total 11 persons namely:

1) Environmentalist, Professional Level, Environmental Quality Control Subdivision, REO 13 (Chonburi), MNRE, here under the assumed name of Government official of the local administration No. 1

2) Director, Environment Subdivision, Provincial Office for Natural Resources and Environment Chonburi, MNRE, here under the assumed name of Government official of the local administration No. 2

3) Environmentalist, Professional Level, Provincial Office for Natural Resources and Environment Chachoengsao, MNRE, here under the assumed name of Government official of the local administration No. 3

4) Environmentalist, Practitioner Level, Provincial Office for Natural Resources and Environment Rayong, MNRE, here under the assumed name of Government official of the local administration No. 4

5) Engineer, Professional Level, Provincial Industry Office Chonburi, M-Industry, under the assumed name of Government official of the local administration No. 5

6) Engineer, Professional Level, Provincial Industry Office Chachoengsao, M-Industry, under the assumed name of Government official of the local administration No. 6

7) Chief, Industrial Factory Group, Engineer, Professional Level, Provincial Industry Office Rayong, M-Industry, here under the assumed name of Government official of the local administration No. 7

8) Chief, Waste and Environment Management Group, Chonburi Provincial Administrative Organization, here under the assumed name of Local officer No. 1

9) Chief, Environment Group, Rayong Provincial Administrative Organization, here under the assumed name of Local officer No. 2

10) Chief, Environment Group, Chachoengsao Provincial Administrative Organization, here under the assumed name of Local officer No. 3

11) Chief, Environment Group, Local Administrative Development Subdivision, Chonburi Provincial Office for Local Administration, here under the assumed name of Local officer No. 4

3.2.4 Managers and private sector employees in companies of electrical and electronic equipment manufacturing, companies sorting/recycling/disposing of e-waste in Industrial Estates in Chachoengsao, Chonburi, and Rayong, in total five persons namely:

1) Environmental employee at a company producing radio and CD player, telephone, and camera in Amata City Chonburi Industrial Estate, here under the assumed name of Company representative No. 1

2) Environmental and safety employee at a company producing electronic parts at Amata City Chonburi Industrial Estate, here under the assumed name of Company representative No. 2

3) Senior Environmental Engineer at a power plant from industrial waste disposal in WHA Chonburi Industrial Estate 1, here under the assumed name of Company representative No. 3

4) Senior Director at a recycling company of fluorescent lamps, and crushing of unused electrical and electronic equipment in WHA Chonburi Industrial Estate 1, here under the assumed name of Company representative No. 4

5) General Manager at a crushing company of electrical and electronic parts in Pinthong Industrial Estate 1 in Chonburi, here under the assumed name of Company representative No. 5

3.3 Tools Used in Research and Inspection of the Quality of Tools

3.3.1 Research Tools

The tools used in the qualitative research of the study of the model of e-waste management for EEC included a semi-structured interview, non-participant observation, and the evaluation form of the model of e-waste management for EEC as follows:

3.3.1.1 Semi-Structured Interview was divided into four sets according to the groups of key informants (Appendix A) as follows:

1) Set 1 For executives and government officials of the central government

2) Set 2 For executives and EECO, and IEAT

3) Set 3 For executives and government officials in local administration and PAOs of Chachoengsao, Chonburi, and Rayong

4) Set 4 For managers and private sector employees in companies producing and disposing of e-waste in the Industrial Estates in Chachoengsao, Chonburi, and Rayong

3.3.1.2 Non-participant: The observation form was the form for observation at the drop-off points of household e-waste and collection locations of e-waste in Chachoengsao, Chonburi, and Rayong. The data included location, date, time, and observer and observation activities at the drop-off points of household e-waste and e-waste storage centers. These were drop-off points, provincial e-waste storage centers, conditions and patterns of containers, amount and types of e-waste, problems found at the drop-off points, tools and equipment, and processes of e-waste collection at the provincial e-waste storage centers (Appendix B).

3.3.1.3 Evaluation form of e-waste management model in EEC. The evaluation form consisted of explaining the model's components based on the framework of the CIPP-I model, questions on the appropriateness of the model, the model implementation, and the model's recommendations (Appendix C).

3.3.2 Determination of Questions in the Interviews

The researcher determined the main, broad questions used in the interviews before collecting data and added in-depth questions during interviews. The interviews consisted of questions related to e-waste management in Chachoengsao, Chonburi, and Rayong. The questions were according to the CIPP-I model under Context, Input, Process, Product, and Impact as follows:

3.3.2.1 Questions on Context such as strategies and plans related to e-waste management, technology to sort, recycle, and dispose of e-waste, as well as laws related to e-waste management.

3.3.2.2 Questions on Input. It consisted of personnel and agencies responsible for household e-waste management, public's knowledge and understanding of e-waste management (Man), budget used in household e-waste management (Money), tools and equipment in household e-waste management (Material and Machine), and household e-waste management (Management).

3.3.2.3 Questions on Process such as planning of work/project related to e-waste management (Plan), operation of project and activity relevant to e-waste management (Do), monitoring of e-waste management (Check), and improvement for proper operation (Act).

3.3.2.4 Questions on Product included results of household e-waste management such as installation of drop-off points of HHW (including e-waste) in all communities. Household e-waste was sorted and brought to drop-off points determined by LAOs, and the amount of household e-waste was more academically collected and sent for disposal.

3.3.2.5 Questions on Impact included positive and negative impacts from e-waste management. It included the environment and local people's health impacts and problems, impact on society such as nuisance, cooperation to solve problems, environmental management of factories in industrial estates, and impact on the economy such as occupation, income.

This research determined questions for collecting data to evaluate e-waste management in EEC based on the CIPP-I model. The details are in Table 3.1.

3.3.3 Inspection of Quality of Tools

The researcher inspected the quality of the interviews through the Item-Objective Congruence Index (IOC) with ten experts on environment, e-waste management, policies, and laws related to e-waste management consisting of four academics and researchers and six lecturers in public universities and employees in the private sector. The Content Validity was evaluated by considering the objectives of the research, theoretical definition, and operational definition. If the questions were congruent, the mark would be 1, not confident, the mark would be 0, and not congruent, the mark would be -1 . Used interview questions were the questions with the IOC over or equaled 0.50 (Suwimol Tirakanan, 2013). Results evaluation of the

congruence of all questions in the interviews were a total of 24 questions with the index 0.60-1.00. The details are in Appendix D.

Table 3.1 Determination of the Questions according to the CIPP-I Model and Interviews with the Key Informants

Issues	Definitions	Data compilation methods	Questions	Key informants
1) Context				
1.1 Strategies, policies, and plans related to e-waste management in EEC in Chachoengsao, Chonburi, and Rayong	Guidelines or framework of government agencies such as MOI, MNRE, M-Industry, MOPH, EECO, IEAT, and other related agencies as determined for use in the operation or implementation to reach the goal	- Documentary study - Interviews - Observation in the areas - Compilation of data in the areas	- Does your agency formulate strategies, policies, plans, or measures in e-waste management? Are they successful? Are there problems or obstacles?	- Executives and government officials of the central government - Executives and officers of EECO and IEAT - Executives and government officials in PAOs and LAOs of Chachoengsao, Chonburi, and Rayong - Managers and private sector employees in companies producing and disposing of e-waste in Industrial Estates in Chachoengsao, Chonburi, and Rayong provinces.

Issues	Definitions	Data compilation methods	Questions	Key informants
1.2 Technology to sort, recycle, and dispose of e-waste	Methods used to sort, recycle, and dispose of e-waste of companies/factories to sort, recycle, and dispose of e-waste	- Documentary study - Interviews - Compilation of data in the areas	- At present, are there a lot of companies/factories to sort, recycle, and dispose of e-waste in EEC? Which are they? - What is the technology to sort, recycle, and dispose of e-waste in factories in EEC?	- Executives and government officials of the central government - Executives and officers of EECO and IEAT - Executives and government officials in PAOs and LAOs of Chachoengsao, Chonburi, and Rayong - Managers and private sector employees in companies producing and disposing of e-waste in Industrial Estates in Chachoengsao, Chonburi, and Rayong provinces

Issues	Definitions	Data compilation methods	Questions	Key informants
1.3 Laws related to e-waste management	Laws and legal measures on e-waste management in EEC in Chachoengsao, Chonburi, and Rayong	- Documentary study - Interviews	- What are the laws and legal measures on e-waste management in the areas at present and in the future? How are they enforced?	- Executives and government officials of the central government - Executives and officers of EECO and IEAT - Executives and government officials in PAOs and LAOs of Chachoengsao, Chonburi, and Rayong - Managers and private sector employees in companies producing and disposing of e- waste in Industrial Estates in Chachoengsao, Chonburi, and Rayong provinces

Issues	Definitions	Data compilation methods	Questions	Key informants
2) Input				
2.1 Personnel, agencies, and people (Man)				
2.1.1 Personnel and agencies responsible for e-waste management	Agencies and personnel of LAOs with a role in e-waste management in the three provinces of EEC	- Documentary study - Interviews	- In EEC, are there agencies responsible for household e-waste management? Do those agencies have sufficient human resource with knowledge and expertise in e-waste management? How can the operation of the agencies responsible for household e-waste management be efficient?	- Executives and officers of EECO and IEAT - Executives and government officials in PAOs and LAOs of Chachoengsao, Chonburi, and Rayong
2.1.2 Knowledge and understanding of household e-waste management of local people	Knowledge and understanding of people on household e-waste management in the three provinces of EEC	- Interviews - Observation in the areas	- What is the knowledge and understanding of household e-waste management of local people?	- Executives and officers of EECO and IEAT - Executives and government officials in PAOs and LAOs of Chachoengsao, Chonburi, and Rayong

Issues	Definitions	Data compilation methods	Questions	Key informants
2.2 Budget for household e-waste management (Money)	Budget of the government for more efficient household e-waste management in the three provinces of EEC	- Interviews - Observation in the areas	- Is the budget for e-waste management in the areas appropriate? How is it operated? - Are the areas receiving budget support from relevant sector for e-waste management more efficient? How?	- Executives and government officials in PAOs and LAOs of Chachoengsao, Chonburi, and Rayong
2.3 Tools, equipment, and technology used in household e-waste management in the areas (Material and Machine)	Tools, equipment, and technology are used to sort, collect, transfer, and store household e-waste of LAOs in the three provinces of EEC	- Documentary study - Interviews - Observation in the areas	- What are the methods of household e-waste management of sorting, collection, transfer, and storage of e-waste in the three provinces of EEC? What are the main tools and equipment?	- Executives and officers of EECO and IEAT - Executives and government officials in PAOs and LAOs of Chachoengsao, Chonburi, and Rayong

Issues	Definitions	Data compilation methods	Questions	Key informants
2.4 Household e-waste management in the areas (Management)	Procedure or process of e-waste management in EEC, such as sorting, collection, transfer, recycling, or disposal of household e-waste under the responsibility of LAOs and agencies responsible for the treatment or disposal of e-waste	- Documentary study - Interviews - Observation in the areas	- In what process is the role of LAOs in e-waste management? How is it operated? - Are the sorting, collection, transfer, recycling, and disposal of e-waste in the areas academically correct? How? Can they reduce the amount of e-waste?	- Executives and government officials of the central government - Executives and officers of EECO and IEAT - Executives and government officials in PAOs and LAOs of Chachoengsao, Chonburi, and Rayong
3) Process				
3.1 Planning of work/project (Plan)	Planning of work/project related to household e-waste management from the cooperation between LAOs and government agencies related to the areas in EEC to ensure success of household e-waste management	- Documentary study - Interviews	- Are there planning and project related to household e-waste management in the areas? How?	- Executives and government officials of the central government - Executives and government officials in PAOs and LAOs of Chachoengsao, Chonburi, and Rayong

Issues	Definitions	Data compilation methods	Questions	Key informants
3.2 Implement action plan/project (Do)	Activities held based on the action plan/project related to household e-waste in EEC of LAOs and relevant government agencies in EEC to reach the set objectives and goals	- Documentary study - Interviews - Observation in the areas - Compilation of data in the areas	- Are the activities held under the action plan or project on household e-waste management in the areas? How? - Are there projects or activities promoting and supporting knowledge, understanding and awareness of household e-waste management from upstream, midstream, and downstream for the community? How? - Are there campaigns and public relations for local communities to understand and realize the importance of correct e-waste management? Through which channels? Are the channels sufficient and easily accessible? How?	- Executives and government officials of the central government - Executives and government officials in PAOs and LAOs of Chachoengsao, Chonburi, and Rayong

Issues	Definitions	Data compilation methods	Questions	Key informants
3.3 Check	Monitor the operation of household e-waste management of LAOs and monitor complaints from household e-waste management in the three provinces of EEC	- Documentary study - Interviews - Observation in the areas - Compilation of data in the areas	- Are there monitoring and evaluation of the success of e-waste management? How? - Are there channels for complaint and follow up the complaints from household e-waste management in the areas? How?	- Executives and government officials of the central government - Executives and government officials in PAOs and LAOs of Chachoengsao, Chonburi, and Rayong
3.4 Act	More efficient and more concrete process to improve or rectify household e-waste management in the three provinces of EEC by LAOs and other related agencies both the public and the private sector, such as inspiration and cooperation with the private sector	- Documentary study - Interviews - Observation in the areas - Compilation of data in the areas	- Is there improvement or rectification of household e-waste management in your agency? If yes, how is it operated? - Are there responsible persons in the improvement and rectification of household e-waste management? Who are they?	- Executives and government officials of the central government, PAOs and LAOs of Chachoengsao, Chonburi, and Rayong - Executives and officers of EECO and IEAT - Managers and private sector employees in companies producing and disposing of e-waste in Industrial Estates in Chachoengsao, Chonburi, and Rayong

Issues	Definitions	Data compilation methods	Questions	Key informants
4) Product				
Results from the operation of household e-waste management	Results from the operation of household e-waste management of LAOs in EEC by the goal of the Action Plan “Clean Province” 2020, such as installation of drop-off points of HHW (including e-waste) in all communities. Household e-waste was sorted and left at the drop-off points as determined by LAOs. More household e-waste was collected and sent for academically correct disposal.	- Documentary study - Interviews - Observation in the areas - Compilation of data in the areas	- At present, how is the operation of household e-waste management of LAOs in EEC? - Does the current household e-waste management of LAOs in EEC align with the Action Plan “Clean Province”? How?	- Executives and government officials of the central government - Executives and government officials in PAOs and LAOs of Chachoengsao, Chonburi, and Rayong

Issues	Definitions	Data compilation methods	Questions	Key informants
5). Impacts				
5.1 Impact on environment and peoples' health	Household e-waste management is not academically correct and will impact the environment in EEC, such as contamination of heavy metals in soil, water, air, and ecosystem, and impact people's health in the community.	- Documentary study - Interviews - Compilation of data in the areas	- Does household e-waste management impact environment such as water, air, soil and local people's health impact in EEC? How?	- Executives and government officials of the central government - Executives and officers of EECO and IEAT - Executives and government officials in PAOs and LAOs of Chachoengsao, Chonburi, and Rayong - Managers and private sector employees in companies producing and disposing of e-waste in Industrial Estates in Chachoengsao, Chonburi, and Rayong

Issues	Definitions	Data compilation methods	Questions	Key informants
5.2 Social impact	Household e-waste management negatively and positively impact society in EEC, such as nuisance, cooperation to solve the problems, environmental management in factories.	- Documentary study - Interviews - Compilation of data in the areas	- Does household e-waste management positively and negatively impact society in EEC? How?	- Executives and government officials of the central government - Executives and officers of EECO and IEAT - Executives and government officials in PAOs and LAOs of Chachoengsao, Chonburi, and Rayong - Managers and private sector employees in companies producing and disposing of e-waste in Industrial Estates in Chachoengsao, Chonburi, and Rayong

Issues	Definitions	Data compilation methods	Questions	Key informants
5.3. Economic impact	Household e-waste management impacts community economy in EEC such as income, occupation.	- Documentary study - Interviews	- Does household e-waste management impact to community economy in EEC, such as income, occupation? How?	- Executives and government officials of the central government - Executives and officers of EECO and IEAT - Executives and government officials in PAOs and LAOs of Chachoengsao, Chonburi, and Rayong - Managers and private sector employees in companies producing and disposing of e-waste in Industrial Estates in Chachoengsao, Chonburi, and Rayong provinces

3.4 Data Compilation

The compilation of the qualitative data was two parts: compilation of secondary data and compilation of primary data.

3.4.1 Compilation of Secondary Data

The researcher studied and compiled academic data through documentary study. The documentary study included books and printed matters between March-December 2019 as academic documents, meeting documents, official letters, annual reports, journals, newspapers, articles, research reports, theses, and information from the internet related to e-waste management in foreign countries, Thailand, and EEC, as well as strategies, policies, plans, and laws of e-waste management, situations of the amount of e-waste, problems and impact from e-waste management, and guidelines to solve the problems of e-waste management.

Moreover, the researcher compiled data of e-waste and HHW management in EEC for the past three years (budget years 2017-2019), including results of the operation of project and activity on household e-waste management, e-waste types, and statistics of the amount of compiled household e-waste, methods of household e-waste management, impact on environment and health of people and economy, complaints from incorrect e-waste management in five municipalities. The municipalities consisted of Chachoengsao Town Municipality in Chachoengsao, Laem Chabang City Municipality and Saen Suk Town Municipality in Chonburi, and Rayong City Municipality and Thap Ma Subdistrict Municipality in Rayong (Appendix E). Then, the researcher prepared the letters seeking cooperation to provide data and submitted the letters in person to the five municipalities that were representatives in the research. The researcher followed up by telephone to receive information late and spent approximately three months compiling data from all municipalities that were representatives after submitting the letters between July and September 2020.

3.4.2 Compilation of Primary Data

The researcher compiled field data by using in-depth interviews and non-participant observations during January-April and July-September 2020. Answering the evaluation form of the e-waste management model for EEC used online and telephone conversations through Line or e-mail or google form during February-March 2021.

3.4.2.1 In-depth interviews consisted of data compilation through the interviews with 27 key informants. They were 1) Executives and government officials of the central government such as PCD, DEQP, DOLA, Department of Health, and Department of Industrial Works 2) Executives and officers of EECO and IEAT 3) Executives and government officials in local administration and provincial administrative organizations such as REO 13 (Chonburi), PONRE, Provincial Industry Offices, Provincial Office for Local Administration, and PAOs of Chachoengsao, Chonburi, and Rayong and 4) Managers and private sector employees in companies producing and disposing of e-waste in Amata City Chonburi Industrial Estate, WHA Chonburi Industrial Estate 1, and Pinthong Industrial Estate 1 in Chonburi. The following processes of interviews presented as follows:

1) The researcher coordinated with the Graduate School of Environmental Development Administration (GSEDA), National Institute of Development Administration (NIDA) to prepare the official letters requesting cooperation for the interviews and collection of data in the related areas.

2) The researcher contacted the key informants requesting them for interviews. Once the key informants agreed to the interviews, the researcher made the appointment date, time, and place of the interviews and sent the interview form to the key informants in advance.

3) The researcher conducted interviews by herself based on the determined question and other additional issues from the interviews and compiled related data. The researcher explained the objectives before the interviews and asked for permission for data and audio recording until the end.

4) As for data obtained from interviews and audio recordings, the researcher would transcribe the audio recording word by word and sentence by

sentence and inspected the accuracy one more time by re-listening to the audio recordings.

3.4.2.2 The non-participant observation in the areas consisted of a data collection by the researcher who made the observation and recorded data in the prepared observation form (Appendix B) with accompanying pictures between January-April and July-September 2020. These pictures were HHW Collection Building in the Rayong Integrated Solid Waste Management Center and the drop-off points of household e-waste in the responsible areas of LAOs with good e-waste management and sufficient potential for self-disposal of e-waste. LAOs referred from PONRE and PAOs of Chachoengsao, Chonburi, and Rayong in five municipalities, namely Chachoengsao Town Municipality, Laem Chabang City Municipality, Saen Suk Town Municipality, Rayong City Municipality, and Thap Ma Subdistrict Municipality.

3.4.2.3 The testing of the e-waste management model for EEC included the data compilation from key informants who were the Line members. They consisted of fifty-five experts, executives, government officials, and officers working on e-waste management of provincial and local government agencies and state enterprises, private sector, and related community leaders in Chachoengsao, Chonburi, and Rayong provinces through online or telephone conversations. The researcher requested the key informants to fill in the evaluation form of the e-waste management model for EEC and comments and recommendations of the model through Line or e-mail or google form. The researcher took approximately 15 days for the model testing in 25 February-March 11, 2021, with the following processes:

1) The researcher prepared the official letters from the GSEDA, NIDA to seek cooperation in filling the evaluation forms of the model through Line or e-mail or google form with the key informants.

2) The researcher coordinated by telephone with the key informants to foster a common understanding of the principle and seek consent in filling the evaluation form. The official letters with the model evaluation forms were sent via Line or e-mail according to the consent of the key informants to ensure that they understood in advance the evaluation form. The initial appointment was made for the date and time to explain the details of the model evaluation form.

3) The researcher explained the objectives of the model testing, details of the evaluation form, and answered questions in the evaluation form to the key informants. The appointment date and time through online or telephone conversations proposed to take back the model evaluation form from the key informants.

4) The researcher collected the evaluation form and inspected the completeness and accuracy of the data in the model evaluation form. If the data was not complete or there were doubts in the data, the researcher asked the key informants to obtain sufficient and accurate data and used the data for further analysis.

3.5 Inspection of Quality of Data

As for the inspection of the reliability of qualitative data and the summary of the research data acquired, the researcher used Triangulation, namely Data Triangulation and Methodological Triangulation. Data Triangulation was the interviews with four groups of key informants relevant to e-waste management, namely representatives of the central government, regional administration, local administration at the provincial and municipal levels, and representatives of the private sector in the industrial estates in EEC. Methodological Triangulation was checked, including observation in parallel with the interview, and study of additional data from relevant documents and research reports or questioning of the key informants after the conclusion of the study to ensure accurate and actual conclusion (Supang Chantavanich, 2010).

3.6 Data Analysis

The qualitative data analysis from this study used the data acquired from the study of documents, in-depth interviews, observation in the areas, and information requests from local relevant agencies. The data analysis used Context and Grouping Analysis. According to the research objectives, the results of data analysis were in the form of Description and Analytical Description. The details of the data analysis are as follows:

3.6.1 Analysis of Household E-Waste Management in EEC Using the Pressure-State-Response Framework

The researcher applied the Pressure-State-Response (PSR) framework to analyze and provide the appropriate guidelines and measures for household e-waste management in EEC based on the household hazardous waste and e-waste management data in Chachoengsao, Chonburi, and Rayong, including relevant data during 2016-2019. Pressures (P) analyzed the growth of the electrical and electronic industry, rising use of electrical and electronic devices, and household e-waste disposal behavior of people. State (S) considered situations, problems, and obstacles of the operation of household e-waste management in the three provinces of EEC. The policies, plans, guidelines, and measures for household e-waste management in EEC were as Responses (R) to manage the state changes. Data analysis used content analysis. Data presentation used the description and analytical description based on the PSR framework.

3.6.2 Analysis to Evaluate the E-Waste Management in EEC in Chachoengsao, Chonburi, and Rayong using the CIPP-I Model

The researcher collected data from relevant documents and field surveys. The data were documents, memorandum, official documents, and reports of the operation performance of e-waste management of five representing municipalities. The field surveys were in-depth interviews with four target groups of key informants and non-participant observation at the drop-off points of household e-waste in five representing municipalities and provincial e-waste storage centers. The collected data would undergo the Content and Grouping Analysis and present data in the form of Description and Analytical Description according to the CIPP-I model under five dimensions: Context, Input, Process, Product, and Impact. Then, the researcher evaluated the e-waste management in EEC and summarized the main issues impacting the success of household e-waste management for EEC in Chachoengsao, Chonburi, and Rayong provinces.

3.6.3 Analysis to Acquire the Model of E-Waste Management for EEC through the SWOT Analysis and TOWS Matrix

The researcher used the results of the CIPP-I model to determine the main issues that impacted the success of the guideline of household e-waste management in EEC by analyzing the external and internal factors. The external factors were on the PESTLE Analysis. It consisted of Policy, Economic, Social, Technology, Legal, and Environment. The internal factors were the components of 4 M, namely Man (personnel and responsible agencies and the people), Money (budget), Material and Machine, and Management including Process (PDCA), Product, and Impact. SWOT Analysis was used to analyze the opportunities and threats of the external factors and analyze the Strengths and Weaknesses of the internal factors. Afterward, TOWS Matrix was used to analyze and recommend the strategy and guideline of the development of household e-waste management and construct and select the model of household e-waste management for EEC in Chachoengsao, Chonburi, and Rayong provinces.

3.6.4 Analysis of the Appropriateness of the Model of E-Waste Management for EEC

The researcher collected data from the evaluation form of the e-waste management model for EEC analyzed the content, and summarized it into three main issues, namely 1) Appropriateness of the model, 2) Implementation of the model, and 3) Recommendation of the model. Afterward, the researcher used the comments and recommendations obtained from the evaluation form to improve the model to acquire the appropriate model for e-waste management in EEC.

3.7 Ethics and Protection of Rights of the Key Informants

This research was to certificate of exemption on human research protection by the Ethics Committee in Human Research, National Institute of Development Administration No. 2019/0035 (Protocol ID No. ECNIDA 2019/0035) dated 29 October 2019 Appendix F. The researcher protected the rights of the interviewees by writing letters to seek permission to collect data from the interviewees and elaborated

on the objectives and details of the research project. Before collecting data, the researcher sought willingness from the interviewees and asked them for audio recording every time. If any interviewees did not wish to provide data, the person could deny it, and the researcher would not use the person as an interviewee in this research. Moreover, the researcher would keep the confidentiality of the interviewees by using assumed names and not revealing the actual names of the key informants.

3.8 Research Limitations

1) The study and data collection from the past till the present (March 2021) had data limitations. For example, the amount of household e-waste collected by some municipalities in EEC between 2017-2018 was the data that combined with the amount of HHW. So, the amount of household e-waste was not known. Some data were also agencies' confidential data and could not be revealed, for example, the budget used in e-waste management. So, some data might not be apparent or complete.

2) The limitations on the part of the key informants who were the private sector, producers of electrical and electronic appliances, and companies dealing in sorting/recycling/disposal of e-waste in the industrial estates in Chachoengsao, Chonburi, and Rayong. In this study, most key informants were company representatives in the industrial estates and assigned by the particular industrial estate offices. As some of the companies' information is confidential, some information might not be apparent or complete.

CHAPTER 4

RESULTS OF STUDY

The research on the Model of Electronic Waste Management for Eastern Economic Corridor (EEC) aimed to 1) study the situations, problems, and impact of e-waste management in the EEC provinces of Chachoengsao, Chonburi, and Rayong between 2016-2020, 2) study and analyze the strategies, policies, and laws related to e-waste management in foreign countries, Thailand, and EEC, and 3) evaluate e-waste management in the three provinces during the year 2018-2020, as well as present the model appropriate to the management of the household e-waste problems in the three provinces of EEC. The research used qualitative research included documentary research, in-depth interviews with key informants, data compilation in the areas, and non-participant observation. The study results consisted of five parts, namely the First Part: Overview of the situations of household e-waste in EEC; The Second Part: Evaluation of household e-waste management in the three provinces of EEC; The Third Part: Success Factors of household e-waste management in EEC; The Fourth Part: Strategies of household e-waste management in EEC, and The Fifth Part: Appropriate Model for household e-waste management for EEC. The details are as follows:

4.1 Analysis of Household E-Waste Management in EEC according to the Pressure-State-Response Framework

This study focused on documentary research. The researcher took the information from literature review, books, academic documents, related research, and various sources on electronics. The data included strategies, policies, plans, and laws on e-waste management in Thailand and EEC, e-waste management, problems, and obstacles to e-waste management in EEC in Chachoengsao, Chonburi, and Rayong

provinces during 2016-2019. The Pressure-State-Response (PSR) framework developed by OECD (Linster, 2003) was applied to analyze the data for household e-waste management in the three provinces of EEC and providing the management guidelines and measures of household e-waste management for EEC. The Pressures (P) included the growing electrical and electronic industry, rising use of electrical and electronic devices, and household e-waste disposal behavior of people. The resulting Pressures (P) causing changes in the State (S) of the situations and operations of household e-waste management in the three provinces. Response (R) as policies, plans, guidelines, and measures of household e-waste management to manage the activities, state changes, and impacts of household e-waste management in EEC as shown in Figure 4.1. The details are as follows:

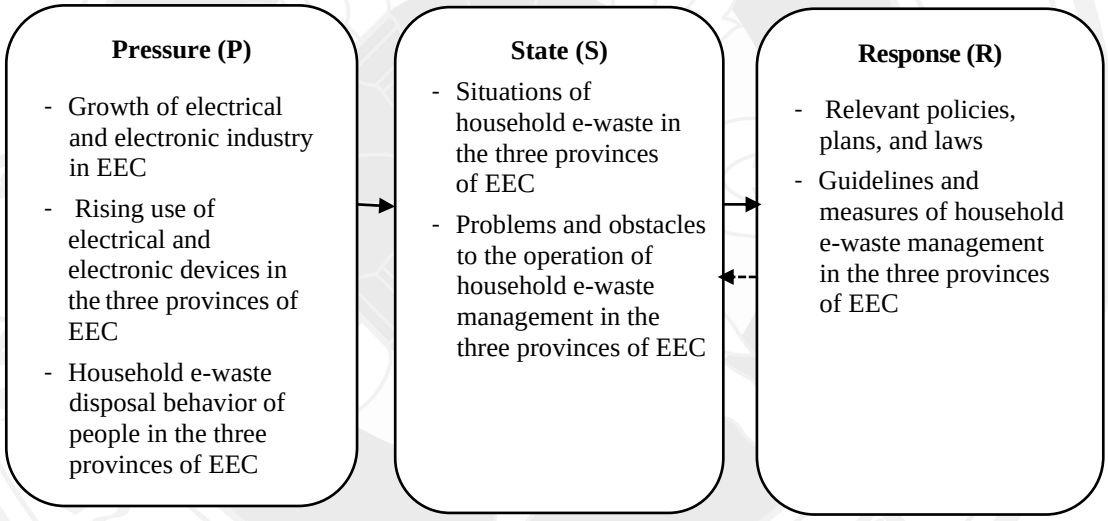


Figure 4.1 Pressure-State-Response Framework
Note: Cause ⟶ Social response ⇢

4.1.1 Pressure (P)

The pressures from household e-waste in EEC were from the growing electrical and electronic industry and rising electrical and electronic devices from EEC development in Chachoengsao, Chonburi, and Rayong provinces. In addition, the household e-waste disposal behavior of people in the three provinces was studied. Details are as follows:

4.1.1.1 Growth of Electrical and Electronic Industry and Increasing Use of Electrical and Electronic Devices

Thailand’s Eastern Economic Corridor or EEC covers Chachoengsao, Chonburi, Rayong provinces, and Special Economic Promotional Zone. EEC was established by the government in the east through special legislation due to high economic growth. The EEC zone will be developed into ASEAN's leading economic zone to promote all or partial 12 targeted industries. Some targeted industries are developed, such as the electrical and electronic industry, telecommunication equipment industry, intelligent electronics industry, digital industry, next-generation automotive industry (Eastern Economic Corridor Office of Thailand, 2018, 2019c). These industries will produce EEE and telecommunication equipment such as computer and screen parts, mobile phones, television, intelligent electrical appliances connected to the internet network, portable electronic system equipment, microelectronic chips, and automotive battery, hardware, and digital part. The EEE from the mentioned industries is e-waste that is expired or damaged or obsoleted, or discarded, or no longer used.

Between 2016-2019, the total population of Chachoengsao, Chonburi, and Rayong provinces had an increased tendency every year. The total population in the three provinces in 2019 was 3,013,167 persons, as shown in Table 2.10 (Department of Provincial Administration, 2020). The average monthly income per household in 2019 of Chachoengsao, Chonburi, and Rayong provinces was 22,875.29 baht, 28,705.91baht, and 24,299.10 baht, respectively. The average monthly income per household of Chonburi was higher than the national level (26,018.42 baht) (National Statistical Office, 2019). One of the top three major industries in the three provinces was the electrical and electronic industry. As for the electrical machinery and supply industry of the Department of Industrial Works, there were 576 factories with 155,241.43 million baht of investment and 71,794 workers in 2019 (Department of Industrial Works, 2019).

The population and the number of households impacted household e-waste generation. Sources of e-waste in Thailand came from communities (81% of the amount of generated e-waste) more than from factories (19% of the amount of generated e-waste) (Center of Excellence on Hazardous Substance Management,

2019b). Most e-waste originated from the community from household consumption in Thailand with increased amounts every year. Between 2016-2019, the generated household e-waste amounted to 393,070, 401,387, 414,6 55, and 421,335 tons, respectively, or the average increase rate of 2.3% a year. The household e-waste came from eight household appliances: television, washing machine, air conditioner, computer, refrigerator, telephone, VCD/DVD player, and digital camera (Pollution Control Department, 2020d). In addition, the income per household impacted the ownership of household appliances and the e-waste generation. Those with high income per household tended to own more household appliances than those with low income per household.

Therefore, the amount of e-waste per household with high income was higher than those with low income per household (Center of Excellence on Hazardous Substance Management, 2019c) In addition, when the EEC developed, people would come to live and do business in the areas. More hidden population, more tourists and workers, change to urban society, and expansion of economic areas due to some target industries in the EEC, such as the electrical and electronic equipment industry, electronic telecommunication industry, digital industry, and intelligent electronics industry. As a result, the amount of e-waste from EEE and household consumption in Chachoengsao, Chonburi, and Rayong tended to increase and impact the overall efficiency of household e-waste management in the three provinces. Forecast of the ten types of e-waste from household consumption in Thailand consisting of television, air condition, washing machine, refrigerator, notebook, tablet, telephone, fluorescent bulb, LED bulb, and battery, the amount of e-waste in 2050 will reach approximately 600,000 tons (Center of Excellence on Hazardous Substance Management, 2019b).

4.4.1.2 E-Waste Disposal Behavior

The behavior of most people in Chachoengsao, Chonburi, and Rayong disposed of household e-waste mixed with solid waste, especially non-valuable e-waste such as lamps, dry cells, and dry batteries. Moreover, the people did not separate household e-waste before disposal (Regional Environment Office 13 (Chonburi), 2017, 2018b, 2019b). Some households kept big-sized e-waste (e.g., air conditioners, television, refrigerators, and washing machines) at home. That was the lost opportunity to recycle and recover precious and rare metals such as gold, silver,

copper, iron, aluminum, yttrium, and gadolinium. These critical metals of e-waste could be recycled as raw materials in producing or assembling new electronic tools, devices, and equipment such as computers and mobile phones. It reduced environmental impact resulting from massive e-waste management and primary raw material extraction (Dheerapon Gangaketu, 2018; Sirirat Suwanidcharoen, 2020).

For this study, the amount of municipal solid waste was applied to analyze household e-waste mixed with solid waste. The overall rate of municipal solid waste in the three provinces between 2016-2019 was in the range of 1.44-1.53 kgs/person/day, which was high as it exceeded the average rate of municipal solid waste in Thailand (1.13-1.18 kgs/person/day) (Pollution Control Department, 2020f). However, proper disposal in the three provinces constituted 51.09% of the amount of municipal solid waste in 2019, which was considered appropriate (over 50%). The details are in Table 2.10 in Chapter 2 and summarized in Table 4.1. The general technology of e-waste disposal in Thailand, such as lamps and batteries, was secure landfill. E-waste consisted of toxic heavy metals, such as copper, mercury, cadmium, lead, beryllium, and lithium (Orawan Phuphisut & Suleeporn Sangrajang, 2010). Therefore, the management of e-waste, which is mixed solid waste be disposed of e-waste in landfills, has led to profound impacts on the environment from e-waste leachate, including to change in the situations of household e-waste management in EEC.

Table 4.1 Generation Rate of Municipal Solid Waste and Ability for Municipal Solid Waste Management in Chachoengsao, Chonburi, and Rayong between 2016-2019

Year	Provinces	Population[1] (persons)	Amount of generated waste[2,3] (tons/day)	Generation rate of solid waste (kgs/persons/day)	Proper disposal[2]	
					Amount[2,3] (tons/day)	Percentage
2016	Chachoengsao	704,399	751.12	1.07	18.41	2.45
	Chonburi and Pattaya	1,483,049	2,619.72	1.77	1,261.40	48.15
	Rayong	700,223	896.88	1.28	547.04	60.99
	Total	**2,887,671**	**4,267.72**	**1.48**	**3,106.20**	**72.78**
2017	Chachoengsao	709,889	751.12	1.06	420.00	55.92
	Chonburi and Pattaya	1,509,125	2,580.66	1.71	2,327.45	90.19
	Rayong	711,236	953.70	1.34	953.70	100.00
	Total	**2,930,250**	**4,285.48**	1.46	**3,701.15**	**86.36**
2018	Chachoengsao	715,009	709.24	0.99	367.42	51.80
	Chonburi and Pattaya	1,535,445	2,591.03	1.69	1,435.58	55.41
	Rayong	723,316	967.80	1.34	744.77	76.95
	Total	**2,973,700**	**4,268.07**	**1.44**	**2,547.77**	**59.69**
2019	Chachoengsao	720,113	733.14	1.02	8.81	1.20
	Chonburi and Pattaya	1,558,301	2,909.86	1.87	1,531.78	52.64
	Rayong	734,753	969.76	1.32	815.86	84.13
	Total	**3,013,167**	**4,612.76**	**1.53**	**2,356.45**	**51.09**

Source: 1 Department of Provincial Administration, 2020
2 Regional Environment Office 13 (Chonburi), 2017, 2018b
3 Pollution Control Department, 2019b, 2020e

4.1.2 State (S)

State studies have highlighted household hazardous waste management (including household e-waste) in EEC in Chachoengsao, Chonburi, and Rayong provinces and the problems and obstacles of household e-waste management in the three provinces. Details are as follows:

4.1.2.1 Situations of Household Hazardous Waste Management in EEC

The household hazardous waste (HHW) management (including household e-waste) in Chachoengsao, Chonburi, and Rayong during 2016-2019 stipulated that LAOs were to provide drop-off points of HHW in villages or communities and sent to the local household hazardous waste storage. After that, HHW and household e-waste were sent to the legal factories for treatment or disposal, such as factory category 1 0 5 , factory category 1 0 6 , and factory category 101 (Table 2.11). For the HHW at LAOs in Chachoengsao, Chonburi, and Rayong, containers were provided for academically correct collection and disposal. It was four groups, namely 1) Lamps such as fluorescent bulb 2) Dry cell and dry battery such as dry cell, alkaline battery, mobile phone battery, digital camera battery, and car battery 3) Containers of chemicals such as spray can, bottle for pesticides, paint bottle, a bottle of cleaner and 4) Electrical and electronic equipment in daily life, expired, or no longer used, and not very large size such as mobile phone waste with peripheral devices.

In 2019, the amount of HHW from the LAOs in Chachoengsao, Chonburi, and Rayong constituted 843.19 tons or 25.23% of the amount of HHW collected from 76 provinces (3,342.31 tons), and 4.54 tons cloud be disposed, or only 0.80% of the total disposal of HHW from 76 provinces (565.33 tons) (Pollution Control Department, 2020f) see Table 4.2. The amount of HHW collected to three provinces in 2019 (843.19 tons) was higher than the amount of HHW collected in 2017. (Details in Table 2.11 in Chapter 2). Because each province installed drop-off points of HHW at community following the MOI policy, as summarized in Table 4.2.

Table 4.2 Amount of HHW Collected and Sent for the Disposal of Chachoengsao, Chonburi, and Rayong in 2019

Provinces (Responsible agencies)	**Collected amount (tons/year)**	**Amount sent for disposal (tons/year)**
Chachoengsao (Chachoengsao PAO)	806.65	Not sent for disposal
Chonburi (Chonburi City Municipality)	32.00	Not sent for disposal
Rayong (Rayong PAO)	4.54	4.54
Total 3 provinces	**843.19**	**4.54**
Total 76 provinces	**3,342.31**	**565.33**

Source: Pollution Control Department, 2020d

The operation results of the LAOs in Chachoengsao, Chonburi, and Rayong achieved the targets of the Action plan "Clean Province" 2019 of MOI. First, 100% setting up drop-off points by the three provinces for HHW collection in all communities or 100% of the communities situated in the areas of each province. Second, 100% of HHW was collected and sent by all 276 LAOs in the three provinces, or transportation of HHW for academically correct disposal was 100% of all LAOs in each province (Ministry of Interior, 2020; Regional Environment Office 13 (Chonburi), 2020b). However, in 2019, the amount of HHW (including household e-waste) collected and sent to academically correct disposal by the LAOs of the three provinces constituted only 0.53% of the collected amount of HHW. The percentage of HHW at the provincial level was collected for academically correct disposal or 16.91% of the collected amount of HHW at the provincial level, as shown in Table 4.2 (Pollution Control Department, 2020d). This percentage was lower than the target of HHW management as devised in the National Solid Waste Management Master Plan (2016-2021). By 2019, the HHW was collected and sent for academically correct disposal was no less than 20% of the amount of HHW (Pollution Control Department, 2016a).

4.1.2.2 The Problems and Obstacles of The Operation of Household E-Waste Management in EEC

The problems and obstacles in the operation of HHW and household e-waste management in Chachoengsao, Chonburi, and Rayong during 2016-2019

included policy and responsibilities of local government, management of local government, budget, cooperation of people and private sector, and enforcement of related laws (see item 2.3.2.4 under chapter 2). The solution of household e-waste management problems and obstacles in the three provinces was driven by the Clean & Green City Project with PCD, REO 13 (Chonburi) , and PONRE since 2014. It depended on the Roadmap of solid waste and hazardous waste management, which passed the National Council for Peace and Order approval on August 26, 2014. The researcher analyzed those problems and obstacles in the operation of HHW and household e-waste management in EEC and summarized as follows:

1) There was no specific unit within LAO with clear household e-waste from sorting, collection, and disposal based on academically correct principles. However, LAOs (i.e., municipalities) had unit responsibilities of household hazardous waste, namely Division of Sanitary Works or Division of Public Health and Environment.

2) There was a small number of lawful treatment or e-waste disposal factories. As a consequence, e-waste management was not sufficient with the amount of household e-waste. According to the Department of Industrial Works, in 2018, there were seven registered factories. They were legal sorting and recycling factories with awards received from the Department of Industrial Works in Chonburi, which was considered a small number of factories with standards, namely 1) Matsuda Sangyo (Thailand) Co., Ltd. 2) Wisetech Solution (Thailand) Co., Ltd. 3) Fuji Xerox Eco- Manufacturing Co., Ltd. 4) Eastern Seaboard Environmental Complex Co., Ltd. 5) Asia Recycle and Service Co., Ltd. 6) Eco-Management Industrial Co., Ltd. and 7) Thai Kurotani Co., Ltd. (Sujitra Vassanadumrongdee, 2019). However, some e-waste sorting and recycling factories in Chachoengsao and Chonburi were not legal and did not meet the standard.

3) Lack of stringency in enforcement of law related to HHW and household e-waste management, including operation of e-waste treatment or disposal factories that met the standards according to Factory Act B.E. 2535 (1992), Hazardous Substances Act B.E. 2535 (1992), and solid waste management including e-waste by local government according to Section 18 under Public Health Act B.E. 2535 (1992). At the same time, there was no enforcement of specific laws on e-waste

management in LAOs, and there was no measure or regulation for people to take part in recycling e-waste (Weerayut Sukhoyachai, 2018). As a result, e-waste dumping in public areas, abandoned places, and landfills impact the environment and people's health from numerous toxic substances in e-waste.

4) Cooperation and awareness of people in reducing and sorting household e-waste from were still little. Moreover, most people lacked awareness of the environmental and health impact of improper household e-waste management. Consequently, the disposal of e-waste mixed with solid waste or disposed of in abandoned public areas causing risks to the environment from heavy metals in e-waste that might contaminate the soil, surface water source, and groundwater sources such as lead, copper, and zinc. Examples of the areas in Thailand that found heavy metal contamination of soil in e-waste dismantling areas included Kalasin, Buriram, and Sua Yai Uthit Community, Chatuchak District, Bangkok (Sujitra Vassanadumrongdee, Puntita Tanwattana, & Seelawut Damronsiri, 2015).

E-waste was hazardous and not biodegradable. Hazardous substances found in e-waste were heavy, primarily metals such as lead, mercury, cadmium, and Brominated Flame Retardants (BFRs). The heavy metals would be discharged into the environment when burning e-waste with BFRs as a component. Each substance would differently impact human health, such as palpitation, damaged nervous system, cancer, and potential death if accumulated in the body in high quantity. Those with health risks from e-waste included workers in the industrial sector, sorters of e-waste for recycling, and users of electronic equipment (Orawan Phuphisut & Suleeporn Sangrajang, 2010). Workers in the industrial sector, sorters of e-waste for recycling, and users of electronic equipment were exposed to toxic substances with different impacts on their health. For example, workers in the industrial sector manufacturing electronic equipment were exposed to contact with heavy metals during the production process, with risks of lung cancer, Nasopharynx cancer, and brain cancer. The users of electronic equipment would risk getting BFRs which were contaminated from the dust on the computer, which would disturb the functioning of the nervous system (Orawan Phuphisut & Suleeporn Sangrajang, 2010). The informal sector used improper e-waste recycling, such as open burning and used acid with e-waste to separate valuable metals, risked receiving heavy metals

such as lead accumulated in the body through the respiratory system, and contamination of lead in the soil at e-waste dismantling areas. (Seelawut Damrongsiri, 2015). If there was accumulated lead in high quantity, it would impact brain development and the central nervous system, causing amnesia (World Health Organization, 2019).

4.1.3 Response (R)

The response to solve the problems of household e-waste management in EEC in Chachoengsao, Chonburi and Rayong included efficient and proper e-waste management appropriate to the context of the areas. From prevention and reduction of e-waste at origin, sorting e-waste for recycling, collection, transportation, and academically correct disposal prevents the problems of impact on people's health and environment. It required the support and cooperation of public agencies responsible for solutions to e-waste problems, including policymakers at central, regional, and local levels. The agencies were responsible for solving the problems of e-waste management such as MNRE, MOI, MOPH, M-Industry, and Ministry of Science and Technology, as well as participation with private sector/entrepreneurs and people sector/local consumers. There must be development and improvement of strategies, policies, action plans, and measures related to household e-waste management to bring them up-to-date, practical, and in line with the economic, social, and environmental changes in the areas.

The guidelines and measures of household e-waste management are in accordance with the “Guideline of solid waste and hazardous waste management at the area level” under the 20-Year Strategic Plan of Ministry of Natural Resources and Environment (2017-2036) Strategy 3: Solid waste and environment management, Annual Action Plan “Clean Province”, and National Solid Waste Management Master Plan (2016-2021) which were connected to the significant policies and strategies of hazardous waste management from 20-Year National Strategy B.E. 2561-2580 (2018-2037) Item 5 : Growth based on environmental-friendly quality of life, the Twelfth National Economic and Social Development Plan B.E. 2560-2564 (2017-2021) Strategy 4: Environmental-friendly growth for sustainable development, Natural Resource and Environmental Reform Plan, Item 5.1.4: Expansion of role, duties, and

responsibilities of private sector in HHW management at origin, and Environmental Quality Management Plan B.E 2560 -2 5 6 4 (2017-2021) Strategy 2: Good management of environmental quality with prevention, treatment, and rehabilitation. Moreover, e-waste should be managed with Reverse Logistics to reduce household e-waste towards management according to the Hierarchy of Product Disposition. First of all, waste should be prevented or reduced at the origin. One waste was generated, it should be reused, recycled, or reproduced as energy respectively (Ampol Navavongsathian et al., 2017; Carter & Ellarm, 1988) as follows:

4.1.3.1 Policies, plans, and laws

1) Policymakers should announce policies, strategies, and plans of e-waste management specifically in the EEC with concrete implementation in the long term. Moreover, they determined duties, authorities, and responsible agencies, as well as the support of policy implementing agencies in terms of budget, tools and equipment, and academic knowledge as follows:

(1) Integrated WEEE Management Strategy B.E. 2557-2564 (2014-2021*)* aimed to target WEEE consisting of 10 types. They consisted of fluorescent bulb, dry battery, refrigerator, television, air conditioner, camera/video camera, portable video/audio device, printer, and fax machine, telephone, and personal computer) to have environmentally-friendly management, and under Strategy 4: Development of a mechanism to sort, collect, and transport e-waste with the following guideline of e-waste management. The guidelines included support extensive LAOs, all city municipalities, Bangkok, and Pattaya; technique and finance provided to sort, buy-back, and collect e-waste from various sources in communities, and support the private sector who were producers and importers of EEE to have the mechanism to buy-back WEEE and send for proper recycling, treatment, or disposal (Pollution Control Department, 2017a).

(2) The 20-Year Master Plan on the Prevention and Management of Pollution caused by Solid and Hazardous Waste (2018-2037), with short-term and long-term measures. In short-term measures (2018-2022), they stipulated the special economic zones and adjacent areas with integrated waste and hazardous waste management without causing trouble to LAOs in adjacent areas. Supporting LAOs prepared proper sorting and collection and in line with the

regulations of the LAOs in the transportation of each type of waste, and using incentives for a discount of fees. The long-term measures (2023-2037) consisted of the general law on the country's waste management, covering all types of waste, responsibilities of all sectors from producers/importers, service providers, consumers, those who disposed of waste and supervising agencies by 2027 (Pollution Control Department, 2018a).

(3) Environment Plan in Eastern Economic Corridor B.E. 2 5 6 1 -2 5 6 4 (2018-2021) under Strategy 1: Management of good environmental quality, measures related to e-waste management such as the provision of collection and disposal sources of HHW and e-waste with standards (Ministry of Natural Resources and Environment, 2019).

2) Acceleration of the legislation on e-waste management such as "the Draft of the Waste from Electrical and Electronic Equipment Management Act B.E. ....".

3) Penalties for LAOs that do not operate academically correct household e-waste management.

4) Increase penalties and stringent enforcement of current laws relevant to e-waste management.

4.1.3.2 Household e-waste management

1) Develop a household e-waste database in the 3 provinces of the EEC to collect data, statistics, and amount of e-waste generated in the EEC.

2) Capacity building of LAOs in the three provinces of the EEC for household e-waste management in the areas. It included budget support from both public and private sectors, knowledge and understanding of the methods or environmentally-friendly innovation and technology in household e-waste management to relevant personnel, and cooperation with other LAOs in household e-waste management (e.g., use of common waste disposal sites, exchange of knowledge and solutions to common problems).

3) Inspiration or motivation of household e-waste management for e-waste treatment and disposal factories in the EEC by providing funds, fund management organization, and buy-back system of e-waste from consumers. It

resulted in sorting and collecting valuable e-waste to recycling factories or factories with e-waste reusing, recycling, or academically correct disposal.

4) Encourage manufacturers of electrical and electronic equipment to develop and design more environmentally-friendly goods (Eco-design), reduce the use of hazardous substances to facilitate recycling and disposal in the future. Furthermore, the electrical and electronics industry manufacturers have responsible measures for society and the environment using the concept of Extended Producer Responsibility (EPR). It includes buy-back of e-waste and discount in bringing old items in exchange for purchasing new items. For example, Advanced Info Services Public Company Limited (AIS) provided bins for the appropriate disposal of collected e-waste mobile phones at AIS shops in department stores such as Robinson, Big C, and Tesco Lotus with six bins Chonburi bins Rayong, and one bin in Chachoengsao (Electronic Waste Drop-Off Points at AIS Shop Eastern Region, 2019).

5) Forge knowledge and understanding of sorting and household e-waste management, purchase environmental-friendly electric and electronic appliances for consumers/people. It enhances recognition and participation in the operation, such as preparing and disseminating public handbooks on e-waste sorting by LAOs and relevant agencies.

6) Importance placed on practical research and development led to innovations in e-waste management and recycling e-waste for maximum benefit in Thailand. For example, the Faculty of Engineering, Thammasat University conducted innovative research on concrete from e-waste, rewards for Tokyo Olympic Games 2020 made from e-waste, such as camera, game player, computer hardware to present to athletes (Anupap Ngernkrachaeng, 2019).

The relationship of the analysis of household e-waste management in EEC in Chachoengsao, Chonburi, and Rayong has based on the Pressure-State-Response (PSR) framework, as shown in Figure 4.2. The obtained results from the PSR analysis framework were considered to evaluate the household e-waste management for EEC in the three provinces according to the CIPP-I model as shown under item 4.2

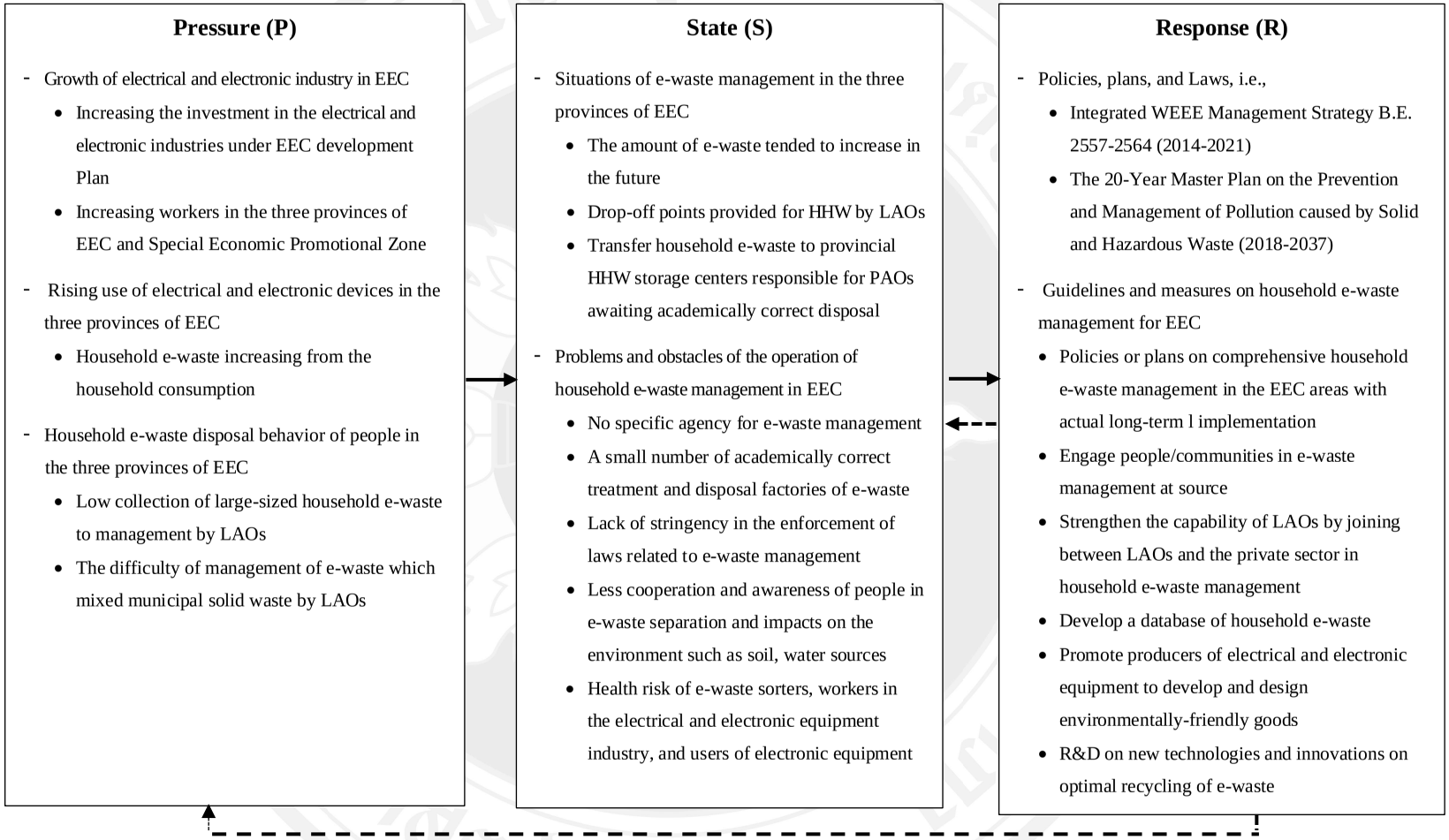


Figure 4.2 Relationship of the Analysis of Household E-Waste Management in the EEC based on the PSR Concept
Note: ⟶ Cause ⇢ Social response

4.2 Evaluation of Household E-Waste Management in EEC

The researcher took the data compiled from the documentary research and the field surveys in EEC in Chachoengsao, Chonburi, and Rayong, such as documents, memos, and operation reports on e-waste management of agencies relevant to EEC and five representing municipalities in the study, namely Chachoengsao Town Municipality in Chachoengsao, Laem Chabang City Municipality and Saen Suk Town Municipality in Chonburi, Rayong City Municipality and Thap Ma Subdistrict Municipality in Rayong. In-depth interviews were conducted with four groups of 27 key informants through Purposive Sampling. The key informants included: 1) Executives and government officials of the central government such as MNRE, MOI, M-Industry, MOPH, 2) EECO and IEAT, 3) Executives and government officials of the regional and local administration, namely REO 13 (Chonburi), PONRE, Provincial Industry Offices, Provincial Office for LAOs and PAOs of Chachoengsao, Chonburi, and Rayong, and 4) Managers and private sector employees in companies producing and disposing of e-waste in industrial estates in Chachoengsao, Chonburi, and Rayong. Moreover, non-participant observation at the drop-off points of household e-waste in the five representing municipalities and local household hazardous waste sites to evaluate e-waste management in EEC in Chachoengsao, Chonburi, and Rayong provinces based on the CIPP-I Model with five dimensions, namely Context, Input, Process, Product, and Impact. The study results of each dimension are as follows:

4.2.1 Context

Context during operation of the project according to the composition of PESTLE Analysis consisted of policies, strategies, and plans relevant to e-waste management (Policy), economic conditions of the east (Economic), social conditions of the east (Social), technology of sorting, recycling, and disposal of e-waste (Technology), laws related to e-waste management (Legal), and environment of the east (Environment). The details are:

4.2.1.1 Policies, Strategies, and Plans related to E-Waste Management

Based on the documentary study, e-waste management in Thailand was related to many of the Sustainable Development Goals (SDGs) . They consisted of SDG 3 (good health and well-being), SDG 6 (clean water and sanitation), SDG 8 (decent work and economic growth), SDG 9 (industry innovation and infrastructure), SDG 11 (sustainable cities and communities), and SDG 12 (responsible consumption and production). The relationship was significant for health and society (SDG 3), economy (SDGs 8, 9, 11), and environment (SDGs 6,12), as shown in Figure 4.3 (Baldé et al., 2017; Bhaskar & Kumar, 2019; Forti et al., 2020; United Nations, 2021). The e-waste management in EEC and its relation to the SDGs targets 3.9, 6.3 , 8.3 , 9.4 , 11.6, and 12.5 are in Figure 4.3 and as follows:

1) SDG 3 target 3.9: By 2030, reduce the illnesses and deaths due to hazardous chemicals and air, soil, and water pollution and contamination. This target is related to heath in e-waste management. E-waste contains many hazardous substances and toxic elements. Improper and unsafe e-waste dismantling, processing, and treatment can threaten human health by contaminating air, water, and soil. During 2018-2020, heavy metal contamination was found in soil, surface water sources, and groundwater sources near some e-waste recycling factories (Category 106) in Chachoengsao province the exceeding the standards of Thailand. Therefore, the appropriate protection of human health for workers and people from illnesses and deaths due to improper managed e-waste related activities is needed.

2) SDG 6 target 6.3: By 2030, reduce pollution, eliminate dumping, and minimize the release of hazardous chemicals and materials. Target 6.3 is related to the environmental aspects of sustainable e-waste management. Reducing hazardous pollutants, which originated from informal dismantling and recycling, and improper disposal of e-waste should be considered through environmentally sound management. During 2018-2020, many e-waste dismantling and recycling factories with improper processing in Chachoengsao and Chonburi provinces. The factories discharged hazardous pollutants in the air, water, and soil during operation.

3) SDG 8 target 8.3: By 2030, Promote development-oriented policies that support productive activities, decent job creation, entrepreneurship, creativity, and innovation, and encourage the formalization and growth of micro-,

small- and medium-sized enterprises, including through access to financial services. Target 8.3 is related to the economy. The EEC's valuable e-waste collection and sorting were mostly processed in the informal sector, such as junk shops, sidecar drivers, and paddlers. These jobs are unsafe and not decent. Therefore, the formalization of this sector is necessary to both ensure the environmentally sound management of e-waste and develop business opportunities.

4) SDG 9 target 9.4: By 2030, upgrade infrastructure and retrofit industries to make them sustainable, with increased resource-use efficiency and greater adoption of clean and environmentally sound technologies and industrial processes. There are legal e-waste recycling factories with the national standard from the Department of Industrial Works in EEC. Therefore, it is critical to make process and recycling technology more environmentally friendly by promoting and developing e-waste recycling technology innovation.

5) SDG target 11.6: By 2030, reduce the adverse impact of cities on the environment per capita, including special attention given to air quality and municipal and other waste management. EEC was developed and promoted to the country's targeted industries towards advanced and environmental-friendly technology and innovation towards Thailand 4.0. Therefore, the sustainable EEC and communities in Chachoengsao, Chonburi, and Rayong provinces require an environmental quality to protect human health and provide amenities. These needs are related to the target 11.6. Air pollution by e-waste recycling factories should be monitored, and openly burning e-waste should be prohibited. Furthermore, e-waste sorting at origin must be regularly promoted.

6) SDG 12 target 12.5: By 2030, substantially reduce waste generation through prevention, reduction, recycle, and reuse. Target 12.5 is related to the environment. Increasing the number of populations and employees in the EEC consumes the growing number of products and goods in electrical and electronic equipment (EEE). Manufacturers must design products that are more durable, easily repairable, recycling, and reuse. In addition, the raising awareness levels of consumers in EEE consumption should be promoted to support prevention, reduction, recycle, and reuse instead of a throw-away society.

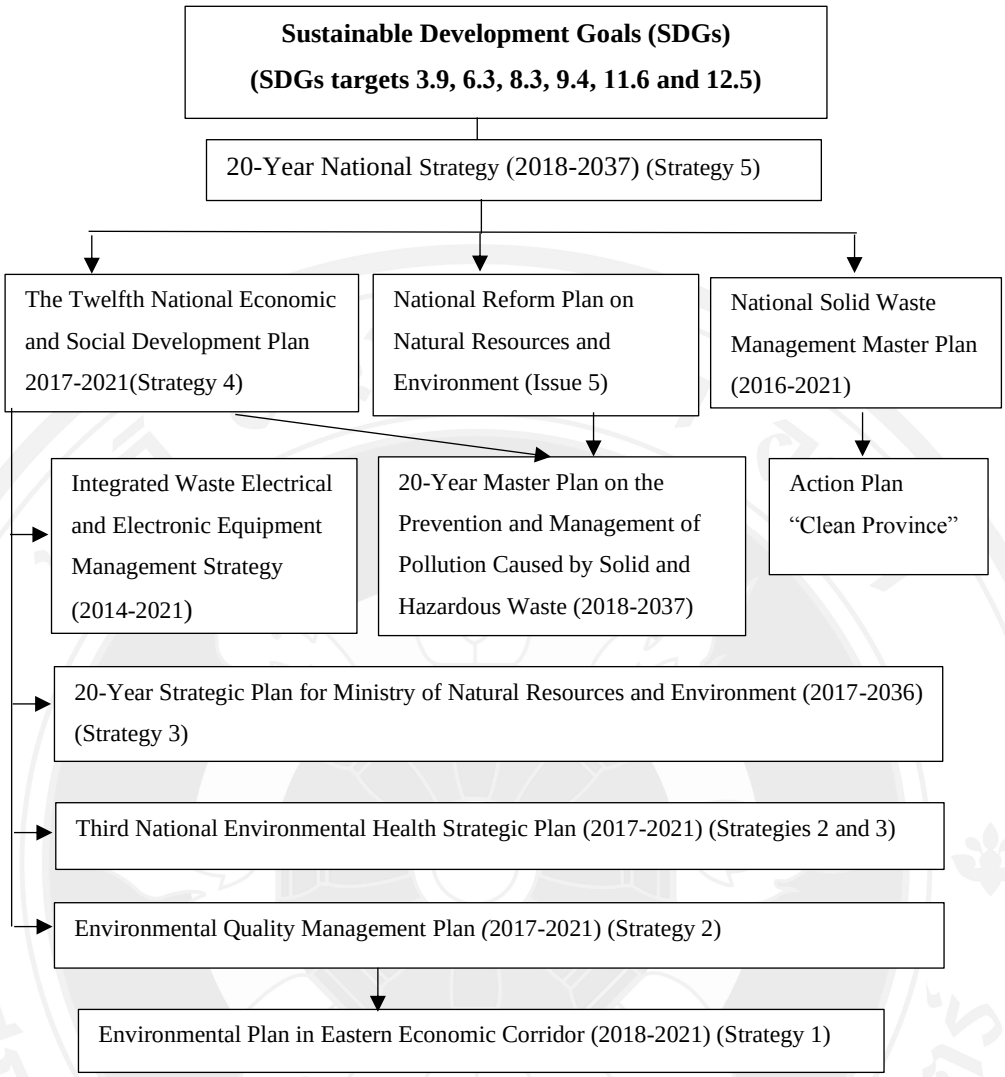


Figure 4.3 SDGs, Strategies and Plans related to E-Waste Management in EEC

Based on the documentary study and the interviews, it was found that Policies, strategies, and plans relevant to e-waste management in EEC in the provinces of Chachoengsao, Chonburi, and Rayong were as follows:

1) 20-Year Strategic Plan for Ministry of Natural Resources and Environment (2017-2036), MNRE, under Strategy 3: Solid waste and environment management with the objective of HHW management (including e-waste) with 100% academically correct methods by 2031 (Ministry of Natural Resources and Environment, 2018).

2) Integrated Waste Electrical and Electronic Equipment Management Strategy 2014-2021, MNRE, with the objectives such as the system for sorting and collection of ten types of target e-waste, namely fluorescent bulb, dry battery, refrigerator, television, air conditioner, camera/VDO, portable VDO/audio device, printer and fax, telephone, and personal computer with efficiency and academically correct methods in extensive LAOs, all city municipalities, Bangkok, and Pattaya, with the collection rate of the average target of e-waste not less than 5% of the amount of e-waste expected to be generated in the target areas by 2021 (Pollution Control Department, 2017a).

3) Third National Environmental Health Strategic Plan, 2017-2021, MOPH and MNRE, under Strategy 2: Forge multilateral cooperation and cooperation among LAOs according to the public, private, and people approach, and Strategy 3: Strengthen environmental health management system (Ministry of Public Health & Ministry of Natural Resources and Environment, 2017).

4) Environmental Plan in Eastern Economic Corridor 2018-2021, MNRE, under Strategy 1: Good environmental quality management with measures relevant to e-waste management such as the provision of collection and disposal of HHW and e-waste based on the standards (Ministry of Natural Resources and Environment, 2019).

5) The Action Plan "Clean Province" 2020, MOI, with three processes of the framework in formulation and determination of measures, namely at upstream with reduced amount and sorting of waste, at midstream with increased efficiency of waste removal of LAOs, and at downstream with the academically correct waste management through the principles of 3 Rs: Reduce, Reuse, and Recycle and the Civil-state concept consisting of public, private, academic, religious, civil society, and people sectors to solve the problems of e-waste on a sustainable basis (Ministry of Interior, 2020).

The goals of household e-waste management at the area level were in accordance with the country's HHW management plans such as 20-Year National Strategy (2018-2037) Item 5: Growth of environmental-friendly quality of life (Office of the National Economic and Social Development Council, 2018a) , The Twelfth National Economic and Social Development Plan (2017-2021) Strategy 4:

Environmental-friendly growth for sustainable development (Office of the National Economic and Social Development Council, 2016), National Reform Plan on Natural Resources and Environment on environment Sub item 5.1.4: Expand role, duty, and responsibility of the private sector in HHW management at origin for the framework of five years 2018-2021 (Office of the National Economic and Social Development Council, 2018b), Environmental Quality Management Plan 2017-2021 Strategy 2: Good environmental quality management with prevention, treatment, and rehabilitation (Ministry of Natural Resources and Environment, 2016) and National Solid Waste Management Master Plan (2016 - 2021) with the goals involving e-waste management such as HHW that was academically correct in terms of collection and disposal of no less than 20% of the amount of HHW within 2019 or 25% and 30% by 2020 and 2021 respectively, and LAOs sorted hazardous waste at origin of no less than 30% of the number of l LAOs nationwide within 2019 or 40% and 50% by 2020 and 2021 respectively (Pollution Control Department, 2016a). The interviews are as follows:

> *"National Solid Waste Management Master Plan (2016-2021) has been formulated with the goal and guideline of e-waste management"* (Government official of the central government No. 4).

> *"Thailand has formulated the Integrated Waste Electrical and Electronic Equipment Management Strategy 2014-2021 as an e-waste management framework. The goals include the system being put in place to sort and collect ten types of target e-waste that are efficient and academically correct in large LAOs and others"* (Government official of the central government No. 5).

> *"The policy and plan relevant to e-waste management in EEC include Environmental Plan in Eastern Economic Corridor 2018-2021 of MNRE and the Action Plan "Clean Province," of Ministry of Interior (MOI). There are installations of drop-off points of HHW including e-waste with one drop-off point per one community"* (Government official of the central government No. 1).

“MOI has formulated the Action Plan "Clean Province" with the guideline of e-waste management. MOI's policy divides municipal solid waste into four types: organic waste, general waste, recycled waste, and hazardous waste. E-waste included into hazardous waste" (Government official of the central government No. 3).

“MOI has formulated the policy for LAOs to operate e-waste management which is the Action Plan “Clean Province” (Government official of the regional administration No. 2).

“*In the Environmental Plan in Eastern Economic Corridor 2018-2021, there is also the guideline of e-waste management*” (EECO officer No. 1).

“The guideline of e-waste management includes management at the origin, which is the duty of household and the government to prepare general public of the knowledge on e-waste sorting. Midstream management is collecting waste, and downstream management includes transport and disposal of waste which is the duty of LAOs” (Government official of the central government No. 2).

Summary of Policies, Strategies, and Plans relevant to E-waste Management in EEC in Chachoengsao, Chonburi, and Rayong is in Figure 4.3.

4.2.1.2 Economic Conditions of the East

The east comprises eight provinces: Chachoengsao, Chonburi, Rayong, Chanthaburi, Trat, Nakhon Nayok, Prachin Buri, and Sa Kaeo. The economic conditions of the east in this study consisted of the economic structure of the east and the average monthly household income.

The east had Gross Regional Product (GRP) at the annual price of 2018 or 3,026,495 million baht or 18.5% of Gross Domestic Product (GDP), and GRP in 2018 grew 2.8%. The economic structure of the east mainly relied on the industrial sector. In 2018, the east had a share of manufacturing in the industrial sector, 65.6 % of GRP or up 65.0% from 2016. Services followed it with the share of manufacturing

28.8% of GRP or down 29.0% from 2016. The rest was agriculture, with the share of manufacturing 5.6% of GRP or down 6.0% in 2016. In 2018, the manufacturing of industrial products was the highest, with the share of manufacturing 50.4% of GRP followed by wholesale and retail trade and repair of motor vehicles, mining, and quarrying with the share of manufacturing 10.2% and 9.5% of GRP, respectively (Office of the National Economic and Social Development Council, 2020) in Table 4.3.

Table 4.3 Overview of the Economic Structure of the East

Report	2016	2017	2018
1. GRP			
- Value (million baht)	2,586,653	2,836,365	3,026,495
- National share (%)	17.7	18.3	18.5
- Actual growth rate (%)	5.7	5.7	2.8
2. Production structure (%)			
2.1 Agricultural sector	**6.0**	**6.6**	**5.6**
- Agriculture, forestry, fishery	6.0	6.6	5.6
2.2 Non-agricultural sector	**94.0**	**93.4**	**94.4**
• **Industrial sector**	**65.0**	**64.8**	**65.6**
- Mining and quarrying	9.8	9.2	9.5
- Production of industrial goods	50.0	50.2	50.4
- Electricity, gas	4.8	5.0	5.3
- Water supply and waste management	0.4	0.4	0.4
• **Services**	**29.0**	**28.6**	**28.8**
- Wholesale, retail, and repair of motor vehicles	9.7	10.1	10.2
- Transport and warehouse	3.7	3.5	3.7
- Others*	15.6	15.0	14.9

Source: Compiled from Office of the National Economic and Social Development Council, 2020

Note: *Others such as construction, hotel and food, information and communication, finance, vocational activities, management and other support services, real estate, public administration, health, education, arts, entertainment and recreation

The top three significant industries in the east included the petrochemical and refinery industry, automotive and part industry, and electrical and electronic industry (Office of the National Economic and Social Development Council, 2019). As of December 2019, the east had 635 factories producing electrical machinery and supplies (Section 19 classified by industrial groups of Department of Industrial Works) with 173,749.89 million baht of investment. There were 86,672 workers and primary production sources in Chonburi, Rayong, and Chachoengsao (Department of Industrial Works, 2019), as shown in Table 4.4.

Table 4.4 Number of Factories of Electrical Appliances Divided by Provinces in the East in 2019

Provinces	**Number of factories (factories)**	**Investment capital (million baht)**	**Number of workers (persons)**
Chachoengsao	115	33,811.26	20,259
Chonburi	343	96,723.84	39,750
Rayong	118	24,706.33	11,785
Chanthaburi	-	-	-
Trat	1	0.23	1
Nakhon Nayok	3	72.72	256
Prachin Buri	50	18,336.88	13,999
Sa Kaeo	5	98.63	311
In total 8 provinces	**635**	**173,749.89**	**86,672**

Source: Compiled from Department of Industrial Works, 2019

In 2019, the highest average monthly income per household in the east was Chonburi. The average monthly household income was 28,705.91 baht, followed by Chanthaburi and Prachin Buri, with the average monthly income per household 28,113.74 baht and 25,843.22 baht, respectively (National Statistical Office, 2019) The average monthly income per household in the east was lower than the national level. The east had an average monthly income per household of 25,060.15 baht in 2019, lower than the national level (26,018.42 baht), as shown in Table 4.5. The income per household impacted the ownership of electrical and electronic appliances

and the generation of e-waste. Those with high income per household tended to own more electrical and electronic appliances than those with low income per household. Therefore, the amount of e-waste per household with high income per household was higher than those with low income per household. The amount of generated e-waste would not be different from the income per household of over 100,001 baht upwards (Center of Excellence on Hazardous Substance Management, 2019c).

Table 4.5 Average Monthly Income per Household in the East in 2019

Provinces	**Average Monthly Income per Household (Baht)**
Chachoengsao	22,875.29
Chonburi	28,705.91
Rayong	24,299.10
Chanthaburi	28,113.74
Trat	24,173.78
Nakhon Nayok	25,784.78
Prachin Buri	25,843.22
Sa Kaeo	20,685.40
Average Monthly Income per Household in the east (Baht)	**25,060.15**

Source: National Statistical Office, 2019

4.2.1.3 Social Conditions of the East

The social conditions of the east in this study included population, the density of population, and the number of households. As of December 31, 2020, the population of the east totaled 5,107,898. The province with the most population was Chonburi, with 1,566,885, followed by Rayong and Chachoengsao, with 741,524 and 720,718. Chonburi province was the highest population density with a population of 359.13 per sq. km. In contrast, Sa Kaeo province was the lowest population density with a population of 77.96 per sq. km. The province with the most increased population was Chonburi, or an increased population of 8,584 from 2019 (Department of Provincial Administration, 2020). he details of the population between 2016-2020

are in Table 4.6. In 2020, the east had 2,046,627 households. Chonburi had the most households of 632,486, followed by Rayong and Chachoengsao with 322,266 and 273,574, respectively (National Statistical Office, 2020) , as shown in Table 4.7.

The population and the number of households impacted the generated amount of community e-waste. Most e-waste originated from the community from household consumption with increased amounts every year. Between 2016-2019, the average annual growth rate was 2.3% (Pollution Control Department, 2020d). Therefore, if the population and the number of households were high, it would impact the increased consumption of EEE. The amount of generated e-waste would tend to increase as well. In the worst scenario, the amount of HHW equaled household e-waste. We found that the amount of e-waste collected in the east in 2019 (as of September 30, 2019) totaled 928.09 tons, as shown in Table 4.8 (Pollution Control Department, 2020d).

Table 4.6 Number of Population and Population Density in the East between 2016-2020

Provinces	2016	2017	2018	2019	2020
Chachoengsao					
No. of population (persons)	704,399	709,889	715,099	720,113	720,718
Density (persons/km^2)	131.64	132.66	133.62	134.58	134.69
Chonburi					
No. of population (persons)	1,483,049 3	1,509,125	1,535,445	1,558,301	1,566,885
Density (persons/km^2)	339.91	345.89	351.92	357.16	359.13
Rayong					
No. of population (persons)	700,223	711,236	723,316	734,753	741,524
Density (persons/km^2)	197.13	200.24	203.64	206.86 5	208.76
Chanthaburi					
No. of population (persons)	532,466	534,459	536,496	537,698	535,559
Density (persons/km^2)	84.01 2	84.33	84.65	84.84	84.50
Trat					
Number of population (persons)	229,437	229,649 8	229,914	229,958	228,536
Density (persons/km.^{2})	81.39	81.46	81.56	81.57	81.07
Nakhon Nayok					
No. of population (persons)	258,358	259,342	260,093	260,751	260,081
Density (persons/km^2)	121.75	122.22	122.57	122.88	122.56
Prachin Buri					
No. of population (persons)	484,829	487,544	491,640	494,680	493,670
Density (persons/km^2)	101.8	102.37	103.23	103.88	103.67
Sa Kaeo					
No. of population (persons)	559,017	561,938	564,092	566,303	560,925
Density (persons/km^2)	77.69	78.1	78.4	78.71	77.96

Source: Department of Provincial Administration, 2020

Table 4.7 Total Number of Households in 2020

Number of households	Chachoengsao	Chonburi	Rayong	Chanthaburi	Trat	Nakhon Nayok	Prachinburi	Sa Kaeo
Inside municipality	94,790	477,560	177,716	98,558	36,676	12,661	32,888	50,788
Outside municipality	178,784	154,929	144,550	91,982	63,835	84,561	195,435	150,914
Total number of households	**273,574**	**632,489**	**322,266**	**190,540**	**100,511**	**97,222**	**228,323**	**201,702**

Source: National Statistical Office, 2020

Table 4.8 Amount of Collected Household E-Waste of the East in 2019

Provinces	Responsible agencies	Collected amount of household electronic waste* (tons)
Chachoengsao	Chachoengsao Provincial Administrative Organization (PAO)	806.65
Chonburi	Chonburi Town Municipality	32.00
Rayong	Rayong PAO	4.54
Chanthaburi	Chanthaburi Town Municipality	29.51
Trat	Trat PAO	0.07
Nakhon Nayok	Nakhon Nayok PAO	2.32
Prachin Buri	Prachin Buri PAO	2.70
Sa Kaeo	Nakhon Nayok PAO	50.30
Total amount of household e-waste		**928.09**

Source: Pollution Control Department, 2020d

Notice: *For the worst scenario, the amount of household e-waste equaled the amount of HHW

4.2.1.4 Technology of Sorting, Recycling, and Disposal of E-Waste

Based on the relevant documentary study and the interviews, the technology used to sort and recycle e-waste, such as lamps, mobile phone waste, and computers of e-waste sorting factories (Category 105) and e-waste recycling factories (Category 106) with licenses in Thailand mostly used two types of physical process, namely disassembly, and crushing. Human labor force and simple tools were mainly used for disassembly, such as a screwdriver, cutting pliers, and clamp to separate low-valued materials (i.e., plastics, glass, iron, and aluminum). Crushing with crusher was mainly used with circuit board waste to obtain appropriate size and sort metals for reusing with different crushed materials, such as specific gravity, electrical conductivity, magnetism. (National Metal and Materials Technology Center, 2010). In the three provinces of EEC, there were seven registered e-waste sorting and recycling factories in Chonburi with safe and environmental-friendly management by international standards (e.g., WEEELABEX, R2, e-Stewards), and with award plaques from the Department of Industrial Works in the budget year 2018. Most were factories operating in crushing of electrical and electronic parts and situated in industrial estates under the Industrial Estate Authority of Thailand (IEAT), namely 1) Matsuda Sangyo (Thailand) Co., Ltd., 2) Wisetek Solutions (Thailand) Co., Ltd., 3) Fuji Xerox Eco-Manufacturing Co., Ltd., 4) Eastern Seaboard Environmental Complex Co., Ltd., 5) Asia Recycle & Service Co., Ltd., 6) Eco Management Industrial Co., Ltd., and 7) Thai Kurotani Co., Ltd. The details are in Table 4 .8 (Sujitra Vassanadumrongdee, 2019).

The company representative No. 4 gave the following opinion:

> *"Technology to sort and recycle e-waste has three processes: disassembly, crushing, and melting into new products. Most sorting and recycling factories in Thailand use the technology of disassembly and crushing. The technology of melting requires high investment. It is not economically worthwhile if the volume of e-waste is not sufficient."*

That was in line with the opinion of the IEAT Officer No. 2 as follows:

"The technology of sorting and recycling of e-waste applied by the factories in Gateway City Industrial Estate, Chachoengsao, mostly use the processes of crushing and disassembly by separating plastics from metals, and in the future, the metal scraps will be melted to increase value."

It was in line with the opinions of the company representative No. 5, who said that.

"*The companies located in the Industrial Estate operate the business of crushing electronic circuit boards, electronic and electrical equipment which mostly used human labor force."*

Table 4.9 Examples of E-Waste Sorting and Recycling Factories in EEC with Awards Won from the Department of Industrial Works in the Budget Year 2018

Names of factory entrepreneurs (Types of factories)	**Awards**	**Locations of factories**	**Services**
Matsuda Sangyo (Thailand) Co., Ltd. (Categories 105 and 106)	Excellent	Pinthong Industrial Estate (Phase 3), Nong Kham Subdistritct, Bueng Subdistrict, Sriracha District, Chonburi	Crush and recycle electronic scraps, metal scraps, and unused electrical parts
Wisetek Solutions (Thailand) Co., Ltd. (Category 106)	Excellent	Laem Chabang Industrial Estate, Thung Sukhla Subdistrict, Sriracha District, Chonburi	Repair electronic parts, buy back electronic equipment, and reuse, or correct disposal
Fuji Xerox Eco-Manufacturing Co., Ltd. (Category 106)	Excellent	WHA Chonburi Industrial Estate 1, Bo Win Subdistrict, Sriracha District, Chonburi	Recycle office equipment and equipment parts (Copier, Printer, Facsimile), and repair those equipment parts

Names of factory entrepreneurs (Types of factories)	Awards	Locations of factories	Services
Eastern Seaboard Environmental Complex Co., Ltd. (Category 106)	Very good	WHA Chonburi Industrial Estate 1, Bo Win Subdistrict, Sriracha District, Chonburi	- Recycle chargeable battery, mobile phone battery, notebook battery, digital camera battery, and electrical and e-waste - Recycle straight fluorescent lamp
Asia Recycle & Service Co., Ltd. (Category 106)	Good	Map Phai Subdistrict, Ban Bueng District, Chonburi	Crush electrical and electronic parts and equipment
Eco Management Industrial Co., Ltd. (Category 106)	Good	Map Phai Subdistrict, Ban Bueng District, Chonburi	- Buy back electronic parts, mobile phone waste, and old electrical appliances - Crush electronic parts
Thai Kurotani Co., Ltd. (Category 106)	Honorable mention	Pinthong Industrial Estate 1, Nong Kham Subdistrict, Sriracha District, Chonburi	Crush electronic circuit board, electronic equipment, electrical equipment, lead solder scrap, copper alloy slag

Source: Sujitra Vassanadumrongdee, 2019

Moreover, the compilation of information in the areas and the interviews revealed that the e-waste disposal of lamps, car battery, battery, secure landfill, and incinerators were widely used. During 2019-2020, the Rayong Integrated Solid Waste Management Center of Rayong PAO hired a private company to transport and dispose of e-waste (lamps, car batteries, batteries) outside the three provinces of EEC. For example, General Environmental Conservation Public Company Limited (GENGO) had an e-waste disposal plant at Hin Kong Subdistrict, Mueang District, Ratchaburi, and Professional Waste Technology (1999) Public Company Limited had an e-waste disposal plant at Huai Chot Subdistrict, Watthana

Nakhon District, Sa Kaeo. The government official of the central government No. 5 gave the following opinion:

> *"The proper disposal of HHW and household e-waste were secure landfill or incinerator such as a rotary kiln. That household e-waste included a fluorescent lamp, telephone battery."*

> *That was in line with the government official of the central government. No. 4, who said the following:*

> *"In Thailand, there are only a few factories for HHW and e-waste disposal such as lamps, battery. For example, GENGO in Ratchaburi and Better World Green Public Company Limited in Saraburi use secure landfill or incineration with incinerator."*

In terms of the technology of sorting, recycling, and disposal of e-waste, the e-waste sorting and recycling factories (category 105, 106) with factory licenses in Thailand, most used human labor and simple tools to disassemble e-waste and separate low-value materials, such as plastics, glass, iron, aluminum. Crusher crushed the e-waste of electronic parts until the size of the e-waste was appropriate. The metals were reusing, the different qualities of the crushed materials were used, such as specific gravity, electrical conductivity, magnetism. However, materials with high value (e.g., copper, gold) required advanced technology for extraction or purification. Most were sent abroad for further operation. The abroad advanced technology for extracting valuable metals of e-waste were the pyrometallurgical and Electrometallurgical processes. The Electrometallurgical process was more appropriate to Thailand than the Pyrometallurgical process. (Center of Excellence on Hazardous Substance Management, 2019b) In Thailand, secure landfills and incineration with incinerators are generally in the disposal of e-waste, such as lamps, car batteries, batteries.

4.2.1.5 Laws Relevant to E-Waste Management

The relevant documentary study and the interviews revealed that currently, in Thailand, there were no specific laws on e-waste management in LAOs (Weerayut Sukhoyachai, 2018). However, there were many laws on pollution and hazardous waste management. The significant laws related to community e-waste management from households in the three provinces of EEC can be summarized as follows:

1) Public Health Act B.E. 2535 (1992) and amended Act (2nd revision) B.E. 2550 (2007) and amended Act (the third revision) B.E. 2560 (2017) are the law related to solid waste management of LAOs. It covers household toxic or hazardous waste (including e-waste) based on Section 4 of this Act. It focuses on the collection, transport, and disposal of waste in local administration, such as PAOs, Municipality, SAOs, and Pattaya, with three methods according to Section 18 and Section 19, Chapter 3: Management of Sewage and Waste, namely 1) Local administration operates by itself, 2) Local administration assigns others to operate, and 3) Local administration allows others to operate in its place. Operators of factories with hazardous waste and the companies collecting, transporting, or disposing of hazardous waste must submit a written paper to local authorities, namely Chief Executive of PAO, Mayor in Municipality, Chief Executive of SAO, and Mayor of Pattaya.

That was in line with the opinion of the government official of the central government No. 4, who said the following:

> "*The law enacted by MOPH on household e-waste management is the Public Health Act B.E. 2535 (1992) and the current Public Health Act (2020) with the third revision in 2017 in Chapter 3: Management of sewage and waste."*

That was in line with the opinion of the government official of the central government No. 1, who stated the following:

"Household e-waste management in Thailand is by Public Health Act B.E. 2535 (1992) with LAOs responsible for collecting and transporting waste for correct disposal."

2) The Act of Maintaining Cleanliness and Tidiness of the City, B.E. 2535 (1992) and the second revision B.E. 2560 (2017) are the law related to the prohibition of dumping of sewage and waste in public places and public buildings. Management of sewage and waste includes collection, transport, and disposal of sewage and waste, and penalty for those who manage sewage and waste without a license. Those who fail to comply with the local legislation are subject to a penalty of imprisonment not exceeding six months or a fine not exceeding 50,000 baht, or both imprisonment and fine. The parts related to e-waste are Section 34/1 Clause 6 under Chapter 3/1 Management of sewage and waste as follows:

According to the factory law, section 34/1 Clause 6, hazardous and non-hazardous waste management must comply with the factory law except in the case where the hazardous and non-hazardous waste are mixed with the collected waste of local administration. That waste collection assignment included local administration or government agencies or other local administration units, and PAOs or the private sector assigned to collect the waste and notify officials responsible for factory law to proceed according to the factory law.

That was in line with the opinion of the officer of the local administration No. 4, who said the following:

"Section 34/1 Clause 6 the Act of Maintaining Cleanliness and Tidiness of the City, B.E. 2535 (1992) and the second revision B.E. 2560 (2017) involve household e-waste management collected by municipalities and PAOs or the private sector assigned to collect and handle e-waste."

3) Notification of Ministry of Interior on Solid Waste Management B.E. 2560 (2017) stipulates the criteria, methods, and conditions that local administration assigns government agencies or local administration, including PAOs, or the private sector as operators or working with the local administration.

That working included collection, transfer, disposal of waste, and exploitation and utilization of the collected waste, and criteria and methods of collection, transfer, and disposal of waste, divided into four sections and a total of 24 items. The container of toxic waste or household hazardous waste in orange is Item 8 Chapter 2 Part 2 Collection and waste transfer. Provinces assign PAOs to serve as hosts to HHW management (including e-waste) relevant to Item 13 Chapter 3 Part 1: Assignment of government agencies or local administration for collection, transfer, and disposal of waste as follows:

Item 13 If the local administration works with government agencies or other local administrative agencies, it will benefit local people more instead of the operation by the local administration itself. The local administration may work with the government agencies or other local administrative agencies to collect, transport, or dispose of solid waste by complying with the guideline announced by the Committee on Decentralization to LAOs on the agreement to cooperate in providing public services of LAOs.

That was by the opinion of the government official of the local administration No. 4 as follows:

> *"Chonburi has formulated the policy to assign Chonburi PAO as a host for HHW and e-waste management. That operating was under the Notification of Ministry of Interior on Solid Waste Management B.E. 2560 (2017) Item 13: Assign Chonburi PAO to collect and transfer e-waste for disposal at locations based on good sanitation."*

That was in line with the opinion of the government official of the central government No. 4 as follows:

> *"Chapter 2 Item 8 of the Notification of Ministry of Interior on Solid Waste Management B.E. 2560 (2017) assigning the local administration to provide orange bins as containers of HHW and e-waste."*

4) Notification of Pollution Control Department on Guideline of household hazardous waste management for local administrative organizations B.E. 2560 (2017) dated May 19, 2017, to enable LAOs to use the guideline for HHW and e-waste management in battery and car battery and fluorescent lamps of all types from preparation, separation, collection, transport, and monitoring and assessment.

5) Ministerial Regulation on Communal Toxic or Hazardous Solid Waste Management B.E. 2563 (2020) determines the criteria, methods, and measures to control and supervise household toxic or hazardous solid waste management. That assigns local administration or those assigned to comply with the criteria and sanitation in this Ministerial Regulation to protect people's health, hygiene, and environmental impact. There are four Chapters. Chapter 1 (General) concerns the responsible officials and the operating personnel for collecting, transferring, and disposal of communal toxic or hazardous solid waste. Chapter 2 (Collection) consists of sorting waste, drop-off points, disposal points, containers, and storage sites. Chapter 3 (Transfer) consists of measures to control the transfer and the vehicles transporting communal toxic or hazardous solid waste. Chapter 4 (Disposal) includes the disassembly of parts that are toxic or HHW disposal methods. Those methods are secure landfill and incinerator, and other methods as stipulated by the Minister and announced in the Royal Gazette.

That was in line with the opinion of the government official of the central government No. 4 as follows:

> *"MOPH is preparing to issue the (Draft) Ministerial Regulation Communal Toxic or Hazardous Solid Waste management B.E. .... This Ministerial Regulation involves the collection, transport, and disposal of toxic or HHW, including e-waste, according to the criteria and sanitation and can be implemented by LAOs."*

That was in line with the opinion of the government official of the central government No. 1 as follows:

"Legal measures involving e-waste management of Ministry of Public Health (MOPH) is Ministerial Regulation Communal Toxic or Hazardous Solid Waste management B.E. .... including e-waste management. The MOPH assigns the local administration to collect or dispose of toxic or HHW."

6) The Draft of the Waste from Electrical and Electronic Equipment Management Act B.E. .... is the law on the management of e-waste through the principle of Extended Producer Responsibility (EPR). That EPR ensures an efficient buy-back system, collection, storage, transport, and disposal of e-waste. National Legislative Assembly already accepted in principle the first reading of the Draft on January 11, 2019. As of June 2021, the Draft is pending consideration of the second and the third readings. The Draft is divided into five Draft Chapters and 36 Draft Sections, namely Chapter 1 Disposal of product waste (Sections 7-14), Chapter 2 Duties and responsibilities (Sections 15-18), Chapter 3 Dissemination of knowledge and information on product waste management (Sections 19-20), Chapter 4 Investigation and control (Sections 21-23), Chapter 5 Penalty (Sections 24-35), and Transitory Provision Section 36 with the following:

(1) Section 5 The electrical and electronic product waste enforced under this Act includes 1) Computer 2) Telephone and wireless telephone 3) Air conditioner 4) Television 5) Refrigerator and 6) Electrical and electronic equipment as stipulated by the Ministerial Regulation, excluding EEE which are weapons used in the military according to Section 3.

(2) Section 7 prohibits the disposal of the product waste in deserted public areas or mixed with solid waste. Upon violation, the penalty is imprisonment not exceeding six months or a fine not exceeding 50,000 baht or both imprisonment and acceptable according to Section 24.

(3) Section 9 Prohibition to those to buy back, store, or collect product waste except by Product Waste Buy-Back Center established and registered according to the criteria, people, or agencies with legal permits only to separate the waste send to or coordinate with the center.

(4) Section 10 Establishment of Product Waste Buy-Back Center by producers or between producers in agreement with LAOs work in their place.

(5) Section 15 Producers are enforced to have a responsibility to buy back, store, and collect product waste of the same type belonging to any producer, as well as product waste imported or without brand or trademark or producers no longer in business. Upon violation, the producers are subject to a penalty of imprisonment not exceeding two years or fined not exceeding 200,000 baht or both imprisonment or fine according to Section 29. The producers cannot refuse or stipulate any criteria that burden those who bring back the product waste.

(6) Section 16 and Section 17 Producers are enforced to formulate the plan responsible for product waste management and present the responsibilities to PCD by March 31 every year. The collected product waste will be sent for recycling, treatment, or disposal at factories with factory permits from relevant agencies. Upon violation, producers are liable to imprisonment for a term not exceeding six months or a fine of not exceeding 50,000 baht or both, according to Section 30.

(7) Section 19 and Section 20 Assign PCD to prepare and disseminate knowledge and information on correct methods of product waste management. There is the Center of Coordination and Dissemination of Knowledge and Information of Product Waste to disseminate information on product waste management and the location of the Product Waste Buy-back Center for people, entrepreneurs, or relevant people.

That was in line with the opinion of the government official of the central government No. 1 as follows:

> *"PCD presented the Draft of the Waste from Electrical and Electronic Equipment Management Act B.E. .... in January 2019 to National Legislative Assembly. This Act is under the participation of all sectors in parallel with Extended Producer Responsibility (EPR). The EPR stipulates that the producers or importers of five types of electrical appliances, namely television, refrigerator, telephone, computer, and air conditioner, must take*

responsibility for expenses in product waste management and correct methods of product waste management as well. It also stipulates people to return product waste to the Product Waste Buy-Back Center, and those who buy back product waste from the public must have licenses."

That was by the opinion of the government official of the central government No. 3 as follows:

"The draft of the Waste from Electrical and Electronic Equipment Management Act B.E. .... depends on the responsibilities of producers and importers of electrical and electronic equipment."

The company representative No. 5 gave the following opinion:

"The Draft of the Waste from Electrical and Electronic Equipment Management Act B.E. .... has not passed the National Legislative Assembly. It depends on the EPR system involving producers, people, e-waste disassembling/recycling factories, and Pollution Control Department (PCD) to take typical responsibilities. The (Draft) Act provides legal measures to enforce waste disposal in public places and disassembly of product waste. Moreover, That Act enforces producers in setting up the Product Waste Buy-Back Center, formulating a plan to take responsibility for product waste management, and transferring collected product waste to recycling or disposal factories with factory permits. As well as assign PCD to disseminate knowledge on product waste management."

Based on the relevant documentary study and the interviews, there were significant laws related to e-waste management for factories producing EEE, factories sorting, recycling, and disposal of e-waste both inside and outside industrial estates as follows:

(1) Hazardous Substance Act B.E. 2535 (1992) and amended (No. 2) B.E. 2544 (2001), (No. 3) B.E. 2551 (2008), (No. 4) B.E. 2562 (2019) controls and supervises business in hazardous substances. E-waste is considered a hazardous substance category three according to Section 18. It requires a permit from the authorities before production, import, export, or in possession according to the duties and responsibilities of producers (Section 59), importers (Section 60), transporters (Section 61), and those in possession that are not factories (Section 62).

(2) Factory Act B.E. 2535 (1992) and amended (No. 2) and (No. 3) B.E. 2562 (2019) is the law that controls factory operation and discharge of waste, sewage, and unused materials from a production process of factories for factory operators and LAOs. The definition of the factory in Section 5 is building premises or vehicles using machines or machines with total power or an equivalent of fifty horsepower or more. That employs fifty workers or more with or without machinery for factory operation. Factories of all sizes category 105 (sorting factory or landfill), category 106 (recycling factory), and category 101 (central treatment plant/waste incinerator) are classified as category three factories according to Section 7, which require a permit before establishment according to Section 12. If the factory is established before obtaining a license, it shall be liable to imprisonment or a fine or both, based on Section 50.

Section 37 (1), In the case where the competent official finds out that any factory operator violates or declines to comply with this Act or engages in factory operation in such a manner as to cause harm, injuries, or distress to people or property in the factory or its vicinity. The competent official shall have the power to order such a person to stop such violating Act or rectify or improve the same or comply accordingly or appropriately within a specified period. Section 39 (1) orders the factory operator who deliberately violates the order of the competent official according to Section 37 without valid reason or in case any factory operation may cause harm, injuries, or distress to people or property in the factory or its vicinity. The competent official shall have the power to order the person to temporarily stop all or some operations and rectify or improve the factory or comply appropriately.

(3) Notification of Ministry of Industry Re: Industrial Waste Management and Disposal, B.E.2548 (2005) and (No. 2) B.E. 2560 (2017) determine the classification, code, and type of sewage or unused material, role and duty of waste generator, waste collector and transporter, waste processor, and criteria and methods of management of sewage or unused materials. It consists of 4 Chapters and 26 items, namely Chapter 1 Waste codes, Chapter 2 Duty of waste generator, Chapter 3 Collection and transport of hazardous waste, Chapter 4 Duty of waste processor, and Chapter 5 Provisional chapter.

(4) Industrial Estate Authority of Thailand Act B.E. 2522 (1979) and amended (No. 2) B.E. 2534 (1991), (No. 3) B.E. 2539 (1996), (No. 4) B.E. 2550 (2007), and (No. 5) B.E. 2562 (2019) is the law on licensing, supervision of factory operation and suspension of factory operation of entrepreneurs in industrial estates both the general industrial zone or free operation zone of IEAT and entrepreneurs in industrial estates. It consists of four Chapters and 80 Sections, namely Chapter 1 Industrial Estate Authority of Thailand, Chapter 2 Industrial Estate, Chapter 3 Competent officer, Chapter 4 Supervision, Chapter 5 Penal provisions, and one Transitory provision.

(5) Enhancement and Conservation of National Environmental Quality Act B.E. 2535 (1992) and amended (No. 2) B.E. 2561 (2018) is the law on the study and reporting of environmental impact assessment from projects or activities or any operation by the government or as licensed by the government in Section 46 Part 4 Providing Environmental Impact Assessment Reports, Solid waste and hazardous waste in Sections 78 and 79, Part 6 Other pollution and hazardous waste, Chapter 4 Pollution control. Collection, transport, and treatment, and disposal of e-waste are combined in Section 78. This law can be enforced only when there is no specific law on e-waste management by the power of Section 79 in issuing the Ministerial Regulation.

The interviews appear as follows:

"The factories of category 105 and category 106 in industrial estates must comply with Industrial Estate Authority of Thailand Act B.E. 2522 (1979) with the latest amendment which is Industrial Estate Authority of Thailand

Act (No. 5) B.E. 2562 (2019). The measures to prevent the impact on the factory's waste and hazardous waste management must comply with the measures as determined in the factory's environmental impact assessment report according to Enhancement and Conservation of National Environmental Quality Act (No. 2) B.E. 2561 (2018)" (IEAT officer No. 1).

"Office of Gateway City Industrial Estate, Chachoengsao, is responsible for licensing, supervision to ensure that entrepreneurs comply with Industrial Estate Authority of Thailand Act B.E 2522 (1979), and Factory Act B.E. 2535 (1992). In the industrial estate, there are waste generators and four processors of imported e-waste who separate, process, and export the e-waste. According to the Hazardous Substance Act B.E. 2535 (1992), there must be law enforcement with these entrepreneurs. The waste generators must separate the types of e-waste and seek waste processors with permit according to Notification of Ministry of Industry Re: Industrial Waste Management and Disposal, B.E. 2548 (2005)" (IEAT officer No. 2).

"The penalty of the factories in the industrial estate according to Section 37, Section 39 of the Factory Act B.E. 2535 (1992) is that the industrial estate can order factory entrepreneurs to stop operation and withhold any wrongdoing for improvement. However, the industrial estate does not have the power to fine" (IEAT officer No. 4).

"The treatment or disposal of e-waste must be sent to the factory with factory permit based on the Factory Act B.E. 2535 (1992) (No. 2) B.E. 2562 (2019). The definition of a factory is the use of machine or machines with total power or an equivalent of fifty horsepower or more, or which employs fifty workers or more" (Government official of the central government No. 5).

However, systematic and more efficient household e-waste management required profound enactment of relevant laws and law amendments by

the opinion of the government official of the central government No. 2, who said the following:

> *"Law is the tool for officials to perform their duties. Law must be enforced and must be amended to be in line with current situations. As many laws in Thailand are 10-20 years outdated, some chapters may have to be amended."*

Moreover, the relevant documentary study and the interviews, the relevant laws of EEC development include Eastern Special Development Zone Act B.E.2561 (2018). That law systematically develops EEC and sustainable development, especially promoting commerce and industry using advanced, modern, innovative, and environmental-friendly technology. Section 10 establishes the Eastern Economic Corridor Office of Thailand (EECO) with the duties according to Section 11, such as formulation of policy for the development of EEC, issuance of rules, regulations, and notifications to determine criteria, methods, and conditions of operation based on this Act. Section 14 establishes the EECO as secretariat to Eastern Special Development Zone Policy Committee (ESDZPO) with the responsibilities such as coordination with relevant government agencies to develop EEC according to the policy, plans, and measures as stipulated by ESDZPO. According to the resolutions of ESDZPO No. 11/2562 dated December 6, 2019, ESDZPO agreed on the guideline of solid waste management in EEC and assigned EECO to operate the following:

(1) Coordinate with the provinces and the LAOs of Chachoengsao, Chonburi, and Rayong: First, prepare the project proposal of waste management in EEC towards the model of sustainable waste disposal, including waste on land, on islands, and in the sea. Second, finish within three months, assign PTT Public Company Limited and Global Power Synergy Public Company Limited (GPSC) to participate in the study.

(2) Assign the provinces in EEC as leading agencies in collaborating with LAOs: First, find appropriate areas for the setting up of solid waste

plants and Refuse-Derived Fuel (RDF) power plants. Second, assign the Ministry of Energy and Ministry of Interior to buy electricity from the RDF power plants in EEC.

That was in line with the EECO officer No. 1, who said the following:

> *"The role and duties of EECO according to Eastern Special Development Zone Act B.E.2561 (2018) will coordinate with government agencies related to the policy as assigned by ESDZPO. According to the resolution of the ESDZPO on December 6, 2019, EECO operates the household solid waste in the three provinces of EEC in Chachoengsao, Chonburi, and Rayong, without having to be host in each field but coordinates and works with the agencies directly responsible. Coordination is sought with LAOs, including PAOs and municipalities, and going on survey trips to solid waste management centers in the three provinces of Chachoengsao, Chonburi, and Rayong to find potential areas to set up a refuse-derived fuel (RDF) powerplant."*

The EECO officer No. 2 gave the following opinion:

> *"As for e-waste management in the three provinces of EEC, EECO has not started operation because no relevant policy has come out. Furthermore, in Eastern Special Development Zone Act, B.E 2561 (2018), no law is directly relevant to e-waste management. At present, EECO focuses on household solid waste disposal both on land and islands such as Ko Lan, Ko Sichang."*

4.2.1.6 Environment of the East

The environment of the east in the study included the environmental problems found in the east (eight provinces), and the guideline to manage HHW management at the provincial level, and problems and obstacles in HHW management in the east.

In the east, the industrial sector is the leading manufacturing sector. The past industrial development caused environmental problems in the areas such as

wastewater, waste, air pollution. During the budget years 2017-2019, environmental complaints in the east (eight provinces) totaled 84, 135, and 145. The causes of most complaints in the east included wastewater, followed by a foul smell, and loud noise, respectively. The province receiving the most complaints was Chonburi, followed by Chachoengsao, and Rayong respectively. Moreover, for the past three years (2016-2019), the number of complaints on hazardous waste in Chonburi, Chachoengsao, Rayong, and Sa Kaeo constituted 5-8% of the total complaints. It was considered small compared to wastewater and a foul smell constituting 41-53% and 18-23% of the total complaints respectively, as shown in Table 4.10 (Regional Environment Office 7 (Saraburi), 2018, 2019, 2020; Regional Environment Office 13 (Chonburi), 2018a, 2019a, 2020a).

As for the guideline of HHW management at the provincial level in the east, PAOs were hosts in the management and transport of HHW for academically correct disposal. LAOs set up drop-off points of HHW in the areas. In 2019, the east collected HHW, which mainly included fluorescent lamps, chemical packaging, and battery for 928.09 tons, and transferred for academically correct disposal for 59.86 tons (as per September 30, 2019). The amount disposed of HHW was only 6% compared to the amount of collected HHW. Only four provinces in the east could collect and transfer HHW for disposal, namely Rayong, Nakhon Nayok, Prachin Buri, and Sa Kaeo. The details are in Table 4.11.

Table 4.10 Number of Complaints on Environment in the East during the Budget Years 2017-2019

Provinces [1,2]	No. of complaints*	Wastewater	Foul smell	Loud noise	Hazardous waste	Solid waste	Dust	Others
Budget year 2017 (Oct. 2016-Sep. 2017)								
Chachoengsao	5	1	2	1	-	1	-	-
Chonburi	52	21	10	3	7	1	2	8
Rayong	7	7	-	-	-	-	-	-
Chanthaburi	-	-	-	-	-	-	-	-
Trat	1	1	-	-	-	-	-	-
Nakhon Nayok	5	3	1	-	-	-	-	1
Prachin Buri	14	2	5	2	-	-	3	3
Sa Kaeo	-	-	-	-	-	-	-	-
Total	**84**	**35**	**18**	**6**	**7**	**2**	**5**	**12**
Budget year 2018 (Oct 2017-Sep 2018)								
Chachoengsao	21	13	1	2	5	-	-	-
Chonburi	68	21	21	9	2	7	2	6
Rayong	19	15	1	-	1	1	-	1
Chanthaburi	5	5	-	-	-	-	-	-
Trat	0	-	-	-	-	-	-	-
Nakhon Nayok	5	3	1	1	-	-	1	-
Prachin Buri	9	2	5	2	-	-	2	1
Sa Kaeo	8	5	3	-	1	-	-	-
Total	**135**	**64**	**32**	**14**	**9**	**8**	**5**	**8**
Budget year 2019 (Oct 2018-Sep 2019)								
Chachoengsao	18	10	-	1	3	3	1	-
Chonburi	77	31	22	15	2	-	3	4
Rayong	15	12	-	-	2	-	1	-
Chanthaburi	10	8	-	-	-	-	2	-
Trat	3	3	-	-	-	-	-	-
Nakhon Nayok	10	7	2	1	-	-	-	-
Prachin Buri	10	4	2	2	-	-	2	-
Sa Kaeo	2	2	-	-	-	-	-	-
Total	**145**	**77**	**26**	**19**	**7**	**3**	**9**	**4**

Source: 1 Regional Environment Office 13 (Chonburi), 2018a, 2019a, 2020a

2 Regional Environment Office 7 (Saraburi), 2018, 2019, 2020

Note: * Complaint each time may have more than one issue

Table 4.11 Guideline of HHW Management in the East in 2019

Provinces[1,2]	Guideline of HHW	Overall performance of provinces	Amount (tons)[3]	
			Collection	Disposal
Chachoengsao[1]	LAO set up drop-off points for HHW in the areas and guidelines for PAO's academically correct collection and disposal responsibilities.	Each LAO collected HHW in its area	806.65	-
Chonburi[1]	LAO set up drop-off points for HHW in the areas and Chonburi PAO was assigned to act as host for the academically correct management and disposal. Chonburi PAO was preparing an "MOU on the cooperation of household hazardous management" with the municipality and subdistrict administrative organization in Chonburi.	Each LAO collected HHW in its area	32.00	-
Rayong[1]	LAO set up drop-off points for HHW in the areas, and PAO was assigned to act as host for the academically correct management and disposal. HHW Collection Center is located in the Rayong Integrated Solid Waste Management Center to receive HHW and household e-waste from LAO in Rayong for collection and further disposal.	Collection and academically correct disposal	4.54	4.54
Chanthaburi[1]	LAO set up drop-off points for HHW in the areas and guidelines of PAO's responsibilities for academically correct collection and disposal.	Each LAO collected HHW in its area	29.51	-
Trat [1]	LAO set up drop-off points for HHW in the areas and guidelines of PAO's responsibilities for academically correct collection and disposal. Building for collection of HHW next to Trat PAO office.	Each LAO collected HHW in its area	0.07	-
Nakhon Nayok[2]	LAO set up drop-off points for HHW in the areas with dates set up for collection of HHW and PAO acted as host for academically correct management and disposal.	Academically correct collection and disposal once	2.32	2.32
Prachin Buri[2]	LAO set up drop-off points for HHW in the areas with PAO acted as host for HHW and set the delivery on the 2nd Friday of every month.	Deliver HHW to a private company for academically correct disposal once	2.70	2.70

Provinces[1,2]	Guideline of HHW	Overall performance of provinces	Amount (tons)[3]	
			Collection	Disposal
Sa Kaeo[2]	LAO set up drop-off points for HHW in the areas, and Sa Kaeo signed the MOU "Sa Kaeo Clean Province" assigning LAO to send it to a private company for direct disposal.	Four LAOs delivered HHW to a private company for academically correct disposal	50.30	50.30
Total			**928.09**	**59.86**

Source: 1 Regional Environment Office 13 (Chonburi), 2020b
2 Regional Environment Office 7 (Saraburi), 2020
3 Pollution Control Department, 2020d

However, problems and obstacles were found in HHW (including e-waste) in the east (Pollution Control Department, 2020d; Regional Environment Office 7 (Saraburi), 2020; Regional Environment Office 13 (Chonburi), 2020b) as follows:

1) Some people did not place importance on sorting of HHW at the origin.

2) Disposal of HHW and household e-waste was mixed with general waste in large quantities in household solid waste disposal locations.

3) Unclear guideline of delivery for disposal of HHW and e-waste in some provinces.

The study could be summarized that Context had an impact on e-waste management in Chachoengsao, Chonburi, and Rayong, consisting of 1) Policies, strategies, and plans related to e-waste management, 2) Economic conditions of the east such as the economic structure of the east and average monthly income per household, 3) Social conditions of the east such as population and number of households, 4) Technology of sorting, recycling, and disposal of e-waste, 5) Laws related to e-waste management, and 6) Environment of the east such as environmental problems and guideline of HHW management. In the east (eight provinces), the manufacturing sector was the main activity of the industrial sector. In 2019, there

were 635 factories producing EEE, with the primary production in Chachoengsao, Chonburi, and Rayong. These factories could generate e-waste in the future. In 2020, the population in the east totaled 5,107,898, and the number of households totaled 2,046,627. In 2019, the average monthly income per household equaled 25,060.15 baht, and the top three provinces with the highest population and households were Chonburi, Rayong, and Chachoengsao, respectively. A higher number of households entailed higher consumption of EEE, generating a higher amount of household e-waste. Those with high household incomes tended to own more EEE than those with low household incomes.

Consequently, the amount of e-waste generated in a household of those with high household income was higher than those with low household income. If the generated amount of e-waste was not properly managed, it would cause problems to people and the environment in the east. The complaints on environmental problems during the past three years (2016-2019) included wastewater, foul smell, loud noise, hazardous waste. However, the eight provinces in the east formulated policies, strategies, and plans relevant to e-waste management, such as the National Solid Waste Management Master Plan (2016-2021), the Action Plan "Clean Province." Moreover, there were laws related to pollution and hazardous waste management in the community. Those laws were the Act of Maintaining Cleanliness and Tidiness of the City, B.E. 2535 (1992) and amended (No. 2) B.E. 2560 (2017), Notification of Ministry of Interior on Waste Management B.E. 2560 (2017), and Ministerial Regulation on Communal Toxic or Hazardous Solid Waste Management B.E.2563 (2020). Those ensured that the sorting and disposal of household e-waste were academically correct. LAOs set up drop-off points in the areas, and PAOs acted as hosts in the academically correct management and disposal of HHW and household e-waste. The disposal technology of household e-waste (e.g., lamps, car batteries, and batteries) of factories (category 101, 105) in Thailand were used secure landfills and incinerator.

4.2.2 Input

The input studied four factors, namely Man, Money, Management, and Material and Machine, with the details of the study results as follows:

4.2.2.1 Personnel and Agencies Responsible for Household E-waste Management and People

1) Personnel and agencies responsible for household e-waste management

The documentary study and the interviews revealed that Chachoengsao PAO, Chonburi PAO, and Rayong PAO had specific units responsible for collecting and storing municipal solid waste and HHW. Rayong PAO and Chachoengsao PAO were under the responsibility of the Division of Natural Resources and Environment. Chonburi PAO was under the responsibility of the Division of Public Works. The municipalities in the three provinces were under the responsibility of the Division of Sanitary Works or Division of Public Health and Environment. That was by the government official of the regional administration No. 2, who stated that

"*At present, the local administration and the provinces operate HHW management of which e-waste is included in HHW*."

As for the sufficient number and knowledge of personnel in household e-waste management in the three PAOs, the interview results revealed that Rayong PAO and Chachoengsao PAO had a sufficient number of personnel with Environmentalists and Sanitation Technical Officers equipped with knowledge on e-waste management. That household e-waste were fluorescent bulbs, mobile phone batteries, digital camera batteries, EEE, wireless telephone, and a peripheral device. That was in line with the opinions of the officer of the local administration No. 2, who stated the following:

"*In Rayong PAO, there was personnel with knowledge and expertise in waste management. Division of Natural Resources and Environment and Department of Environment serves as driving agencies and supervise the*

Rayong Integrated Solid Waste Management Center with sufficient Environmentalists and Sanitation Technical Officers knowledgeable in the waste disposal and e-waste disposal."

The officer of the local government No. 3 said

"*PAOs are more ready in terms of personnel. Nevertheless, some municipalities and SAOs do not have Sanitation Technical Officers or Environmentalists. They have to resort to the assistant, clerical officer to drive e-waste management on which the officer does not have sufficient knowledge or expertise."*

Chonburi PAO faced insufficient personnel and a lack of personnel with knowledge and expertise in e-waste management. The government official of the local administration No. 1 provided the following information.

"*PAO has only one official and one assistant. The personnel are in small number, have to fulfill many tasks, and are overload. At the same time, the personnel do not have expertise in e-waste management."*

2) People

In terms of people's knowledge and understanding of e-waste management, the interview results showed that most people in the three provinces of EEC understood that e-waste management was the duty of LAOs, namely PAOs and Municipalities. Most people did not sort e-waste before disposal and left it to mix with general waste in the container for general waste (Dark blue container). Only the minority of people left it in the container for hazardous waste (Orange container) or container for household e-waste as a typical cupboard at drop-off points for HHW as determined by LAOs. Moreover, most people did not realize the danger of e-waste, which might impact people's health and the environment from heavy metals in e-waste such as lead, mercury, cadmium, as in the following interviews:

"Most people understand that e-waste management is the duty of LAOs. It is the duty of people as well. People in each area do not sort waste, or only a small number of people do so. Some say it is sorted, but LAO collects and mixes it" (Officer of the local administration No. 4).

"People are knowledgeable but are not interested in e-waste sorting because they see that the garbage truck collects and mixes the waste although they have sorted the waste. So, they see no reason to sort it" (Officer of the local administration No. 1).

"Some communities do not sort waste and do not realize that it is e-waste such as dry cell or battery. When discharged into water sources, the waste will result in lead and cadmium contamination impacting the younger generation. They think that they are already tired after work and do not have time to sort and dispose of it. The government will take care of it" (Officer of the local administration No. 2).

"People lack knowledge and understanding of the impact on environment and health from e-waste" (Officer of the local administration No. 3).

"*People do not separate mixed waste. They say that even if they separate the waste, the municipality will collect the mixed waste. However, the officers say that if people do not separate the waste, how can they expect the officers to separate it"* (Government official of the regional administration No. 2).

"The community is not cooperative or interested in e-waste management or sorting because they think that they do not generate e-waste. That only use a few pieces such as batteries, lamps which will be changed once every five years" (Government official of the regional administration No. 7).

"People have little knowledge and understanding of e-waste sorting and do not see the importance of e-waste sorting such as what is the use of

separation. Once separated, personnel will mix it just like before" (IEAT officer No. 4).

4.2.2.2 Budget for Household E-waste Management

The budget for household e-waste management included a budget for e-waste disposal of PAOs and a budget for the campaign, public relations, and knowledge on e-waste management provided to people.

The documentary study, the field survey, and the interviews revealed that Chachoengsao, Chonburi, and Rayong PAOs formulated a sufficient budget for HHW disposal allocated by the Provincial Office for Local Administration, including three main types of household e-waste. The types were 1) Lamps such as straight and compact fluorescent bulbs, 2) Dry cells and dry batteries such as mobile phone battery and digital camera battery, and 3) Electrical and electronic equipment waste such as mobile phone, computer. As of September 2020, only Rayong PAO collected and stored household e-waste of the three mentioned groups in the HHW collection building at the Rayong Integrated Solid Waste Management Center before disposal based on sanitation principles. The center is located in Nam Khok Subdistrict, Mueang District, Rayong (Figure 4.4). Once the amount of e-waste was large enough, a private company was sent for outside disposal. The collection of household e-waste awaiting disposal was based on sanitation principles. It was a CSR project of Rayong Renewable Energy CO., Ltd. in compliance with Rayong PAO. It provided the opportunity for communities and LAOs in Rayong to bring in e-waste for storage at the center free of charge. The delivery agency must comply with the regulation by clearly sorting household e-waste and putting it in containers. If the delivery agencies did not cooperate to sort the types of e-waste before the delivery at the center, the center would require service fees of 500 baht/ton for waste sorting. The garbage truck must weigh before and after the delivery of the waste, and there must be an officer accompanying the transfer of household e-waste to the center every time. In 2019 the budget of Rayong PAO for transferring HHW for disposal was approximately 130,000 baht. The interviews are as followed:

"Supporting budget came from the service fees of e-waste disposal of each local authority. Rayong LAO signed the MOU assigning Rayong PAO for e-waste management by assigning every LAO to sort the types of e-waste at origin and send it to Rayong PAO. Once the collected e-waste is delivered at the center, PAO will pay for the disposal" (Officer of the local administration No. 2).

"Chonburi PAO has sufficient budget for HHW disposal. Chonburi PAO does not do anything with e-waste but waits for the MOU with all LAOs in the province first" (Officer of the local administration No. 1).

"In 2020, Chonburi PAO has already formulated the budget for the purpose. However, Chonburi PAO is in the process of preparing the MOU on HHW management with 95 LAOs in the province to assign the PAO to send HHW and household e-waste for disposal, which requires the approval of all local councils" (Officer of the local administration No. 4).

Rayong Integrated Solid Waste Management Center

Rayong Renewable Energy Co., Ltd.

Storage Building of HHW

Figure 4.4 Rayong Integrated Solid Waste Management Center

Moreover, the PAOs and regional agencies in the three provinces of EEC, such as REO 13 (Chonburi) and PONRE, allocated the budget of their agencies for the campaign, public relations, and knowledge transfer e-waste sorting to local people. PAO received the most cooperation from REO 13 (Chonburi) and PONRE, who sent Environmentalists to provide knowledge and bring documents, posters, or

brochures on HHW sorting to disseminate to people. Those consisted of brochures on reducing and sorting solid waste and hazardous waste and posters on waste disposal for correct types of bins and correct types of colors (Provincial Office of Natural Resources and Environment Chonburi), brochures on waste management with 3Rs, Public-Private People Partnership (Chonburi PAO), a handbook on sorting of HHW (Rayong PAO) at least once a year. The interviews were as follows:

> *"Chonburi PAO has campaigned and disseminated brochures and received cooperation from Provincial Office of Natural Resources and Environment Chonburi to use the brochures for the campaign. Training is also organized, and there have been campaigns on HHW management and general solid waste management since 2017"* (Officer of the local administration No. 1).

> *"E-waste management focuses on encouraging villagers to separate the waste at the origin. It is the budget of the local administration, and it is the budget for the invitation by the local administration. There is a project of sorting waste at the origin. The PONRE sends officials as academic advisors and supports lecturers approximately three times a year. There is also follow-up and advice on e-waste management as well"* (Government official of the local administration No. 2).

> *"Provincial Office of Natural Resources and Environment Rayong mostly organizes training projects for the youth, such as sorting different types of waste because the requested budget is for organizing training projects. The training projects spread to eight districts (In Rayong, there are eight districts). The target group of the training projects is junior high school students. The schools participating in the projects are volunteers in the Provincial Office of Natural Resources and Environment Rayong activities such as Zero Waste, which is built on waste. As for the projects operated with villagers or community leaders, there is little or not due to the limited budget. The training can be organized about twice a year"* (Government official of the regional administration No. 4).

4.2.2.3 Household E-Waste Management

The interviews, the observation of the areas, and the compilation of information in the areas revealed that, in general, household e-waste management of LAOs in the three provinces of EEC consisted of five main processes. The process included the First Process: Sorting and collection at origin, Second Process; Collection, Third Process: Storage, Forth Process: Transfer, and Fifth Process: Disposal. The details of each process were as follows:

1) The First Process: Sorting and collection at the origin

Each LAOs in the provinces provided containers for household e-waste, which were mostly divided into three groups, namely 1) Lamps 2) Dry cell 3) Electrical and electronic equipment waste such as mobile phone waste at least one in each community at the drop-off point of e-waste in various locations as determined by the LAOs. Those locations were market, community, convenience store, academic institution, the center of construction material, and LAOs offices in the areas to allow local people to conveniently dispose of e-waste as in Figure 4.5.

2) The Second Process: Collection (midstream)

By Division of Sanitation Works or Division of Public Health and Environment of LAOs in transporting household e-waste from the drop-off points in communities by specific trucks for hazardous waste or modified trucks for general solid waste (Figure 4.6) on the date and time as specified by each LAO such as once a month, once a week. The drop-off points of e-waste were also inspected every week. If there were a large amount of disposed of e-waste at any drop-off point, there would be an additional transfer of e-waste in the particular drop-off point.

Global House, Rayong

Seven-Eleven, Rayong City Municipality

Office of Laem Chabang City Municipality, Chonburi

Community in Chachongsao Town Municipality

Ruen Jum Community, Cheong Nern Subdistrict, Rayong

Community in Bang Phra Subdistrict Municipality, Rayong

Tourist Information Center at Bang Saen Beach, Chonburi

Rayong Business Administration Technological College

Nong Mon Market, Chonburi

Thap Ma Subdistrict Municipality, Rayong

Banchakyaichin Community, Laem Chabang City Municipality

Office of Rayong Provincial Administrative Organization

Figure 4.5 Examples of Drop-off Points in Various Locations

3) The Third Process: Storage (midstream)

Household e-waste was collected and stored at premises for household e-waste of each LAO which was closed building such as storage building of HHW of Laem Chabang City Municipality and Saen Suk Town Municipality in Chonburi, and Rayong Integrated Solid Waste Management Center and containers of Chachoengsao Town Municipality in Chachoengsao as in Figure 4.7

Collection truck for hazardous waste[1]

Modified collection truck for general waste[2]

Modified collection truck for general waste[3]

Ten Wheel Roll-off Truck[4]

Figure 4.6 Examples of Collection Trucks of HHW and E-Waste
Source: 1,4 Laemchabang City Municipality, 2020a
2 Chachoengsao Town Municipality, 2020c
3 Saen Suk Town Municipality, 2020b

Rayong Provincial Administrative Organization[1]

Laem Chabang City Municipality[2]

Saen Suk Town Municipality[3]

Chachoengsao Town Municipality[4]

Figure 4.7 Examples of Household E-Waste Storage Sites
Source: 1 Rayong Integrated Solid Waste Management Center, 2020b
2 Laemchabang City Municipality, 2020a
3 Saen Suk Town Municipality, 2020c
4 Chachoengsao Town Municipality, 2020b

4) The Forth Process: Transfer (midstream)

When household e-waste was collected insufficient amount for disposal, Rayong PAO or some municipalities with sufficient potential for disposal

such as Laem Chabang City Municipality in Chonburi, Chachoengsao Town Municipality in Chachoengsao, etc. would hire private company for the transfer of waste to proper disposal.

5) The Fifth Process: Disposal (downstream)

Most hired private companies would take household e-waste to the company or factory for disposal or recycling of e-waste outside the areas such as Saraburi, Nakhon Sawan, and Samut Prakan.

That was by the opinion of the officer of the regional administration No. 2, who said

> "*Rayong PAO is the big brother in the collection. Rayong City Municipality has drop-off points of household e-waste as the collection cupboards or orange bins according to the Notification of MOI. People will bring dry cells, lamps, batteries here, and all local agencies must do the same. Once the amount is large, the municipality will bring in a truck to transport the waste to Rayong Integrated Solid Waste Management Center. When the amount is stored in large quantity, a private company will be contacted for disposal such as Saraburi will send garbage truck for disposal.*"

Moreover, the IEAT officer No. 4 gave the following comment,

> "*The good method of e-waste management is that there should be sorting at origin first. The community should know how to sort waste. The local authorities should also determine the sorting dates and the collection as household e-waste is not large. Most are non-valuable waste such as lamps, mobile phone waste."*

That was in line with the IEAT officer No. 1, who gave the following comment,

> "*Community can focus only at origin. If we ask the residents to sort waste, if there are garbage bins, and if the e-waste is valuable, people will sell it to*

junk shops and take lamps and mobile phone waste to LAOs. However, there must be sufficient drop-off points for e-waste, and the date of the collection must be set."

Computers and television under the stipulation of the Draft of the Waste from Electrical and Electronic Equipment Management Act B.E. .... most are e-waste that could not be disposed of in the container for HHW currently in use due to its relatively large size. So, most people chose to keep e-waste at home or have it repaired for reuse or sell it to junk shops or sidecars within local communities through selling by kilogram or donation to Suankaew Foundation in Nonthaburi through LAOs (e.g., Thap Ma Subdistrict Municipality and Rayong City Municipality in Rayong). Thap Ma Subdistrict Municipality signed a Memorandum of Understanding (MOU) with Suankaew Foundation to integrate cooperation in waste management. That included offering e-waste to the temple and preaching on "Separate waste and cleanse your mind" by Phra Payom Kalayano, Abbot of Wat Suan Kaew. Rayong City Municipality received a donation of electric appliances, electronic equipment, and computers to donate to the Suan Kaew Foundation. Therefore, there was no action on e-waste management for computers and televisions in Rayong City Municipality and Thap Ma Town Municipality as in the following interviews:

"*Most e-waste sorted from household is mostly lamps or batteries. Whatever can be sold, villagers will sell them to junk shops or sidecar buyers of used items. If they dispose of it at the waste disposal center, and if it is not recycled bank, the villagers will not earn income. Therefore, the e-waste that can be sold will not come to the community's drop-off points. As for many junk shops, they refuse mobile phones but accept televisions, and refrigerators, to take out circuit boards and batteries."*, who said the government official of the regional administration No. 1.

"*Residents in all households do not dispose of e-waste to the municipality. When the electrical appliances are out of order, they will take them to the*

repair shops. If the repair shop cannot repair it, the residents will ask the repair shop to discard them. Another channel is that a vehicle will come by at their houses and buy back the appliances and then resell them to junk shops who will disassemble the parts.", who said the government official of the central government No. 1.

"*Household e-waste will mostly be resold, or sold off to those who will buy back the waste. If the owner does not like to part with it, it will be kept as a junkyard in the house"* (IEAT officer No. 3).

"Nowadays, vehicles come by and announce to buy back old computers, motors, and televisions. The vehicles will accept only e-waste, and they will weigh the devices in kg." (IEAT officer No. 4).

"People sell or discard e-waste such as old computers, old televisions, or broken refrigerators. Small sidecar drivers will come to pick up the e-waste and send it to large junk shops such as Wongpanit. Then, e-waste disposal plants will come to bid for further sorting, recycle, or disposal.", who said the government official of the regional government No.6.

In conclusion, the current overview of household e-waste management systems in Chachoengsao, Chonburi, and Rayong revealed that household e-waste could be divided into two groups, namely, non-valuable e-waste and valuable e-waste. Non-valuable e-waste was small-sized e-waste, such as lamps, dry cell and battery, electrical and electronic devices, and mobile phone waste. Valuable e-waste was a medium to large-sized e-waste, such as computer, television, air-condition, and refrigerator. The non-valuable e-waste that was not large would be mixed mainly with general solid waste, and people would partly take them to drop-off points of HHW in various locations specified by LAOs. The amount of that e-waste would be collected by LAOs and stored at its own LAO's hazardous waste collection sites. When the amount of e-waste was sufficiently large, the five LAOs with sufficient potential of collection and transfer for disposal by themselves in the three

provinces of EEC. The LAOs were 1) Laem Chabang City Municipality, 2) Chaoprayasurasak City Municipality, 3) Pattaya, 4) Bo Win Subdistrict Administrative Organization, Chonburi, and 5) Chachoengsao Town Municipality in Chachoengsao. They would send the e-waste for disposal to the private sector's disposal of HHW outside the areas of EEC. Rayong PAO would collect household e-waste from various LAOs in Rayong to be stored at the Rayong Integrated Solid Waste Management Center until the amount was sufficiently large to be sent for disposal to the private sector. As for valuable, large-sized e-waste, most people would keep the e-waste at home or have it repaired for reuse or sell it to junk shops or sidecar buyers of old items in the local areas or make a donation. That large-sized e-waste included computers, television, air conditioner, and refrigerator. Moreover, some people called LAO to set the appointment to transfer large-sized e-waste, as shown in Figure 4.8.

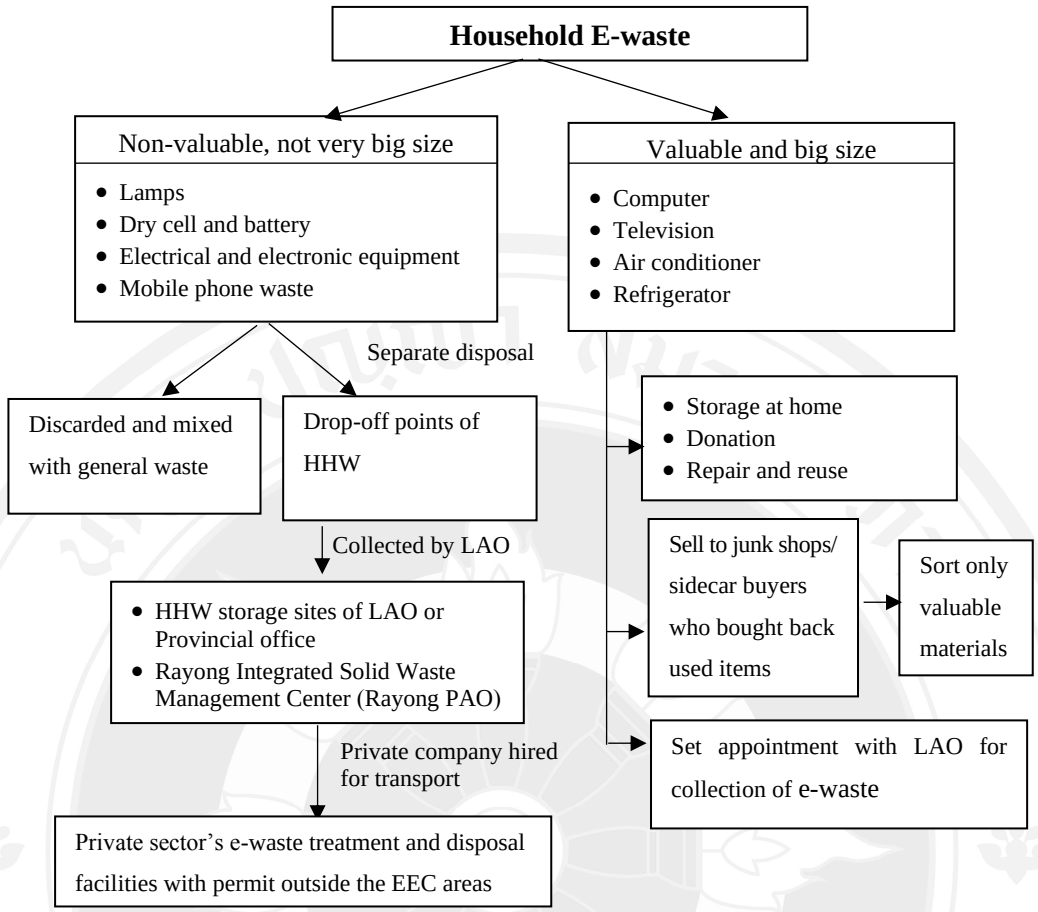


Figure 4.8 Conditions of Household E-Waste Management System in Chachoengsao, Chonburi, and Rayong

4.2.2.4 Tools and Equipment for Household E-Waste Management

The findings of the collected information in the areas and the observation in the areas revealed that the tools and equipment necessary for household e-waste management of LAOs in the three provinces of EEC consisted of containers, collection trucks, and storage sites. Each LAO prepared the containers for e-waste in various forms, such as orange or red garbage bin, collecting cupboard, a box of various shapes (i.e., rectangular, cylindrical) as shown in Figure 4.9. They have installed the drop-off point of HHW at least one point per community. After that, household e-waste was collected by modified truck to collect general solid waste by LAO (Figure 4.6) and then initially at storage sites of its own LAO building, container (Figure 4.7). When the amount of e-waste was sufficiently large, PAO was the principal responsible agency for disposal, including some LAOs with sufficient potential

for e-waste disposal by themselves, and would hire a private company to transfer for proper disposal.

The area observation revealed that a typical cupboard would facilitate people to sort household e-waste from other types of waste better than other forms such as orange or red garbage bins, different forms of boxes such as rectangular or cylindrical. There were boxes in different sizes in the typical cupboard for sorting e-waste, such as boxes for short light bulbs, long light bulbs, dry cells, mobile phone waste, and batteries (Figure 4.9).

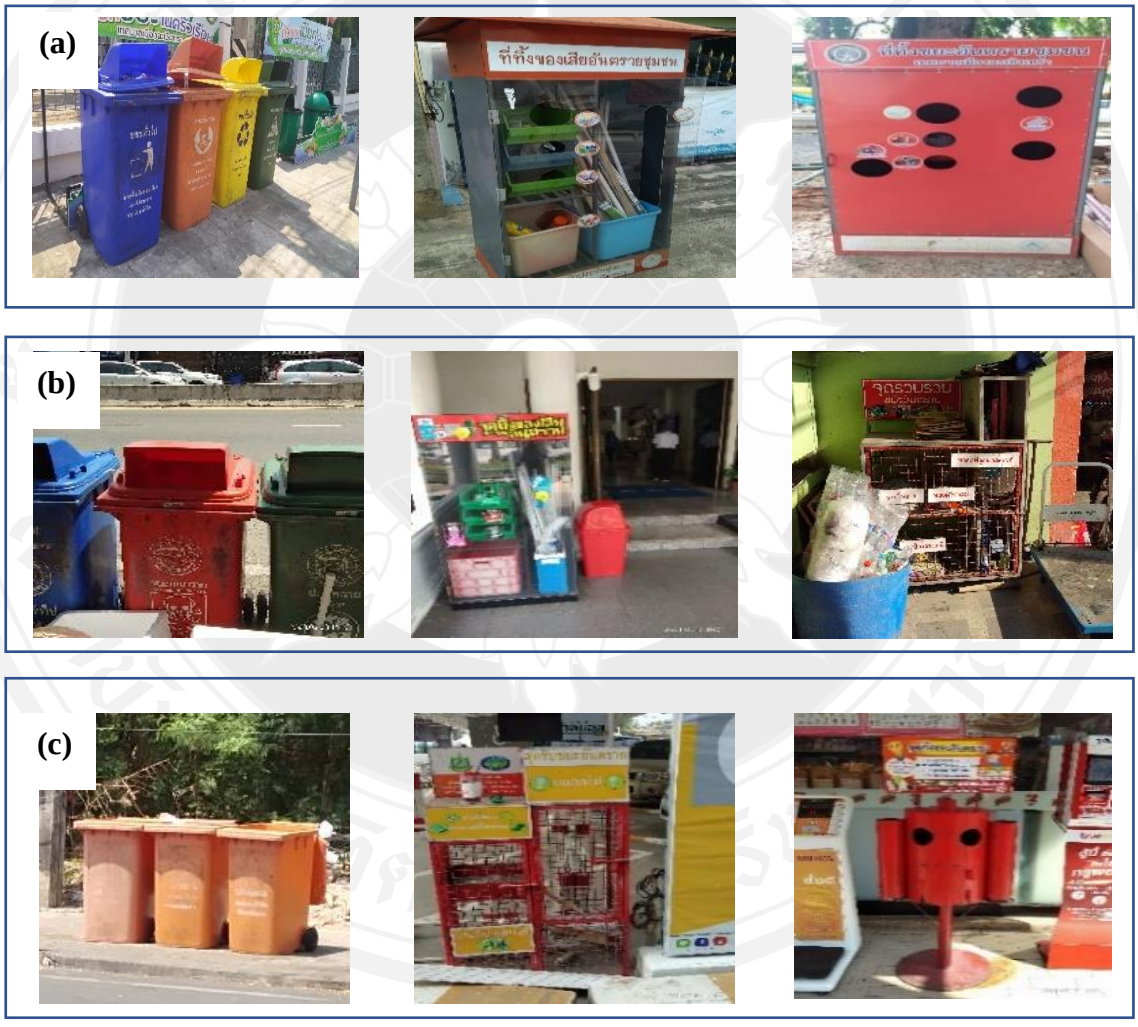


Figure 4.9 Different Types of Containers for E-Waste in Chachoengsao[a], Chonburi[b], and Rayong[c] Provinces

The standard cupboards at the LAOs in Chachoengsao, Chonburi, and Rayong were mainly taken from PCD and appropriately applied to the areas. There were two types of collection cupboards for HHW: a large cupboard with 78 X 70 X 173 cm and small size of 54 X 46 X 155 cm. In the collection cupboards, there were boxes of different sizes to collect and separate each type of HHW, such as boxes for short light bulbs, long light bulbs, dry cells, mobile phone waste, and batteries, and spray cans, as shown in Figure 4.10 (Pollution Control Department, 2020a).

Large Size Container

Small Size Container

Figure 4.10 Types of Containers of HHW by PCD
Source: Pollution Control Department, 2020a

The interviews and observation in the Rayong Integrated Solid Waste Management Center revealed that LAOs in Rayong province was responsible for collecting and transferring e-waste with LAOs garbage trucks or delivery agencies. Those trucks were four-wheel trucks and open hatch trucks. Then, the garbage truck would weigh the waste. The personnel of the delivery units would load the e-waste down to the building to collect and store HHW at the Rayong Integrated Solid Waste Management Center. Types of e-waste were separated, stored in groups, contained together in large bags, and placed in building for storing HHW, such as a straight fluorescent lamp, compact fluorescent lamp, and dry cell and dry battery separately (Figure 4.11). When the amount of e-waste was sufficiently large, Rayong Renewable Energy Co., Ltd would hire private companies to transfer e-waste for disposal outside

the areas by transporting hazardous waste vehicles. Those companies were General Environmental Conservation Public Company Limited (factory located in Ratchaburi) and Professional Waste Technology (1999) Public Company Limited (factory located in Sa Kaeo). That was by the officer of the local administration No. 2, who said the following:

> "*The local administration collects and sorts waste and sends it to Rayong PAO for storage and finding a place for disposal. PAO has a the Rayong Integrated Solid Waste Management Center. No date is set for waste collection. When the waste is full, the garbage truck will come to the waste disposal center to collect the waste awaiting disposal. Nowadays, the private company will do the disposal."*

Area for weighing the waste

Four wheels garbage pick up truck of LAO

Open hatch garbage truck of LAO

Forklift to transport e-waste for storage in building

Container of straight fluorescent lamps by delivery agency

Bag containing fluorescent lamps

Figure 4.11 Tools and Equipment of E-Waste Management in Rayong Integrated Solid Waste Management Center

The documentary study, the compilation of information in the areas, and the interviews revealed that LAOs in Chonburi collected and sent e-waste to the drop-off point of HHW situated at least one per community, and then to HHW storage

sites in its own office. Most LAOs did not send household e-waste for disposal except for four LAOs which are potential for e-waste disposal themselves, namely 1) Laem Chabang City Municipality 2) Chaoprayasurasak City Municipality 3) Pattaya, and 4) Bo Win Subdistrict Administrative (Regional Environment Office 13 (Chonburi), 2020b). When the household e-waste was sufficient storage for disposal, the four potential LAOs would hire private companies for academically correct transport and disposal by transporting hazardous waste such as Roll-off Truck (Figure 4.6). Although in September 2020, Chonburi PAO was assigned by the province to collect HHW and send it for disposal, Chonburi PAO had not sent household e-waste from LAOs for disposal. That was because Chonburi PAO was in the process of preparing the "Memorandum of Cooperation on Household Hazardous Waste management" or MOU with 95 municipalities and SAOs in Chonburi according to the document of Chonburi Province No. Chor Bor 0023.3/Circular 5615 dated September 15, 2020, on the MOU and in the process of study provincial hazardous waste center. In the past, Chonburi PAO used to have the Chonburi Integrated Solid Waste Management Center located at Moo 11, Ban Nong Kha, Bang Phra Subdistrict, Sriracha District, Chonburi on the land of approximately 510 rais. However, it was long closed down due to the problems of foul smell. The center used German technology, an integrated management system, including the waste sorting system, landfill, wastewater treatment system, reuse system, incinerator, fertilization, biogas production that could accommodate waste approximately 300-400 tons/8 hours/day (Chonburi Provincial Administration Organization, 2010). That was in line with the officer of the local administration No. 1, who said the following:

> "*Waste management requires hiring the private company for disposal as there is no disposal location of its own. Chonburi PAO used to have Chonburi Integrated Solid Waste Management Center at Bangphra Subdistrict but was closed down about ten years ago, probably in 2006. The center is not reopened due to foul smell that disturbs residents living nearby."*

The EECO officer No. 2 said the following:

"*Chonburi Integrated Solid Waste Management Center was long closed down due to foul smell.*"

As for Chachoengsao, only Chachoengsao Town Municipality collected different types of e-waste such as a fluorescent lamp, dry cell, mobile phone battery, EEE from the drop-off points of Chachoengsao Town Municipality. The garbage truck would come to collect HHW every Friday between 09.00-11.00 a.m. (Figure 4.6) and send it to private companies being hired for solid waste management of Chachoengsao Town Municipality. That private company was the Clean city CSR Co., Ltd. and transferred household e-waste to the disposal company outside the EEC areas, such as Mechanitec Limited Partnership in Saraburi. That was in line with the opinion of the officer of the local administration No. 3 as follows:

"*Chachoengsao Town Municipality is the only place in the province with e-waste management. Other LAOs in the province still cannot manage e-waste. They only collect it*."

Other LAOs in Chachoengsao collected and transported e-waste from the drop-off points of household e-waste from each community to storage sites of each LAO such as buildings, containers. Nevertheless, it was not properly disposed of because Chachoengsao PAO had not been accepted as the e-waste disposal operator. However, Chachoengsao PAO only collected HHW mixed with household solid waste to Integrated Solid Waste Management Center of Chachoengsao PAO for disposal only.

"*Every community generates waste but does not know where to send it for final disposal, unlike Rayong PAO, who receives HHW from all LAOs for disposal. As for Chachoengsao PAO, it has not yet been accepted to be host to collect HHW from each LAO for disposal.*"

The officer of the local administration No. 3 said the following:

"*Within Integrated Solid Waste Management Center Zone 1 of Chachoengsao PAO, hazardous waste is sorted, and e-waste is separated from the general solid waste by hiring labor force working in the Center*."

4.2.3 Process

The process of household e-waste management in the EEC areas of Chachoengsao, Chonburi, and Rayong consisted of planning of work or projects (Plan), operation of projects or activities (Do), monitoring, and inspection (Check), and improvement and rectification for proper operation (Act). The details of the study results are as follows:

4.2.3.1 Planning of Work/Projects Relevant to E-waste Management

The interviews revealed that the provinces' policies and plans on waste management mainly depended on the government's policies, focusing on the types of waste management and the governor's policies and the importance and urgency of the particular policies and plans. That was by the interview with the government official of the local administration No. 2 who said the following:

"*At present, the government campaigns for plastic waste. Our agency also has many plans for the campaign. For example, the project to reduce plastic waste in the mobile provincial activity. If the governor's policy focuses on the solid waste disposal sites, it must be provided."*

The government official of the central government No. 1 also said the following:

"*The province has many responsibilities. In rural areas, the environment, such as waste, is not the top priority. If no stringent indicators are devised or if there is no active order, it may not be given due priority."*

For the planning to formulate action plan or project on household e-waste management in Chachoengsao, Chonburi, and Rayong in the past, LAOs implemented solid waste management and HHW management according to the

Action Plan “Clean Province” for the budget years 2017-2019, by Department of Local Administration, MOI. The operation framework under the Action Plan consisted of three processes. The process was upstream, meaning reduce and sort waste at origin, midstream meaning increase efficiency in transporting the waste of LAO, and downstream, meaning waste is disposed of based on academically correct methods using the principle of 3Rs: Reduce, Reuse, and Recycle. The action plan was continued from the Action Plan “Thailand Zero Waste” according to the Participatory “Civil State” Principle 2016 -2017 using the principles of 3Rs and in line with the National Solid Waste Management Master Plan (2016-2021) of PCD, MNRE as in the following interviews:

> “*Ministry of Interior’s policy is the holistic policy on household solid waste management by dividing waste into four major types, namely general waste, organic waste, recycled waste, and hazardous waste, with projects and activities such as sorting before disposal. The Ministry will also cascade policy on municipal solid down to each local authority. The local authority must establish indicators stressing origin, an intermediate point, and destination*” (Government official of the central government No. 3)

> *“The governor’s policies such as 3 Rs, Participatory Principle, Action Plan “Clean Province” will assign all local authorities to implement MOI's policies. Meetings will be held with Rayong PAO and local authorities, depending on the governor. Policies will be implemented by the local administration by which the local administration will order LAOs to sort waste, and Rayong PAO will arrange to work together at destination”* (Officer of the local administration No. 2).

> *“As for the trend of HHW management including e-waste, Chonburi PAO will see to it as it is the order of the province as stipulated by MOI. However, the drive may be slow as there is low personnel and without close follow-up on the part of the province”* (Officer of the local administration No. 1).

"The local administration and the province of Rayong mostly deal with HHW, including e-waste which constitutes part of the HHW as well" (Government official of the regional administration No. 2).

"Planning of work and projects relevant to local e-waste management in Rayong is still rare. It is mostly holistic action plan on the waste of all types" (Government official of the regional administration No. 4).

4.2.3.2 Operation of Projects and Activities Relevant to E-Waste Management

The operation of projects and activities relevant to e-waste management in this study consisted of building awareness and cooperation with relevant government agencies. Details are:

1) Building awareness

From interviews and the compilation of information in Chachoengsao, Chonburi, and Rayong revealed that between 2016-2020 most projects or activities-built awareness and discipline to the people and youth and motivation to LAOs. Regarding general waste management and HHW management, issues were minor and involved e-waste management of mobile phones, computers, fans, hairdryers, and steamers. The provincial office managed the operation or agencies responsible for solid waste management and HHW management of the LAOs in the particular province. For example, PAOs were under the Division of Natural Resources and Environment or Division of Public Works. Municipalities were under the Division of Sanitary Works or Division of Public Health and Environment with the campaign and public relations through various media to ensure acknowledgment of all people in the responsible areas. The media consisted of voice announcement lines, door knocking, public relation boards, public relation vehicles, brochures, public handbooks, stickers, and posters. Projects and activities were divided for LAOs (e.g., a contest for household solid waste management) and projects or activities for the public and the youth (e.g., sorting of HHW, setting up of drop-off points, collection of e-waste, and training on HHW management) as summarized in Table 4.12 and Figure 4.12.

Table 4.12 E-Waste Management in Various Projects of LAOs of Chachoengsao, Chonburi, and Rayong

Year	Name of projects	Details and activities
Contest and award bestowing ceremony of household solid waste management "Clean Province"		
2018-2019	Project of 2019 contest for household solid waste management "Clean Province"	Project to inspire LAOs by which each province selected and ranked the LAOs, namely city municipalities, town municipalities, and subdistrict municipalities or SAOs, passed the criteria of assessment of cleanliness and orderliness 60% (clean LAO). The results of the selection between July-August 2019 revealed that some LAOs won the rewards, such as Thap Ma Subdistrict Municipality in Rayong, Chonburi City Municipality, and Nongprue Municipality in Chonburi by the Department of Local Administration, MOI.

Year	Name of projects	Details and activities
Sorting of household hazardous waste in in households and establishments		
2019	Project to sort waste for clean Chachoengsao	Project for the public to sort household waste before disposal, divided into four types of solid waste: organic waste/wet waste/degradable waste, recycled waste, hazardous waste, and general waste by the Division of Public Health and Environment Chachoengsao Town Municipality, Chachoengsao.
	Project of 3 uses, if you don't use, please give it to us	Campaign activities to sort e-waste in 50 hairdresser establishments in Rayong City Municipality by Office of Public Health and Environment, Rayong City Municipality, Rayong.
2017-2019	Project to manage hazardous waste	Activities of offering recycled and hazardous waste (just like off-season offering of robes and other needs to monks) in Saen Suk Town Municipality, Chonburi. Those campaign for the public to take an interest in the sorting of hazardous waste and make merits at the same time, and to prevent danger and reduce the impact on people's health from hazardous waste disposed and mixed with other types of waste by the Division of Public Health and Environment, Saen Suk Town Municipality, Chonburi province.
Setting up of drop-off points of HHW as determined by LAO		
September 2016	Project to provide cupboard to contain community hazardous waste	Provide HHW containers in Laem Chabang City Municipality (23 communities) with additional 14 communities totaled 24 communities (104% of total villages/communities) by the Division of Sanitary Works, Laem Chabang City Municipality, Chonburi province.

Year	Name of projects	Details and activities
Setting up of drop-off points of HHW as determined by LAO (Continued)		
2016-2017	Project to sort hazardous waste	Provide HHW containers to all communities in Thap Ma Subdistrict Municipality, Rayong (eight communities) at 22 locations (100% of total villages/communities) by the Division of Public Health and Environment, Thap Ma Subdistrict Municipality, Rayong province.
2019	Project to sort waste for clean Chachoengsao	Place cupboards to contain HHW at 24 points in communities and households by the Division of Public Health and Environment, Chachoengsao Town Municipality, Chachoengsao province.
2017-2020	Project to provide cupboard for disposal of sorted hazardous waste and bin for hazardous waste in communities	Place containers for disposal of hazardous waste and bins of hazardous waste in 25 communities by the Division of Public Health and Environment, Saen Suk Town Municipality, Chonburi province.
Collection of electrical and electronic product waste		
2018	Project of E-waste market place	Activities to receive the donation of electrical and electronic product waste from general public, schools, and private companies and to join Suan Kaeo Foundation in waste management, offering ceremony of e-waste, and the sermon on "Separate waste and cleanse the mind" by Phra Payom Kalayano, abbot of Wat Suan Kaeo by the Division of Public Health and Environment, Thap Ma Subdistrict Municipality, Rayong province.
2018	Project of out the old mobile phones and welcome new lives to donate books to child development center	Compile unused mobile phones and points to receive donation of old mobile phones at the drop-off point of HHW, on the 1st floor, Building of Rayong PAO, to send to the collection center of e-waste by the Division of Natural Resources and Environment, Rayong PAO.

Year	Name of projects	Details and activities
Training on community hazardous waste		
November 2016	Project to sort hazardous waste	Activities on training of sorting of hazardous waste and the practical guideline to community leaders, public and private agencies, entrepreneurs, field operators, and general public in Thap Ma Subdistrict with 133 participants by Division of Public Health and Environment, Thap Ma Subdistrict Municipality, Rayong province.
2017	Project on training of community hazardous waste management for academic institutions	Training on HHW management to students at Watmainernpayom School, Baan Chak Yai Jeen School, Watphrapratanporn School, Watlaemchabang School, and Watmanorom School, 302 students participating in the project by the Division of Sanitary Works, Laem Chabang City Municipality, Chonburi province.
2018	Project on training of community hazardous waste management for academic institutions	Training on HHW management to students at Watnongkhla School, Ban Banglamung School, and Watbanna School, 260 students participating in the project by the Division of Sanitary Works, Laem Chabang City Municipality, Chonburi province.
2019	Project on training of community hazardous waste management for academic institutions	Training on HHW management to teachers and students at Laemchabang 1 Municipality School, Laemchabang 2 Municipality School (Foundation Tailong-Cheng Phornprapha), and Laemchabang 3 Municipality School, 234 teachers and students participating in the project by the Division of Sanitary Works, Laem Chabang City Municipality, Chonburi province.

Project of Old Mobile Phones and Welcome New Lives to Donate Books to Child Development Center[1]

Project of 3 Uses, If You Don't Use, Please Give It to Us[2]

Activity to Provide Drop-off Point of Household Hazardous Waste in the project to sort hazardous waste[3]

Project to Sort Waste for Clean Chachoengsao[4]

Project of Trainings on Household Hazardous Waste Management at Watmainernpayom School[5]

Activities of Offering of Recycled Waste and Hazardous Waste[6]

Figure 4.12 Examples of Projects and Activities of Household Hazardous Waste and E-Waste Management

Source: 1 Rayong Provincial Administrative Organization, 2020

2 Rayong City Municipality, 2020b

3 Thap Ma Subdistrict Municipality, 2020

4 Chachoengsao Town Municipality, 2020d

5 Laemchabang City Municipality, 2020b

6. Saen Suk Town Municipality, 2020a

That was by the interviews as follows:

"Chachoengsao PAO organizes activity on waste sorting project to provide knowledge and understanding to the people and the youth in the sorting of general solid waste and not specifically e-waste" (Officer of the local administration No. 3).

"*Rayong PAO organizes projects and activities such as the project of old mobile phones and welcome new lives of MNRE. However, e-waste is more*

than mobile phones. It also includes television, refrigerator, computer, and washing machine" (Officer of the local administration No. 2).

"*Municipalities have drop-off points of HHW and orange garbage bins in many locations in the municipalities, including at the municipal offices which receive unbiased feedback. People bring lamps, old batteries, and mobile phones for disposal*" (Officer of the local administration No. 3).

"There are projects and activities of public relations to collect 1,000 mobile phones of MOI for disposal at a company in Bo Win to use the acquired money to buy books for donation at child development center" (Officer of the local administration No. 4).

"Every province has a contest project of the clean province. The main activity of the project includes sorting before disposal. The activities of the campaigned project at origin include people's sorting of four types of waste. The waste types are organic waste, hazardous waste, recycled waste, and general waste. The activities at midstream management include the local authorities' designation of the date of collection, disposal area, storage area, and the date of disposal, sending out letters such as the date of collection of particular villages or subdistricts. The activities at destination include disposal at the pond, disposal at the landfill, power generation from the waste disposal factory. However, the actual campaigned project and activities include sorting waste at origin (i.e., brochures) and sorting municipal waste. Moreover, there was providing bins of hazardous waste and installing e-waste drop-off points of PONRE, separating lamps and battery and matching them with bins for hazardous waste seen in various communities" (Government official of the central government No. 3).

2) Cooperation with relevant government agencies

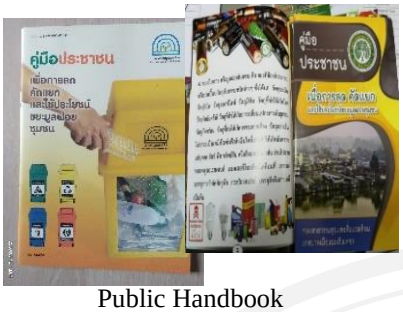
From the interviews, the information compilation, and the observation in the three provinces of the EEC revealed that PAOs and municipalities

used the methods of the campaign and public relations for people to acquire information, knowledge, and understanding, as well as create and promote discipline on proper e-waste management under the various activities of the projects. The projects mainly related to solid waste and HHW management, such as sorting the types of waste based on correct methods, collecting and transferring HHW to the designated drop-off points, the knowledge provided on the toxicity of HHW, and impact from HHW management with incorrect methods. As for the specific projects on e-waste management for telephones and computers between 2016-2019, there were one to two projects a year, such as a project of out the old mobile phones and welcome new lives, the marketplace project of e-waste. As for the activities in these projects, PAOs and municipalities relied on cooperation and support from other government agencies, both central and regional. Those agencies were REO 13 (Chonburi), PONRE, PCD, and DEQP in terms of personal media, printing media, and containers for e-waste to ensure that the operation of the projects was continuously in line with the action plan as follows:

(1) Activities to campaign and provide knowledge and understanding of e-waste management and HHW management mainly depended on cooperation from other government agencies, both local and central. Those agencies were REO 13 (Chonburi), PONRE, PCD in assigning environmentalists as lecturers to provide knowledge.

(2) Printing media used in dissemination and public relations to forge acknowledgment on e-waste management and HHW management, such as brochures, public handbooks, posters, stickers, as shown in Figure 4.13. PAOs and municipalities themselves mainly produced them. However, sometimes they needed to request support of printing media from government agencies, both central and regional, to produce this printing media, such as REO 13 (Chonburi), PONRE, PCD, and DEQP. The printing media was disseminated during activities or at households by LAO officers' door knocking or placed at the agencies' offices in the areas.

(3) Containers for HHW were supported by government officials, central and regional such as the PCD and PONRE, as shown in Figure 4.2-11.



Public Handbook

Brochure

A 3 Poster

A 4 Poster

Public Relation Board

Sticker

Environmentalist

HHW Container in the Form of Collection Cupboard

HHW Container

Figure 4.13 Examples of Printing Media and HHW Containers Used in the Projects or Activities of E-Waste and HHW Management

The interviews were as follows:

"*Chonburi PAO conducts mobile public relations to districts. That is distributing brochures to people and seeking cooperation from REO13 (Chonburi) and Provincial Office of Natural Resources and Environment Chonburi to provide knowledge to PAOs and people on general waste management, HHW management, and e-waste management*" (Officer of the local administration No. 1).

"Rayong PAO provides knowledge to people on possible contamination of HHW which is toxic and in the environment such as orange bins for disposal

of HHW. While meeting with local people during mobile PAO events, we send officers to publicize Rayong Integrated Solid Waste Center of Rayong PAO. Once they know, it is good that they collect hazardous waste and e-waste for disposal once a month" (Officer of the local administration No. 2).

"PCD cooperates with the local administration by assigning PONRE, which are regional authorities to campaign, publicize, and transfer knowledge to the villagers on e-waste management, danger from e-waste, and caution such as children are prohibited to tear e-waste because it will be mixed with heavy metals" (Government official of the central government No. 1)

"As for regional agencies such as PONRE, REO, our DEQP distribute documents to them, or they come to pick up the documents and produce them themselves. If they send us letters of assistance, we will send the documents for the projects we operate with the PONRE and REO. We do not have media directly on e-waste management but rather HHW. We have many campaigning personnel, but rather, the problems consist of expertise, knowledge, and experience. There are a few personnel who can be lecturers. If people contact us and we cannot go, we recommend contacting the REO or PONRE. Many agencies invite us to give lectures such as schools, the general public, government agencies, private companies, hotels" (Government official of the central government No. 2).

"*Public relations should repeatedly mention waste reduction, waste sorting, and waste management*" (Government official of the central government No. 4).

"*Provincial Office of Natural Resources and Environment Chachoengsao operated the project to provide knowledge to the local people who were seriously affected by e-waste in Phanom Sarakham District and Plaeng Yao District in Chachoengsao. The inviting lecturer from PCD provided*

knowledge on the types of e-waste, the government's mechanism to bring e-waste in the country and our area, the management methods, and the necessary precautions. The feedback is quite good. People network with knowledge actively monitor the areas" (Government official of the regional administration No. 3).

"Usually, waste falls under the responsibility of the local administration. Provincial Office of Natural Resources and Environment Rayong places bins for hazardous waste in easily accessible public areas such as town hall, schools' canteens. It distributes to approximately ten LAOS participating in the project with the PONRE in Rayong and schools. Most public relations media consist of posters, brochures received from the DEQP for dissemination to LAOs and schools, and lecturers to provide knowledge at LAOs on waste sorting or any topic of training required by the LAOs".(Government official of the regional administration No. 4).

"Public relations and campaign to understand e-waste management to people is still necessary. Although the people already know how to sort e-waste, the e-waste is already stored at the Rayong Integrated Solid Waste Center of Rayong PAO" (Government official of the regional administration No. 7).

4.2.3.3 Monitoring and Inspection

The monitoring and inspection of e-waste management in the three provinces of EEC in Chachoengsao, Chonburi, and Rayong (Check) consisted of the Provincial Sewage and Solid Waste Management Committee, recording of the information on the amount of household e-waste in the local areas, and monitoring and inspection of complaints on household e-waste management. Details are:

1) Provincial Sewage and Solid Waste Management Committee

The results of the documentary study, the collection of information in the areas, and the interviews revealed that there were the following orders: the order of Chachoengsao Province No. 1102/2560 on the establishment of

Chachoengsao Committee on Sewage and Solid Waste Management dated April 28, 2017, the order of Chonburi Province No. 2721/2560 on the establishment of Chonburi Committee on Sewage and Solid Waste Management dated May 24, 2017, and the order of Rayong Province No. 9893/2560 on the establishment of Rayong Committee on Sewage and Solid Waste Management dated May 9, 2017. Consequently, Chachoengsao, Chonburi, and Rayong had established the Provincial Sewage and Solid Waste Management Committee. The committee of each province had similar compositions and responsibilities. The committee's composition included 16-19 representatives from the public and people sectors depending on the province. For example, the Chachoengsao Committee and the Rayong Committee each had 16 members, whereas the Chonburi Committee had 19 members consisting of the following:

(1) Chairman - Governor

(2) One Vice-chairman - Vice Governor assigned by the governor

(3) 11-14 members - representatives of relevant public and people sectors such as REO 13 (Chonburi), PONRE, PAO, Provincial Industry Office, Provincial Public Health Office, Provincial Office of Public Works and Town & Country Planning, Provincial Energy Office, and Natural Resources and Environmental Protection Volunteer.

(4) One member and secretary - representative of Provincial Office for Local Administration of the particular province

(5) One to two assistant secretaries - representatives of Local Administrative Development Subdivision, Department of Local Administration (DOLA) of the particular province

Their duties and authorities involved monitoring and inspection of household solid waste management and HHW management as follows:

(1) Recommend, give advice, and assist local administration on sewage and solid waste management of LAOs at the provincial level

(2) Invite people or government agencies related to sewage and solid waste management of LAOs to give information, facts, technical

and academic advice, as well as submit documents to seek the guideline to solve the problems of sewage and solid waste management of LAOs

(3) Consider and screen the projects on sewage and solid waste management of LAOs at the provincial level that request budget for DOLA

(4) Consider the clusters to operate the projects on sewage and solid waste management of LAOs, as well as consider the appropriateness of the locations of solid waste disposal

(5) Supervise, follow up, and assess the operation based on the action plan on sewage and solid waste management and budget spending according to sewage and solid waste management projects with financial support from the government and report to the MOI for acknowledgment.

Moreover, the Action Plan "Clean Province" 2019 and 2020 had the practical guideline on household e-waste relevant to the Provincial Sewage and Solid Waste Management Committee as follows:

(1) The Action Plan "Clean Province" 2019

(1.1) In compliance with management goals: The Province held the Provincial Sewage and Solid Waste Management Committee meetings at least six times a year for 100%. The operation results found that 40 out of 76 provinces held the committee's meetings over six times, or 52.63%.

(1.2) In compliance with the goals of management at destination: The local clusters of solid waste management of LAOs for 100%. Each province formulated solid waste management by considering the Provincial Sewage and Solid Waste Management Committee. The operation results found 221 out of 266 local clusters on provincial solid waste management of LAOs in each province operating waste disposal or formulating such action plan through the consideration of the committee or 83.08% (Ministry of the Interior, 2020).

(2) The Action Plan "Clean Province" 2020

In compliance with the goal of management at destination: Local clusters of solid waste management of LAOs for 100 %. Each province formulated solid waste management by considering the Provincial Sewage and Solid Waste Management Committee (Ministry of Interior, 2020).

The Provincial Sewage and Solid Waste Management Committee of each province and the committee meetings held to consider the plans on solid waste management, supervise, monitor the progress, and recommend the activities according to the plans of solid waste management projects the areas under the responsibilities of LAOs. The committee would assist the LAOs in conducting household solid waste management following the area context efficiently.

That was by the government official of the regional administration No. 4, who provided the following opinion:

> *"In Rayong, many committees/task forces on waste management are set up but not specifically on e-waste such as Rayong Committee on Sewage and Solid Waste Management is the main committee overseeing the province. It was established in 2017 to monitor, inspect, consider, and decide on the waste problems, such as the transfer of waste into the province, requiring this committee's approval. There are many projects according to the Clean Province under the local plan. Meetings are also continuously held."*

That was by the officer of the local administration No. 3, who said the following:

> *"Chonburi Committee on Sewage and Solid Waste Management was set up following the order of the province in 2017. The governor serves as the chairman. As for us, the Provincial Office for Local Administration serves as secretary to the committee. This committee has many responsibilities such as advice to the local administration on formulating the action plan on waste management and follows up on waste management according to the action plan."*

2) Recording of information on the amount of household e-waste in the areas

The documentary study and the interviews revealed that the LAOs in the three provinces recorded the information and reported the hazardous

waste management (including e-waste) in the “Monthly report form on solid waste management of LAO (Mor Phor 2)". LAO officers reported through the information system of DOLA or the central information system of LAO (INFO system) every month (Figure 4.14). The system started in the budget year 2017 and continued until the present. The recorded data in the Mor Phor 2 Form included the amount of household solid waste, collected e-waste, stored waste for disposal, solid waste utilization, and the number of drop-off points of LAOs and villages/communities each month. Data of household solid waste consisted of general solid waste, organic waste, recycled waste, and hazardous waste.

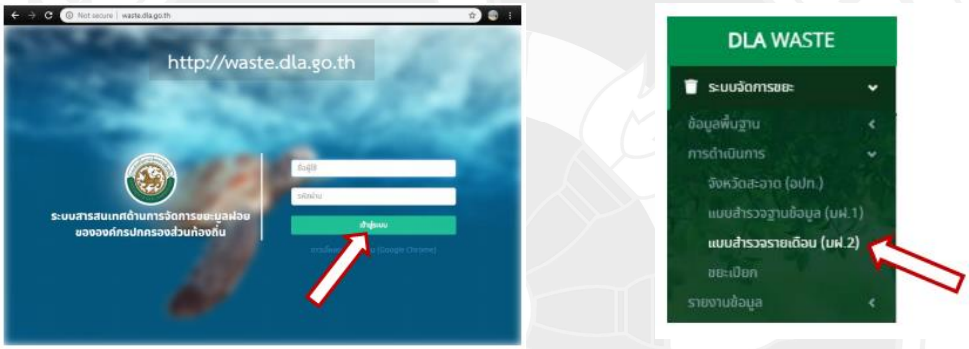


Figure 4.14 Example of the Image on the Screen in the Mor Phor 2 Form
Source: Department of Local Administration, 2020b

The follow-up of hazardous waste management and household e-waste of LAOs according to the Mor Phor 2 Form ensured accurate and up-to-date on the amount of e-waste. Moreover, that formulated the action plan/project, budget planning for e-waste management, and technology on e-waste management that suited the areas. However, the problem still existed on the amount of e-waste, which might not be accurate due to the incorrect information on e-waste that was filled in.

The government official of the regional administration No. 1 stated the following:

“Provincial Office of Natural Resources and Environment Chonburi takes the information on the amount of solid waste and e-waste from PAOs, and we

at Provincial Office for Local Administration do not compile information ourselves. The information of the amount of household e-waste comes from the Mor Phor 2 Form, and PONRE in Chonburi uses the information for analysis and visits the disposal sites to plan the household e-waste disposal."

The government official of the regional administration No. 3 gave the following comment:

"Ministry of Interior orders all local authorities to report the waste management through Mor Phor 2 Form filled in by local officers. The Mor Phor 2 Form will be linked in with the tables separating the types of solid waste, namely general waste, organic waste, recycled waste, hazardous waste, e-waste, and industrial waste. After asking the officers responsible for filling in the information, the filling is still incorrect. Some do not understand if it is e-waste or industrial waste. Some are still confused. Therefore, it is risky to take the information for analysis. It is a problem of the public information."

As for Chonburi, Chonburi PAO was assigned as the principal agency responsible for HHW management in the areas of LAOs in Chonburi. LAOs must report the amount of HHW to Chonburi PAO on the 15th of each month based on the report form of the amount of HHW according to the letter of Chonburi Province No. Chor Bor 0023.3/Circular 1560 dated March 7, 2019. The information recorded in the Mor Phor 2 consisted of types and amounts of household e-waste (e.g., lamps, dry cell/battery, electronic equipment) and HHW such as spray cans and other contaminated materials (e.g., toilet cleaner bottle, expired medicine bottle, and used lubricant packaging). As for the responsible person/coordinator and telephone number, the follow-up of the information on HHW ensured correct and up-to-date information on the amount of e-waste to use to plan the budget on e-waste management of Chonburi PAO.

That was by the officer of local administration No. 1, who gave the following comment:

"*Chonburi PAO collects the amount of hazardous waste and household e-waste. It divides the types into the lamps, dry cell/batter, electronic equipment, spray can, and other contaminated materials by assigning local authorities to send the information to Chonburi PAO to serve as basic information in formulating the budget for e-waste disposal. We have asked 4-5 disposal companies about the fees of e-waste disposal. The disposal fee for sorted waste is approximately 10,000 baht/ton and for non-sorted waste is approximately 15,000 baht/ton."*

3) Follow-up and inspection of complaints on e-waste management

From the documentary study and the interviews, in the case of complaints on e-waste and HW management in Chachoengsao, Chonburi, and Rayong, the residents in trouble could place complaints through the agencies receiving complaints in the provinces, such as Provincial and district/municipal Damrongtham Centers, REO 13 (Chonburi), PONRE, Provincial Industry Office via various channels of the particular agencies receiving complaints such as Website, hotline, e-mail, submission of the letter in person, Fax, and Application. When the agencies received the complaints and the issues could be solved, the agencies receiving the complaints would notify LAOs and other relevant agencies in the province to jointly inspect the facts, problems, causes, and guidelines to solve the problems. In addition, prevention of recurring problems to solve the problems of the complainants and the people with maximum urgency and efficiency. In the case of the complaints on the environment and the inspection of the environmental quality such as water quality, dust, and soil, the leading agencies related to inspection of facts in the areas included REO 13 (Chonburi), PONRE. Between 2017-2019, Chonburi had 11 cases and eight cases of the most complaints on hazardous waste and solid waste, followed by Chachoengsao with eight cases and four cases respectively, and Rayong with three cases and one case respectively (Regional Environment Office 13 (Chonburi), 2018a, 2019a, 2020a) as summarized in Table 4.13.

Table 4.13 The Number of Complaints on Hazardous Waste and Solid Waste in Chachoengsao, Chonburi, and Rayong in the Budget Years 2017-2019

Provinces	**Budget year 2017[1]**		**Budget year 2018[2]**		**Budget year 2019[3]**		**Total (complaint issues)**	
	Oct. 2016-Sep. 2017		**Oct. 2017-Sep. 2018**		**Oct. 2018-Sep. 2019**			
	Hazardous waste	**Solid waste**	**Hazardous waste**	**Solid waste**	**Hazardous waste**	**Solid waste**	**Hazardous waste**	**Solid waste**
Chachoengsao	-	1	5	-	3	3	**8**	**4**
Chonburi	7	1	2	7	2	-	**11**	**8**
Rayong	-	-	1	1	2	-	**3**	**1**

Source: 1 Regional Environment Office 13 (Chonburi), 2018a
2 Regional Environment Office 13 (Chonburi), 2019a
3 Regional Environment Office 13 (Chonburi), 2020a

Note: Each complaint may have more than one issue

Moreover, the results of the documentary study and the interviews revealed that the complaints on e-waste in Chachoengsao, Chonburi, and Rayong between 2019-May 2020 were foul smells from the factories/companies producing and disposing of e-waste and causing troubles to the residents living near the factories. The reasons were that the factories did not install an air pollution treatment system (Wet Scrubber) or the air pollution treatment system was not ready to function. In addition, leaked dust filters, faulty air ventilators, and wastewater discharge to the external environment around the factories were found too. These problems were often found in Chonburi and Chachoengsao, as summarized in Table 4.14.

Table 4.14 Examples of Follow-up and Inspection of Complaints on E-Waste in Chachoengsao and Chonburi between 2019-May 2020

Topics of complaints (from the agencies receiving complaints)	Follow-up and inspection of complaints
Operation of Fongkai Electronics Technology (Thailand) Co., Ltd. (Chonburi Provincial Industry Office)[1]	December 20, 2019 Joint inspection of facts with Chonburi Damrongtham Center, Chonburi Internal Security Operations Command, Chonburi Provincial Industry Office, Chonburi Provincial Health Office, Phan Thong District and Nong Hong SAO following the complaints on the operation of Fongkai Electronics Technology (Thailand) Co., Ltd. located at Nong Hong Subdistrict, Phan Thong District, Chonburi that there was import of illegal machinery, expansion of factory without permit, and discharge of wastewater outside in the area of the factory. According to the inspection, the company had permit to produce mold for computer parts. The operation was by the permit. The warehouse was under construction with a construction permit from Nong Hong SAO, and no action from the complaint was found. The team of inspecting officials advised the entrepreneur to operate with caution not to cause problems and trouble to the surrounding residents.
Problems of foul smell from operation of Polythai Resources Co., Ltd. (Chonburi Provincial Industry Office) [1]	March 11, 2020: The Provincial Office of Natural Resources and Environment Chonburi went on the field inspection in collaboration with Chonburi Provincial Industry Office, Bo Thong District, Thadtong SAO, Thadtong Subdistrict Headman, and Moo 4 Village Headman. Following the complaint, the local people received a foul smell from Polythai Resources Co., Ltd. on the crushing of all electronic and plastic parts, the factory operation type three, category 106. From the field inspection, the factory conducted some operations. It stopped the operation of plastic melting but assigning workers to sort and prepare plastic scraps for the production process of the plastic resin in building no. 1. That was the area of installing the machine for plastic melting, with partly covered walls, and with the installation of air pollution treatment system or Wet Scrubber which was not in ready condition to function due to the wastewater in the system. Moreover, in the building no. 3 where plastic melting took place, the machine for plastic resin melting was installed without an air pollution treatment system which might cause a foul smell to the outside environment. Chonburi Provincial Industry Office as a competent official, according to Factory Act B.E. 2535 (1992), would order the improvement or the suspension of operation to solve the problems.

Topics of complaints (from the agencies receiving complaints)	Follow-up and inspection of complaints
Problems of foul smell from the operation of Fu-I Electronics & Plastic Recycle Company Limited in Chachoengsao (Damrongtham Center in Chachoengsao)[2]	Fu-I Electronics & Plastic Recycle Company Limited located at Plaeng Yao District, Chachoengsao operated the factory category 106 crushing with melting oven. May 10, 2019 Plaeng Yao District conducted the inspection and found the following 1) The material used for melting did not go through the process of separating plastic from copper, so it generated a foul smell and 2) Due to some decay, there were three spots of the leaked treatment room. So, Plaeng Yao District orders the suspension of operation for rectification. June 6, 2019 PCD and Provincial Office of Natural Resources and Environment Chachoengsao inspected the complaint again. September 11, 2019 Plaeng Yao District received the complaint that people were affected by chemical foul smell and went to inspect the factory. The District found that the factory's operation caused a foul smell similar to chemicals due to leaked filter bag and faulty air ventilator, so ordered the factory's closure.
Problems of foul smell from melting and wastewater from crushing from the operation of Ney Sky Metal Co., Ltd. in Chachoengsao (via Social Media)[2]	New Sky Metal Co., Ltd. located at Ko Khanun Subdistrict, Phanom Sarakham District, Chachoengsao operated seven factories under category 105 and nine factories under category 106 in total 16 permits within the same compound with the operation of disassembling of electrical and electronic devices and crushing of electrical and electronic parts August 14, 2019 The Province inspected the factory and found that the factory's operation used water to separate the crushed materials with one metal melting oven with electronic equipment using coal as fuel. There was the drainage of coolant from the oven to the puddle in the factory. There was a residue pile from crushing at the side of the puddle, which risked hazardous substance contamination in the environment and into underground. Chachoengsao PAO sought assistance from REO 13 (Chonburi) to analyze the water quality of shallow ponds of villagers at Moo 9, Ko Khanun, Phanom Sarakham District.. September 6, 2019 The MOU was signed between all sectors concerned by ordering the factory to improve and solve environmental impact and people's health and the factory closure during improvement. October 2, 2019 Due to the case, the Provincial Office of Natural Resources and Environment Chachoengsao proposed to Chachoengsao Province to assign Phanom Sarakham District to issue the order to establish a committee to solve the problems of the factories category 105 and category 106 in Ko Khanun Subdistrict.

Topics of complaints (from the agencies receiving complaints)	Follow-up and inspection of complaints
Problems of foul smell from melting and wastewater from crushing from the operation of Ney Sky Metal Co., Ltd. in Chachoengsao (via Social Media)[2]	October 31, 2019 The Provincial Office of Natural Resources and Environment Chachoengsao reported the results of the inspection of the contamination of heavy metals by PCD to relevant agencies within Chachoengsao

Source: 1 Provincial Office of Natural Resources and Environment Chonburi, 2020
2 Provincial Office of Natural Resources and Environment Chachoengsao, 2020a

For each complaint, advice was given to problem solutions and follow-up on solving the agencies' problems receiving the complaints and the agencies responsible for the joint follow-up of the complaints. The problems after the inspection of facts included: 1) No report on solutions of the problems to agencies responsible for the joint follow-up of the complaints, and 2) No appointment with all agencies responsible for the joint follow-up of the complaints to come for reinspection after the dateline to solve the problems.

The interviews were as follows:

"*Complaints are done via telephone to our REO 13 (Chonburi), photos sent via line, or complaints to PONRE who will coordinate with REO 13 (Chonburi). For the inspection of complaints, the PONRE will coordinate with us. For environmental inspection such as water and soil, the PONRE must conduct the inspection. The survey on the collection of waste was conducted before the field trip. Then, discussions and planning on the problems and scope, such as if there are dead fish in this canal, how far it goes. Afterward, the position is identified and collected. Mostly, the work finishes in a day. When we are notified and coordinated by the PONRE, we will set the appointment and bring equipment with us. Mostly, the PONRE will have initial information of the types of problems, and initial telephone conversations are done on what to collect*" (Government official of the regional administration No. 1).

"Villagers file complaints to the Provincial Damrongtham Center, who in turn notifies the PONRE. For some complaints, our REO 13 (Chonburi) is invited for inspection as well. Upon inspection of e-waste factories, we find that, in some factories, the conditions are not appropriate. As officers inspecting with the province and Provincial Damrongtham Center team, we order improvement within the set time frame. Once the time frame is reached, most factories do not set up appointments with all agencies for inspection. Each agency follows up. If we do not know, the case goes silent, and there is no notification of the inspection results. Finally, the case is silent with no further coordination" (Government official of the regional administration No. 1).

"*Complaints can be sent to our Provincial Office of Natural Resources and Environment Chachoengsao or Provincial Damrongtham Center. Damrongtham Center will send the case to REO 13 (Chonburi). Sometimes, the same case is sent from many agencies such as Damrongtham Center, PCD, Chief Executive of the SAO, district-chief officer, and PSC 111. Most complaints from the villagers are the foul smell from the e-waste melting factory. If the factory operates, villagers cannot stay at home due to a foul smell. Our PONRE will coordinate with REO 13 (Chonburi) to come for an inspection. The inspection can only be done for soil. The smell is never inspected. There is no mercury inspection while melting. Once we receive the information, we send it to the Provincial Office of Local Administration, who may notify the villagers. Up till now, it was not as serious as smell. There might be water sources and soil contaminated with heavy metals and might exceed the standards without causing trouble or diseases. However, we are not sure"* (Government official of the regional administration No. 3).

"*The cases of complaints on e-waste are mostly foul smell and wastewater*" (Government official of the regional administration No. 4).

"For the last three years, Chonburi Provincial Industry Office recorded the complaints between 2017-2019, mostly from sorting factories category. We were notified of the e-waste container, and we went to the area. We coordinated the inspection with Internal Security Operations Command, SAOs, and local police. If it was found to be e-waste, we would record and order the forfeiture of the waste. If the area were closed in a building already, we would keep it there under the owner's responsibility. With the information we received, such as the information source, if the operation were illegal, except it was disposed of in deserted public places, we would report to the police for investigation. When the police finished collecting the information, they would send the information to the prosecutor. Further action ensued following the court's judgment. For example, what agency was assigned for disposal, whether Chonburi Provincial Industry Office or Department of Industrial Works? If Provincial Industry Office were responsible for disposal, there would be rules and regulations such as mid-price bidding for the agency to dispose of waste. We used to send the waste to the factory category 106 in Saraburi for disposal. Disposal sometimes depended on factory owners, or entrepreneurs, or bidders, which depowered on pricing" (Government official of the regional administration No. 5).

"In responsible are agencies an, there are some complaints on sorting of e-waste especially the melting of metal boards which cause a foul smell. Sometimes depended Chachoengsao Provincial Industry Office goes to inspect if the factory complies with the attached permit. Chachoengsao Provincial Industry Office will order the suspension of the operation and forfeit the raw materials. Chachoengsao Provincial Industry Office must collaborate with the Department of Industrial Works as the Provincial Industry Office does not have the authority to close down factories. In the areas, almost all factories category 106 have the problems of the foul smell that the Officers monitor and control. Most are factories owned by Chinese,

so there is not much cooperation" (Government official of the regional administration No. 6).

"During the first three months of 2020, Rayong Provincial Industry Office did not receive complaints on e-waste. From the history of the factories, there was no complaint about e-waste. Most problems included wastewater and foul smell. Complaints can be made by telephone, and officers from various units will be dispatched immediately. When local people place complaints, factories do not know. We do not have to notify the factories in advance. We can go and inspect the factories as it is our duty" (Government official of the regional administration No. 7).

4.2.3.4 Improvement for appropriate operation

The improvement for proper operation (Act) in this study consisted of motivation to the people and cooperation with the private sector. The details of the study results are as follows:

1) Motivation to the people

The information compilation in the areas, the observation in the areas, and the interviews revealed that LAOs motivated the people of the three provinces to take an interest and realize the importance of sorting e-waste from general waste. Since household (at origin) and take e-waste to discard in the drop-off points at various locations designated by LAOs. However, LAOs and other relevant agencies in the areas such as REO13 (Chonburi) and PONRE still faced problems in the areas. Those problems included: 1) Non-valuable e-waste was discarded and mixed with general waste which was in dark blue bins (general waste), 2) General waste was discarded in the containers for e-waste at drop-off points, and 3) Some drop-off points of e-waste were seldom used or damaged such as broken glass in the box in the collecting cupboard (Figure 4.15). The problems are derived from many reasons. Drop-off points of household e-waste were situated far from communities, so it was not convenient for people to go and discard the waste. People did not know where the drop-off points of household e-waste were located, or the containers of household e-waste were not sufficient.

That was by the interview of the officer of the local administration No. 4 who stated the following:

> *"E-waste management must be conducted at origin by sorting. Nevertheless, sorting e-waste does not provide sufficient motivation. Drop-off points are located far from communities. In the past, Chonburi Provincial Office for Local Administration used to place bins for hazardous waste to encourage the sorting of e-waste, but people discarded general waste instead. So, in the end, the agency had to take the bins for hazardous waste back."*

Similarly, the IEAT officer No. 1 said the following:

> "*There are only a few drop-off points in communities. Each point is far from the others. So, people do not dispose of their waste at the designated point."*

General Waste Disposed in the Container for Hazardous Waste

Drop-off Point of E-Waste with Little Use

Damaged Drop-off Point of E-Waste

Figure 4.15 Problems of E-Waste Management Found in the Three Provinces

LAOs and other agencies relevant to the areas, such as REO 13 (Chonburi) and PONRE, viewed that people are motivated to take interest and realize the importance of sorting e-waste at the origin and transfer to drop-off points the locations as designated by LAOs to accommodate disposal. The recommendations are summarized as follows:

(1) Relevant government agencies or local authorities should conduct public relations through advertising media via television and social media to attract people's interest, such as YouTube, Line. That provides knowledge on e-waste management such as local drop-off points, types of e-waste, correct methods of e-waste sorting, recyclable valuable e-waste, and impact from improper e-waste management. At present, the advertising media and online media had a significant influence on people in society, such as using film stars to make public relations on management and using Line to provide knowledge on waste management, as shown in the following interviews:

"*The most successful channels for public relations on waste are television, social media, and visits to communities as some residents do not have access to social media*" (Officer of the local administration No. 1).

"*The use of television and film stars in the public relations on waste will attract people's interest than brochures. And the social media and the advertisement constitute good motivation*" (Government official of the regional administration No. 1).

"*The campaign on sorting of hazardous waste or e-waste requires the mainstream media to encourage trend and not local media. To succeed, the campaign on plastic bags, for example, requires film stars*" (Government official of the regional administration No. 2).

"*To provide knowledge on e-waste management, the government should use television, YouTube, electronic media. Brochures need to be put in public places. If the brochures are disseminated, people will throw them away. So, the message must not belong; people will not like it. If film stars campaign, young children will like them. If not, no one is interested*" (Government official of the regional administration No. 7).

"Our agency does not have media on e-waste management directly. We produce printing media, social media, Line, television, Facebook, Twitter, such as plastic bags that constitute the topic of interest. The media will repeat the topic. Television is the media that can reach most target groups because many people in the rural areas do not have access to mobile phone" (Government official of the central government No. 1).

"Use channels to publicize waste such as television, or Line by using short messages such as old gloves should not be discarded or the disposal location should be notified" (IEAT officer No. 4).

(2) LAOs should provide more containers for e-waste, determine more locations of the drop-off points, and set up the date and time for e-waste collection to allow people to specifically separate e-waste for convenient disposal.

That was in line with the IEAT officer No. 1, who gave the following opinion:

"More drop-off points for e-waste should be set up for people's convenience and more public relations on the locations of the drop-off points."

Similarly, the IEAT officer No. 4 gave the following opinion:

"LAOs should specify the date and time of e-waste collection. The collection should also be right on time. More drop-off points of e-waste should be set up and more public relations to ensure acknowledgment by all."

It was in line with the IEAT officer No. 3, who gave the following opinion:

"The locations of the drop-off points of e-waste, the determination of the separate garbage bins, and the set a date for collection must be seriously done as in Japan. If the disposal is not on the right date or not of the right type, people should be fined with the fine rate sent to their house."

2) Cooperation with the private sector

LAOs should forge cooperation with the private sector in the EEC areas of Chachoengsao, Chonburi, and Rayong regarding the processes of collection and disposal of household e-waste. The observation results revealed that LAOs in Chachoengsao, Chonburi, and Rayong received cooperation from private entrepreneurs in the process of e-waste collection. The private entrepreneurs provided locations where many service recipients were already as the locations to install drop-off points. The drop-off points consisted of gas stations, convenience stores, construction material centers, academic institutions (Figure 4.5). The information compilation in the areas and the interviews revealed that when collecting household e-waste of each LAO was sufficient for disposal, most PAOs and municipalities hired private companies to transfer and dispose of the waste outside the areas in Saraburi and Nakhon Sawan provinces.

Consequently, PAOs and municipalities had additional expenses of e-waste transfer for disposal outside the areas. Moreover, in the three provinces of EEC, there were legal factories for sorting and recycling of e-waste, with the factories category 105 (sorting factories or landfills) and the factories category 106 (recycling factories) located within and outside the industrial estates (Table 4.9). Therefore, the local factories should provide incentives to LAOs and private companies hired to transfer e-waste to send the e-waste to the legal factories for disposal situated in the EEC areas. They would also reduce costs for LAOs' disposal of e-waste, such as facilitation to transfer waste to disposal factories/companies, public relations of disposal factories/companies, and locations, methods, and technology.

That was by the interview with the officer of the local administration No. 2 who said the following:

"From the locations for disposal of hazardous waste in Rayong, the waste is sent to private company's disposal facilities in Saraburi, Ratchaburi, and Sa Kaeo. However, if there is a disposal company in the industrial estate, the disposal fees will be lower."

The government official of the local government No. 3 said the following:

"E-waste disposal is the responsibility of the disposal company or the producers themselves who will have to turn to the local administration or PAOs who collect e-waste. If the local administration agrees, then we can operate the disposal. If not, that is the end."

Moreover, the entrepreneurs of e-waste sorting and recycling factories must operate legally and with academically correct e-waste sorting and recycling methods similar to e-waste sorting and recycling factories within industrial estates, such as Pinthong Industrial Estate, Amata City Industrial Estate, and WHA Chonburi Industrial Estate. The factories are primarily Japanese factories that invest in Thailand using efficient technology of e-waste sorting and recycling. The operation of the factories is under the supervision and revocation of operation by the Industrial Estate Authority of Thailand according to the Industrial Estate Authority of Thailand Act No. 5 B.E. 2562 (2019), Factory Act B.E. 2535 (1992), Hazardous Substances Act B.E. 2535 (1992) and other relevant laws. Moreover, factories must comply with measures to prevent and solve the environmental impact of the industrial estates to reduce the pollution problems on the environment and communities surrounding the factories. However, the number of sorting and recycling factories of e-waste situated in each industrial estate is still small and not sufficient for e-waste management services for the manufacturers of EEE within the industrial estate. The interviews were as follows:

"*Area-specific, e-waste disposal factory should be set up because the origin of the waste is in the area. The purple zone should be set up in the industrial estate under IEAT's supervision due to stringent measures. It is better to take*

care of the environment and the factories than being dispersed outside" (Government official of the regional administration No. 1).

"*E-waste sorting and disposal factories should be promoted in industrial estates so that they can control disposal system more easily than factories outside industrial estates*" (Government official of the regional administration No. 2).

"*If factories producing and discarding e-waste are situated in industrial estates, management will be better due to the supervision of Industrial Estate Authority of Thailand Act (No. 5) B.E. 2562 (2019)" (*Government official of the regional administration No. 7).

*Factories were generating e-waste, and factories sorting and recycling e-waste should be located in industrial estates in large numbers as IEAT monitors these factories. Industrial Estate Authority of Thailand Act (No. 5) B.E. 2562 (2019) and Factory Act B.E. 2535 (1992) also supervise them" (*Government official of the central government No. 5).

"*There are only a few disposals or recycling factories in the industrial estate where the company is situated. There is a need for the government to support the setting up of more proper e-waste recycling companies or factories situated near the factories or in the same industrial estate as the producing factories*" (Company representative No. 1).

Similarly, the company representative No. 2 said

"*There are only a few factories for disposal and recycling of e-waste in the industrial estate where the company is situated*."

"*IEAT and the local administration control and inspect the operation of the companies through the report on the measures to prevent and solve the problems of environmental impact. In addition, the measures follow up and inspect environmental impact and tripartite meetings to receive information, raise questions, and determine the follow-up and solutions to problems in case of environmental and health impact from e-waste management in the location where the company is situated. However, there is no complaint from the community on the company's operation*" (Company representative No. 3).

"*Our company sorts the types of e-waste mainly to increase value. The parent company from Japan decided to set up a company in the industrial estate under the conditions, control, and supervision of IEAT to reduce environmental impact. An expert from the parent company (Japan) came to supervise and provide knowledge to employees on the methods of sorting and sending employees to participate in the activities arranged by the government to enhance knowledge and laws that need to be complied with*" (Company representative No. 5).

For the private companies producing EEE, there should be motivation to develop environmental-friendly products and easy disposal of product waste (expiration) to reduce costs and difficulties in e-waste management. There must also be responsibilities in collection and reuse as much as possible and appropriate. Academically correct disposal of e-waste based on the principle of Extended Producer Responsibility (EPR) as shown in the following interviews:

"Everything goes back to responsibility. One needs to be aware of one's responsibility and not leaving the burden to the disposal factory. Products must be produced with quality, long working life, and must not be replaced often" (Government official of the regional administration No. 5).

"It is best to sort waste at origin and reduce household consumption. Nevertheless, as people will not reduce consumption, producers will have to

produce products efficiently, with long working life, and responsibilities towards their products" (Government official of the regional administration No. 7).

"The principles of EPR should be adopted, meaning extend responsibilities of producers or increase responsibilities of producers. Producers of EEE in Thailand must design more environmental-friendly products which will reduce hazardous substances in e-waste and reduce e-waste management" (Government official of the central government No. 5).

"Waste management of the local administration is not complex. It suffices to respect duty. The garbage bins are already in three colors for three bins. One more bin should not be difficult. It suffices to persuade people to sort e-waste like municipal waste. What should the local administration do to enable waste such as lamps, dry cells, telephones to come to us in large amounts? It is a big question. It is divided into at origin by which the local administration must collaborate with the private sector to find a way to drive and motivate people. At the destination, the private sector should publicize the buy-back of the waste and not only focus on the sale. They must have their own CSR. They should show the picture. If we sell lamps, dry cell, telephone, television, and computer, we must repurchase them every time as well. The value of the products should include disposal costs. They should not claim that they do not have money for disposal" (Officer of the local administration No. 2).

"The buy-back system of electrical equipment waste of producers or owners of the product waste in the household e-waste management system should reduce the amount of e-waste" (Government official of the regional administration No. 6).

4.2.4 Results from the Operation of Household E-Waste Management (Product)

The documentary study, the information compilation in the areas, the observation in the areas, and the interviews revealed that the results of the operation of household e-waste management (Product) in Chachoengsao, Chonburi, and Rayong were by the goals as specified in the Action Plan "Clean Province" for 2019 and 2020 of MOI. They included: 1) Establishment of drop-off points of HHW (including e-waste) in all communities, 2) Sorted and collected household e-waste at drop-off points as specified by LAOs, and 3) Amount of household e-waste with more academically correct sorting and transfer for disposal. Details are as follows:

4.2.4.1 Establishment of Drop-off Points of HHW in All Communities

The information compilation in the areas, the observation in the areas, and the interviews revealed that in all LAOs in Chachoengsao (109 LAOs), Chonburi (99 LAOs), and Rayong (68 LAOs), drop-off points of HHW were established in all communities, at least one drop-off point per village or community. It achieved the goals as specified in the Action Plan "Clean Province" 2019. It accorded with the information on establishing the number of drop-off points of HHW (including e-waste) in the communities of five municipalities in Chachoengsao, Chonburi, and Rayong, which were used as representatives in this study. In the communities of the five municipalities, drop-off points were set up to collect HHW (including e-waste) in all communities. There was more than one drop-off point per community (two to four drop-off points/community) or 100% of the communities in the particular municipalities (Figure 4.5), as shown in Table 4.15. The interviews were as follows:

> *"LAOs have set up one drop-off point per one community to collect HHW and residents bring e-waste such as lamps, dry cells to dispose of in the boxes separating the waste"* (Government official of the central government No. 1).

"In each LAO, there are measures to promote people to sort e-waste at the origin. One drop-off point is specified in each village. Officials will collect the e-waste according to the determined time by delivering the collected e-waste to the Rayong Integrated Solid Waste Management Center of Rayong PAO for further disposal in factories in the rural areas" (Government official of the regional administration No. 4).

"Every LAO must set up 100% drop-off points for HHW in all communities" (Government official of the central government No. 3).

"Chonburi PAO has set up at least one drop-off point per one community for HHW or 100% since the end of 2017" (Government official of the local government No. 4).

Table 4.15 Number of Drop-off Points in Some Municipalities during the Budget Year 2019

Municipalities	**Number of drop -off points for HHW**	**Number of communities**
Chachoengsao Town Municipality, Chachoengsao	23 points	21 communities
Laem Chabang City Municipality, Chonburi	52 points	25 communities
Saen Suk Town Municipality, Chonburi	24 points	23 communities
Rayong City Municipality, Rayong	60 points	29 communities
Thap Ma Subdistrict Municipality, Rayong	36 points	8 communities

4.2.4.2 Sorted and Collected Household E-Waste at the Drop-off Points as Specified by LAOs

The information compilation in the areas, the observation in the areas, and the interviews revealed that the LAOs in Chachoengsao, Chonburi, and Rayong prepared containers for HHW. The containers were in the form of collection cupboards at the drop-off points of HHW at different locations specified by LAOs to ensure sorting of different types of HHW and facilitate the collection and disposal. The types of HHW

could be divided into four groups, namely 1) Lamps, 2) Dry cell and battery, 3) Electrical and electronic equipment such as mobile phone and peripheral devices, and 4) Spray cans and other contaminated materials, such as toilet cleaner bottles, expired medicine bottle, packaging of lubricant or contaminated material of used lubricant. The e-waste was divided into three groups, namely 1) Lamps both long (straight) and short (compact) such as fluorescent bulb, 2) Dry cell and battery such as a chargeable battery, mobile phone battery, and 3) Electrical and electronic equipment, such as mobile phone and peripheral devices, television screen. That was by the information from the recording of household e-waste classified by types of the three municipalities in Chachoengsao, Chonburi, and Rayong during the budget years 2017-2019. In each municipality, the amount of sorted e-waste was approximately 1,500-2,000 kgs per year. Most e-waste was lamps, or approximately 82% (Figure 4.16). The amount of sorted e-waste in Laem Chabang City Municipality, Chonburi, tended to increase every year for the past three years between 2017-2019, as shown in Table 4.16. It was in line with the government official of the central government No. 3 who said the following:

"Drop-off points are set up to collect HHW and sort different types of e-waste such as dry cells, light bulbs, mobile phone waste, and batteries. Light bulbs were mostly found".

Government official of the local government No. 2 said the following:

"LAOs in Rayong set up drop-off points to collect HHW in every community."

Straight Fluorescent Bulbs

Compact Fluorescent Bulbs

Figure 4.16 Straight and Compact Fluorescent Bulbs

Table 4.16 Amount of Sorted and Collected Household E-Waste at Drop-off Points in Some Municipalities during the Budget Years 2017-2019

Municipalities / Budget years	**Amount of collected household hazardous waste (kgs)**					
	Lamps	**Dry cells and batteries**	**Electrical and electronic equipment**	**Spray cans and other contaminated materials**	**Total of e-waste (1)+(2)+(3) (% of household hazardous waste)**	**Total**
	(1)	**(2)**	**(3)**	**(4)**		
Chachoengsao Town Municipality, Chachoengsao[1]						
2017	1,363.59	187.31	82.00	139.20	**1,632.90 (86.96)**	**1,772.10**
2018	1,325.70	109.35	68.00	90.30	**1,503.05 (94.33)**	**1,593.35**
2019	1,173.46	70.04	76.00	62.90	**1,319.50 (95.45)**	**1,382.40**
Laem Chabang City Municipality, Chonburi[2]						
2017	1,618.00	120.00	260.80	94.20	**1,998.80 (95.50)**	**2,093.00**
2018	1,668.09	120.38	164.45	700.44	**1,952.92 (73.60)**	**2,653.36**
2019	1,792.76	111.68	206.93	276.71	**2,111.37 (88.41)**	**2,388.08**
Rayong City Municipality, Rayong[3]						
2017	1,241.14	540.07	-	96.60	**1,781.21 (92.14)**	**1,877.81**
2018	1,171.14	285.71	-	111.70	**1,456.86 (94.33)**	**1,568.55**
2019	1,111.71	331.94	-	95.90	**1,443.66 (95.45)**	**1,539.55**

Source: 1 Chachoengsao Town Municipality, 2020a

2 Laem Chabang City Municipality, 2020

3 Rayong City Municipality, 2020a

4.2.4.3 Amount of Household E-Waste with More Academically Correct Sorting and Transfer for Disposal

The documentary study, the information compilation in the areas, and the interviews found the guideline for PAO to take significant responsibilities in transferring HHW for academically correct disposal. As of September 2020, only Rayong PAO was ready to handle household e-waste from various LAOs in Rayong areas to the Rayong Integrated Solid Waste Management Center and could be sent for disposal outside the areas by private companies. The amount of e-waste was divided into three main groups, namely 1) Lamps, 2) Dry cells and batteries, and 3) Electrical and electronic equipment that was sent for disposal based on academically correct methods. The amount of e-waste for disposal increased in 2018 and 2019 equaled 4,862.50 kgs and 11,466.50 kgs, respectively (there was no information recording of the amount of e-waste in 2017). Most were lamps, as shown in Table 4.17. For Chonburi, the local administration responsible for collection and transfer for disposal of HHW by themselves consisted of four agencies, namely 1) Laem Chabang City Municipality, 2) Chaoprayasurasak City Municipality, 3) Pattaya, and 4) Bo Win Subdistrict Municipality. As for Chachoengsao, Chachoengsao Town Municipality was responsible for collecting and transferring HHW for disposal by itself. Most of LAOs with the potential for e-waste disposal by themselves would hire a private company to transfer e-waste for proper disposal outside the areas when the collected household e-waste was enough. For example, the amount of collected e-waste (October 2019-August 2020) for disposal by Chachoengsao Town Municipality equaled 2,040 kgs (Pollution Control Department, 2020d). That was by the government official of the central government No. 1, who said the following:

> *"PAO will be responsible for the collection of e-waste and disposal by hiring the legitimate private company for disposal of e-waste."*

The government official of the central government No.3 said the following:

"PAO has the main duty of disposal of e-waste. At Rayong PAO, there is a storage center of HHW within the Rayong Integrated Solid Waste Management Center."

The government official of the regional administration No. 4 gave the following opinion:

"The collected HHW may not contain e-waste. Some months, there may be a lot. There must be a lot of this e-waste to make the collection worthwhile. It thus has become the duty of LAO to collect in large quantity and deliver to PAO and PAO will, in turn, hire private company for further disposal."

Table 4.17 Amount of Household E-Waste for Disposal by Rayong Integrated Solid Waste Management Center between 2018-2019

Types	Amount of HHW for disposal (kgs)	
	2018	**2019**
1. Lamps	4,323.00	11,405.50
2. Dry cells and batteries	378.00	46.00
3. Electrical and electronic equipment	161.50	15.00
4. Spray cans and other contaminated materials	28.40	65.50
Total e-waste	**4,862.50**	**11,466.50**
(% of HHW)	**(99.42)**	**(99.43)**
Total HHW	**4,890.90**	**11,532.00**

Source: Rayong Integrated Solid Waste Management Center, 2020a

4.2.5 Impact form E-Waste Management (Impact)

The impact of e-waste management in EEC in Chachoengsao, Chonburi, and Rayong (Impact) impacted the environment and people's health, social impact, and economic impact. The details of the study results are as follows:

4.2.5.1 Impact on Environment and People's Health

From the documentary study, the information compilation in the areas, and the interviews, the inappropriate household e-waste management caused leakage of hazardous substances and heavy metals from parts of e-waste. It contaminated the air, soil, surface water source, and ground waste source. That appropriate e-waste management included disposal of e-waste mixed with general solid waste, clandestine dumping in public places, improper disassembly and recycling of e-waste (e.g., open burning and acid to separate valuable metals), poor operation of e-waste treatment and disposal plants. The accumulated heavy metals (i.e., mercury, cadmium, lead, arsenic, and copper) in the environment would impact the ecosystem and people's health before dismantling community areas in Bangkok and the country's northeast. The areas were 1) Sua Yai Uthit Community, Chatuchak District, Bangkok 2) Khok Sa-at Subdistrict, Khong Chai District, Kalasin 3) Daeng Yai Subdistrict, Ban Mai Chaiyaphot district, Buri Ram and 4) Ban Pao Subdistrict, Phutthaisong District, Buriram. Some heavy metals were contaminating soil in some areas, such as lead, zinc, copper, which exceeded the soil quality standard for agriculture and habitation in Thailand. According to Notification of the National Environmental Board No. 25 B.E. 2547 (2004) and the Intervention Value, they indicated that the concentration of some heavy metals in the soil was at a deep level and required treatment (Saijai Withaya-Anumas, 2017; Seelawut Damrongsiri, 2015; Sujitra Vassanadumrongdee, 2015). The interviews were as follows:

> *"In the provinces, some entrepreneurs will sort household e-waste by outdoor burning, dispose e-waste from disassembly of WEEE in deserted areas or dump it in community pools. The disassembled parts of e-waste are mixed with heavy metals. Hazardous substances and heavy metals may leak and impact the environment, such as at Khong Chai District, Kalasin, and Khueang Nai District, Ubon Ratchathani. In January 2019, PCD found the contamination of heavy metals in the soil where the areas of disassembling of e-waste exceeded the standards such as lead, zinc, copper, arsenic in natural water sources, groundwater sources, and silt. Heavy metals were found to exceed the standards, such as lead, cadmium, copper, arsenic, and*

manganese. As for waste pond with disposal and burning of waste, contamination was found with copper, lead, nickel, and arsenic, exceeding the standards and foul smell. Based on the information of the health impact from e-waste management in 2011 in Khok Sa-at District, Khong Chai District in Kalasin, lead in the blood of 19 out of 132 children with less than five years of age had exceeded the standards " (Government official of the central government No. 1).

"Private entrepreneurs managing e-waste do not take into account the impact on the environment such as dumping of non-valuable e-waste which consists of the hazardous substance in the environment. It accumulates hazardous substances in the food chain which will, in turn, become hazardous to people" (Government official of the central government No. 4).

"*Inefficient e-waste management will impact the environment. Improper disposal will contaminate the environment. In e-waste, there is a component of heavy metals"* (IEAT officer No. 1).

"*With inefficient e-waste management, it will impact the environment due to chemicals in the products. We cannot know what they are or how dangerous they are, such as a fluorescent lamp. If it is not properly discarded, the mercury will be hazardous to health*" (IEAT officer No. 3).

"*E-waste will be mixed with general waste. Without a good disposal system, there will be contamination in the environment, such as contamination of heavy metals, lead in the soil, and inevitably pose a danger to health. The next generation will have cancer because our generation is unaware of the danger of hazardous waste in e-waste*" (Government official of the regional administration No. 2).

"*Impact on health derived from the problems of e-waste management that used to take place in Khong Chai District in Kalasin and Buriram. However, not in EEC in which Department of Health used to collect samples of soil and water, and might not wish the same problem in other areas*" (Government official of the central government No. 4).

"If e-waste is not in a community, it will not generate residue, and the health of community residents is good. Unlike villages with the profession of improper disassembling of parts of e-waste in Buriram and Kalasin, people have cancer due to residue in a human body" (Government official of the central government No. 3).

"E-waste certainly impacts health. Due to the melted e-waste to extract some parts, or smoke from the melting, or welding, if the factories do not have their system to trap air pollution, it will be emitted to the environment. The high wind will cause a foul smell. Some residents living near the factories cannot bear the smell and have to move out. Certainly, it will impact the health of workers and residents in surrounding areas, such as headaches through a long period of inhalation. It impacts air quality. It also contaminates water, soil, and surrounding water sources. We have found the factories who bought back the type of Big Bag and common piles of CDs outdoor, various large-sized electronic devices, and old copper oven on the soiled ground outdoor" (Government official of the regional administration No. 1).

From the information compilation in the areas and the interviews, among the three provinces of EEC, Chachoengsao experienced the most problems of environmental impact from factories transforming used EEE. Factory owners were mainly Chinese because of the order of the Head of National Council for Peace and Order No. 4/2016 on the exception of the enforcement of the Ministerial Regulation for Overall City Planning for some types of establishments, including the establishment of factories category 105 and 106 on Ministerial Regulation B.E. 2535

(1992) issued under Factory Act as well. The order was adequate for one year from January 20, 2016, to January 20, 2017, covering all areas nationwide. As a result, there was a rapid increase in the number of e-waste sorting and recycling factories category 105 and category 106 in Chachoengsao areas, without considering the limitations of location or public participation of the community. That was in line with the government official of the regional administration No. 1, who said the following:

> "*Since 2016, the order of National Council for Peace and Order No. 4 by Section 44 stipulated that the sorting plants and landfills, and e-waste recycling plants types 105 and 106 could be located in any area not limited to the purple area. So, more plants of these types were set up near communities. Among the three provinces in the EEC, these types of plants were mostly located in Chachoengsao*."

Similarly, the government official of the regional administration No. 3 said the following:

> "*There were 40-50* e-*waste sorting and recycling plants set up within 1-2 years in Chachoengsao. It was by order of the National Council for Peace and Order which exempted the city plan. If it had not been permitted since NCPO, these plants would not have been set up. These plants would import e-waste through the customs for disposal not for recycling to obtain valuable materials but disposal through incineration. This type of melting plant with small investment all had the problems of foul smell. They were 100% Chinese investment with Thais as nominees. When problems arose, they just disappeared."*

In the past, the operation of factories caused an impact on environmental quality around the factories, such as soil, dust, wastewater, groundwater, and silt. The inspection results mostly found the number of heavy metals exceeding the specified standards and the problems of foul smell. The air pollution treatment system was out of order and faulty, without the Wet Scrubber

system to eliminate the smell, dust, smoke, or damaged dust filter bag, and a small number of ventilation ducts. It also ensured that the factories would solve the problems based on the recommendations of the government agencies who came for inspection, such as the PONRE, Chachoengsao Industry Office, REO 13 (Chonburi), or order the factory to suspend operation during improvement temporarily. The order for a factory to close to improve operation was under the authority of the Chachoengsao Industry Office. As for the Provincial Office of Natural Resources and Environment Chachoengsao and REO 13 (Chonburi), they had the duty to report the results of the inspection of environmental quality to other relevant agencies in Chachoengsao for acknowledgment which was in line with the government official of the regional administration No. 3 who stated the following:

> *"Provincial Industry Office had some authorities such as order to improve premises by installing meter or Scrubber. But it cannot order the closedown of factories. It must compile the case and send it to the Department of Industrial Works. As for the academic agency on the environment such as the PONRE and REO, they will jointly inspect, collect information, give advice, and report the results of the inspection to relevant agencies in the province for acknowledgment. But it may not solve the problems if the agency supervising the factory does not use the results to order the factory to take action for improvement."*

It was by the government official of the regional administration No. 6 who stated the following:

> *"In Chachoengsao area, the main problem is the foul smell from e-waste recycling factory type 106. Provincial Industry Office inspects the compliance with the permit based on the specified attached permit and orders the temporary suspension of operation for improvement or seizes raw materials. We recommend installing CCTV in front of the oven to see if the production process and raw materials are proper as specified in the permit. The installation of a meter at the treatment system of the air ventilation*

passage to see if, during melting, the smell and smoke treatment system is open or not. The cooperation with Department of Industrial Works is compulsory as Provincial Industry Office has no authority to order the factory to close down."

Examples of environmental quality impacts from the e-waste disassembly factory operation in Chachoengsao and the past operation show in Table 4.18.

The observation of the drop-off points of e-waste in Chachoengsao, Chonburi, and Rayong revealed that the household e-waste collected from the various drop-off points as specified by LAOs were mostly fluorescent lamps, car batteries, mobile phone batteries, mobile phone waste, and old, unused electrical and electronic equipment, such as mobile phone battery charger, battery charger, and ballas. Those e-waste parts contained hazardous substances and heavy metals, such as mercury, lead, cadmium, arsenic, beryllium, copper, lithium, Brominated Flame Retardants. They would pose risks to health for those who came into direct contacts with them, such as collectors of e-waste, those who incorrectly sorted e-waste for recycling, and those who worked in the manufacturing industry of electronic equipment, as in Table 4.19

Table 4.18 Examples of Environment Impact from the Operation of Disassembly Factories in Chachoengsao between 2018-May 2020

Factories	Impact on quality of environment												Operation
	Quality of environment	Contamination of heavy metals exceeding the standards											
		Ba	Cu	Pb	Zn	As	Mn	Ni	Total Cr	Cd	Se	Total Hg	
Ei Hui (Thailand) Company Limited, Plaeng Yao district Factory type 106	**Soil quality**												- PCD and REO 13 (Chonburi) collected the samples of soil, water, and air for the 1st time between June 5-7, 2018 and for the 2nd time between December 25-27, 2018 - On October 31, 2019, the Provincial Office of Natural Resources and Environment Chachoengsao reported the inspection results of contaminated heavy metals from PCD to relevant agencies in Chachoengsao for acknowledgement.
	Within factory												
	1st time (Jun. 2018)	/	/	/	/								
	2nd time (Dec. 2018)	/	/	/	/								
	Outside factory												
	1st time (Jun. 2018)		/	/	/	/	/						
	2nd time (Dec. 2018)		/	/		/	/	/					
	Dust From incinerator and residue from the factory who came to fill in the land (Dec. 2018)		/	/	/			/	/				
	Water quality												
	Wastewater from factory												
	1st time (Jun. 2018)				/			/		/			
	2nd time (Dec. 2018)									/	/		
	Soil surface around the factory (Dec. 2018)			/		/				/			
	2nd time (Dec. 2018)	/											

Factories	Impact on quality of environment												Operation
	Quality of environment	Contamination of heavy metals exceeding the standards											
		Ba	Cu	Pb	Zn	As	Mn	Ni	Total Cr	Cd	Se	Total Hg	
Ei Hui (Thailand) Company Limited, Plaeng Yao district Factory type 106	**Silt**												
	Within factory												
	1st time (Jun. 2018)		/	/	/	/		/		/			
	2nd time (Dec. 2018)		/	/	/	/		/		/			
	Outside factory												
	1st time (Jun. 2018)		/	/	/	/	/			/			
	2nd time (Dec. 2018)		/	/	/			/		/			
	Underground water quality (Dec. 2018)					/					/		
	Outside factory												
	1st time (Jun. 2018)		/	/	/	/	/			/			
Supcharoen Recycle Company Limited, Phanom Sarakham District Factory type 106 with 2 permits	**Soil quality**												- On June 21, 2019, PAO conducted inspection and found that the factory did not run a machine with no foul smell from melting around the factory. The factory added one set of Wet Scrubber and added ventilation duct.
	Within factory												
	1st time (Jun. 2018)	/			/								
	2nd time (Dec. 2018)	/											
	Outside factory					/							
	1st time (Jun. 2018)												
	2nd time (Dec. 2018)		/	/	/		/	/					

Factories	Impact on quality of environment												Operation
	Quality of environment	Contamination of heavy metals exceeding the standards											
		Ba	Cu	Pb	Zn	As	Mn	Ni	Total Cr	Cd	Se	Total Hg	
Supcharoen Recycle Company Limited, Phanom Sarakham District Factory type 106 with 2 permits (continued)	**Dust** From incinerator and residue from the factory who came to fill in the land (Dec. 2018)		/		/								- On October 31, 2019, PONRE in Chachoengsao reported the inspection results of the contamination of heavy metals from PCD to relevant agencies in Chachoengsao for acknowledgement.
Ei Hui (Thailand) Company Limited, Plaeng Yao district Factory type 106	**Water quality** Wastewater from factory 1st time (Jun. 2018)		/	/	/		/	/		/			
	2nd time (Dec. 2018)			/	/					/	/		
	Soil surface around factory (Dec. 2018)		/	/	/		/			/			
	Silt Pond in factory (Jun. and Dec. 2018)		/	/	/								
	Outside factory 1st time (Jun. 2018)		/	/	/		/			/			

Factories	Impact on quality of environment												Operation
	Quality of environment	Contamination of heavy metals exceeding the standards											
		Ba	Cu	Pb	Zn	As	Mn	Ni	Total Cr	Cd	Se	Total Hg	
Ei Hui (Thailand) Company Limited, Plaeng Yao district Factory type 106 (continued)	**Underground water quality** Community around factory						/						
	1st time (Jun. 2018)												
	2nd time (Dec. 2018)					/	/				/		

Source: Provincial Office of Natural Resources and Environment Chachoengsao, 2020b

Table 4.19 Impact and Health Risks from Household E-Waste

Types of e-waste	Hazardous substances and heavy metals	Impact and health risks [1, 2]
1. Fluorescent lamp	Mercury	Destroy the nervous system, affect memory and concentration. If received in a large quality, it will affect the kidney, respiratory system and may cause death.
2. Car battery and mobile phone battery	Lead	Affects central nervous system and brain, causing irritability, restlessness, dizziness, and amnesia. For children younger than six years old, it will affect their development and maybe a carcinogen.
	Cadmium	If received a large quantity in a short time, it will cause fever, headache, vomit as long as 20 hours. In the long run, it will cause osteoporosis and bone pain all over the body (Itai-Itai disease).
	Lithium	Severely destroy tissues of mucous membranes of various organs, respiratory organ, eyes, skin. Inhalation may cause seizure, bronchitis, headache, vomit, and may cause pneumonia from chemicals and pulmonary edema.
3. Mobile phone waste	Lead	Affects central nervous system and brain, causing irritability, restlessness, dizziness, and amnesia. For children younger than six years old, it will affect their development.
	Arsenic	Destroy the nervous system, skin, and digestive system. If received in large quantities, it may cause death and affect the fetus.
	Beryllium	Cause irritation in respiratory mucosa, coughing, and difficulty breathing, causing pneumonia and carcinogen in human beings, especially lung cancer.
	Copper	Vomit, diarrhea, inflammation in the abdomen and muscles, arrhythmia. If accumulated in large quantities, it may cause the body to shake all the time, have muscular rigidity, and have difficulty in controlling speech.
4. Unused electrical and electronic devices such as mobile phone charger, battery charger, and ballast, etc.	Brominated Flame Retardants	Disturbs the functioning of the nervous system, brain, ductless gland, and hormone, affecting the development of the fetus and increased the risk of gastric cancer and lymphoma.

Source: 1 Orawan Phuphisut & Suleeporn Sangrajang, 2010

2 Sopana Jirawongnusone et al., 2018

The summary of environmental and health impact in EEC for the past three years between 2018-2020 in Chachoengsao and Chonburi found the contamination of some heavy metals in the soil, surface water source, and groundwater sources exceeding the Thailand standards of soil quality, surface water quality, and groundwater quality respectively, such as lead, copper, zinc, arsenic, cadmium, and nickel. Foul smell around the factories from improper sorting and recycling e-waste came from burning, clandestine dumping, and failing air pollution treatment systems in factories. That failing included no wet scrubber to eliminate the smell, dust, smoke, or damaged filter bag and a small number of ventilation ducts. In addition, some residents living near the factories experienced a headache from smelling foul air for an extended period.

4.2.5.2 Social Impact

The social impact in the study consisted of disturbance and cooperation in solving the problems of e-waste management. Details of the study results are as follows:

1) Disturbance

The documentary study and the interviews revealed that people were disturbed by the foul smell from the operation of the factories that processed e-waste by crushing and melting metals with the furnace, especially in Chonburi and Chachoengsao. As a result, some residents living near the factory had to move away after the relevant government agencies did not solve the foul smell. People viewed that the local authorities did not fully perform their tasks. At the same time, some factories which caused the problems ignored the order from the local officials to rectify the problems. The penalty for the factories causing the problems and ignoring the order of the local officials to rectify the problems was lenient. That was by the penalty in the case of disturbance that occurred in private premises in Chapter 15 Penalties in Section 74 of Public Health Act B.E. 2535 (1992). It stated that any person who fails to comply with an order of the competent local official without reasonable cause or excuse should be liable to imprisonment of not exceeding three months or to a fine of not exceeding 15,000 baht, or to both. That was by the interview with the government official of the regional administration. No. 1 who said the following:

"*The residents who have serious problems with the foul smell from the factory of e-waste recycling with a furnace will move away if they can no longer bear it. Nevertheless, the residents reflect that the government agencies and the responsible local authorities do not take action. There is public health law regarding problems and nuisances, but the penalties are lenient and small. Many factories received orders from the Chief Executive of SAOs to rectify the nuisances from the foul smell, which impacted people's ways of life. Some even answered that there was no evidence of the factory's wrongdoing and impact on the environment, and the factory did not break the law."*

Moreover, the interview results revealed a conflict between residents and factory entrepreneurs or local authorities on e-waste disposal or recycling factories in the areas. The residents viewed that some local government agencies facilitated factory operation or issued factory permits during public hearings in the areas. Request for factory operation permit in the three provinces in EEC must-have documents and opinions of LAOs and Provincial Industry Offices. They must inspect the factories before factory operation, whether the details to request for construction were in order such as machine installation, production process, solutions to problems, and prevention of problems and nuisances. That was in line with the government official of the regional administration No. 3, who said the following:

"These factories will submit the letters to Provincial Industry Office, and Provincial Industry Office will notify the local authorities and pin the letters to the boards announcing that there will be factories categories 105, 106 sets up in the areas. If there is no objection from residents within 15 days, the letters will be returned. When there is an objection, the Provincial Office for Local Administration will order the entrepreneurs to organize public relations in the communities. The factories will unenthusiastically organize the forum. In some areas, residents are against, and they will send opposition letters to PONRE to assist them."

The government official of the regional administration No. 5 said the following:

> *"Before setting up an e-waste recycling factory, people forum should be organized for villagers' acknowledgment. Provincial Industry Office will coordinate with the local authorities, including district offices, SAOs, and entrepreneurs, in organizing the forum. Opinions will be expressed whether for or against the causes, law compliance, process, raw materials, prevention, worries, before seeking a permit to set up the factory. Provincial Industry Office must inspect the factory before operation on the details of the request for construction, whether the machine matches the document, the maintenance of the machine, and whether the factory is legal."*

2) Cooperation to solve the problems of e-waste management

The interview results revealed that the solutions to the problems of household e-waste management in the three provinces of EEC required cooperation and responsibilities of operation of household e-waste management from all sectors, including the public, the private sectors, and the people in the communities. Cooperation was received by people or network "Natural Resources and Environmental Protection Volunteers" or "NEV" to monitor their areas. Suppose they found dumping of e-waste and offenses by e-waste sorting and recycling factories, such as loud noise, foul smell from chemicals, discharge of pollution to the environment outside the factories, nuisances, and impact on ways of lives of communities around the factories. In that case, they could act as whistleblowers for community leaders or make complaints to the relevant public agencies in their areas, such as Provincial Damrongtham Centers, Provincial Industry Offices. At the same time, government agencies were responsible for rigorous investigation and control of factory operations and complied with the law. In Provincial Industry Offices, they must inspect factory permits and compliance with the law in the attached permit and supervise factory operation based on academic principles to reduce the impact on local people. Department of Industrial Works must promote, support, and upgrade the standards of the factories for sorting and recycling e-waste in EEC to ensure safe and

environmental-friendly management on a par with international standards such as WEEELABEX, R2, e-stewards. The interviews were as follows:

"*For the e-waste management, agencies including the public, private, and people sectors must have sufficient and robust cooperation during the investigation. For example, the people sector must monitor and notify the authorities if a factory clandestinely discharges waste. The public sector must be strict, and the private sector must have responsibilities and ethics because e-waste management entails high costs. They may evade the costs through illegal dumping of the waste*" (Government official of the central government No. 2).

"All sectors should take joint responsibilities in efficient e-waste management. Each unit has a clear and unique function. It suffices to do complementary work" (IEAT officer No. 3).

"*We have local volunteers who are natural resources and environmental protection volunteers. If an area has trouble with the e-waste sorting and recycling factory, can villagers use this mechanism? However, it depends on the readiness of the local people as well"* (Government official of the regional administration No. 3).

"Department of Industrial Works operated the project to increase the efficiency of e-waste sorting and recycling factories in the budget year 2018. That upgraded the standards of the operation of e-waste recycling factories for environmental-friendly, safe management based on international standards such as R2, e-Stewards. Twenty factories were participating in the project with the factory assessment and awards bestowed on the factories which passed the assessment criteria" (Government official of the central government No. 5).

Moreover, the documentary study and the interviews revealed that the entrepreneurs with producing or disposing of factories of e-waste in industrial estates and Office of Industrial Estates in EEC participated in solving the problems of e-waste in various forms as follows:

(1) Reduce the amount of e-waste through recycling in the production process as much as possible

That was by the IEAT officer No. 1, who said the following:

> *"Each factory tries not to generate a lot of waste or scrap by remelting as fees for disposal of waste or scrap are expensive. What can be melted again will be remelted or can serve as raw material in other factories? There is direct sale or sale in the industrial estates. The factories in the industrial estates are more skillful in waste resorting with fewer pieces that do not meet the standards. The waste will be reproduced or sold. There is an attempt to generate income instead of paying disposal fees. Most focus on recycling more than disposal."*

(2) E-waste management of industrial estates and factories in the industrial estates revealed that each factory would collect e-waste by itself while waiting to transport it to private companies licensed for disposal or recycling under the responsibilities of environmental or safety unit in the factories. Some factories would compile e-waste and request the industrial estates to collect the waste on the specified dates. The industrial estate would then hire a private company to collect the e-waste for correct disposal. The interviews were as follows:

> "*As for waste management in industrial estates, some industrial estates will manage it by themselves, or some may hire companies for disposal. Own management is for each factory to collect the waste, and the industrial estates will come to collect it on specified dates. The waste is general waste. As for hazardous waste and e-waste, a private company is hired for direct disposal such as Waste Management Siam Ltd: WMS"* (IEAT officer No. 1).

"E-waste in the factories in the industrial estates are already managed. The factories will send the waste to the disposal factories with correct methods" (IEAT officer No. 3).

"The factory operates e-waste sorting from the beginning of the production, collects it to one area while waiting for the transport for disposal through recycling by a company or factory licensed by the government and can safely recycle e-waste in the environment. There is an environmental unit responsible for the factory for sorting, collection, and search for appropriate waste processor" (Company representative No. 1).

"The company operates academically correct sorting, collection, and transport for recycling and e-waste disposal with the supervision of employees responsible for safety" (Company representative No. 2).

"*The company separates, collects, and disposes academically of correct e-waste that goes through the Department of Industrial Works permit system. Machine operators and occupational health and safety employees responsible for sending expired e-waste to agencies licensed by the authorities for disposal"* (Company representative No. 3).

(3) Environmental management of factories in industrial estates with the operation of Green Star on White Flag Project. The Environmental Governance Project allowed the public and local government agencies to supervise factories in industrial estates under IEAT on environmental management and factory safety. The project provided forging cooperation and good relationship between factories in the industrial estates and the surrounding communities and understanding and trust in the environmental operation of factories in the industrial estates. A committee was to assess factories from all sectors, such as IEAT, entrepreneurs, local government agencies, and communities surrounding the industrial estates, to monitor the plan to reduce and eliminate pollution. The assessment was conducted every quarter with the criteria of bestowing of White Flag with Green Star (Environmental

Governance Flag) with the signal of Green Star for industrial entrepreneurs to maintain the environmental management standards on a par with international standards.

In 2019, the evaluation results of the 23 factories in the three provinces of EEC industrial estates by the Factory Assessment Monitoring Committee under IEAT revealed that there had 22 factories in six industrial estates with excellent criteria and one factory with suitable criteria. Those industrial estates were WHA Chonburi Industrial Estate, Amata City Chonburi Industrial Estate, Pinthong Industrial Estate Chonburi, Amata City Rayong Industrial Estate, Gateway City Industrial Estate, and TFD Industrial Estate. It showed that these factories were the model of factories with outstanding quality in good governance in the environment, business, and industrial operations based on standards, transparency, accountability, and happy and sustainable co-existence with the community. The criteria of factory evaluation consisted of five dimensions, namely 1) Physical dimension, 2) Economic dimension, 3) Environmental dimension (such as water management, industrial waste management, air quality management, employees' safety, and health), 4) Social dimension (such as quality of life and society of employees in the factories and the surrounding communities), and 5) Management dimension (Industrial Estate Authority of Thailand, 2019).

IEAT officer No. 1 said

> "*IEAT has the Environmental Governance Project (White Flag with Green Star Project), which provides the opportunity to communities and invites local government agencies such as LAOs and schools to serve as IEAT's committee. The communities will participate in the random investigation of factories in industrial estates, mostly those with problems to reduce complaints."*

That was by IEAT officer No. 4, who said

> "*The Environmental Governance Project (White Flag with Green Star Project) will invite communities around industrial estates and LAOs to take*

part in the investigation of environmental management of factories in industrial estates. The LAOs participating in the project will regularly talk of awareness to the factories in the industrial estates on waste sorting."

The social impact from e-waste management in EEC was found to have a negative social impact. Some residents who lived near incorrectly e-waste sorting and recycling factories in Chachoengsao and Chonburi were troubled by a foul smell, impacting the way of life of residents living near the factories, and some had to move out. However, it also had a positive social impact, such as motivation of "Natural Resources and Environmental Protection Volunteers" or NEV" to monitor their areas. If e-waste dumping, incorrect deeds of e-waste sorting and recycling factories were found in their areas, such as smell from chemicals or pollution outside the factories to the environment. It also forges a good relationship between communities and entrepreneurs in production plants and e-waste disposal plants in industrial estates in Chachoengsao, Chonburi, and Rayong through the Environmental Governance Project of IEAT.

4.2.5.3 Economic Impact

The documentary study and the interviews revealed that household e-waste in Chachoengsao, Chonburi, and Rayong provinces positively impacted the economy. Those positive impacts consisted of generated income to local communities from e-waste sorting and recycling (e.g., making the offering of recycled waste or recycling bank) and selling waste to sidecar buyers or peddlers. They depended on cooperation between community residents, community leaders, and assistance from the local government and the local private sector regarding budget support. Based on the reference purchase prices of household e-waste of Wongpanit International Co., Ltd. on December 29, 2020, the purchase prices of most e-waste were in the range between 0.50-8.00 baht/unit, such as mobile phone waste, old television, computer, fan, refrigerator, washing machine, air conditioner. Except for the circuit board. IC from CPU with golden legs (rectangular shape) were high purchase prices between 50-200 baht/unit (Wonpanit International Co., Ltd, 2020). The details are in Table 4.20.

Table 4.20 Purchase Prices of Household E-Waste as of December 29, 2020, at Wongpanit International Co., Ltd.

Types of e-waste	Price per unit (baht)
Computer screen (glass screen)	0.50
Old television (glass screen)	0.50
Computer screen (LED screen)	1.00
Old television (LED screen)	1.00
Mobile phone	1.50
Electric rice cooker	1.50
Washing machine	2.00
Computer case	2.50
Refrigerator with compressor	3.50
Air condition with compressor	8.00
No 1. Circuit board	150.00
No 2. Circuit board	50.00
IC from CPU with Golden Legs (rectangular shape)	200.00

Source: Wongpanit International Co., Ltd., 2020

The government official of the regional administration No. 4 stated the following:

"If the community can sort e-waste, the community can sell it to sidecar buyers and can generate income from waste recycling. For waste recycle bank, initially may receive a budget from the local administration. The community leaders and community residents will jointly drive the activities."

That was by the government official of the regional administration No. 2, who said the following:

"Some communities organize activities such as making the offering of recycled waste so that some parts of e-waste can be sold by being sorted for separate recycling. Some parts can also be cheaply sold to peddlers who buy back the waste."

The same was for the company representative No. 5, who said the following:

> "*E-waste can increase value, certainly making a positive economic impact on community such as setting up of recycling bank in the community where the government or public agencies can buy back every month or as appropriate."*

The interviews also revealed that household e-waste could generate employment and income for small entrepreneurs in the areas such as junk shops and mobile units to buy e-waste in the areas and entrepreneurs or waste recycling factories with legally obtained licenses. Most people opted to sell the large-size e-waste in whole such as computers, television, refrigerator, and air condition to junk shops, sidecar drivers, and peddlers to go to communities in the areas to buy back used items. Afterward, this household e-waste would enter the recycling process and be sold to entrepreneurs or factories to sort and recycle e-waste, the parts of which would be disassembled. The valuable components would be reused, such as plastics, gold, copper, aluminum. Academically correct extraction or sorting of electronic parts would reduce the problems of illegal dumping of e-waste. The government official of the regional administration No. 1 said:

> *"People sell e-waste to sidecar drivers and junk shops such as television, refrigerator, computer, air conditioner, and mobile phone waste. Many junk shops will not accept mobile phones but will take refrigerators, television, computer, and air conditioner because they can disassemble circuit boards and batteries. The factories buying back e-waste from sidecar drivers or junk shops will continue with sorting or recycling. For example, the factories will buy circuit boards to melt them to obtain gold, copper, and valuable materials. Economically speaking, for the higher value of e-waste by recycling, there will be employed in the sorting and recycling factories. Nevertheless, most workers are foreign workers rather than Thai workers."*

That was by the government official of the central government No. 4, who said:

"Systematic e-waste management certainly has positive economic impact such as additional occupation and income for sidecar drivers buying back used items. At the same time, illegal junk shops should come into the proper system more. With the Act on e-waste management, the problems of illegal dumping of waste in abandoned areas will decrease."

It was in line with the company representative No. 3, who said:

"E-waste management will create positive economic impact for communities in EEC by increasing the business of e-waste recycling/disposal, generating employment and continuous local business, providing local maintenance tax. Department of Industrial Works or IEAT is responsible for supervising and monitoring the correct e-waste management."

Similarly, the government official of the regional administration No. 3 said the following:

"Correct e-waste management will create economic growth with people generating income from the recycling business."

The IEAT officer No. 2 said the following:

"E-waste management will have a positive impact on entrepreneurs of recycling business more and should not have a serious economic impact on local people."

That was by the IEAT officer No. 4, who stated the following:

"Initially, the e-waste management in the three provinces in EEC did not have much economic impact. It did not generate much-increased income for buyers of waste. However, it might help people with good conscience in e-waste sorting start to take interest and campaign for more e-waste management which will take 5-10 years to help the economy."

The documentary study and the interviews revealed that people sorted small-sized e-waste that was not valuable from households to the drop-off points of e-waste in each LAO. That e-waste was fluorescent bulbs, LED bulbs, mobile phones, mobile phone batteries, batteries, and small electronic equipment. People's cooperation in sorting and disposing of e-waste to various drop-off points as arranged by LAOs would reduce the problems of e-waste disposal mixed with general waste. Moreover, that would reduce costs in sorting and collecting e-waste by the government or LAO and reduce transport costs and costs to hire private companies for correct disposal or recycling outside the areas. It could also reduce the budget for improving or rehabilitating environmental quality and people's health from the disposal of non-valuable e-waste through improper methods, such as clandestine burning, open burning, and disassembling of parts. The government official of the central government No. 2 gave the following opinion:

"*Participation in e-waste management in EEC among the public, private, and people sectors and systematic success of e-waste management enable good environment, good society, and good quality of life for people due to absence of toxic residue. If people do not get toxic substances, they will not get sick and do not have to pay for medical treatment and for improvement and rehabilitation costs of environmental quality, which are much higher than the fees for e-waste management. With good e-waste management, there is no need to pay the fees for rehabilitation of the environment and people's health, and it will reduce costs and the government's budget."*

In summary, the economic impact from e-waste management in EEC revealed a positive economic impact. People generated income from large-sized

e-waste such as computers, television, refrigerator, and air conditioner to local junk shops, sidecar drivers, and peddlers buying back used items. Moreover, it could generate income for local buyers of e-waste by sorting e-waste bought from people, creating a local circular economy. However, there was also a negative economic impact. The government might have to use the budget to improve or rehabilitate people's environmental quality and health from the academically incorrect disposal of e-waste in EEC.

4.3 Success Factors of Household E-Waste Management in EEC

The researcher evaluated household e-waste management for EEC in Chachoengsao, Chonburi, and Rayong under the CIPP-I Model consisting of five dimensions, namely Context, Input, Process, Product, and Impact details shown in item 4.2. Afterward, the SWOT Analysis analyzed the internal and external factors affecting household e-waste management in EEC. Internal factors were analyzed under four dimensions, namely Input, Process, Product, and Impact, to identify the Strength (S) and the Weakness (W) of the effective household e-waste management in EEC. External factors were analyzed under PESTLE to identify Opportunity (O) and Threat (T) of the effective household e-waste management in EEC. Analysis of those factors proposed the significant issues, which were the success factors of household e-waste management for EEC in Chachoengsao, Chonburi, and Rayong. The details of the analysis are as follows:

4.3.1 Analysis of the Internal Factors

The researcher used the evaluating of household e-waste management for EEC according to the CIPP-I Model to identify the Strength (S) and the Weakness (W) of the internal factors. Those factors consisted of input, process, product, and impact. Inputs consisted of four elements, namely Man, Money, Management, and Material and Machine. Process included Plan, Do, Check, and Act. Product included setting up of drop-off points, amount of collected household e-waste at the drop-off points, and household e-waste for proper disposal. Impact included environmental impact,

people's health impact, social impact, and economic impact from household e-waste management in EEC. The results of the analysis are as follows:

4.3.1.1 Strength (S)

1) Personnel and agencies responsible for e-waste management, the significant issues found were as follows:

(1) PAOs (Chachoengsao, Chonburi, and Rayong) had units accommodating e-waste management, namely Division of Natural Resources and Environment (Chachoengsao PAO and Rayong PAO) or Division of Public Works (Chonburi PAO)

(2) Chachoengsao, Chonburi, and Rayong Municipalities had units accommodating e-waste management, namely Division of Sanitary Works or Division of Public Health and Environment

2) Budget used in household e-waste management, the significant issues found were as follows:

(1) Rayong PAO had an annual budget for disposal of HHW and household e-waste to the private sector's disposal facilities for the community and Rayong LAOs without charges. However, the responsible units must separate the household e-waste in the container and transport it to the Rayong Integrated Solid Waste Management Center at Namkhok Subdistrict, Mueang District, Rayong for further disposal by Rayong Renewable Energy Co., Ltd.

(2) PAOs and the regional government agencies in the three provinces of EEC, such as REO 13 (Chonburi) and PONRE, had their budget for public relations campaigns and knowledge provided to the public on e-waste management.

3) Household e-waste management, the significant issues found were as follows:

(1) Rayong PAO had Rayong Integrated Solid Waste Management Center to collect HHW and household e-waste from LAOs to disposal facilities of the private sector for disposal of HHW.

(2) There were five LAOs in Chachoengsao and Chonburi responsible for collection and transfer of household e-waste for disposal by themselves, namely 1) Laem Chabang City Municipality, 2) Chaoprayasurasak City

Municipality, 3) Pattaya, 4) Bo Win Subdistrict Administrative Organization, Chonburi, and 5) Chachoengsao Town Municipality, Chachoengsao.

4) Planning of work/projects relevant to e-waste management, the significant issues found were the following: LAOs had planned work or projects on e-waste management according to the concrete and continuous Annual Action Plan "Clean Province" of MOI.

5) Operation of projects and activities relevant to e-waste management, the significant issues found were as follows:

(1) Some LAOs in the three provinces of the EEC won the awards for Clean LAO under the Project of competition for household solid waste management "Clean Province" for 2019, such as Thap Ma Subdistrict Municipality Rayong, Chonburi Town Municipality, and Nongprue Municipality in Chonburi. It showed that LAOs drove and operated the Action Plan "Clean Province" 2019 in upstream, midstream, downstream waste management, as well as motivation to LAOs to perform their tasks (passed the assessment criteria of cleanliness and orderliness of the country of LAOs (Clean LAOs) or 60% upwards).

(2) LAOs in the three provinces operated projects and activities to provide knowledge, raise awareness, promote and forge discipline in e-waste management for the people and youth on concrete and continuous basis. The projects and activities were training to provide knowledge on household e-waste management, sorting community hazardous waste in households, setting up drop-off points, and collecting household e-waste.

(3) LAOs in the three provinces received cooperation and support from personal media, printing media, and the container of HHW to operate projects or activities on e-waste management from relevant government agencies, central and regional, such as REO 13 (Chonburi), PONRE, PCD, and DEQP.

6) Monitoring and investigation of e-waste management in the EEC, the significant issues found included the following:

(1) Provincial Sewage and Solid Waste Committees in each province (Chachoengsao, Chonburi, and Rayong) enable efficient solid waste management and HHW management.

(2) LAOs in the three provinces prepared records and reports on the results of e-waste management in "Monthly Report Form on Solid Waste Management of LAO (Mor Phor 2 Form)" through the IT system of the DOLA every month. To ensure correct and up-to-date information on the amount of e-waste to be used in planning work/projects, preparation of the budget for e-waste management, and use of technology in e-waste management appropriate to the areas.

(3) There were agencies to receive complaints on the e-waste problems in the three provinces of the EEC. Many agencies and channels were put in place to receive complaints, such as Damrongtham Centers at provincial and district levels/municipalities, REO 13 (Chonburi), PONRE, Provincial Industry Offices through various channels the particular agencies receiving the complaints. Those channels consisted of website, hotline, e-mail, submission of complaints in person, and Fax.

7) The improvement for proper operation, the significant issues found were the following: Some entrepreneurs in the three provinces offered space in their establishments to set up drop-off points of household e-waste, such as at gas stations, convenience stores, construction material centers, and academic institutes.

8) The operation of household e-waste management, the significant issues found were the following: LAOs in the three provinces (109 LAOs in Chachoengsao, 99 LAOs in Chonburi, and 68 LAOs in Rayong), drop-off points of HHW were set up in all communities with at least one point in village/community, achieving the goal of the Action Plan "Clean Province" 2019.

9) The impact from household e-waste management, the significant issues found were as follows:

(1) Creation of "Natural Resources and Environmental Protection Volunteers" or "NEV" to monitor the situations of e-waste management in their areas, such as illegal dumping of e-waste and offenses of e-waste sorting and recycling factories (e.g., loud noise, smell from chemicals, and discharge of pollution into the outside of factories).

(2) Good relationship forged between communities and entrepreneurs in EEE manufacturing factories and e-waste treatment or disposal

factories in the industrial estates in Chachoengsao, Chonburi, and Rayong through the Environmental Governance Project of IEAT.

(3) The residents earned income from the sale of large-sized e-waste sold as a whole (i.e., computers, television, refrigerator, and air conditioner) to junk shops in local areas, sidecar buyers of used items, and peddlers. Local buyers of e-waste earned income from e-waste sorting bought back from the residents.

4.3.1.2 Weakness (W)

1) Personnel and agencies responsible for e-waste management and people, the major issues found were as follows:

(1) The insufficient number of personnel with knowledge in e-waste management in LAOs. As a result, the task of household e-waste management in the local areas was not as continuous and not efficient as it should be.

(2) People understood that e-waste sorting was the duty of LAOs. So, most people did not separate e-waste before disposal. People disposed of e-waste in a general garbage bin, mixing e-waste with general solid waste.

2) Household e-waste management, the significant issues found were the following: Household e-waste in large sizes (i.e., computers, televisions, refrigerators, and air conditioners) mainly was not managed by LAOs. People kept it at home, repaired it for reuse, sold it to junk shops or sidecar buyers of used items in local areas, or donated it.

3) Tools and equipment in household e-waste management, the significant issues found included the following:

(1) Lack of necessary and academically correct tools and equipment such as trucks for HHW, storage sites of HHW.

(2) Containers for HHW did not have appropriate box sizes to contain household e-waste as the types of household e-waste were varied and prominent, such as televisions, computers.

4) Operation of projects and activities related to e-waste management, LAOs focused on operating projects and activities related to household e-waste management of some types, such as lamps, batteries, small EEE, mobile

phones. However, household e-waste included other types of e-waste such as televisions, computers.

5) Monitoring of e-waste management in EEC, the significant issues found included the following:

(1) Recording of collected e-waste by types (divided into four types, namely lamps, dry cells and batteries, mobile phones and peripheral devices, and EEE) in the "Mor Phor 2 Form" by LAO officials was not accurate in terms of separation of the e-waste, hazardous waste, and industrial waste.

(2) No follow-up report e-waste solutions in Chachoengsao and Chonburi to the agencies that joined the investigation of the complaints after the investigation in the areas was completed.

(3) No appointment with the agencies that monitored e-waste complaints in Chachoengsao and Chonburi to rejoin the monitoring after the expired period of the solutions of the complaints.

6) Improvement for proper operation, the major issues found included the following:

(1) People lacked the motivation to sort e-waste at households and collected household e-waste at the drop-off points from various areas as stipulated by LAOs.

(2) Drop-off points of household e-waste were not convenient for people's access and did not cover all areas.

(3) Campaign and public relations on household e-waste of LAOs and related agencies in the EEC did not attract people's interests and did not cover all areas and communities.

(4) LAOs in the three provinces sent e-waste for disposal to private companies outside their areas, such as Saraburi, Nakhon Sawan, Ratchaburi. That generated more costs for LAOs regarding household e-waste disposal on top of the additional costs in transporting it to the private companies.

7) The operation of household e-waste management, the significant issues found included the following:

Most of the collected household e-waste in Chachoengsao and Chonburi was stored at storage sites of each LAO awaiting proper disposal.

Chonburi PAO had just signed in “Memorandum of Cooperation on Household Hazardous Waste Management” with municipalities and SAOs in Chonburi but did not transfer household e-waste of LAOs for proper disposal. Chachoengsao PAO had not accepted to be host to household e-waste management.

8) Impact from household e-waste management, the significant issues found included the following:

(1) Problems found on the heavy metal contamination in soil, surface water source, and groundwater source around the e-waste sorting and recycling factories in Chachoengsao and Chonburi. The concentration of some heavy metals had exceeded the standards of soil quality, surface water quality, and groundwater quality in Thailand, such as lead, copper, zinc, arsenic, cadmium, and nickel. In the long run, heavy metal contamination would impact the ecosystem's food chain in the surrounding areas of their factories. It might impact the health of residents living near their factories.

(2) Conflicts arose between entrepreneurs of e-waste sorting and recycling factories with incorrect methods and residents living near the factories in Chachoengsao and Chonburi due to nuisances from foul smells and dust. The factories did not install air treatment systems, such as wet scrubbers, bag filters, or air treatment systems. Those were not ready for usage, leak of bag filters, faulty odor absorbers, and wastewater discharged to water sources outside the factories.

(3) Conflicts arose between people and local government agencies, such as LAOs and Provincial Industry Offices, on establishing sorting and recycling or e-waste disposal factories in Chachoengsao and Chonburi. People viewed that some local government agencies facilitated factory operation or factory permits.

(4) Most people sold valuable e-waste to junk shops, sidecar buyers with improper sorting and recycling systems because it was convenient for them. People could earn income from the sales of e-waste.

The summary of internal success factors affecting EEC household e-waste management in Chachoengsao, Chonburi, and Rayong is in Table 4.21.

Table 4.21 Summary of the Internal Success Factors Affecting Household E-Waste Management for EEC

Internal factors	Strength (S)	Weakness (W)
Input		
1.1 Responsible personnel and agencies and people	**S1:** PAOs (Chachoengsao, Chonburi, and Rayong) had units accommodating e-waste management, namely Division of Natural Resources and Environment (Chachoengsao PAO and Rayong PAO) or Division of Public Works (Chonburi PAO). **S2:** Chachoengsao, Chonburi, and Rayong Municipalities had units accommodating e-waste management, namely Division of Sanitary Works or Division of Public Health and Environment.	**W1:** Insufficient number of personnel with knowledge in e-waste management in LAOs. As a result, household e-waste management in the local areas was not as continuous and inefficient as it should be **W2**: People understood that e-waste sorting was the duty of LAOs.
1.2 Budget	**S3** Rayong PAO had the annual budget for disposal of HHW and household e-waste to the private sector's disposal facilities for the community and Rayong PAO without charges. **S4:** PAOs, REO 13 (Chonburi), and PONRE in the three provinces of EEC had their budget for public relations campaigns and knowledge provided to the public on e-waste management.	
1.3 Household e-waste management	**S5:** Rayong PAO had the Rayong Integrated Solid Waste Management Center to collect HHW and household e-waste from LAOs to disposal facilities of the private sector. **S6:** There were five LAOs in Chachoengsao and Chonburi responsible for collecting and transferring household e-waste for disposal by themselves.	**W3:** Large-sized household e-waste, such as computers, televisions, refrigerators, and air conditioners, mainly was not managed by LAOs
1.4 Tools and equipment		**W4**: Lack of necessary and academically correct tools and equipment, such as collection trucks for HHW, storage sites of HHW. **W5:** Containers for HHW did not have appropriate box sizes to contain household e-waste as the types of household e-waste were varied and big, such as televisions, computers.

Internal factors	Strength (S)	Weakness (W)
Process		
2.1.Planning of work/projects	**S7:** LAOs had planned work or projects on e-waste management according to the concrete and continuous Annual Action Plan "Clean Province" of MOI.	
2.2 Operation of projects and activities	**S8:** Some LAOs in the three provinces of the EEC won the awards for Clean LAO under the Project of competition for household solid waste management "Clean Province" for 2019, such as Thap Ma Subdistrict Municipality in Rayong, Chonburi Town Municipality, and Nongprue Municipality in Chonburi. **S9:** LAOs in the three provinces of the EEC operated projects and activities to provide knowledge, raise awareness, promote and forge discipline in e-waste management for the people and youth on a concrete and continuous basis. **S10**: LAOs in the three provinces received cooperation and support from personal media, printing media, and containers of HHW to operate projects or activities on e-waste management from the relevant central and regional government agencies.	**W6:** LAOs focused on operating projects and activities related to household e-waste management of some types such as lamps, batteries, small EEE, mobile phones.
2.3 Monitoring	**S11:** Provincial Sewage and Solid Waste Committees in each province (Chachoengsao, Chonburi, and Rayong) enable efficient solid waste management and HHW management of the provinces **S12:** LAOs in the three provinces of the EEC prepared records and reports on the monthly e-waste management in the "Mor Phor 2 Form" through the IT system of DOLA every month. **S13:** There were many agencies and channels to receive complaints on the e-waste problems in the three provinces of the EEC.	**W7:** Recording the amount of collected e-waste by types of e-waste in the "Mor Phor 2 Form" by LAO officials was inaccurate in terms of separation of e-waste, hazardous waste, and industrial waste. **W8:** There was no follow-up report on solutions of e-waste complaints in Chachoengsao and Chonburi to the joint agencies' investigation after the complete investigation. **W9:** There was no appointment with joint agencies that monitored the e-waste complaints in Chachoengsao and Chonburi after the expired period of the complaint solutions.

Internal factors	Strength (S)	Weakness (W)
Process		
2.4 Improvement for appropriate operation	**S14:** Some entrepreneurs in the three provinces of the EEC offered space in their establishments to set up drop-off points of household e-waste, such as at gas stations, convenience stores, construction material centers, and academic institutes.	**W10:** People lacked the motivation to sort e-waste at households and collect household e-waste at the drop-off points. **W11:** Drop-off points of household e-waste were not convenient for people's access and did not cover all areas. **W12:** Campaign and public relations on household e-waste of LAOs and related agencies in EEC did not attract people's interests and did not cover all areas and communities. **W13:** LAOs in the three provinces of EEC sent e-waste for disposal to private companies outside of their areas, such as Saraburi, Nakhon Sawan, Ratchaburi provinces.
Product		
3.1 Setting up of drop-off points for HHW	**S15:** In all LAOs in the three provinces of the EEC, drop-off points of HHW were set up in all communities, with at least one point in the village/community.	
3.2 Amount of collected household e- waste and sent for proper disposal		**W14:** The collected amount of household e-waste in Chachoengsao and Chonburi was primarily stored at storage sites of each LAO awaiting academically correct disposal.
Impact		
4.1 Impact on environment and people's health		**W15:** Found problems were the contamination of some heavy metals in soil, surface water source, and groundwater source around the e-waste sorting and recycling factories in Chachoengsao and Chonburi might impact residents' health living near their factories..
4.2 Social impact	**S16:** Creation of NEV to monitor the states of e-waste management in their areas. **S17:** Good relationship forged between communities and manufacturing entrepreneurs and e-waste treatment and disposal factories in the industrial estates in EEC through the Environmental Governance Project of IEAT.	**W16:** Conflicts arose between entrepreneurs of e-waste sorting and recycling factories with incorrect methods and residents living near their factories in Chachoengsao and Chonburi. **W17:** Conflicts arose between people and local government agencies (i.e., LAOs and Provincial Industry Offices) to establish e-waste sorting, recycling, and disposal factories in Chachoengsao and Chonburi.

Internal factors Impact	Strength (S)	Weakness (W)
4.3 Economic impact	**S18:** The residents earned income from the sale of large-sized e-waste as a whole and local buyers of e-waste earned income from e-waste sorting bought back from the residents.	**W18:** Most people sold valuable e-waste to junk shops and sidecar buyers with improper sorting and recycling systems.

4.3.2 Analysis of External Factors

The researcher used the evaluating of household e-waste management for EEC according to the CIPP-I Model to identify Opportunity (O) and Threat (T) of external factors. Those factors consisted of the PESTLE, namely policy, economic, social, technology, legal, and environment. Policy (P) was policies, strategies, and plans relevant to e-waste management. Economic (E) was economic conditions of the east, such as the economic structure of the east and average monthly income per household. Social (S) was social conditions in the east, such as population, the density of population, and the number of households. Technology (T) was technologies for sorting, recycling, and disposal of e-waste. Legal (L) was laws related to e-waste management. Environment (E) was the east environment, such as environmental problems in the east, guideline of HHW management at the provincial level, and problems and obstacles of HHW management in the east. The results of the analysis were as follows:

4.3.2.1 Opportunity (O)

1) Policies, strategies, and plans relevant to e-waste management, the significant issues found were the following:

(1) The government formulated the strategies, policies, and plans on the concrete operation of HHW management and household e-waste management. Those were Integrated Waste Electrical and Electronic Equipment Management Strategy (2014-2021), National Solid Waste Management Master Plan (2016-2021), and the 20-Year Master Plan on the Prevention and Management of Pollution caused by Solid and Hazardous Waste (2018-2037).

(2) The Action Plan “Clean Province” and Environmental Plan in Eastern Economic Corridor B.E. 2561-2564 (2018-2021) enabled provinces and LAOs in EEC. Those plans have efficient guidelines and indicators of HHW and

household e-waste management, not impacting the environment and health of local people.

2) Technology of sorting, recycling, and disposal of e-waste, the significant issues found included the following:

(1) Correct and efficient technology of household e-waste disposal, such as secure landfill, Rotary Kiln with high temperatures between 1,000-1,200 degrees Celsius.

(2) There were sorting factories (category 105) and e-waste recycling factories (category 106) with legal permits and awards from the Department of Industrial Works (in the budget year 2018) in total seven registered factories situated in Chonburi.

3) Laws related to e-waste management, the significant issues found included the following:

(1) Laws were enacted to facilitate HHW management and household e-waste management of LAOs in the EEC, such as Public Health Act B.E. 2535 (1992) and amended (No. 2) B.E. 2550 (2007) and (No. 3) B.E. 2560 (2017), the Act of Maintaining Cleanliness and Tidiness of the City, B.E. 2535 (1992) and amended (No. 2) B.E. 2560 (2017), Notification of Ministry of Interior on Solid Waste Management B.E. 2560 (2017), and Ministerial Regulation on Communal Toxic or Hazardous Solid Waste Management B.E. 2563 (2020).

(2) Eastern Special Development Zone Act B.E. 2561 (2018) determined the guideline of systematic development in EEC by promoting commercial and industrial activities using advanced, up-to-date, and environmental-friendly technology.

(3) Laws were enacted on the control of factory operation and discharge of waste or unused materials from the production process of factories and used to determine the methods of management, collection, and transport of sewage or unused materials in the factories of all sizes category 105 (sorting factories or landfills) category 106 (recycling factories) and category 101 (waste treatment plants/incinerators). The relevant laws consisted of the Factory Act B.E. 2535 (1992) and amended and Notification of the Ministry of Industry on Disposal of Waste or Unusable Materials B.E.2548 (2005) and *(*No. 2) B.E. 2560 (2017).

4) The environment of the east, the major issues found were the following: Provinces in the east devised the guidelines of HHW management (including e-waste) at the provincial level. The guidelines consisted of PAOs as hosts for management and transfer of HHW for proper disposal, and LAOs set up drop-off points of HHW in the areas.

4.3.2.2 Threat (T)

1) Economic conditions of the east, the major issues found included the following:

(1) Most factories in the east's electrical and electronic manufacturing industry were located in Chonburi, Rayong, and Chachoengsao (576 factories in 2019). Those factories could generate e-waste in the future.

(2) Households in the east (eight provinces) had, on average high monthly income per household (25,060.15 baht in 2019). Increasing the trend for ownership of household electrical appliances and the amount of household e-waste also increased accordingly.

2) Social conditions in the east, the major issues found were as follows: There was a large population (5,107,898 persons in 2020) and households (2,046,627 households in 2020). The technological advancement and the rapid development of communication systems and electronic equipment nowadays, in tandem with the New Normal, increased the consumption of EEE. The amount of e-waste increased accordingly as well.

3) Laws related to e-waste management, the significant issues found included the following:

(1) The Draft of the Waste from Electrical and Electronic Equipment Management Act B.E. .... was not yet enacted and enforced.

(2) Many laws on HHW management and household e-waste management lacked stringency and seriousness in enforcement, especially penalties such as Factory Act B.E. 2535 (1992) and amended, Public Health Act B.E. 2535 (1992) and amended.

(3) Some laws or provisions related to HHW and household e-waste management were outdated and inappropriate to current situations, such as

Control of Sale by Auction and Trade of Antiques Act B.E. 2474 (1931), Hazardous Substances Act B.E. 2535 (1992).

4) Environment of the east, the major issues found were the following:

(1) Problems of complaints on hazardous waste and solid waste in the east, mainly in Chachoengsao and Chonburi.

(2) Some people did not realize the importance of sorting HHW at the origin.

(3) HHW and household e-waste were dumped and mixed with general waste in the solid waste disposal sites in large quantities.

The summary of the external success factors affecting household e-waste management for EEC in Chachoengsao, Chonburi, and Rayong shows in Table 4.22.

Table 4.22 Summary of the External Success Factors Affecting Household E-Waste Management for EEC

External factors	Opportunity (O)	Threat (T)
Policies, strategies, and plans relevant to e-waste management	**O1:** The government formulated the strategies, policies, and plans on the concrete operation of HHW management and household e-waste management, such as Integrated WEEE Management Strategy B.E. 2557-2564 (2014-2021), National Solid Waste Management Master Plan (2016-2021), the 20-Year Master Plan on the Prevention and Management of Pollution caused by Solid and Hazardous Waste (2018-2037). **O2:** The Action Plan "Clean Province" and Environmental Plan in Eastern Economic Corridor B.E. 2561-2564 (2018-2021) enabled provinces and LAOs in the EEC to have clear, academically correct, and efficient guidelines and indicators of HHW management and household e-waste management, not impacting environment and health of local people.	

External factors	Opportunity (O)	Threat (T)
Economic conditions of the east		**T1:** Electrical and electronic manufacturing plants in the east were primarily located in Chonburi, Rayong, and Chachoengsao (576 factories in 2019). Those plants could generate e-waste in the future. **T2:** Households in the east (eight provinces) had on average relatively high monthly income per household (25,060.15 baht in 2019), increasing the trend for ownership of household electrical appliances. The amount of household e-waste also increased accordingly.
Social conditions of the east		**T3:** There was a large population (5,107,898 persons in 2020) and households (2,046,627 households in 2020) in the east. The present age of technological advancement and the rapid development of communication systems and electronic equipment were in tandem with the New Normal, which increased electrical and electronic equipment consumption. The amount of e-waste increased accordingly as well.
Technology of sorting, recycling, and disposal of e-waste	**O3:** There was an academically correct and efficient household e-waste disposal for suitable e-waste disposal, such as secure landfills and incinerators with high temperatures. **O4:** There were e-waste sorting factories (category 105) and recycling factories (category 106) with factory permits and awards from the Department of Industrial Works (in the budget year 2018) in total seven registered factories situated in Chonburi	

External factors	Opportunity (O)	Threat (T)
Laws related to e-waste management	**O5:** Laws were enacted to facilitate HHW and household e-waste management of LAOs in EEC, such as Public Health Act B.E. 2535 (1992) and amended, the Act of Maintaining Cleanliness and Tidiness of the City, B.E. 2535 (1992) and amended (No. 2) B.E. 2560 (2017), Notification of Ministry of Interior on Solid Waste Management B.E.2560 (2017), and Ministerial Regulation on Communal Toxic or Hazardous Solid Waste Management B.E. 2563 (2020). **O6:** Eastern Special Development Zone Act B.E. 2561(2018) determined the guideline of systematic development of EEC by promoting commercial and industrial activities using advanced, up-to-date, and environmentally-friendly technology. **O7:** Laws were enacted on the control of factory operation and discharge of waste or unused materials from the production process of factories and used to determine the methods of management, collection, and transport of waste or unused materials in the factories, such as Factory Act B.E. 2535 (1992) and amended, Notification of the Ministry of Industry on Disposal of Waste or Unusable Materials B.E.2548 (2005) and (No .2) B.E. 2560 (2017).	**T4:** The Draft of the Waste from Electrical and Electronic Equipment Management Act B.E. .... was not yet enacted and enforced. **T5:** Much HHW management and household e-waste management laws lacked stringency and seriousness in enforcement, especially penalties such as Factory Act B.E. 2535 (1992) and amended, and Public Health Act B.E. 2535 (1992) and amended. **T6:** Laws or provisions in some laws related to HHW and household e-waste management were outdated and inappropriate to current situations, such as Control of Sale by Auction and Trade of Antiques Act B.E. 2474 (1931), Hazardous Substances Act B.E. 2535 (1992).
Environment of the east	**O8:** Provinces in the east devised the guideline of HHW management (including e-waste) at the provincial level. Those included PAOs as hosts for management and transfer of HHW for academically correct disposal and LAOs set up drop-off points of HHW in the areas.	**T7:** Problems of complaints on hazardous waste and solid waste in the east, mainly in Chachoengsao and Chonburi. **T8:** Some people did not realize the importance of sorting HHW at the origin. **T9:** HHW and household e-waste were dumped and mixed with general waste in the solid waste disposal sites in large quantities.

4.4 Strategies of Household E-Waste Management in EEC

The success factors affecting household e-waste for EEC in Chachoengsao, Chonburi, and Rayong derived from the analysis of Strength (S), Weakness (W), Opportunity (O), and Threat (T) using the SWOT Analysis (Table 4.21 and Table 4.22). After that, the critical success factors were analyzed and determined the relationship of the matrix matching using the TOWS Matrix. The TOWS Matrix consisted of the four relationships between strength (S) and opportunity (O), strength (S) and threat (T), weakness (W) and opportunity (O), weakness (W), and threat (T) to be combined into four strategies, namely SO Strategy, ST Strategy, WO Strategy, and WT Strategy, respectively. The strategies of household e-waste management for EEC in the three provinces were studied using TOWS Matrix and using Pressure-State-Response (PSR) concept (Topic 4.1.3), as shown in Table 4.23.

Table 4.23 Strategies for Household E-Waste Management in EEC

SO Strategy	ST Strategy
S1S2O1O2O8: Drive the establishment of the provincial HHW storage center to collect household e-waste. **S1S2S6S11O1O2:** Encourage LAOs to collect and send household e-waste for disposal by themselves, forming adjacent areas in each province (clusters) in sending household e-waste of LAOs for academically correct disposal. **S1S2S3S5S17O3O4O6O7O8:** Encourage the preparation of the list of private companies with efficient, academically correct, and e-waste legal treatment and disposal factories situated in the EEC, both in and outside industrial estates **S1S2S8O1O2O5:** Promote, honor, and publicize LAOs with good performance on household e-waste management	**S1S2S9S10T2T3:** Encourage people or consumers to carefully choose household electrical and electronic equipment and products with environmentally-friendly labels of Thai Industrial Standards (TIS). **S1S2T1T4:** Encourage factories of electrical and electronic industries in the EEC areas to produce environmentally-friendly electrical and electronic equipment, easy to recycle, energy-saving, durable, including reduced use of hazardous waste in the production process. **S1S2T4T5:** Accelerate the drive of law on e-waste management or the Draft of the Waste from Electrical and Electronic Equipment Management Act B.E. .... to be enforced.

SO Strategy	ST Strategy
S1S2S4S7S9S10O1O2O8: Promote and support the provision of more news, knowledge, understanding, and public relations on household e-waste management in the areas. **S1S2S3S6O2O6:** Drive the comprehensive and efficient action plan on household e-waste management in EEC under the EEC Development Plan. **S1S2S12O2O8:** Monitor and inspect the accurate, complete, and up-to-date monthly recording of the information on e-waste management by types on "Mor Phor 2 Form". **S1S2S13S16O1O2O5:** Encourage LAOs to cooperate with people networks and local agencies receiving complaints to solve household e-waste problems continuously. **S1S2S14S15O2O8:** Increase good drop-off points of household e-waste covering all areas, including areas in the establishments of the private sector, government buildings, and communities. **S1S2S18O7:** Drive the pricing of the WEEE of local junk shops with the same standards.	**S1S2S11T6:** Improve rules, regulations, and laws relevant to HHW and household e-waste for more clarity and facilitation of household e-waste management of LAOs. **S1S2S4S7S9S10S14T2T3T8:** Support the integration of the household e-waste management plan in the 4-Year Government Action Plan for LAO. **S1S2S3S5S6T9:** Drive LAOs to collect and send for disposal household e-waste by themselves by setting the timeframe of the transport of household e-waste for treatment or disposal. **S1S2T8T9:** Support the academically correct maintenance of the solid waste management system and environment of solid waste disposal sites. **S1S2S14S15T8:** Drive private entrepreneurs to participate in public relations and determine the areas to set up the drop-off points of household e-waste. **S1S2S17T1:** Support the buy-back of factories producing electrical and electronic appliances in the EEC. **S1S2S8T8:** Construct the model community for household e-waste management at the origin.
WO Strategy	**WT Strategy**
W1O1O2O5O8: Promote and support REO 13 (Chonburi) and PONRE to serve as coaches (coaching) to personnel of LAOs in operating projects/activities on household e-waste management.	**W1T4T5T6:** Support personnel of LAOs to have academic knowledge and understanding of household e-waste management at upstream, midstream, and downstream, as well as relevant laws, skills for proper and efficient operation of household e-waste management to reduce external dependency.

WO Strategy	WT Strategy
W2W10O1O2O8: Promote and support people for more household e-waste management at origin.	**W1W2W10W12T5T8:** Plan and allocatee expected budget between LAOs and relevant agencies in EEC to drive and operate action plans/projects of household e-waste management according to the principles of 3Rs.
W3W4W5W11W13W15O1O2O5O7O8: Promote increased academic efficiency correct collection, transport, and treatment or disposal of household e-waste.	**W3W5T2T3:** Create value for people to use household electrical and electronic appliances for maximum benefit and to change their appliances once they are expired or irreparable.
W6W10W12O1O2O6: Develop channels of public relations on household e-waste to attract interest and easy access for people of all ages via social media such as television, YouTube, Facebook.	**W4W7W13W14T4T5T6:** Support preparation of the budget for household e-waste management of LAOs.
W7O1O2O5O8: Develop the recording and reporting system of household e-waste management for clarity, easy understanding, convenience, and speed in utilizing the information.	**W2W10W11T7T8T9:** Support space for correct and safe arrangement of general garbage bin, hazardous waste bin, and cupboard collecting household e-waste.
W8W9O1O5O7: Notify the investigation results of complaints on e-waste to the agencies with joint monitoring and investigation and the complainants by the agencies receiving the complaints.	**W5W6W11T4T5:** Survey and monitor the conditions of drop-off points of household e-waste within the LAOs' areas.
W13W15W16O3O4O6O7O8: Promote and develop innovation and technology on sorting, recycling, and disposal of household e-waste appropriate to the EEC areas.	**W8W9T7:** Prepare personnel, system, and channel readiness for receiving complaints of provincial agencies receiving complaints.
W14O1O2O5O8: Drive the preparation of a memorandum of cooperation on HHW management (MOU) between PAOs and municipalities and SAOs in provinces.	**W15W16W17T1T4T5T6:** Inspect air pollution treatment and wastewater treatment systems of electrical and electronic manufacturing plants and e-waste treatment and disposal plants in the EEC to ensure that it is reasonable factories' operation.
	W3W18T4T5T6: Prepare personnel of LAOs and set the date and appointment time in big e-waste transporting from people’s houses.

WO Strategy	WT Strategy
W17O1O2O5O7O8: Drive Provincial Industry Offices to inspect factories and receive opinions from people on e-waste treatment and disposal factories before permit issuance of factory operation.	
W18O1O2O5: Upgrade the standards of junk shops and small local establishments disassembling e-waste.	

4.4.1 SO Strategy

The SO Strategies were the strategies derived from assessing the internal factors (Strengths) and external factors (Opportunities) for joint consideration. The SO Strategies used the strengths to provide opportunities as follows:

4.4.1.1 Drive the establishment of the provincial household hazardous waste storage center to store household e-waste of LAOs and transport it for appropriate disposal.

4.4.1.2 Encourage LAOs to collect and send household e-waste for proper disposal by themselves from clusters within the province by considering the Provincial Sewage and Solid Waste Management Committee in each province.

4.4.1.3 Encourage the preparation of the list of private companies and factories with academically correct and legal treatment or disposal of e-waste located in EEC, including in and outside industrial estates.

4.4.1.4 Promote, honor, and publicize LAOs with good performance on household e-waste management. Those serve as good examples for other LAOs, such as LAOs, which won the clean LAO awards with the implementation of household e-waste management in conformance with the Action Plan "Clean Province."

4.4.1.5 Promote and support providing news, knowledge, understanding, and public relations on household e-waste management in the local areas through cooperation with relevant agencies, such as REO 13 (Chonburi), PONRE, PCD, DEQP, and Provincial Offices for Local Administration. Those relevant agencies operate projects or activities to promote, promote, and provide

public relations to people and the youth through various media, such as local radio and television, public relations boards, the public handbook for household e-waste sorting, door-knocking of residents the local areas. The public relations include e-waste separation, household e-waste management, locations of drop-off points, collection date, and time arranged by LAOs.

4.4.1.6 Drive the comprehensive and efficient action plan on household e-waste management in EEC under EEC Development Plan to ensure comprehensive and concrete household e-waste management in the EEC areas.

4.4.1.7 Monitor and inspect the accurate, complete, and up-to-date monthly recording of the information on e-waste management by types on the “Mor Phor 2 Form” to serve as the database in household e-waste management of LAOs.

4.4.1.8 Encourage LAOs to cooperate with local people networks and local agencies receiving complaints about solving the problems on household e-waste. Those agencies receiving complaints are Damrongtham Center of Province /District/Municipality, REO 13 (Chonburi), PONRE, and Provincial Industry Offices). Moreover, the “Natural Resources and Environmental Protection Volunteer Network” or "NEV-Net" assist LAOs and those agencies monitor and report e-waste management situations in the local areas.

4.4.1.9 Promote good drop-off points of household e-waste covering all areas. Those areas are the private sector establishments (e.g., convenience stores, Big C, Lotus, gas stations, building material centers, and academic institutes), government buildings, and communities (e.g., town halls, village town halls).

4.4.1.10 Drive the e-waste pricing of local junk shops with the same standards to ensure people's fairness regarding return or selling prices and motivate people to separate correct types of household e-waste.

4.4.2 ST Strategy

The ST Strategies were the strategies derived from assessing the internal factors (Strengths) and external factors (Threats) for joint consideration. The ST Strategies used strengths to avoid threats as follows:

4.4.2.1 Encourage people or consumers to carefully choose household electrical and electronic equipment and products with environmentally-friendly labels or labels of Thai Industrial Standards (TIS).

4.4.2.2 Encourage factories of electrical and electronic industries in the EEC areas to produce environmentally friendly electrical and electronic equipment, easy to recycle, energy-saving, durable, and reduce hazardous waste in the production process.

4.4.2.3 Accelerate to enforce the law on e-waste management or the Draft of the Waste from Electrical and Electronic Equipment Management Act B.E. .... under the principle of EPR; this law ensures the system of buy-back, collection, transport, and disposal of e-waste. It enforces all relevant sectors, including people, producers (importers), LAOs, and PCD.

4.4.2.4 Improve rules, regulations, and laws relevant to HHW and household e-waste for more clarity and facilitation of household e-waste management of LAOs.

4.4.2.5 Support the integration of the household e-waste management plan in the 4-Year Government Action Plan for LAOs. It entails academically correct household e-waste management upstream, midstream, and downstream, and forge more cooperation between the public, the private, and the people sectors in the provinces.

4.4.2.6 Drive LAOs collecting and sending for disposal household e-waste by themselves set the transportation timeframe for disposal of household e-waste. It reduces the amount of household e-waste waiting for disposal at private disposal sites. In addition, it prevents the leakage of hazardous substances from the changed conditions of the e-waste upon expiration or storage for a long time.

4.4.2.7 Support the academically correct maintenance and environment of solid waste disposal sites. It prevents the problems of e-waste leachate

mixed with general solid waste and contaminated in the environment (e.g., surface water source, groundwater source, and soil).

4.4.2.8 Drive private entrepreneurs to participate in public relations and set up the drop-off points of household e-waste. Those entrepreneurs are gas stations, convenience stores, construction material centers, department stores, and academic institutes. It helps attract interest, is easily observable, and is accessible to motivate more people to sort and leave e-waste at the drop-off points.

4.4.2.9 Support the e-waste buy-back of electrical and electronic appliances manufacturing factories in EEC with various methods. Their methods include exchanging old items for new ones and discounts to buy EEE for people who brought e-waste back.

4.4.2.10 Construct the community model for household e-waste management at sources, such as consumption reduction, reuse, recycling, and sorting. People and personnel of other LAOs in the provinces could come for study tours, exchanges of experience in household e-waste management, and appropriate application to their areas

4.4.3 WO Strategy

The WO Strategies were the strategies derived from assessing the internal factors (Weaknesses) and external factors (Opportunities) for joint consideration. The WO Strategies used opportunities to reduce weaknesses as follows:

4.4.3.1 Promote and support REO 13 (Chonburi) and PONRE to serve as coaches for coaching to personnel of LAOs in operating projects/activities on household e-waste management. It provides knowledge and develops the potential of LAOs' personnel in household e-waste management.

4.4.3.2 Promote and support people for household e-waste management at the origin. These include reducing the amount of generated e-waste, reuse, recycling, sorting, and separating types of e-waste before disposing it at drop-off points of LAOs.

4.4.3.3 Promote increased efficiency in academically correct collection, transport, and treatment or disposal of household e-waste. Those consist of adding more proper containers, improving tools and equipment, correct transferring

and storage, and appropriate disposal of household e-waste at treatment and disposal factories.

4.4.3.4 Develop public relations channels on household e-waste to attract interest and easy access for people of all ages. We use role models in public relations via social media to clear the picture, such as television, YouTube, Facebook.

4.4.3.5 Develop the recording and reporting system of household e-waste management information for clarity, easy understanding, and convenience and speed in utilizing the information such as QR Code. It provides benefits between LAOs and other relevant organizations.

4.4.3.6 Notify the investigation results of e-waste complaints to their agencies with joint monitoring and investigation, and the complainants are receiving the complaints. It is to update those agencies and the complainants to solve the problems.

4.4.3.7 Promote and develop innovation and technology on sorting, recycling, and disposal of household e-waste appropriate to the EEC areas. Recycling technology and environmentally-friendly disposal technology adopt in e-waste treatment and disposal factories. In addition, they are promoting and supporting research and development of quality technology used in e-waste treatment and disposal factories to achieve environmental quality and good health.

4.4.3.8 Drive the preparation of a Memorandum of Cooperation on Household Hazardous Waste Management (MOU) between PAOs, municipalities, SAOs in the provinces to solve the remaining household e-waste for disposal jointly.

4.4.3.9 Drive Provincial Industry Offices to inspect factories and receive opinions from people on e-waste treatment and disposal factories before permitting factory operation, according to the process of the permit for factory operation/expansion (Ror Ngor 4).

4.4.3.10 Upgrade the standards of junk shops and small local establishments disassembling e-waste to ensure hygienic working space, considering safety and danger to workers' health.

4.4.4 WT Strategy

The WT Strategies were the strategies derived from assessing internal factors (Weaknesses) and external factors (Threats) for joint consideration. The WT Strategies minimized weaknesses and avoid threats as follows:

4.4.4.1 Support personnel of LAOs have academic knowledge and understanding of household e-waste management at upstream, midstream, and downstream, relevant laws, and proper and efficient household e-waste management skills to reduce external dependency.

4.4.4.2 Plan and allocate expected budget between LAOs and relevant agencies in EEC to drive and operate action plans/projects of household e-waste management according to the principle of 3Rs. Their relevant agencies are REO 13 (Chonburi), PONRE, and Provincial Offices for Local Administration.

4.4.4.3 Create value for people to use household electrical and electronic appliances for maximum benefit and to change their appliances once they are expired or irreparable.

4.4.4.4 Allocate and prepare budgets for household e-waste management of LAOs. These are the budget for e-waste disposal, procurement, and repair, improvement of tools and equipment for collecting and transporting household e-waste based on appropriate and hygienic methods in compliance with relevant agencies. Those tools and equipment are household hazardous waste collection trucks and hazardous waste storage sites of LAOs.

4.4.4.5 Support the correct and safe space for garbage bins, hazardous waste bin, and collecting cupboard household of e-waste. Most bins are put outdoor and risked leachate to the environment and mixed household e-waste.

4.4.4.6 Survey and monitor the conditions of drop-off points of household e-waste within the LAOs' areas to ensure correct and appropriate methods and ready to function all the time.

4.4.4.7 Prepare readiness of personnel, system, and channels for receiving complaints of provincial agencies receiving complaints. That is speedy, efficient, and up-to-date solutions to people's problems.

4.4.4.8 Regularly monitor air pollution treatment system and wastewater treatment system of electrical and electronic manufacturing plants and

e-waste treatment and disposal factories in EEC. It ensures that treatment systems are in good condition and can function during factories' operation. Moreover, impacts on the environment and health of residents living near the factories, including conflicts with residents, are reduced.

4.4.4.9 Prepare personnel of LAOs and set the date and appointment time for collecting big-sized e-waste (e.g., computers, televisions, refrigerators, and air conditions) from people's houses. The management of big-sized e-waste would correct by LAOs, and reduce e-waste to junk shops and sidecar buyers of used items.

4.5 Appropriate Model of Household E-Waste Management for EEC

The researcher used the success factors and strategies of household e-waste management in EEC to develop the draft model of household e-waste management for the three provinces of EEC. The draft model consisted of the relationship between external factors (Context) and internal factors (Input, Process, Product, and Impact), and the draft guideline of household e-waste management for EEC developed from the SO Strategies, ST Strategies, WO Strategies, and WT Strategies according to the framework of CIPP-I Model. Then, the draft model of household e-waste for EEC was tested with the evaluation form with 55 assessors via Line, e-mail, and google form from February, 25-March, 11, 2021. The researcher used the testing results of the draft model and comments and recommendations of the assessors to develop and improve the draft model for more appropriateness and implementation. After that, the appropriate model of household e-waste management for EEC in Chachoengsao, Chonburi, and Rayong was developed. The study details are as follows:

4.5.1 Development of the Draft Model of Household E-Waste Management for EEC

The researcher used the success factors and the guidelines of household e-waste management in EEC obtained from the strategies to develop the draft model of household e-waste management for EEC based on the CIPP-I Model covering Context, Input, Process, Product, and Impact. Details are as follows:

4.5.1.1 Context

The context consists of policies, strategies, and plans relevant to e-waste management (Policy), economic conditions of the east (Economic), social conditions of the east (Social), technology of sorting, recycling, and disposal of e-waste (Technology), laws relevant to e-waste management (Legal), and environment of the east (Environment). The researcher takes the context and the guidelines of household e-waste management in Chachoengsao, Chonburi, and Rayong to propose the draft model of household e-waste management for EEC as follows:

1) Policies, strategies, and plans relevant to e-waste management

LAOs prepare the comprehensive and efficient plan for household e-waste management in EEC under the EEC development plan submits it to EECO for consideration and drive for concrete implementation.

2) Economic conditions of the east

(1) Relevant government agencies encourage factories of electrical and electronic industries in EEC to produce environmentally-friendly EEE with easy recycling, energy-saving features, durability and reduce the use of hazardous substances in the production process. It leads to recycling e-waste that facilitates sorting parts and circularity acquiring Rare Earth Elements (REEs). Furthermore, some valuable elements (e.g., gold, silver, platinum, aluminum.) for recycling as primary raw materials for electrical and electronic industries. Moreover, it leads to opportunities for investment and development in electrical and electronic manufacturing industries and e-waste sorting and recycling industries in the east in the future.

(2) Relevant government agencies promote electrical and electronic manufacturing plants in industrial estates in the EEC to buy back e-waste using several methods. The methods consist of exchanging old items with new ones, price reduction for the purchase of EEE for the public who brought in e-waste for the buy-back.

3) Social conditions of the east

(1) People plan the purchase of household electrical and electronic devices (e.g., mobile phones, computers, television) for appropriate and correct usage to extend their working life. If the devices are damaged after use, they should be repaired before changing to new ones.

(2) LAOs and related government agencies promote the public and consumers to reduce the unnecessary purchase of household electrical appliances and choose to buy them with caution, quality, standards, and environmentally-friendly labels or labels of Thai Industrial Standards (TIS).

4) Technology of sorting, recycling, and disposal of e-waste

(1) Relevant public sector drives e-waste treatment and disposal factories to use more recycling technology and serve as renewable raw materials for other industries according to the circular economy principle.

(2) Relevant public sector promotes and supports R&D on technology or use of advance and quality technology in the processes of treatment and disposal plants in EEC (e.g., sorting, recycling, and disposal of e-waste). It leads to good environmental quality and health for the public, such as waiver of income tariff for energy-saving, efficient machinery.

5) Laws relevant to e-waste management

(1) Relevant public agencies accelerate the enactment of the law on e-waste management or the Draft of the Waste Electrical and Electronic Equipment Management Act B.E. .... for enforcement.

(2) Relevant public agencies should amend related laws and improve rules and regulations related to HHM and household e-waste management for more clarity and accommodation of LAO's work on household e-waste management. It includes the stipulation of regulations on the provincial hazardous waste collection center, enacts municipal law on household e-waste management classified by types to ensure LAO's compliance with the laws.

6) Environment of the east

(1) Provincial agencies responsible for receiving complaints prepare to receive complaints and solve the problems all the time in terms

of personnel, complaint channels, investigation of facts, and report of the solutions to the problems.

(2) LAOs maintain the landfill system within the solid waste disposal sites based on academically correct methods to prevent the problems derived from e-waste leachate mixed with general solid waste and contaminated in the environment (i.e., surface water and groundwater sources and soil).

(3) LAOs provide the areas to put bins for general solid waste, hazardous waste, and cupboards collecting household e-waste that are proper and safe. As most of the areas where the bins are placed outdoor, they risk leaching contaminating the environment, such as surface water and groundwater sources, and soil.

4.5.1.2 Input

Input consists of personnel in responsible agencies and people (Man), budget (Money), e-waste management (Management), and equipment and tools (Material and Machine). The researcher uses the input and the guidelines of household e-waste management in Chachoengsao, Chonburi, and Rayong to propose the draft model of household e-waste management for EEC as follows:

1) Personnel and agencies responsible for e-waste management and people sector

(1) LAOs hold training for their personnel to acquire academic knowledge and understanding of household e-waste management at upstream, midstream, and downstream, as well as relevant laws, and to strengthen skills in the proper and efficient operation of household e-waste management.

(2) LAOs promote and support REO 13 (Chonburi) and PONRE for the coaching of operations and activities on household e-waste management to ensure learning and development of the potential of LAO's personnel.

(3) Provinces and LAOs hold activities to forge awareness, transfer of knowledge, and advice to the public or household representatives on e-waste management at origin, such as the household e-waste reduction, sorting, and separation by types of e-waste.

2) Budget for household e-waste management

(1) LAOs and relevant agencies in the EEC plan and allocate the budget to drive and operate the projects on household e-waste management. The project should use the concept of 3Rs and assign provinces, LAOs, communities, and the public to operate according to those projects jointly. The agencies are REO 13 (Chonburi), PONRE, and Provincial Office for Local Administration.

(2) LAOs prepare the budget for the purchase, repair, or improvement of collection trucks and storage sites of HHW with appropriateness and good hygiene according to relevant laws.

(3) PAOs prepare the budget for expenses in transferring household e-waste disposal using the recorded information of household e-waste in the Mor Phor 2 Form to prepare the budget.

3) Household e-waste management

(1) The people make an appointment of time and date with LAOs for the latter to collect large-sized e-waste (i.e., computer, television, refrigerator, and air conditioner) from people's houses.

(2) LAOs make a list of private legal companies dealing in the treatment or disposal of household e-waste located in the three provinces of EEC, both in and outside industrial estates.

(3) Rayong PAO or Rayong Integrated Solid Waste Management and LAOs in Chachoengsao and Chonburi collecting and sending household e-waste for disposal themselves determine the time of transfer of household e-waste to private sector's disposal facilities at least twice a year. It reduces the amount of remaining e-waste of LAOs for disposal and prevents the leak of hazardous substances of e-waste after the end of life or storage for a long time.

4) Equipment and tools for household e-waste management

(1) Chonburi PAO and Chachoengsao PAO accelerate the establishment of household hazardous waste provincial storage centers to collect and transfer household e-waste for academically correct disposal.

(2) LAOs improve the size of containers for more appropriateness and convenience to allow support of the household e-waste with an increased amount, such as computer, tablet, notebook, mobile phone, and television.

(3) LAOs should improve the household e-waste storage sites into closed buildings with sufficient space to accommodate the household e-waste collection in the year and prevent the leak of hazardous substances into the outside environment.

(4) LAOs should provide proper space in the collection trucks of HHW to prevent the leak of hazardous waste during transport.

4.5.1.3 Process

The process of household e-waste management in Chachoengsao, Chonburi, and Rayong consists of planning of work or project (Plan), operation of project or activity (Do), monitoring and inspection (Check), and improvement or rectification for proper operation (Act). The researcher uses the process and the guidelines of household e-waste management in Chachoengsao, Chonburi, and Rayong to propose the draft model of household e-waste management for EEC as follows:

1) Planning of work or project

(1) LAOs formulate the plan of household e-waste management integrated into the 4-Year Government Action Plan for LAOs to cover the three phases of household e-waste management: upstream, midstream, and downstream management. It determines the projects or activities to develop knowledge of officials and the public to understand the academically correct and efficient household e-waste management.

(2) LAOs in Chachoengsao and Chonburi that collecting and sending household e-waste for disposal by themselves devise the action plan of clusters. Their nearby LAOs within the provinces should send household e-waste of other LAOs for appropriate disposal by considering the Provincial Sewage and Solid Waste Management Committee in each province.

2) Operation of project or activity

(1) Provinces promote, applaud, and publicize the LAOs who received the clean LAO awards with the performance of household e-waste

management by the Action Plan "Clean Province" to serve as an excellent model to other LAOs.

(2) LAOs construct the community model of household e-waste management at origin to enable the public and the officials of other LAOs in the provinces to make field trips, exchange experiences in household e-waste and appropriately apply the knowledge and experience in their areas.

(3) LAOs collaborate with relevant agencies, such as REO 13 (Chonburi), PONRE, PCD, DEQP, and Provincial Office for Local Administration, to operate projects or campaign activities of household e-waste management local people and youth. They should regularly promote, provide knowledge, and publicize the e-waste reduction, sorting, collecting, and managing household e-waste at least twice a year. In their interviews, the government officials of the provincial administration No. 2 and No. 4 mentioned public relations and knowledge provided on household e-waste management to the public approximately two and three times a year, respectively (Detail under topic 4.2).

(4) LAOs regularly publicize the locations of the drop-off points of household e-waste, determine the date and time of the LAOs' collection to local people through various media such as at least twice a year. Their media are local radio and television, information board, people manual for e-waste sorting, and door knocking to acknowledge all the local people. From the interviews, the government officials of the provincial administration No. 2 and No. 4 stated that public relations and knowledge transfer to the public on household e-waste were conducted approximately two and three times a year, respectively (Detail under topic 4.2).

3) Monitoring and inspection

(1) LAOs monitor and inspect the information recording on the monthly e-waste management using the “Mor Phor 2 Form” for an accurate, complete, and up-to-date database of LAOs’ household e-waste management.

(2) LAOs cooperate and render assistance in solving complaints on household e-waste management of local agencies receiving complaints, such as Damrongtham Center of Province/District/Municipality, REO 13 (Chonburi), PONRE, and Provincial Industry Office.

(3) Local agencies receiving complaints notify the results of the investigations of the complaints on e-waste problems for the agencies responsible for joint investigations and the complainants. It ensures that they would be acquainted with the progress to solve the problems.

4) Improvement and rectification for appropriate operation (Action)

(1) LAOs engage private establishments (i.e., gas stations, convenience stores, centers of construction materials, department stores, and academic institutions in public relations) and determine the areas for installing visible drop-off points of household e-waste. It attracts interest and motivates people to reduce e-waste, sort, and bring e-waste for more disposal at the drop-off points.

(2) LAOs in collaboration with relevant government agencies (e.g., REO 13 (Chonburi), PONRE, Provincial Office for Local Administration, PCD, and DEQP) develop the model of public relations of household e-waste management to attract the people interests of all ages such as the use of role models through various social media for clarity (e.g., television, YouTube, Facebook).

(3) LAOs monitor the conditions of drop-off points in their areas to assess the conditions and the number of e-waste types and prepare the procurement or improvement of the e-waste containers. It ensures that all the drop-off points are appropriate and ready to use.

(4) DOLA and PCD develop the system and the model of recording and reporting of the information on household e-waste management for clarity, easy understanding, convenience, and speed to use the information such as through QR code.

4.5.1.4 Product

Product is household e-waste management in Chachoengsao, Chonburi, and Rayong under the Action plan “Clean Province” of MOI and relevant plans. The researcher uses the product and the guidelines of household e-waste management in Chachoengsao, Chonburi, and Rayong to propose the draft model of the household e-waste management for EEC as follows:

1) Installation of drop-off points of HHW (including e-waste) in all communities

LAOs install the appropriate drop-off points of household e-waste to cover all areas, such as the sign or message saying "drop-off point of household e-waste" and information on hazardous substances, impact on health, and environment attached to the container for household e-waste. The locations are private establishments (e.g., convenience stores, Big C, Lotus, gas stations, centers of tools and equipment, academic institutions), government buildings, and communities (e.g., provincial hall, village hall).

2) Sorted and collected household e-waste at the drop-off points as determined by LAOs.

LAOs install more bins for hazardous waste (orange) together with the collection cupboards of HHW to cover the areas of government agencies, private establishments, and academic institutions and to ensure more collection of household e-waste.

3) Amount of e-waste with more academically correct sorting and transfer for disposal

(1) Chachoengsao PAO accelerates the memorandum of agreement on HHW management (MOU) cooperation with municipalities and SAOs to reduce the amount of household e-waste from various LAOs awaiting academically correct disposal.

(2) LAOs collecting and sending household e-waste for disposal themselves should consider transferring household e-waste to the legal treatment or disposal plants situated in the EEC provinces and areas as a priority. Moreover, their plants have the permit for factory operation with efficient treatment or appropriate disposal.

4.5.1.5 Impact

The impact results from e-waste management in Chachoengsao, Chonburi, and Rayong, impacting the environment and health of local people, social impact, and economic impact. The researcher uses the impact and the guidelines of household e-waste management in Chachoengsao, Chonburi, and Rayong provinces to propose the draft model of the household e-waste management for EEC as follows:

1) Impact on environment and health of local people

(1) Provincial Industry Office inspects factories and announcements for the public opinions on e-waste treatment and disposal plants before issuing the permit for factory operation based on the process of request for factory operation/expansion (Ror Ngor 4).

(2) Electrical and electronic manufacturing plants and e-waste treatment and disposal plants in EEC must regularly inspect the air pollution treatment system and wastewater treatment system to their excellent conditions and functioning during the whole time the plants are operational. If the air pollution treatment and wastewater treatment systems do not function, rectifications must be made immediately.

2) Social impact

LAOs coordinate and forge cooperation with the local "Natural Resources and Environmental Protection Volunteer Network" or "NEV-Net" to regularly monitor and report the situations of household e-waste management to LAOs and agencies receiving complaints.

3) Economic impact

(1) LAOs coordinate with local junk shops for the standard pricing of WEEE. It ensures public fairness in compensation or the sold prices and motivates the public to sort correct types of household e-waste.

(2) LAOs support local junk shops and small entrepreneurs who disassemble e-waste to register and receive a permit for Operation License for Business of Health Hazards under Public Health Act B.E. 2535 (1992) and amended. It leads to upgrade the standards of junk shops and small local establishments for hygienic working areas and safety and good health for workers.

The draft model of household e-waste management for EEC in the provinces of Chachoengsao, Chonburi, and Rayong according to the framework of the CIPPI-Model is shown in Figure 4.17

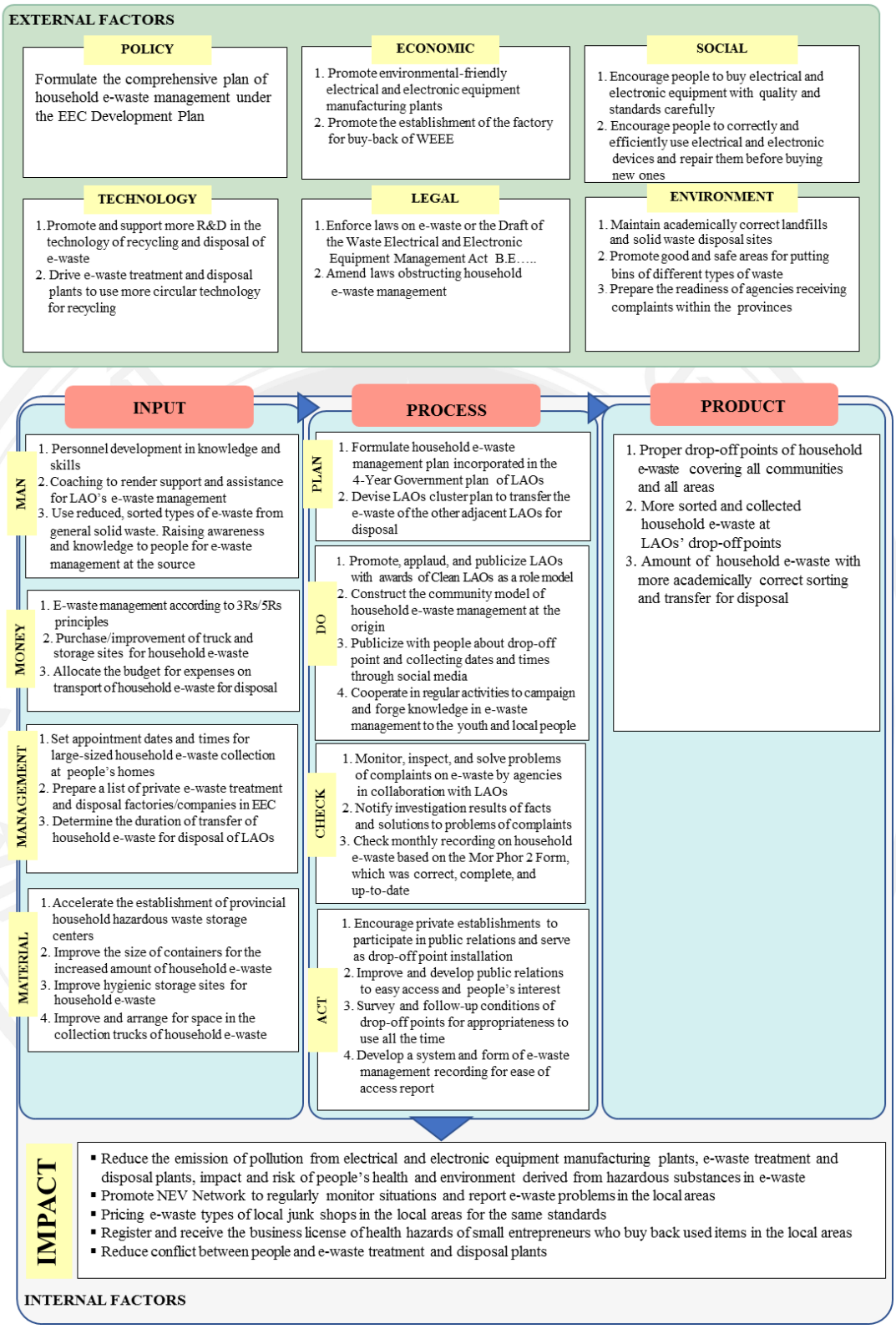


Figure 4.17 Draft Model of Household E-Waste Management for EEC

4.5.2 Appropriate Model of Household E-Waste Management for EEC

The researcher developed the draft model of household e-waste management for EEC in Chachoengsao, Chonburi, and Rayong based on the framework of the CIPP-I Model covering Context, Input, Process, Product, and Impact (Details under topic 4.5.1). The researcher tested the draft model with the appropriate evaluation form of the draft guidelines of household e-waste management for EEC. The online evaluation was conducted with replies back through e-mail, Line, and google form to avoid the risk of contracting COVID-19 during the disease outbreak in Thailand with 55 key informants between February, 25-March, 11, 2021. The key informants consisted of the target groups used to evaluate household e-waste management in EEC based on the CIPP-I Model (Details under topic 4.2) and more experts, scholars, and people sectors to express opinions on the draft model. The researcher sent the official letters seeking cooperation in filling in the evaluation form and coordinating with the assessors in advance to foster understanding with them and allow them to have sufficient information to express their opinions (Detail under item 3.4.2.3). The assessors were classified into five groups as follows:

1) The total of seven experts and scholars, namely lecturers in the public university, directors, supervisors, and environmental officers in the fields of environmental policy, HHW management, and household e-waste management of relevant government agencies such as the public university, PCD, Secretariat of the House of Representatives, and Solid Waste and Sewage Management Office of BMA.

2) The total of 30 executives, technical officers, plan and policy analysts, and officials responsible for the management of the environment, solid waste, HHW, and e-waste from government agencies of the central, regional, and local administration, namely PCD, DOLA, Department of Health, Secretariat of the House of Representatives, DEQP, REO 13 (Chonburi), PONRE, Provincial Office for Local Administration, Provincial Industry Office, Health Provincial Office, PAOs, and Division of Sanitary Works and Division of Public Health and Environment of city municipality, town municipality, and subdistrict municipality in Chachoengsao, Chonburi, and Rayong.

3) The total of six executives and technical officers responsible for environmental management in EEC and industrial estates, namely the EECO, IEAT, and industrial estates in Chachoengsao, Chonburi, and Rayong.

4) The total of two persons, namely manager and employee in the private sector who worked in electrical and electric manufacturing plants, e-waste treatment and disposal plants in the industrial estate in EEC.

5) The total of ten persons in the people sector, namely community leaders, household leaders, community committee members, and village health volunteers in municipalities of Chachoengsao, Chonburi, and Rayong.

Afterward, the researcher calculated the percentage of the appropriateness of draft guidelines and presented the analysis results with the opinions and recommendations of the assessors in the Table. The testing of the draft model with the evaluation form revealed that most assessors or 78.18-100.00% thought each guideline was appropriate and met the standard criteria compared to the evaluation criteria of efficient solid waste management for the budget year 2019 REO 13 (Chonburi). The criteria determined the standard equal to or more than 75% (Regional Environment Office 13 (Chonburi), 2021a). Details of the testing results are in Appendix G. However, and the researcher used the opinions and recommendations of the assessors to improve and rectify the draft guideline for more appropriateness, implementation, and efficiency of household e-waste management in EEC. The researcher also proposed the additional guidelines regarding the context (Social) and the environmental and people's health impact (Impact) and recommended the improved/rectified guidelines in the draft model. Then, the researcher developed the appropriate model of household e-waste management for EEC in Chachoengsao, Chonburi, and Rayong based on the framework of the CIPP-I Model consisting of Context, Input, Process, Product, and Impact with the following details:

4.5.2.1 Context

Context is the external factor and consists of policies, strategies, and plans relevant to e-waste management (Policy), economic conditions of the east (Economic), social conditions of the east (Social), technology of sorting, recycling, and disposal of e-waste (Technology), laws relevant to e-waste management (Legal), and environment of the east (Environment). The improved guidelines and

recommendations relevant to context are integrated with the draft model to develop the appropriate model of household e-waste management for EEC as follows:

1) Policies, strategies, and plans relevant to e-waste management

Potential LAOs and LAO models formulate the proposal comprehensive and efficient plan on household e-waste management in EEC and submit it to the EECO. After that, EECO submits it to the Eastern Special Development Zone Policy Committees (ESDZPO) to consider and drive for concrete implementation to continue (i.e., integrate it into the holistic EEC Development Plan and support the budget integrated budget of the EEC).

2) Economic conditions of the east

(1) Relevant government agencies encourage factories of electrical and electronic industries in EEC to design and produce environmentally-friendly EEE with easy recycling, energy-saving features, durability and reduce the use of hazardous substances in the production process.

(2) Relevant government agencies promote producers of electrical and electronic manufacturing plants in industrial estates in the EEC to set up product waste buy-back centers or make an agreement with LAOs to operate in their places with various methods. Their methods include exchanging old items with new ones, purchase discounts of EEE for the public, or returning e-waste.

3) Social conditions of the east

People plan the purchase of household electrical and electronic devices (e.g., mobile phones, computers, television) for appropriate and correct usage to extend their working life. If the devices are damaged after use, they should be repaired before changing to new ones.

(2) LAOs and related government agencies promote and provide knowledge about the plan and reduce the unnecessary purchase of household electronic appliances o the public and consumers. That encourages the public and consumers to choose or use the products with caution, quality, standards, and environmentally-friendly labels or labels of Thai Industrial Standards (TIS).

(3) LAOs cooperate with entrepreneurs to repair EEE in their areas set up the center for service and repair learning of household electronic appliances in communities. The center services the public and serves as a learning

source of repair and maintenance for household electronic appliances based on academic principles without impacting the environment and health for repairers.

4) Technology of sorting, recycling, and disposal of e-waste

(1) Relevant public sector drives e-waste treatment and disposal plants to use more recycling technology and serve as renewable raw materials for other industries according to the circular economy principle through the support of knowledge and budget assistance.

(2) Relevant public sector promotes and supports R&D on technology or use of advance and quality technology in the processes of e-waste treatment and disposal plants in EEC (e.g., sorting, recycling, and disposal of e-waste). It leads to good environmental quality and health for the public, such as waiver of income tariff for energy-saving, efficient machinery.

5) Laws relevant to e-waste management

(1) Relevant public agencies accelerate the enactment of the law on e-waste management or the Draft of the Waste Electrical and Electronic Equipment Management Act B.E. .... for enforcement, and there should be public relations and dissemination of the law content. It ensures advance acknowledgment for the people sector and related sectors before the enforcement.

(2) Relevant public agencies should amend related laws, rules, and regulations to HHW and household e-waste management to clarify and accommodate LAOs' work on household e-waste management. Examples are stipulation of regulations on the provincial hazardous waste collection center, enacts municipal law on household e-waste management classified by types to ensure LAOs' compliance with the laws.

6) Environment of the east

(1) Provincial agencies responsible for receiving complaints prepare to receive complaints and solve the problems of the complaints in terms of incorrect e-waste management all the time. It includes personnel, complaint channels, investigation of facts, solutions to the problems, and reports.

(2) LAOs maintain and improve the landfill system in the old solid waste disposal sites based on academically correct methods to prevent

leachate problems from e-waste. Leachate can mix solid waste and contaminate the environment, such as surface water, groundwater sources, and soil.

(3) LAOs provide the areas to put bins for general solid waste, hazardous waste, and collection cupboards of household e-waste based on correct and safe methods such as put in the areas protected from sunshine and rain.

4.5.2.2 Input

Input is the internal factor and consists of personnel in responsible agencies and people (Man), budget (Money), e-waste management (Management), and equipment and tools (Material and Machine). The improved guidelines and recommendations relevant to input are integrated with the draft model to develop the appropriate model of household e-waste management for EEC as follows:

1) Personnel and agencies responsible for e-waste management and people sector

(1) LAOs in collaboration with related public and private sectors hold training for their personnel to acquire academic knowledge and understanding of household e-waste management at upstream, midstream, and downstream, relevant laws, and strengthen skills in the proper and efficient operation of household e-waste management.

(2) LAOs promote and support REO 13 (Chonburi) and PONRE to coach operations/activities on household e-waste management to ensure learning and development of the potential of LAOs' personnel.

(3) Provinces and LAOs hold activities to forge awareness, foster knowledge and understanding for the youth, the public, and household representatives on e-waste management at origin (e.g., e-waste reduction, sorting of household e-waste, and separation by types of e-waste).

2) Budget for household e-waste management

(1) LAOs collaborate with relevant agencies in the EEC plan and allocate the budget to drive and operate the plans/projects on household e-waste management based on the concept of 3Rs by assigning provinces, LAOs, communities, and the public according to the plans. Those relevant agencies are REO 13 (Chonburi), PONRE, and Provincial Industry Office.

(2) LAOs collecting and transferring household e-waste by themselves prepare the budget for purchasing, repairing, or improving collection trucks and storage sites of household hazardous waste with appropriateness and good hygiene according to relevant laws.

(3) PAOs allocate the budget for expenses in transferring household e-waste for appropriate disposal to legal disposal plants and prepare the handbook of hiring the private sector in compliance with the law and related government regulations. The recorded data of the amount of household e-waste in the Mor Phor 2 Form is used to plan the budget.

3) Household e-waste management

(1) LAOs provide the service of collecting large-sized e-waste from people's houses (e.g., computer, television, refrigerator, and air conditioner.) The public can appoint a time and date with LAOs in advance (e.g., first Saturday of the month), or LAOs determine the date for collection and conduct public relations to ensure all people's acknowledgment.

(2) LAOs, in cooperation with relevant government agencies such as the PCD and Department of Industrial Works, make a list of private legal companies dealing in the treatment or disposal of household e-waste located in the three provinces of EEC, both in and outside industrial estates.

(3) Rayong PAO or Rayong Integrated Solid Waste Management and LAOs in Chachoengsao and Chonburi collecting and sending household e-waste for disposal themselves determine the time of transfer of household e-waste to the private sector's disposal facilities. That time would be when there is a large amount of collected e-waste or at least twice a year according to the handbook for transportation of HHW and WEEE for LAOs to the disposal sites (Pollution Control Department, 2020b).

4) Equipment and tools for household e-waste management

(1) Chonburi PAO and Chachoengsao PAO accelerate establishing provincial household hazardous waste storage centers to collect and transfer household e-waste for academically correct disposal.

(2) LAOs improve the size of containers for more appropriateness and could separate the types of e-waste for more convenience at work

and accommodate household e-waste with an increased amount such as computer, tablet, notebook, mobile phone, television.

(3) LAOs that sending household e-waste for disposal by themselves should improve household e-waste storage sites with the standard storage. That is closed buildings with sufficient space to accommodate the household e-waste collection in the whole year and prevent the leak of hazardous substances into the outside environment.

(4) LAOs should provide proper space in the specific collection trucks of e-waste types to prevent the leak of hazardous waste during transportation.

4.5.2.3 Process

The process is the internal factor and the processes of household e-waste management in Chachoengsao, Chonburi, and Rayong. It consists of planning of work or project (Plan), operation of project or activity (Do), monitoring and inspection (Check), and improvement or rectification for proper operation (Act). The improved guidelines and recommendations relevant to the process are integrated with the draft model to develop the appropriate model of household e-waste management for EEC as follows:

1) Planning of work or project (Plan)

(1) LAOs formulate the plan of household e-waste management integrated into the LAOs' 4-Year Government Action Plan to cover the 3 phases of household e-waste management: upstream, midstream, and downstream management. It determines the projects or activities to develop knowledge of officials and the public to understand the academically correct and efficient household e-waste management.

(2) LAOs in Chachoengsao and Chonburi collecting and transferring household e-waste for disposal by themselves devise the action plan of clusters in transferring other LAOs’ household e-waste within the provinces for appropriate disposal through the consideration of the Provincial Sewage and Solid Waste Management Committee in each province.

2) Operation of project or activity

(1) Provinces promote, applaud, publicize, and support the budget for household e-waste management to the LAOs who received the clean LAO awards with the performance of household e-waste management by the Action plan "Clean Province." It enhances better household e-waste management and serves as an excellent model to other LAOs.

(2) LAOs construct the community model of household e-waste management at the origin of at least one in every province. It enables the public and the officials of other LAOs in the provinces to make field trips and exchange experiences in household e-waste management and appropriately apply the knowledge in their areas.

(3) LAOs collaborate with relevant agencies, such as REO 13 (Chonburi), PONRE, PCD, DEQP, Provincial Office for Local Administration, Provincial Industry Office, to operate projects or campaign activities of household e-waste management for local people and youth. They should regularly promote, provide knowledge, and publicize the e-waste reduction, sorting, collection, and household e-waste management at least twice a year.

(4) LAOs regularly publicize the locations of the drop-off points of household e-waste, determine the date and time of the LAOs' collection to local people regularly through various media such as at least twice a year. Their media are local radio and television, information board, people manual for e-waste sorting, and door knocking to acknowledge all the local people.

3) Monitoring and inspection

(1) LAOs monitor and inspect the information recording on the monthly e-waste management using the “Mor Phor 2 Form” for an accurate, complete, and up-to-date database of LAOs’ household e-waste management.

(2) LAOs cooperate and render assistance in solving complaints on household e-waste management of local agencies receiving complaints such as Damrongtham Center of Province/District/Municipality, REO 13 (Chonburi), PONRE, and Provincial Industry Office.

(3) Local agencies receiving complaints notify the results of the investigations of the complaints on household e-waste problems for the agencies responsible for joint investigations and the complainants.

4) Improvement and rectification for appropriate operation

(1) LAOs engage private establishments (i.e., gas stations, convenience stores, centers of construction materials, department stores, and academic institutions in public relations) and determine the areas for installing visible drop-off points of household e-waste. It attracts interest and motivates people to reduce e-waste, sort, and bring e-waste for more disposal at the drop-off points.

(2) LAOs in collaboration with relevant government agencies (e.g., REO 13 (Chonburi), PONRE, Provincial Office for Local Administration, PCD, DEQP, and local academic institutions) develop the model of public relations of household e-waste management to attract the people interests of all ages such as the use of role models through various social media for clarity (e.g., television, YouTube, Facebook).

(3) LAOs monitor the conditions of the drop-off points in their areas to assess the conditions and the amount of e-waste of each type and prepare the procurement or improve the e-waste containers. It ensures that all the drop-off points are appropriate and ready to use.

(4) DOLA and PCD develop the system and the model of recording and reporting of the information on household e-waste management for clarity, easy understanding, convenience, and speed to use the information for other relevant agencies (e.g., QR code and reporting on Smartphone).

4.5.2.4 Product

Product is the internal factor and consists of household e-waste management in Chachoengsao, Chonburi, and Rayong under the Action Plan “Clean Province” and relevant plans. The improved guidelines and recommendations relevant to the product are integrated with the draft model to develop the appropriate model of household e-waste management for EEC as follows:

1) Installation of drop-off points of HHW (including e-waste) in all communities

LAOs add more installations of good drop-off points of household e-waste to cover all areas, with a clear sign or message. The message includes saying "drop-off point of household e-waste," information on hazardous substances, impact on health, and environment attached to the containers for household e-waste. The locations are private establishments (e.g., convenience stores, Big C, Lotus, gas stations, centers of tools and equipment), academic institutions, hospitals, government buildings, and communities (e.g., provincial hall, village hall).

2) Sorted and collected household e-waste at the drop-off points as determined by LAOs.

LAOs installs more bins for hazardous waste (orange) together with the collection cupboards of HHW to cover the areas of government agencies, private establishments, and academic institutions and to ensure more collection of household e-waste.

3) Amount of e-waste with more academically correct sorting and transfer for disposal

(1) Chachoengsao PAO accelerates the memorandum of agreement on HHW management (MOU) cooperation with municipalities and SAOs to reduce the amount of household e-waste from various LAOs awaiting academically correct disposal.

(2) LAOs collecting and sending household e-waste for disposal themselves should consider transferring household e-waste to the legal treatment or disposal plants situated in the EEC provinces and areas as a priority. Moreover, their plants have the permit for factory operation and with efficient treatment or appropriate disposal.

In summary, the indicators of the Product for the appropriate model of household e-waste management for EEC comprise 1) The number of proper drop-off points of household e-waste covering all communities and all areas, 2) Amount of household e-waste that was sorted and discarded at drop-off points, 3) The number of PAOs and LAOs as hosts for household e-waste disposal, and 4) Amount of remaining household e-waste that was proper disposal as shown in Figure 4.18.

4.5.2.5 Impact

The impact is the internal factor and consists of impact on environment and health of local people, social impact, and economic impact in Chachoengsao, Chonburi, and Rayong. The improved guidelines and recommendations relevant to impact are integrated into the draft model to develop the appropriate model of household e-waste management for EEC as follows:

1) Impact on environment and health of local people

(1) Provincial Industry Office inspect factories and announces the public opinions on e-waste treatment and disposal plants before issuing the permit for factory operation based on the process of request for factory operation/expansion (Ror Ngor 4).

(2) Relevant agencies such as the Department of Industrial Works, Provincial Industry Office, and IEAT promote and drive new e-waste treatment and disposal plants located in industrial estates in the EEC. As the operation of these plants will be under the supervision and revocation of operation of IEAT, which is by the Industrial Estate Authority of Thailand Act (No. 5) B.E. 2562 (2019). Moreover, their factories must comply with the mitigation measures to prevent and solve the environmental and health impacts of the particular industrial estate.

(3) Electrical and electronic manufacturing plants and e-waste treatment and disposal plants in EEC must regularly monitor the air pollution treatment and wastewater treatment systems. To ensure their good conditions and their functioning during the whole time the plants are operational. If the air pollution treatment and wastewater treatment systems do not function, rectifications must be made immediately. The monitoring and inspection of air quality and wastewater quality and the solutions to the problems must be regularly reported. Suppose the monitoring and inspection of air quality and wastewater quality show environmental problems or excess set standards. In that case, the problems must be solved in no time.

2) Social impact

LAOs coordinate and forge cooperation with NEV-Net and other local networks such as Local Environmental Volunteer Network (LEV-Net) to monitor and regularly report the unusual events of e-waste management in the local areas to LAOs and agencies receiving complaints.

3) Economic impact

(1) LAOs coordinate with local junk shops for the standard pricing of WEEE. It ensures public fairness in compensation or the sold prices and motivates the public to sort correct types of household e-waste.

(2) LAOs support junk shops and local small entrepreneurs who disassemble e-waste to register and receive a permit for Operation License for Business of Health Hazards under Public Health Act B.E. 2535 (1992) and amended. It leads to upgrade the standards of junk shops and small local establishments for hygienic working areas and safety and good health for workers.

Therefore, the appropriate model of household e-waste management for EEC in Chachoengsao, Chonburi, and Rayong according to the framework of the CIPP-I Model shows in Figure 4.18

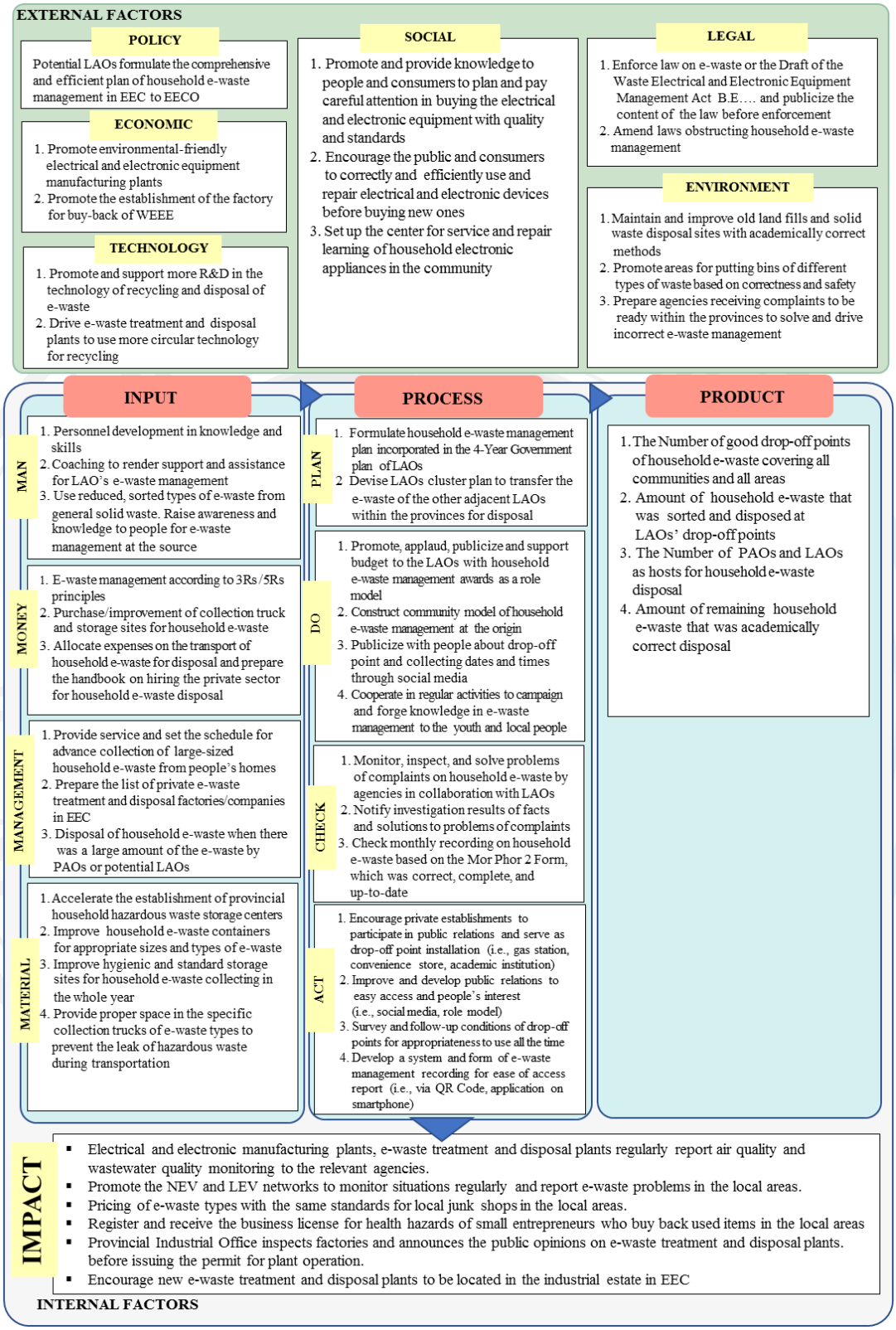


Figure 4.18 Appropriate Model of Household E-Waste Management for EEC

CHAPTER 5

Conclusion, Discussions, and Recommendations

The research on the Model of Electronic Waste Management for Eastern Economic Corridor (EEC) aimed to study the situations, problems, impacts, and guidelines of household e-waste management for EEC in Chachoengsao, Chonburi, and Rayong provinces according to the Pressure-State-Response (PSR) framework. Those could evaluate household e-waste management in Chachoengsao, Chonburi, and Rayong according to the CIPP-I Model and recommend the appropriate model of household e-waste management for EEC in the three provinces at the policy level. The conclusion, discussions, and recommendations are as follows:

5.1 Conclusion

5.1.1 Situations, Problems, Impacts, and Guidelines of Household E-Waste Management for EEC

The Pressure-State-Response (PSR) framework was applied to analyze EEC's household e-waste management overview in Chachoengsao, Chonburi, and Rayong provinces between 2016-2019. Those included situations, problems, impacts, and guidelines of household e-waste management in the three provinces from documentary research. **The pressure**s **(P)** were from the growing electrical and electronic industry and rising electrical and electronic devices from EEC development, including e-waste disposal behavior. In the future, the EEC zone will be developed into ASEAN's leading economic zone to promote 12 targeted industries. Some targeted industries, such as the electrical and electronic industry, telecommunication equipment industry, intelligent electronics industry, digital industry, the next-generation automotive industry, will develop in the three provinces and produce EEE and telecommunication equipment. EEE from the mentioned industries is e-waste that is expired or damaged or obsoleted, or discarded, or no

longer used. More population, workers, and manufacturers of electrical and electronic factories would come to live and do business in the EEC. Moreover, most people disposed of household e-waste mixed with solid waste, especially non-valuable e-waste, such as lamps, dry cells, and dry batteries. Therefore, the amount of e-waste from EEE and household consumption tended to increase and impact the overall efficiency of household e-waste management in the three provinces. **The state (S)** consisted of the situations, problems, and obstacles of household e-waste management in the three provinces from 2016-2019. In 2019, all LAOs provided at least one drop-off point of household e-waste per community or village, such as fluorescent bulbs, batteries, small electrical and electronic equipment (i.e., mobile phone waste with peripheral devices). The problems and obstacles to household e-waste management in EEC included 1) no specific unit in LAOs responsibility for household e-waste management; 2) a small number of lawful e-waste treatment and disposal factories; 3) lack of stringency in the enforcement of law related to household e-waste management; 4) no specific laws on e-waste management, and 5) less cooperation and awareness of people in e-waste separation and impacts on the environment and health. **The responses (R**) were policies, plans, guidelines on household e-waste management for EEC. Those examples included 1) announce policies and plans of e-waste management in EEC with concrete implementation; 2) accelerate the legislation on e-waste management; 3) engage people and communities in e-waste management at the origin; 4) develop the household e-waste database; 5) encourage manufacturers of electrical and electronic equipment to develop and design more environmentally-friendly goods, and 6) research and development on technology and innovations on optimal recycling of e-waste.

5.1.2 Evaluation of Household E-Waste Management in EEC

The evaluation of household e-waste management for EEC in Chachoengsao, Chonburi, and Rayong according to the CIPP-I Model was the study results of relevant academic documents, a compilation of information on household e-waste management, non-participant observation of the provincial e-waste storage centers, and the drop-off points in five municipalities, namely Chachoengsao Town Municipality, Laem Chabang City Municipality, Saen Suk Town Municipality,

Rayong City Municipality, and Thap Ma Subdistrict Municipality, as well as in-depth interviews with 27 key informants by semi-structured questionnaire. They were executives, policymakers, experts of e-waste management from government agencies and state enterprises both central and regional in the three provinces, including managers and employees in EEE manufacturing factories and e-waste sorting or recycling factories in industrial estates. Information was compiled between January-September 2020. The data analysis used content and grouping analysis. The study results are summarized as follows:

5.1.2.1 Context

1) Policies: The government formulated the policies, strategies, and plans which determined the clear guideline and goals of household e-waste management, such as 20-Year Strategic Plan for the Ministry of Natural Resources and Environment 2017-2036 with the goals of HHW management (including e-waste) based on academically correct methods for 100% by 2031, Integrated Waste Electrical and Electronic Equipment Management Strategy (2014-2021) determined that the ten types of target e-waste namely fluorescent bulb, dry battery, refrigerator, television, air conditioner, camera/video camera, portable video/audio devices, printer and Fax, telephone, and personal computer must be managed based on academically correct methods and safe for the environment, and National Solid Waste Management Master Plan (2016-2021) stipulated that for the goal of household e-waste management, HHW collected and disposed of with the academically correct methods must not be less than 30% of the amount of generated HHW by 2021. At the EEC area level, an Environmental Plan in Eastern Economic Corridor 2018-2021 focused on the standards of the collection and disposal sites of hazardous waste and household e-waste in EEC. Action Plan "Clean Province" determined the guideline of household e-waste management at upstream, midstream, and downstream using the principle of 3 Rs: Reduce, Reuse, and Recycle so that the PAOs and LAOs in EEC had clear guidelines and indicators of efficient household e-waste management.

2) Economics: Economic conditions of the east in Chachoengsao, Chonburi, and Rayong mainly depended on the industrial sector, with the EEE industry as one of the top three industries (Office of the National Economic and Social Development Council, 2019). In 2019, the number of industrial factories

under Electrical Machinery and Supplies totaled 576 factories (Department of Industrial Works, 2019). These factories would generate e-waste in the future. When EEE expired and as the households in EEC had relatively high average monthly household income (25,293.43 baht in 2019) (National Statistical Office, 2019), the ownership of EEE in households tended to increase, and the amount of e-waste from households tended to increase accordingly.

3) Social: In 2020, the population in Chachoengsao, Chonburi, and Rayong totaled 3,029,127 (Department of Provincial Administration, 2020), and the number of households was 1,228,329 (National Statistical Office, 2020). The consumption of EEE in households increased. Therefore, the amount of household e-waste increased accordingly. In the worst scenario, the amount of HHW equaled the amount of household e-waste. The amount of e-waste collected in the three provinces in 2019 (as of September 30, 2019) totaled 843.19 tons (Pollution Control Department, 2020d).

4) Technology: In household e-waste such as lamps, batteries, and dry cells, it was popular to use secure landfill and incineration with Rotary Kiln. As for sorting and recycling of household e-waste with factories permitted in Thailand, most used human labor and simple tools for disassembling e-waste parts and sorting non-valuable materials such as plastics, glass, iron. E-waste part crushing, a crusher, was used until the parts had appropriate size, and metals were sorted for reuse by using different qualities of the crushed material powder, such as specific gravity, electrical conductivity, and magnetism. (National Metal and Materials Technology Center, 2010). In Chonburi, there were sorting factories (category 105) and recycling factories of e-waste (category 106) awarded with plaques from the Department of Industrial Works in 2018 totaled seven registered factories (Sujitra Vassanadumrongdee, 2019).

5) Law: The government amended the laws and improved the measures to accommodate household e-waste management of LAOs more, such as Public Health Act B.E. 2535(1992) and amended (No.3) B.E. 2560 (2017) focused on the collection, transportation, and disposal of toxic waste or HHW in the local government agencies including PAOs, municipalities, and Pattaya with three methods, namely the local government agencies operated themselves, the local government

agencies assigned others to operate, and the local government agencies allowed others to operate. The Act of Maintaining Cleanliness and Tidiness of the City, B.E.2535 (1992) and amended (No. 2) B.E. 2560 (2017) involved the assignment to PAOs or the private sector to collect and handle HW with mixed sewage and solid waste collected by the local government agencies. Notification of Ministry of Interior on Solid Waste Management B.E. 2560 (2017) involved the orange containers for household toxic or hazardous solid waste. The provinces assigned PAOs to act as hosts in HHW management. Ministerial Regulation on Communal Toxic or Hazardous Solid Waste Management B.E. 2563 (2020) proposed the methods and measures to control and supervise hygienic toxic solid waste or household hazardous solid waste management. Those were sorting, containers, storage locations, and disposal with secure landfill and incinerator to protect people's health and hygiene prevent environmental impact. The Draft of the Waste Electrical and Electronic Equipment Management Act B.E.... was the law on e-waste management using Extended Producer Responsibility (EPR) principle to ensure the efficiency of buy-back system, collection, storage, transport, and disposal of e-waste. Moreover, laws were supporting LAOs' household e-waste for academically correct disposal, such as Factory Act B.E. 2535 (1992) and amended (No. 3) B.E. 2562 (2019) controlled factory operation. Industrial Estate Authority of Thailand Act B.E. 2522 (1979) and amended (No. 5) B.E. 2562 (2019) involved permit, supervision of operation, and revocation of operation of operators in industrial estates.

6) Environment: The environmental problems in EEC due to the expansion and development of industries of both the public and private sectors in the areas causing problems to the local people. Between 2017-2019, the complaints on the environment in the three provinces mainly were wastewater, followed by a foul smell, loud noise, hazardous waste, and garbage, respectively.

5.1.2.2 Input

1) Man: In terms of personnel and agencies responsible for household e-waste management and people sector, the PAOs (Chachoengsao, Chonburi, and Rayong) had agencies accommodating household e-waste management. Rayong PAO and Chachoengsao PAO were under the responsibility of the Division of Natural Resources and Environment. Chonburi PAO was under the

responsibility of the Division of Public Works. The municipalities in the three provinces were under the responsibility of the Division of Sanitary Works or Division of Public Health and Environment. Chonburi PAO faced insufficient personnel, lacked personnel with knowledge and expertise in household e-waste management. The personnel was also responsible for other tasks assigned, such as solid waste disposal and control of wastewater treatment systems. Most people in the three provinces thought that e-waste management was the duty of LAOs, so most people did not sort e-waste before disposal. They also mixed it with general solid waste in bins for general waste (dark blue bins). Only a minority of people discarded it in orange bins or drop-off points in communities.

2) Money: Budget used in household e-waste management, the three PAOs (Chachoengsao, Chonburi, Rayong), sufficient budget was formulated for HHW disposal (including household e-waste such as lamps, dry cell, and dry battery, mobile phone, computer). Supporting budget was also allocated from Provincial Office for Local Administration. Budget for the campaign, public relations, and knowledge on e-waste management, PAOs, Regional Environment Office (REO)13 (Chonburi), and Provincial Office of Natural Resources and Environment (PONRE) allocated budget for their agencies for the campaign, public relations, and knowledge on sorting of e-waste to people and young people at least 1-3 times a year, such as dissemination of brochures, posters, public handbooks, and training for the youth in academic institutions.

3) Management: In terms of household e-waste management, the classification of household e-waste was divided into non-valuable e-waste and valuable e-waste. Non-valuable e-waste was not popular with buyers of old items mixed with general solid waste. They were small e-waste such as lamps, dry cells and batteries, small electrical and electronic devices, and old mobile phones. The valuable e-waste was e-waste that buyers of old items could buy or resell to junk shops. Most were large-sized e-waste such as computers, television, air conditioner, and refrigerator. The non-valuable household e-waste management consisted of five main steps: ***Step 1*** Sorting and collection from drop-off points of household e-waste designated by LAOs, such as market, communities, convenience stores, academic institutions, department stores, construction material centers, and LAO offices. ***Step 2***

Transport by trucks specifically for HW or modified trucks transporting general solid waste according to each LAO set date and time. ***Step 3*** Storage by bringing collected household e-waste to be stored at storage sites of each LAO. The Rayong Integrated Solid Waste Management Center at Namkhok Subdistrict, Mueang Rayong District, Rayong, operated by Rayong Renewable Energy Co., Ltd. Within the center, there was a storage building of HHW. Whereas in Chonburi, there was no provincial storage center of HHW. In Chachoengsao, there was the Chachoengsao Integrated Solid Waste Management Center, but there was no collection system of household e-waste from each LAO for disposal. ***Step 4*** Transfer: When sufficiently collected household e-waste for disposal, some PAOs (Rayong PAO) or some municipalities sending it for disposal by themselves, such as Laem Chabang City Municipality, Chachoengsao Town Municipality. ***Step 5*** Disposal: Most hired private companies transfer e-waste for disposal or recycle outside the areas, such as Saraburi, Nakhon Sawan, and Samut Prakan. However, most people kept large-sized household e-waste (e.g., computer, television, air conditioner, and refrigerator) at home or repaired or sold it to local junk shops or sidecar buyers of old items or donate it. The large-sized household e-waste would be managed by the LAOs when people called in to make the appointment of date and time for the LAOs to collect it from people's homes.

4) Material and Machine: In terms of tools and equipment for household e-waste management, most LAOs in the three provinces had tools and equipment necessary for household e-waste management, such as containers, trucks for transporting household e-waste, and storage buildings. Nevertheless, they were not academically correct especially transporting trucks of household e-waste. For example, the use of modified garbage trucks in place of specific trucks for transportation of HHW, some storage buildings were not closed building, or with insufficient space to accommodate the amount of household e-waste collected during the year. The containers at the drop-off points had many forms, including orange or red rubbish bins, cupboards (prototype from PCD), and different square and cylindrical boxes (prototype from PONRE). The cupboards assisted people in sorting and separating household e-waste better than other forms because there were boxes of different sizes in the cupboards to accommodate the four main types of e-waste: short

light bulbs, long light bulbs, dry cell, mobile phone, and battery. Within the Rayong Integrated Solid Waste Management Center, there was an HHW storage closed building. There were tools and equipment necessary to transfer household e-waste to the HHW storage building and containers with sorted e-waste, such as the weighing machine for weighing trucks, forklifts, and large bags containing each type of e-waste.

5.1.2.3 Process

1) Plan: LAOs in the three provinces formulated plans or projects on household e-waste management continuously through the Action Plan "Clean Province" for the budget years 2017-2019. The Action Plan consisted of upstream, midstream, and downstream using the principle of 3Rs: Reduce, Reuse, and Recycle. However, the plan's operation on household e-waste management of LAOs depended on the government's policy, whether it focused on the types of waste, governors' policies, and the importance and urgency of the particular plan.

2) Do: Operation of project and activity included project and activity to foster the perception of e-waste management with relevant government agencies. Between 2016-2020, they were divided into projects or activities to inspire LAOs, such as the annual contest of municipal solid waste management "Clean Province" and projects or activities for people. They were: (1) training to provide knowledge on HHW management; (2) sorting of HHW; (3) installation of drop-off points such as the project to place cupboards; (4) collection of household e-waste, such as the project of out the old mobile phones and welcome new lives, the project of a marketplace for e-waste, project of 3 uses, if you do not use, please give it to us. LAOs determined projects or activities using personal media (lecturers), printing media (brochures, public handbooks, posters, stickers), and containers for HHW (cupboards from PCD) with reasonable cooperation and support from relevant public agencies, such as REO 13 (Chonburi), PONRE, PCD, DEQP which ensured that the operation of projects or activities continuously complied with the determined plans.

3) Check: Chachoengsao, Chonburi, and Rayong set up the Provincial Sewage and Solid Waste Management Committee in 2017 to supervise, follow-up, and evaluate the operation according to the plans and projects of LAOs' sewage and solid waste management at the provincial level by meetings the

Committee at least six times a year. LAOs recorded the information and monthly reported the results of HW management (including e-waste) based on the Mor Phor 2 Form in the IT system of DOLA, MOI since the budget year 2017, and reported of the amount of household e-waste to PAOs every month. As a result, the amount of e-waste was correct and up-to-date and used to plan the budget on LAOs' household e-waste disposal. In addition, there was the management of complaints of e-waste management problems by agencies receiving complaints, such as Provincial and District/Municipal Damrongtham Centers, REO 13 (Chonburi), PONRE, Provincial Industry Office through various channels. Those channels included the hotline, website, e-mail, submission of the letter in person, and Fax. Chachoengsao and Chonburi provinces found mostly foul smells and wastewater discharge from improper treatment and disposal e-waste factories. However, the agencies receiving complaints were no reports on the solutions to the local agencies who made joint follow-up and investigation of facts for acknowledgment. There was no appointment with their agencies, which made joint follow-up and investigation to make joint investigation again.

4) Act: LAOs in the three provinces motivated local people to take an interest and realize the importance of sorting e-waste at household and discarding it at drop-off points designated by LAOs. However, LAOs and other relevant local agencies such as REO 13 (Chonburi) and PONRE thought that more public relations in e-waste management issues through billboards, local radio, and television use role models and social media interest YouTube, Line. Their issues should be correct sorting of e-waste, types of e-waste, local drop-off points of e-waste, valuable e-waste, and impact from improper e-waste management. Each LAO also had to provide containers for e-waste, determine more drop-off points in communities, and schedule the date and time for collection of household e-waste. LAOs forged cooperation with the local private sector in EEC in the collection process. The private entrepreneurs offered locations where many people used services to install drop-off points of household e-waste, such as gas stations, convenience stores, construction material centers, academic institutions. So, drop-off points of LAOs' household e-waste covered all areas and made it more convenient for people to come and discarded more e-waste. E-waste treatment or disposal factories must

operate sorting, recycling, and disposal of e-waste based on legal and correct methods. Producers of EEE should develop environmental-friendly products with easy product waste management in the future (at the end of working life). They must also be responsible for collection and reuse as much as possible and appropriate disposal of e-waste.

5.1.2.4 Product

1) The installation of drop-off points in all communities: All LAOs in Chachoengsao (109 LAOs), Chonburi (99 LAOs), and Rayong (68 LAOs), there was the installation of drop-off points in all communities, at least one point per village or community. It accomplished the goal as determined in the Action Plan "Clean Province" 2019. For example, there was the installation of drop-off points of HHW (including e-waste) in all communities of the representative five municipalities in the three provinces. In those communities, there was the installation of more than one drop-off point per community (2-4 points/community) or 100% of the communities situated in particular municipalities (as of September 2020).

2) Sorted and disposed e-waste at drop-off points designated by LAOs: The storing cupboards could accommodate household e-waste in three main groups, namely (1) Long and short light bulbs such as fluorescent bulb, (2) Dry cell and battery such as the chargeable battery, mobile phone battery, and (3) EEE such as mobile phone and a peripheral device, television screen. Similarly, compilation results on different household e-waste in the budget years of 2017-2019 of three municipalities, namely Chachoengsao Town Municipality, Laem Chabang City Municipality, and Rayong City Municipality. In each municipality, the amount of sorted e-waste was approximately 1,500-2,000 kgs/year. Lamps found the most or the average of approximately 82% of the amount of collected e-waste. The amount of sorted e-waste in Laem Chabang City Municipality in Chonburi tended to increase for the past three years or equaled 1,998.60, 1,952.92, and 2,111.37 kgs/year, respectively (as of September 2020).

3) Increasing the amount of disposed of e-waste based on academically correct methods: Rayong PAO could send e-waste of three main groups of lamps, dry cell and battery, and EEE for proper disposal outside the areas. In 2018, the amount of e-waste sent for disposal totaled 4,862.50 kgs, and in 2019, the amount

increased to 11,466.50 kgs, mostly lamps (as of September 2020 from the Rayong Integrated Solid Waste Management Center). In Chonburi and Chachoengsao, five local government agencies collected and sent household e-waste for disposal, namely Laem Chabang City Municipality, Chaoprayasurasak City Municipality, Pattaya, Bowin SAO in Chonburi, and Chachoengsao Town Municipality in Chachoengsao. Most of these municipalities would hire private companies to transport e-waste for proper disposal outside the areas when the collected household e-waste was sufficiently large. For example, Chachoengsao Town Municipality's remaining household e-waste disposal during October 2019-August 2020 totaled 2,040 kgs (Pollution Control Department, 2020a).

5.1.2.5 Impact

1) Impact on environment and health: Between 2018-2020 in Chachoengsao and Chonburi provinces, contamination with some heavy metals such as lead, copper, arsenic, cadmium found in the soil, surface water sources, and groundwater sources exceeding the Thailand standards. In addition, foul smell problems found near the e-waste sorting and recycling factories with incorrect methods, such as burning, clandestine dumping, damaged/faulty air pollution treatment system, no air ventilation system, damaged dust filter bag, a small number of air ventilators. Some residents near the factories experienced headaches due to inhaling foul smells for a long time.

2) Social impact: The negative social impact included some residents living near improper e-waste sorting and recycling factories in Chachoengsao and Chonburi. They were troubled by a foul smell and had to move out. There was a conflict between residents and local government agencies on establishing e-waste treatment or disposal factories. The residents viewed that some local government agencies such as LAO and Provincial Industry Office facilitated operation or issuance of factory permits during the process of the local public hearing. The positive social impact included stimulation of "Natural Resources and Environmental Protection Volunteers or NEV." They monitored local areas in case of clandestine dumping of e-waste, foul deeds of e-waste sorting, and recycling factories, including good relationships between communities and entrepreneurs of factories

producing or disposing of e-waste in industrial estates in EEC through the Environmental Good Governance Project of IEAT.

3) Economic impact: The positive economic impact included the people earned income from the sales of large-sized e-waste in wholes such as computers, television, refrigerator, and air conditioner to local junk shops, sidecar buyers, and peddlers, employment, and income for local buyers from sorting of e-waste which brought back from the people. The negative economic impact included the public sector had to spend budget on improving or rehabilitating the environmental quality and health of local people in EEC from academically incorrect e-waste disposal methods and disassembling such as clandestine dumping and open burning.

5.1.3 Model of Household E-Waste Management for EEC

According to SWOT Analysis and TOWS Matrix Analysis, the draft model of household e-waste management for EEC in Chachoengsao, Chonburi, and Rayong provinces was developed based on the CIPP-I Model, the critical success factors, and the guidelines of household e-waste management in the three provinces. The draft model was tested with the evaluation form of the appropriateness of the draft guideline of household e-waste management for EEC during February 25-March 11, 2021, with 55 assessors. They were scholars, experts, executives in e-waste management of government agencies, state enterprises, managers and operators in EEE manufacturing factories and e-waste treatment or disposal factories in industrial estates, and representatives of the people sector in municipalities in the three provinces. The draft model testing revealed that 78.18-100.00% of the total assessors shown that each draft guideline was appropriate to implement, including within the standard criteria. It compared with the criteria of evaluation of efficient solid waste management for the budget year 2019 of REO 13 (Chonburi) who determined the standard to be equal or to exceed 75 % (Regional Environment Office 13 (Chonburi), 2020a) The comments and recommendations of the assessors were compiled to improve the draft model to be implemented and increased the efficiency of household e-waste management in EEC. Therefore, an appropriate model of household e-waste management for EEC is shown in Figure 4.18 and could be summarized as follows:

5.1.3.1 Guideline of Household E-Waste Management for EEC

1) Policy: Potential LAOs prepare the proposal of the comprehensive and efficient plan of household e-waste management for EEC and submitted it to the Eastern Economic Corridor Office Thailand (EECO) to drive for concrete implementation and integrate it into the holistic EEC Development Plan (Rectification/improvement).

2) Economic: First, relevant government agencies encourage EEE manufacturing factories in EEC to design and produce EEE, which is environmental-friendly, easy to recycle, energy-saving, durable, and reduces toxic substances in the production process. Second, promote EEE in industrial estates in EEC to set up WEEE buy-back center to receive the returned WEEE (Rectification/improvement).

3) Social: First, people plan the purchase of EEE in households appropriate to usage. If the products are damaged, they should repair them before buying new ones. Second, LAOs and relevant government agencies promote and provide knowledge to people and consumers to buy EEE with caution, quality, standards, and environmental-friendly labels or Thai Industrial Standard (TIS) labels. Third, LAOs and entrepreneurs set up a center for services and repair learning of household EEE in communities (Addition).

4) Technology: First, relevant government agencies drive the waste treatment or disposal factories to use recycling technology. Second, relevant government agencies promote and support research and development on technology or the application of advanced technology in the sorting, recycling, and disposal of e-waste.

5) Law: First, relevant public sector accelerates the drive of the Draft of the Waste Electrical and Electronic Equipment Management Act B.E. .... for enforcement, and there should be public relation and dissemination of the content of this law (Rectification/improvement). Second, the relevant public sector should amend laws and improve rules and regulations on household e-waste for clarity and more accommodations for the operation of LAOs.

6) Environment: First, agencies receiving complaints prepare to receive complaints and solve the problems of the complaints about improper e-waste management all the time. Second, LAOs monitor the landfill system within

solid waste disposal sites based on academically correct methods to prevent leachate problems and contaminate the environment. Third, LAOs provide the locations to put bins for general solid waste, hazardous waste, and storing cupboards of household e-waste based on correct and safe methods.

5.1.3.2 Input

1) Man: First, LAOs collaborate with related public and private sectors to hold training and acquire academic knowledge for understanding household e-waste management, including promoting household e-waste management skills for LAOs' personnel. Second, LAOs promote and support REO 13 (Chonburi), and PONRE serves as coaching in the operation of projects/activities related to household e-waste management. Third, Provinces and LAOs regularly organize activities to forge awareness, provide knowledge and advice to people in e-waste management at the origin.

2) Money: First, LAOs, in collaboration with relevant agencies in EEC, formulate and allocate the budget to drive and operate action plans/projects on household e-waste management based on the principles of 3Rs/5Rs. Second, LAOs allocate the budget for purchasing, repairing, or improving trucks collecting HHW and storage buildings with appropriateness and good hygiene. Third, LAOs should prepare a budget as expenses for sending household e-waste for disposal and prepare the handbook of hiring the private sector for proper disposal of household e-waste (Rectification/improvement).

3) Management: First, LAOs provide services of collecting large-sized e-waste for people at their homes. The people would make an appointment in advance for the date and time (Rectification/improvement). Second, LAOs, in cooperation with the PCD and Department of Industrial Works, make a list of private companies dealing in the treatment or disposal of household e-waste located in the EEC. Third, Rayong PAO and potential LAOs in Chachoengsao and Chonburi send collected household e-waste to private sector’s disposal sites at least twice a year when there is a large amount of collected e-waste.

4) Material and Machine: First, Chonburi PAO and Chachoengsao PAO accelerate the drive to establish the provincial storage center for HHW. Second, LAOs improve the size of containers for HHW for more

appropriateness and can separate e-waste. Third, LAOs should improve the household e-waste storage sites into closed buildings with sufficient space and correctly arrange the boxes for collecting household e-waste in the collection trucks of HHW.

5.1.3.3 Process

1) Plan: First, LAOs formulate the plan of household e-waste management integrated with the 4-Year Government Action Plan for LAOs. Second, LAOs in Chachoengsao and Chonburi who collected and sent household e-waste for disposal by themselves formulate the action plan of clusters in each province for sending household e-waste of other adjacent LAOs to proper disposal.

2) Do: First, Provinces promote, applaud, publicize, and support the budget to the LAOs which received Clean LAO Awards (Rectification/improvement). Second, LAOs construct a community model in household e-waste management at the origin. Third, LAOs cooperate with relevant agencies to operate projects or activities to the campaign, promote, provide knowledge, conduct public relations on household e-waste management to local people and young people regularly at least twice a year. Forth, LAOs regularly conduct public relations on the locations of drop-off points, scheduled the date and time of LAOs' collection of e-waste to all local people through various media at least twice a year.

3) Check: First, LAOs monitor the monthly recording of the information on e-waste management according to the "Mor Phor 2 Form" for up-to-date completeness. Second, LAOs cooperate and assist solve problems on e-waste from the local agencies receiving complaints. Third, the local agencies receiving complaints notify the investigation of e-waste problems to agencies who made the joint investigation.

4) Act: First, LAOs engage private entrepreneurs such as gas stations, convenience stores, construction material centers, department stores, and academic institutions to participate in public relations and determine the locations to install the drop-off points. Second, LAOs collaborate with relevant government agencies to develop the public relation of household e-waste to draw interest and easy access of people of all ages, such as role models via social media, i.e., television, YouTube, and Facebook. Third, LAOs survey and monitor the conditions of all

drop-off points to prepare or improve the appropriate size of containers for e-waste which would be ready to use. Forth, DOLA and PCD develop the system and record and report on household e-waste management for clarity, easy understanding, convenient use, and more speed to use the information.

5.1.3.4 Product: First, LAOs add more appropriate drop-off points to cover all areas with the sign, information on hazardous substances, and impact on health and environment attached to the containers. Second, LAOs add bins for hazardous waste (in orange) side by side the storing cupboards of HHW covering government buildings, private establishments, and academic institutions. Third, Chachoengsao PAO accelerates the Memorandum of Cooperation on HHW Management (MOU) with municipalities and SAOs in the provinces. Forth, LAOs who collected and transported household e-waste by themselves should consider sending household e-waste for treatment or disposal factories within the provinces and EEC as a priority.

5.1.3.5 Impact: First, Provincial Industry Office inspects factories and announces the public opinions on e-waste treatment or disposal factories before issuing factory permits. Second, the Department of Industrial Works, Provincial Industry Office, and IEAT promote and drive new e-waste treatment plants and disposal plants in industrial estates in the EEC (Addition). Third, EEE manufacturing plants and e-waste treatment and disposal factories in EEC must regularly inspect air pollution and wastewater treatment systems for excellent and prompt conditions during the whole operation. Suppose the monitoring of air quality and wastewater quality show environmental problems or excess set standards; the problems must quickly be solved. (Rectification/improvement). Forth, LAOs coordinate and collaborate with NEV-Net and LEV-Net to monitor and report the e-waste situations. Fifth, LAOs coordinate with local junk shops in pricing WEEE types for the same standards. Sixth, LAOs support local junk shops and small entrepreneurs who disassembled e-waste to register and receive operation licenses for health-hazardous business to the Public Health Act B.E. 2535 (1992) and amendment.

The summary of linkage of the study results of the model of household e-waste management for EEC in Chachoengsao, Chonburi, and Rayong shows in Figure 5.1.

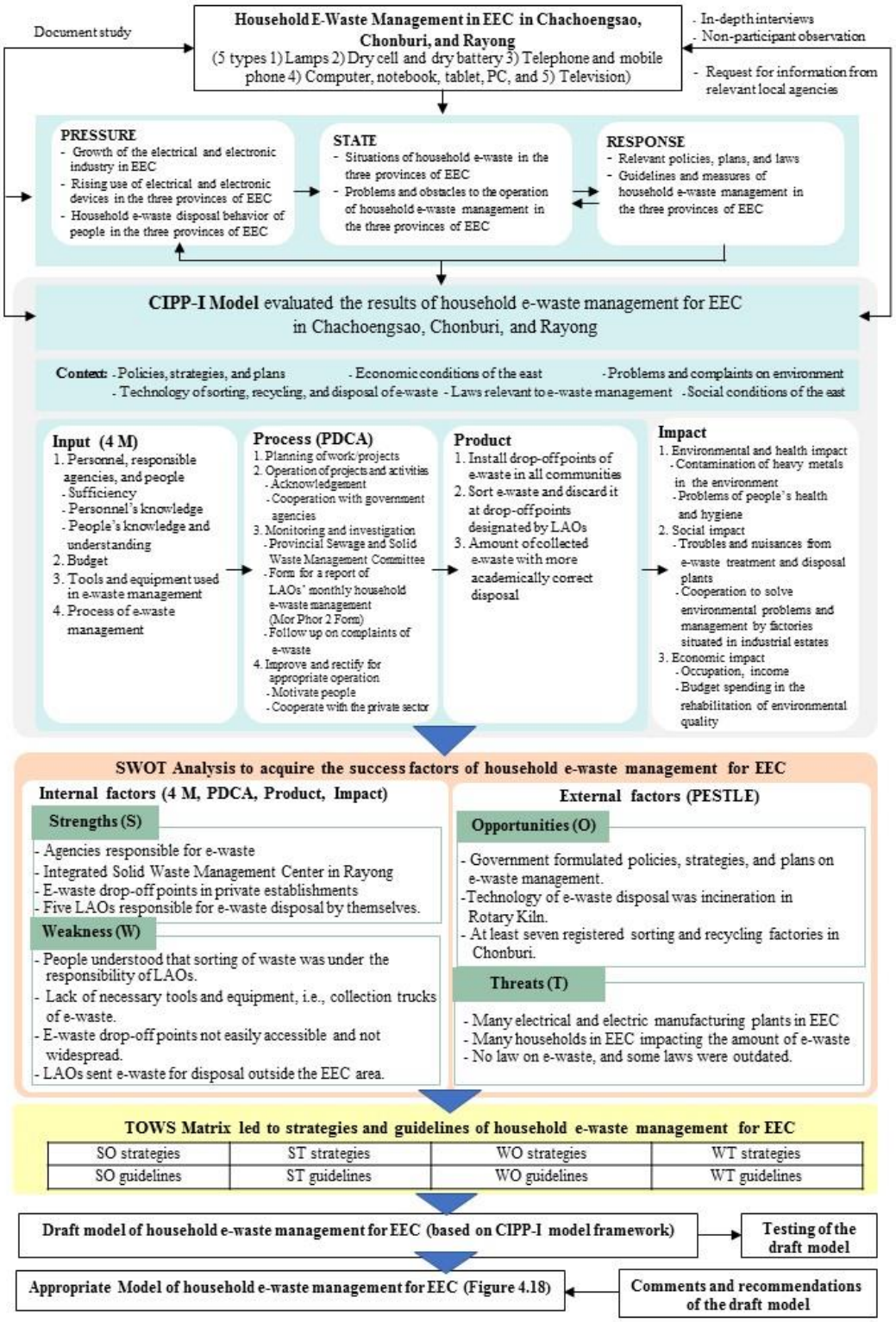


Figure 5.1 Summary of Linkage of the Study Results of the Model of Household E-Waste Management for EEC

5.2 Discussions

5.2.1 Household E-Waste Management in EEC

5.2.1.1 Local Administrative Organizations and Types of E-Waste

The household e-waste management of LAOs in Chachoengsao, Chonburi, and Rayong provinces had the guideline for LAOs to set up household hazardous waste drop-off points (including household e-waste) in local areas. Including PAOs acted as hosts to collect household e-waste from each LAO and send it for proper disposal. LAOs had to record the information and report the monthly of household e-waste management in Mor Phor 2 Form on the IT system of the DOLA according to the policy of the MOI of the Action Plan “Clean Province” (Ministry of Interior, 2018) and the policy of MNRE of the National Solid Waste Management Master Plan (2016-2021) (Pollution Control Department, 2016a). There were 276 LAOs in the three provinces, with 109 LAOs in Chachoengsao, 99 in Chonburi, and 68 in Rayong. (Department of Local Administration, 2020a). The study results revealed that the LAOs in the three provinces had no specific agencies responsible for e-waste management but had agencies responsible for collecting household solid waste and HHW instead. Rayong PAO and Chachoengsao PAO were under the responsibilities of the Division of Natural Resources and Environment, whereas Chonburi PAO was under the responsibilities of the Division of Public Works. As for the municipalities in the three provinces, they were under the responsibilities of the Division of Sanitary Works or Division of Public Health and Environment. In line with the study of Weerayut Sukhoyachai (2018) who stated that no internal unit of LAOs was explicitly responsible for the e-waste management system in Thailand. As a result, the e-waste management was not as proper and efficient as it should be.

However, the “Ministerial Regulation on Communal Toxic or Hazardous Solid Waste Management B.E. 2563 (2020)”, effective January 2021, assign the local administration to collect, transfer, or dispose of toxic or household hazardous solid waste, such as lamps, dry cell, and battery, EEE and comply with the criteria and hygienic principles of this Regulation. Therefore, LOAs must prepare containers, sort, collect, transfer, and disposal through sanitary landfills and incinerators to prevent impact on people's health and environment. Five types of

household e-waste in this study are namely, (1) Fluorescent bulb both compact and straight, (2) Dry cell and dry battery such as a chargeable battery, mobile phone battery, (3) Mobile phone and accessory, (4) Computer, tablet, notebook, and (5) Television. The study results revealed that between 2018-2020, most people in the three provinces did not sort e-waste before disposal. They discarded the waste with general solid waste in the bins for general waste (dark blue bins). Only a minority of people discarded it in bins for hazardous waste (orange bins) or at drop-off points of HHW. People thought that e-waste management was the responsibility of LAOs. Most e-waste such as dry cells and batteries were not valuable and could not be sold. However, dry cells and batteries, fluorescent bulbs, mobile phones, and accessories were small-sized e-waste. People could discard them in the containers of HHW, such as orange rubbish bins, square and cylindrical boxes, and cupboards by PCD. Consequently, that small-sized e-waste was managed as HHW following the Action Plan “Clean Province” by assigning LAOs to collect and send it for further disposal.

Computers and television, most people would keep them at home, have them repaired for reuse, sell them to junk shops or sidecar buyers of used items, or donate to others. Large-sized e-waste could not be discarded in the existing containers for HHW as prepared by LAOs. Therefore, LAOs could collect and manage both types of e-waste only in small quantities except when people called in to set the date and time with the LAOs collection of e-waste at their homes. Also, Sasiwimon Mudju (2018) studied the Bangkok Metropolitan Administration's e-waste management. The study revealed four e-waste management methods in people's households, namely (1) Mixed disposal with general waste, (2) Sell it to junk shops, (3) Keep it at home, and (4) Donate to others for repair. Most people chose to sell e-waste to junk shops and discard non-valuable e-waste mixed with general solid waste as they did not know about correct e-waste management. They thought it was the responsibility of the public sector to sort the types of waste. So, they thrust the BMA responsibility by discarding e-waste mixed with general waste. According to the study of Somsiri Decharat (2018) on people’s participation in hazardous waste management in Pa-payom District, Phattalung Province. It revealed that most people (53%) understood that once HHW such as dry cell, mobile phone, mobile phone battery was sorted and stored from general waste, it was the responsibility of LAOs for further

hazardous waste management. Moreover, the people's participation in HHW management was at a low level.

5.2.1.2 Collection of Household E-Waste

The collection of household e-waste of the LAOs during 2018-2020 revealed that in 2019 all LAOs in Chachoengsao, Chonburi, and Rayong provinces (276 LAOs) set up drop-off points for HHW (including household e-waste) in all communities at least one point in every village/community. Examples included Chachoengsao Town Municipality (23 drop-off points in 21 communities), Laem Chabang City Municipality in Chonburi (52 drop-off points in 25 communities), Saen Suk Municipality in Chonburi (24 drop-off points in 23 communities), Rayong City Municipality (60 drop-off points in 29 communities), and Thap Ma Subdistrict Municipality in Rayong (36 drop-off points in 8 communities). Regional Environment Office 13 (Chonburi) (2020b) found that the drop-off points were 100% set up in each province, reaching the goal in the Action Plan "Clean Province" 2019, which was higher than the setting up of the total drop- off points in 76 provinces or 98.83% (Ministry of Interior, 2020). Similarly, in 2021, the drop-off points in the three provinces were set up in all communities in each province or 100% (Regional Environment Office 13 (Chonburi), 2021b) It accomplished the goal set in the Action Plan "Clean Province" 2020 and was equaled to the setting up of drop-off points of HHW in all 76 provinces or 100% (Ministry of Interior, 2021).

Although all communities installed the drop-off points in the study results, people still discarded general waste in the bins for hazardous waste (orange bins) or the cupboards storing HHW. Some drop-off points had low usage and were damaged. The amount of household e-waste found the most was fluorescent bulb (approximately 82% of household e-waste collected by Chachoengsao Town Municipality, Laem Chabang City Municipality, and Rayong City Municipality in the budget years 2017-2019). It was probably because: (1) The drop-off points were located far from communities, so it was inconvenient for people to come and discard e-waste, (2) The containers for household e-waste did not have appropriate sizes for usage. The e-waste with the tendency to increase included mobile phones, computers, tablets, notebooks, television, and (3) People did not know where the drop-off points location. In line with the study of Mok Tuntipalaku (2016) ,who discussed e-waste management in Bangkok, most people (90%) thought that sorting of e-waste before disposal was necessary and

convenient for the government agencies' waste management. However, in implementation, the people's disposal of e-waste was still not correct due to insufficient locations for the disposal. Most people sold nearly all types of e-waste and had them repaired for reuse, except lighting equipment mostly put in separate bags.

5.2.1.3 Collaboration with Relevant Agencies

LAOs, in collaboration with local government agencies in EEC such as REO 13 (Chonburi) and PONRE, inspired local people to take an interest and realize the importance of sorting e-waste at household and disposal at drop-off points various locations as designated by LAOs with various patterns. Those patterns were activities to provide knowledge, publicize via media, and add more drop-off points. However, LAOs must increase public relations through social media to attract people's interest, such as local radio and television, billboard, Line, YouTube. At the same time, knowledge is regularly provided on proper methods of e-waste management, such as types and correct methods of sorting, locations of drop-off points in communities, schedule of date and time for large-sized e-waste collection. Those stimulate people to sort and take e-waste for disposal at the drop-off points or take old EEE for repair to reusing and donation. That is in line with Sasiwimon Mudju (2018) study, which found that advertisement and public relation media were crucial to people's good behavior on more e-waste management based on academically correct methods. At the same time, LAOs must set up drop-off points that quickly cover more areas to accommodate people who came to disposal. Those locations were convenience stores, department stores, tool shops, academic institutions, gas stations, and LAO offices. LAOs cooperated with the private sector to provide drop-off point locations that could LAOs collect more household e-waste in the areas. It might increase sales for the private entrepreneurs because people might use more services in the locations, such as purchasing daily goods and other tools, filling up gas. That is by the research of Chetphanat Leelasrisiri and Chutimaporn Mhonyai (2018). They found that the success was the enactment of laws enforcing hazardous waste management such as alkaline batteries and fluorescent bulbs, which included: (1) Public participation in all sectors, (2) Monitoring system, and (3) The sufficient number of drop- off points

covering all areas. The drop-off points were within a short distance (0.5-3 km) and convenient for consumers such as Seven-Eleven, Big C Mini, Lotus Express.

5.2.1.4 Disposal of Household E-Waste

The study findings revealed that between 2018-2020, six LAOs in the three provinces collected and sent HHW for disposal (including household e-waste) by hiring private companies. They were one in Chachoengsao, namely Chachoengsao Town Municipality, four in Chonburi, namely Pattaya, Laem Chabang City Municipality, and Chaoprayasurasak City Municipality, and Bowin SAO, and one in Rayong, namely Rayong PAO. Only Rayong PAO accepted to be host to collect and send household e-waste from all LAOs in Rayong for proper disposal (68 LAOs). The communities and LAOs in Rayong have brought e-waste to the Rayong Integrated Solid Waste Management Center free of charge since 2017. The center under the services and management of the Rayong Renewable Energy Co., Ltd. is at Nam Khok Subdistrict, Mueang Rayong District. Chonburi PAO was a host for the HHW collection of each LAO for disposal. That was because Chonburi PAO had already signed the "Memorandum of understanding of the cooperation on household hazardous waste management" with 95 municipalities and SAOs in Chonburi on September 25, 2020, but had not transferred e-waste of all 95 LAOs for disposal. At the same time, Chachoengsao PAO did not accept to be a host for collection and transfer of household e-waste for disposal due to determining the e-waste management guideline. Following the Pollution Control Department (2020d) information, Chachoengsao did not have a host for the HHW collection of each LAO for disposal.

Therefore, the tendency of household e-waste stored at each LAO office awaiting disposal was the highest in Chachoengsao, followed by Chonburi and Rayong, respectively. In the past three years, between 2018-2020, Chachoengsao and Chonburi did not have the collection system of each LAO's household e-waste for disposal. At the same time, only one out of 109 LAOs in Chachoengsao could collect and transfer household e-waste for disposal or 0.9% of all LAOs in the province. In Chonburi, there were 4 out of 99 LAOs or 4% of all LAOs in the province. Pollution Control Department (2020d) stated that the amount of collected household e-waste (e.g., lamps, dry cell, battery, electrical and electronic waste combined with chemical containers) of LAOs in Chonburi and Chachoengsao in 2019 (as per September 2019)

totaled 32 tons and 806 tons, respectively. Whereas in Rayong, the collected amount of that e-waste was 4.5 tons and transferred all for disposal. Similar to the latest information in September 2020, the collected household e-waste in each LAO in Chachoengsao, Chonburi, and Rayong totaled 25 tons, 22 tons, and 0.4 tons, respectively. However, there was no recording of the amount of e-waste sent for disposal (Regional Environment Office 13 (Chonburi), 2021b).

5.2.2 Impacts of E-Waste Management

5.2.2.1 Environmental Impact

For the past three years (2018-2020) in Chachoengsao and Chonburi, contamination of some heavy metals was found in soil, surface water sources, and groundwater sources around the e-waste recycling factories (category 106) with improper operation with exceeded the Thailand standards of soil quality, surface water quality, and groundwater quality, respectively. For example, lead and arsenic in soil exceeded 400 mg/kg and 3.9 mg/kg, respectively. Lead and arsenic in surface water sources exceeded 0.05 mg/L and 0.01 mg/L, respectively, which did not pass the surface water quality standard in class 3 (used for agriculture). Arsenic in groundwater sources exceeded 0.01 mg/liter. The survey reports heavy metal contamination in the soil around the disassembling, recycling, and landfill areas of e-waste in Thailand. During 2014-2017, lead and arsenic in soil exceeded the soil quality standard (> 400 mg/kg). Those included the areas for disassembling and crushing e-waste parts in Sua Yai Uthit Community, Chatuchak District, Bangkok, with lead found in soil 1,058 mg/kg (Seelawut Damrongsiri, 2015), Landfill of e-waste at Khok Sa-At Subdistrict, Khong Chi District, Kalasin with lead and arsenic found in soil 3.21-7,719.16 mg/kg and 0.74-12.90 mg/kg, respectively (Pornpilai Thanomsangad et al., 2018). E-waste recycling shops in Nakhon Si Thammarat, Songkhla, Phatthalung, and Trang, lead found in soil was less than 1.15-2,886.97 mg/kg (Peeranat Kiddee & Somsiri Decharat, 2017) Also, contamination of lead (0.183-2.106 mg/L), cadmium (0.007-0.179 mg/L), and copper (0.647-69.759 mg/L) at three surface water sources in e-waste landfill in Khong Chi District, Kalasin. The concentration of those heavy metals was exceeded the surface water quality standard

in class 3 (used for agriculture) due to leachate impact (Pornpilai Thanomsangad et al., 2018).

5.2.2.2 Health Impact

For the past three years (2018-2020), some residents living near improper processing of e-waste sorting factories (category 105) and e-waste recycling factories (category 106) in Chonburi and Chachoengsao experienced dizziness from inhaling foul smells for a long time. However, no report has shown other health symptoms from the accumulation of heavy metals in their areas. Nevertheless, if the bodies received heavy metals through breathing, dermal contact, or oral contact and accumulated in the body in large quantities, it would impact workers' health and people living nearby. For example, the lead would cause dizziness, destroy the central nervous system, cause amnesia, and impact a child's brain development (World Health Organization, 2019). Arsenic would destroy the nervous system, cause skin irritation and the digestive system. If exposed in large quantity at a short time, cadmium would cause headaches, vomit, and skin irritation. If exposed in the long run, it would cause Itai-Itai disease, brittle bones, and danger to the kidney (Department of Health, 2015; Orawan Phuphisut & Suleeporn Sangrajang, 2010). The study of Peeranat Kiddee and Somsiri Decharat (2017) found that the density of lead and cadmium in the blood of the 71 workers in e-waste recycling shops in Nakhon Si Thammarat, Songkhla, Phatthalung, and Trang was 1-17 microgram/deciliter (µg/dl) and 0.3-2.6 microgram/liter (µg/l), respectively. The density of lead and cadmium was within the standards according to the Notification of the Department of Disease Control on the Biological Exposure Indicies: Thai BEIs determined at 30 µg/dl and five µg/l, respectively. About 24% of workers (17 out of 71 persons) experienced head dizziness.

However, the study on the health risk assessment of e-waste dismantling workers exposed to heavy metals via dermal absorption in Daeng Yai subdistrict, Ban Mai Chaiyaphot district, Buriram province revealed that the concentrations of zinc > copper> lead> nickel> cadmium> arsenic in the dust on workers' hand. The heavy metals through dermal on-hand contact did not find the opportunity to increase health risk because workers were exposed to those heavy

metals through other parts of the body, such as the arm, leg, knee, and face (Kakanan Konjanawan et al., 2020).

5.2.2.3 Social Impact

For the past three years (2018-2020) in Chonburi and Chachoengsao, the most problem found was a foul smell from the incorrect operation of e-waste sorting and recycling plants. The causes were numerous such as the air pollution treatment system was out of order/faulty, absence of air pollution treatment system such as Wet Scrubber to eliminate the smell, dust, and smoke, damaged filter bag, low number of air ventilator. Consequently, some residents living near the factories were troubled by the foul smell and moved out. The study of Chatralada Kanchanasuttisang et al. (2015) revealed that in Chiang Rak Noi Subdistrict Municipality, Bang Pa-in District, Ayutthaya, e-waste mainly caused foul smell due to chemicals (61.30%) from three businesses, namely wooden pallets, recycled waste, and e-waste. Dizziness mainly occurred in workers during or after work (29%). People living in nearby communities (3 km radius) were mainly dissatisfied with the operation of e-waste disassembly (65%). Also, Narakorn Nuntatripob (2018) stated that the machine in plastic melting of e-waste caused a loud noise, foul smell from chemicals, and affected the residents living in communities near e-waste sorting and recycling factories.

5.2.2.4 Economic Impact

For the past three years (2018-2020), local people earned income from the sales of large-sized, valuable e-waste such as computers, television, refrigerator, air conditioner to junk shops, sidecar buyers, and peddlers. The buy-back prices of WEEE of Wongpanit International Co., Ltd. (as per December 29, 2020) such as mobile phone, old television with glass screen and LCD screen, computer case, and refrigerator with compressor equaled 1.50, 0.5-1.00, 2.50, and 3.50 baht/unit, respectively. The buy-back prices would be in the range of 50-200 baht/unit (Wongpanit International Co. Ltd., 2020). Income was generated for junk shops, sidecar buyers, and peddlers who bought back e-waste sorted by people and sold the sorted parts to industrial plants for further recycling. Pachanit Naovapun and Anusara Chaodorn (2020) , who found that the segregation parts of old CPUs' computers such as a circuit board, copper, aluminum, plastic, and iron could all be sold with 3,000, 156, 28, 12, and 9 baht per kg respectively, generating the average monthly profit of

9,963.53 baht or 41.72% of income. Also, Thitichai Athikomkulchai and Viroj Jadesalug (2015) presented that valuable e-waste such as television, refrigerator, air conditioners would be sold by the informal sector (i.e., junk shops, sidecar buyers, and peddlers). So, people would earn income through the informal sector. They employed people in communities to separate parts and valuable materials from e-waste for reselling with reasonable prices or recycling factories for reuse. Those led to create occupation and generate income for people in communities.

In addition, all LAOs with the potential of e-waste disposal by themselves hired private companies for disposal outside the EEC areas (i.e., Saraburi, Sa Kaeo, Ratchaburi, Nakhon Sawan, and Samut Prakan). The government might spend a budget on improving or rehabilitating environmental quality and people's health from poor e-waste management in EEC. That is by the study of Janejira Jannuwat (2019), who found that discarded e-waste with mixed general solid waste caused environmental contamination and impacted people's health. Those would cause affecting the economy as the government must spend a big budget for improvement and rehabilitation of environmental quality and people’s health.

5.2.3 Model of Household E-Waste Management for EEC

The model of household e-waste management for EEC consisted of success factors and guidelines of household e-waste management in Chachoengsao, Chonburi, and Rayong according to the CIPP-I Model framework.

5.2.3.1 Internal and External Factors

The critical success internal factors of household e-waste management for EEC in this study included: 1) Awareness and cooperation of people in household e-waste management at source through reduced consumption, sorting of waste at household, repair or improvement, and disposal of waste at drop-off points as designated by LAOs; 2) Campaign and public relations to provide correct knowledge and understanding on household e-waste management to people by LAOs and relevant government agencies; 3) Encourage the private sector on household e-waste management such as drop-off points of HHW to cover all areas with easy access and disposal; 4) Clarity of the guideline of large-sized e-waste management (i.e., computer, television) and transfer them by LAOs for disposal. The critical success

external factors of household e-waste management for EEC in this study included: 1) Enactment of laws on e-waste or Act on Management of Waste Electrical and Electronic Equipment; 2) Enactment of current laws related to e-waste management; 3) Environmental-friendly factories producing EEE; 4) Limited of e-waste recycling technology; 5) E-waste treatment and disposal plants with the standard operation in the EEC.

As mentioned above, several studies focused on the problems or barriers to the implementation of e-waste management. Kumar and Dixit (2018) showed that the policy and regulatory and technological barriers were the most critical barriers to implementing e-waste management in India. The infrastructural barriers (I), policy and regulatory barriers (PR), socio-cultural barriers (SC), socio-economic barriers (SE), and technological barriers (T) were the significant barriers to drive the overall e-waste management system such as storage, transportation, and treatment technology (I), delay in extended producer responsibility approaches (PR), low public environmental consciousness (SC), low recycling penetration and supply of domestic WEEE (SE), and limited skill workforce (T). In Thailand, the significant HHW management problems in Chonburi, Rayong, Chachoengsao, Chanthaburi, Trat, and Samut Prakan provinces during 2019-2020 included the following: people did not place importance on e-waste management at source, people still lacked knowledge and understanding of the e-waste sorting and collecting it at drop-off points, LAOs lacked public relations to provide knowledge and understanding on e-waste management to people, and the guidelines of e-waste disposal of many LAOs in some provinces was still unclear (Regional Environment Office 13 (Chonburi), 2020b, 2021b). Also, Saringkhan Khlaikhaek (2018) found that the significant obstacles of e-waste management included the absence of specific laws relevant to e-waste management. Government officials were not strict in enforcing laws and neglected to perform their duties.

5.2.3.2 Guidelines of Household E-Waste Management in EEC

The guidelines of household e-waste management in EEC for the study model can divide into two guidelines: policy guidelines and practical guidelines for household e-waste management in Chachoengsao, Chonburi, and Rayong provinces. The primary policy guidelines are: 1) Accelerate the enforcement of the Draft of the

Waste Electrical and Electronic Equipment Management Act B.E. .... and conduct public relations of the content of the law before implementation; 2) Promote and provide knowledge to people and consumers to plan and reduce the purchase of EEE with caution, quality, and standards; 3) Formulate the comprehensive plan on household e-waste management in EEC under the EEC Development Plan; 4) Promote EEE manufacturing plants in EEC to design and produce environmental-friendly EEE; 5) Drive e-waste treatment or disposal plants to use recycling technology, and new plants should be located in industrial estates; 6) Drive the establishment of a provincial center for e-waste storage; 7) Promote and support research and development on the technology of e-waste recycling and disposal.

The primary practical guidelines recommended to LAOs in their implementation include: 1) Regularly hold activities to raise awareness and provide knowledge, understanding, and advice to the youth, people, or household representatives on e-waste management at source (3 Rs/5Rs); 2) Provide services to pick up large-sized e-waste for people at their house; 3) Construct model community in household e-waste at source; 4) Add the installation of correct drop-off points with signs and information on the impact of hazardous substances at all private establishments, such as convenience stores, Big C, Lotus, gas stations, academic institutions, hospitals, government buildings, and communities (i.e., town halls, village town halls); 5) Forge cooperation with NEV-Net in monitoring, supervision, and reporting of e-waste management situations; 6) Develop public relations to draw interest and easy access of people via social media; 7) Encourage local junk shops to register and receive a permit to operate the business, which was hazardous to health, to upgrade the standard of the shops to be hygienic and safe for workers' health.

The guidelines from this study are in line with the United Nations Development Program; Republic of Korea (2019) reported that the Ministry of Environment of Korea installed recycling bins for batteries and other e-waste such as cell phones and fluorescent light bulbs in various public places. These public places were subway stations, community centers, parks, roads, and apartment complexes. The average of recycling bins in Seoul was 15 bins per administrative sub-unit in 2019. These easily accessible recycling bins led to an increase in the collection and

recycling of batteries. There was a "Seoul Recycling Centre" established by Seoul Metropolitan Government (SMG) and operated by "Eco-City Seoul." The center recycled mobile phones and small-scale appliances, such as rice cookers, computers, electric fans, heaters. The products were classified and disassembled by material types and then sold to secondary processing companies through bidding processes. Moreover, the Korean government continuously introduced new legislation and revised their existing laws related to e-waste management.

In raising awareness of consumers or people and other public relations, Park et al. (2019) showed that raising awareness of consumers and additional public relation activities for Door-to-Door (D-to-D) Service in South Korea were important. The public relations activities to the public were all media types, especially mass media such as radio or television. The D-to-D service was a successful WEEE collecting system of the Ministry of Environment of Korea and the Korea Electronics Recycling Cooperative (KERC) and used by the consumers with high satisfaction. The survey results in 2017 revealed that 48 % of respondents were aware of the operation of the service, with the highest awareness level in the two previous years. The effective routes of D-to-D recognition were mass media such as radio and television (24%), followed by promotional literature and inquiries to local authorities (19%), acquaintances (15 %), internet (14%), and online paths (4%) such as blog and Social Network Service (SNS), respectively.

Furthermore, the study results of the guidelines of household e-waste management in EEC are in line with the several studies in Thailand. For example, Sasiwimon Mudju (2018) reported that the guidelines of household e-waste management of Bangkok included: 1) Accelerate the drive of the law on e-waste management by stipulating that producers must be responsible for e-waste disposal based on correct methods; 2) Determine the role of producers to be responsible for their products from the production process, collection, and disposal; 3) Add more channels for e-waste collection, and 4) Encourage awareness and good behavior on e-waste management to people by which the government used advertising media to attract people’s interest and provide knowledge on correct methods of e-waste management. Janejira Jannuwat (2019) revealed that the guidelines of Thailand’s appropriate e-waste management focusing on the promotion of e-waste recycling included: 1) The public

sector should forge knowledge and understanding of the necessity to sort e-waste and the dangers of e-waste on environment and people's health continuously through the media; 2) The public sector should conduct public relations of the knowledge on purchase, use of EEE, recycling, and e-waste management to the public via media including documents and public relations; 3) Introduce tax exemption measures of e-waste to motivate consumers to take an interest in new products with components partly from recycling; 4) Promote the business of e-waste recycling such as financial support or technical support. Also, Chutima Keereeruttapisal (2020) suggested that Thailand should use tax measures to motivate the reduced amount of e-waste. The public sector should devise tax measures to donate the used EEE and collect value-added tax at the rate of 0% for the business of repair of EEE. Some countries had tax measures for e-waste management, such as tax reduction on EEE repair in Sweden (Margolis, 2017). Tax reduction for the donation of EEE found in the United States (Pandika, 2013) , and recycling fee paid by consumers when they purchased new household appliances (air conditioner, refrigerator, and television) in Japan (Ministry of Economy Trade and Industry, 2018).

However, cooperating with all sectors, including the public, private, and people sectors or stakeholders such as producers and consumers, is vital for more efficient household e-waste management in EEC. These can reduce the amount of household e-waste, more proper disposal of household e-waste, reduce impacts on the environment and people's health, and reduce expenses for e-waste management in EEC. The relevant government agencies and LAOs should apply the principle of 3Rs (Reduce, Reuse, and Recycle) at origin to reduce e-waste (Ministry of Interior, 2018; Pollution Control Department, 2018b) in parallel with the principle of Public-Private Partnerships. Those promoted and supported the private sector or manufacturer to invest or make a joint investment in a waste management system with the government and the local government such as factories for treatment or disposal of e-waste. The private sector was ready and had potential in maintenance and care of the system in the long run.

In contrast, many LAOs had limited budgets, machines, and personnel with knowledge and expertise in monitoring waste management systems (Pollution Control Department, 2018a). That is in line with Republic of Korea (2019) found that

the Ministry of Environment of Korea (MOE) started free collection services for large household appliances (i.e., refrigerators, washing machines, air conditioners, and televisions) with two partners. These partners were the Korea Electronics Recycling Cooperative (KERC) or private recyclers managing and coordinating a free-of-charge collection service network. Another partner, the Korea Environment Corporation (K-eco), monitored the implementation of recycling programs and ran management training programs for improving resources efficiency in e-waste management. The private sector or entrepreneurs or producers should apply the EPR principle in e-waste management. The producers must be responsible for the buy-back, recycling, and disposal of e-waste (Lindhqvist, 2000) in parallel with the concept of Circular Economy in the production process such as product design for long working life, easy to recycle, and easy to repair (Office of Industrial Economics, 2020a; Thailand Institute of Scientific and Technological Research, 2019). For example, in 2021, the "Thais without E-Waste" project of MNRE cooperated with Advanced Wireless Network Co., Ltd. to receive the donation of old, unused mobile phones and peripheral devices to collect and take them for environmental-friendly management. The donation box was set up at REO 13 (Chonburi) (Regional Environment Office 13 (Chonburi), 2021a). Also, Ampol Navavongsathian et al. (2017) stated that producers must also be legally responsible for buy-back, return their products, and design products with long working life, easy to repair and reuse. Similarly, Paphada Pramanpon et al. (2019) stated that the government of Thailand must accelerate the enforcement of the Draft of the Waste Electrical and Electronic Equipment Management Act B.E. ...., including must receive cooperation from producers and importers to buy-back WEEE.

Moreover, the government must also receive cooperation from the people for the return of EEE products. This Draft Act (Draft version in 2019) used the EPR principle in e-waste management by determining the duty of producers to set up the WEEE Buy-back Center and responsible for expenses in the operation of the Buy-back Center. Those measures might force producers to extend the working life of EEE products or postpone new EEE products to reduce the expenses of the Buy-back Center. In addition, there were measures enforcing people and penalties such as prohibition to dump waste in public places or deserted areas or e-waste disposal by mixing with solid waste. Upon violation, the penalties included imprisonment for a

term of not exceeding six months, or to a fine of not exceeding 50,000 baht, or to both. Japan successfully enacted laws specific to e-waste management by using EPR due to clear law, efficient law enforcement, and basic infrastructures such as storage sites and recycling factories (Ratchaphong Klinsrisuk & Wassana Jangprajak, 2016)

People sector or consumers should apply the principle of 5 Rs in e-waste management consisting of Reduce, Reuse, Recycle, Repair, and Reject (Department of Labour Protection and Welfare, 2011). According to Bovea et al. (2020) stated that the repair and reuse option of small household EEE in Span generally proved environmentally better than the replacement. However, for some EEE types of related failures, such as those related to the printed circuit boards (PCB) or motors, the replacement option was better than repair and reuse. That was because the environmental impact from PCB or motors repairing was higher than when new small household EEE was obtained.

5.3 Recommendations

5.3.1 Recommendations from the Study Results

5.3.1.1 Policy Recommendations

1) Central government agencies (e.g., PCD, DOLA, and DEQP) should provide e-waste management resources. They are budgets, human resources, equipment, and disseminate documents to Local Administration Organizations (LAOs) and local governments (e.g., REO 13 (Chonburi), PONRE). These can be improved their household e-waste management and operated without the central government assistance in the long term.

2) Department of Industry, Provincial Industrial Office, and Manufacturers in EEC should promote and support the designing and producing environmental-friendly EEE, such as the extension of life span, product reuse, component reuse, and material recycling. Furthermore, EEE manufacturers in Industrial Estates of Chachoengsao, Chonburi, and Rayong should set up a Product Waste Buy-Back Center or run a campaign to buy back WEEE with various methods. They are the exchange of old items for new ones or discounts for the customers who

returned WEEE. Furthermore, the principle of EPR can be corporate into the operation.

3) Department of Industry, Provincial Industrial Office, Industrial Estates, and LAOs in Chachoengsao, Chonburi, and Rayong provinces should encourage new e-waste treatment or disposal plants situated in industrial estates. Also, the recycling technology should develop in their plants for recyclable raw material used for other industries based on the circular economy's principle. They are the jewelry industry and electronic industry. Therefore, the pilot projects and guidelines of household e-waste recycling can transfer knowledge to operators of e-waste treatment or disposal plants.

4) The Eastern Special Development Zone Policy Committee (ESDZPO) should announce the policy on e-waste management in EEC that supports LAOs' e-waste reduction and separation household e-waste policy. Also, the Eastern Economic Corridor Office of Thailand (EECO) should coordinate with the Chachoengsao, Chonburi, and Rayong provinces and relevant LAOs to submit a comprehensive and efficient plan on household e-waste management. The EECO should drive the plan to implementation, such as budget support from the integrated budget of EEC or integration on the overall EEC Development Plan.

5) The policy of clusters of LAOs within the three provinces should be considered to reduce household e-waste. The Provincial Administration Organizations (PAOs) and potential LAOs could cooperate with other adjacent LAOs in the province to collecting household e-waste for academically correct disposal. That could reduce the remaining household e-waste in LAOs for proper disposal.

6) The relevant policies and laws of household e-waste management should be updated and revised. Those are policies and laws governing e-waste separation at origin, collecting large e-waste types, e-waste to repair, recycling, securing landfills, and incineration. Moreover, the EPR and Polluter Pay Principle can incorporate into the legislation.

7) The effective monitoring system of household e-waste management is necessary for executives of PAOs, LAOs, and local governments in EEC. That can continually check and investigate results following their indicators.

5.3.1.2 Implementation Recommendations

1) LAOs in Chachoengsao, Chonburi, and Rayong provinces should cooperate with relevant government agencies to regularly hold activities and provide knowledge on household e-waste management at source according to the principle of 5 Rs (Reduce, Reuse, Recycle, Repair, and Reject) for people. The agencies are the Regional Environment Office, PONRE, Provincial Office for Local Administration. Moreover, the public relations at the local areas about separation at source, locations of drop-off points, and schedule of e-waste collection need through various media, such as local radio and television, people handbook, and door knocking.

2) LAOs should cooperate with relevant public and private agencies in EEC to develop the pattern of public relations on household e-waste management to attract the interest of people of all ages. Using role models through various social media (e.g., television, Line, YouTube, Facebook).

3) LAOs should cooperate with relevant public and private agencies in EEC to install proper household e-waste drop-off points (i.e., signs showing the drop-off points, information showing impact from hazardous substances in e-waste) covering all areas. The areas include convenience stores, Big C, Lotus, gas stations, material and equipment centers, academic institutions, hospitals, town halls, village town halls. Moreover, monitoring and evaluating the condition of drop-off points are necessary to use all the time and improve the containers of e-waste according to e-waste types and amount of disposed of e-waste in each area.

4) PAOs and LAOs in cooperation with related agencies such as the Department of Industrial Works, Industrial Estates, and PCD should prepare the list of private companies dealing in the treatment or disposal of household e-waste in EEC. They should also consider sending household e-waste for treatment or disposal factories with the legal permit located in the EEC as the priority.

5) The Provinces in EEC should promote, applaud, publicize, and support the budget for household e-waste management to the LAOs with the Clean LAO award. Also, those LAOs should construct the community model of household e-waste management at the origin to serve as a learning source, study tour, and exchange of experience among LAOs.

6) PAOs and LAOs in EEC should provide enough personnel and budget for household e-waste management in their areas. However, budgets for the training of people awareness, transporting e-waste disposal, improvement, and purchase of equipment and facilities (e.g., container, bin, truck) should allocate for increasing efficient household e-waste management.

7) LAOs in Chachoengsao, Chonburi, and Rayong provinces and PONRE should announce the application of Local Environment Volunteer (LEV) and Natural Resources and Environmental Protection Volunteer ((NEV). Also, LAOs should coordinate and forge cooperation with Natural Resources and Environmental Protection Volunteer Network (NEV-Net) and Local Environment Volunteer Network (LEV-Net) in monitoring and reporting household e-waste management situations for receiving complaints. Moreover, there should be awarded NEV and LEV for excellent and regular operation.

8) The safety and good health for workers and upgrading the standards for clean working areas in junk shops and small entrepreneurs must be improved. LAOs should support junk shops and local small entrepreneurs who disassembled e-waste to register and receive a permit for Operation License for Health Hazardous Business under Public Health Act B.E. 2535 (1992).

5.3.2 Recommendations for Further Study

1) The practical guidelines of the model of household e-waste management for EEC in this study should be studied and conducted on the success and effectiveness of using those guidelines in EEC. Quantitative and qualitative research should be acquired to implement the guidelines of household e-waste management with several stakeholders, such as people, LAOs, public, government, and private agencies.

2) The transportation costs and promotion process of LAOs for transferring the collected household e-waste to factories or private entrepreneurs in the EEC areas should be further studied to reduce the collected household e-waste transportation cost of LAOs outside the EEC.

3) The appropriate model of large-sized household e-waste collection in EEC (e.g., television, computer, air conditioner) should be developed in further

study to create the proper collection by LAOs and reduce improper disposal of people. Those are selling to junk shops, leaving it at home, or discarding and mixing it with general solid waste.

4) The assessment of the value of the valuable metals in household e-waste (i.e., mobile phones, television, and computers) should be further studied to enhance awareness and implementation of people to sort the household e-waste at the source. That leads to adequately collect e-waste by formal sector because e-waste consists of valuable metals, such as gold, copper, and aluminum, which could be sold at reasonable prices and used as raw materials in numerous industries such as the jewelry and electronic industries.

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APPENDICES

APPENDIX A

Semi-Structured Interview Question

Set 1 For Executives and Government Officials of the Central Government

Set 1 For Executives and Officers of Eastern Economic Corridor Office of Thailand and Industrial Estate Authority of Thailand

Set 3 For Executives and Specialists of Regional Government Agencies and Provincial Administrative Organizations of Chachoengsao, Chonburi, and Rayong

Set 4 For Managers and Personnel of Private Companies, Producers, and Entrepreneurs in Electronic Waste Disposal in Industrial Estates in Chachoengsao, Chonburi, and Rayong

Semi-Structured Interview Set 1

For Executives and Government Officials of the Central Government

Name-Surname of Interviewed Person _____Position_____

Office Address_____

Telephone_____Email_____

Day/Month/Year_____Time_____

Place of Interview_____

Interviewer _____

1. Does the agency have policies, strategies, laws, or measures relevant to electronic waste (e-waste)? What are they? Are they successful, or do they encounter problems and obstacles? How?
2. At present, are there many companies/factories with operation in sorting, recycling, and disposal of e-waste in Eastern Economic Corridor (EEC)? What are they?
3. What is the technology of sorting, recycling, and disposal of e-waste in the factories in EEC?
4. What are the current and future laws and legal provisions on household e-waste management in EEC? How are they enforced?
5. In what process is the role of local administrative organizations (LAOs) in EEC in household e-waste management? How is it operated?
6. Are sorting, collection, transport, recycling, and disposal of e-waste in EEC academically correct? Can they reduce the amount of e-waste? How?
7. In the agency, are there plans and projects relevant to household e-waste management in EEC? What are they?
8. In the agency, are there activities held according to the plans or projects on household e-waste management in EEC? What are they?
9. In the agency, do projects or activities promote and support knowledge, understanding, and awareness of household e-waste management upstream, midstream, and downstream for local communities? How?

10. In the agency, are there campaigns and public relations to the communities in EEC to understand and realize the importance of correct household e-waste management? Through which channels? Are the channels sufficient and easily accessible? How?
11. In the agency, are there monitoring and evaluation of the success of household e-waste management? How?
12. In the agency, are there channels for complaints and follow-up on the complaints on household e-waste management in the three provinces in EEC? What are they?
13. Are there improvements or rectification of household e-waste management in the agency? How?
14. In the efforts for improvement and rectification of household e-waste management, are there responsible persons? Who are they?
15. How are the LAOs' current operations of household e-waste management in EEC?
16. Are the LAOs' current operations of household e-waste management in EEC by the Action Plan "Clean Province"? How?
17. Does household e-waste management impact the environment, such as water, air, soil, and people's health in EEC? How?
18. Does household e-waste management have both positive and negative social impacts in EEC? How?
19. Does household e-waste management have an economic impact on local people in EEC, such as income, occupation? How?

Semi-Structured Interview Set 2

For Executives and Officers of Eastern Economic Corridor Office of Thailand and Industrial Estate Authority of Thailand

Name-Surname of Interviewed Person _____Position_____

Office Address_____

Telephone_____Email_____

Day/Month/Year_____Time_____

Place of Interview_____

Interviewer _____

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1. Does the agency have policies, strategies, laws, or measures relevant to electronic waste (e-waste)? What are they? Are they successful or do they encounter problems and obstacles? How?
2. At present, are there many companies/factories with operations in sorting, recycling, and disposal of e-waste in EEC? What are they?
3. What is the technology of sorting, recycling, and disposal of e-waste in the factories in EEC?
4. What are the current and future laws and legal provisions on household e-waste management in EEC? How are they enforced?
5. Do local people have knowledge and understanding of household e-waste management in EEC? How?
6. How are the methods of household e-waste from sorting, collection, transport, and storage of e-waste in the three provinces of EEC? What are the main tools and equipment used?
7. In what process is the role of local administrative organizations (LAOs) in EEC in household e-waste management? How is it operated?
8. Are sorting, collection, transport, recycling, and disposal of e-waste in EEC academically correct? Can they reduce the amount of e-waste? How?

9. In the agency, are there plans and projects relevant to household e-waste management in EEC? What are they?
10. Are there improvements or rectification of household e-waste management in the agency? How?
11. In the efforts for improvement and rectification of household e-waste management, are there responsible persons? Who are they?
12. How are the LAOs' current operations of household e-waste management in EEC?
13. Are the LAOs' current operations of household e-waste management in EEC by the Action Plan "Clean Province"? How?
14. Does household e-waste management impact the environment, such as water, air, soil, and people's health in EEC? How?
15. Does household e-waste management have both positive and negative social impacts in EEC? How?
16. Does household e-waste management have an economic impact on local people in EEC, such as income, occupation? How?

Semi-Structured Interview Set 3

For Executives and Specialists of Regional Government Agencies and Provincial Administrative Organizations of Chachoengsao, Chonburi, and Rayong

Name-Surname of Interviewed Person _____Position_____

Office Address_____

Telephone_____Email_____

Day/Month/Year_____Time_____

Place of Interview_____

Interviewer _____

1. Does the agency have policies, strategies, laws, or measures relevant to electronic waste (e-waste)? What are they? Are they successful or do they encounter problems and obstacles? How?
2. At present, are there many companies/factories with operations in sorting, recycling, and disposal of e-waste in EEC? What are they?3. What is the technology of sorting, recycling, and disposal of e-waste in the factories in EEC?
3. What is the technology of sorting, recycling, and disposal of e-waste in the factories in EEC?
4. What are the current and future laws and legal provisions on household e-waste management in EEC? How are they enforced?
5. In EEC, are there agencies responsible for household e-waste management? Do the agencies have personnel with sufficient knowledge and expertise in e-waste management? How do they efficiently operate e-waste management?
6. Do local people have knowledge and understanding of household e-waste management in EEC? How?
7. Is the budget used in household e-waste management in EEC appropriate? How is it operated?
8. Is the area with budget support from relevant sectors render e-waste management more efficient? How?

9. How are the methods of household e-waste from sorting, collection, transport, and storage of e-waste in the three provinces of EEC? What are the main tools and equipment used?
10. In what process is the role of local administrative organizations (LAOs) in EEC in household e-waste management? How is it operated?
11. Are sorting, collection, transport, recycling, and disposal of e-waste in EEC academically correct? Can they reduce the amount of e-waste? How?
12. In the agency, are there plans and projects relevant to household e-waste management in EEC? What are they?
13. In the agency, are there activities held according to the plans or projects on household e-waste management in EEC? What are they?
14. In the agency, do projects or activities promote and support knowledge, understanding, and awareness of household e-waste management upstream, midstream, and downstream for local communities? How?
15. In the agency, are there campaigns and public relations to the communities in EEC to understand and realize the importance of correct household e-waste management? Through which channels? Are the channels sufficient and easily accessible? How?
16. In the agency, are there monitoring and evaluation of the success of household e-waste management? How?
17. In the agency, are there channels for complaints and follow-up on the complaints on household e-waste management in the three provinces in EEC? What are they?
18. Are there improvements or rectification of household e-waste management in the agency? How?
19. In the efforts for improvement and rectification of household e-waste management, are there responsible persons? Who are they?
20. How are the LAOs' current operations of household e-waste management in EEC?
21. Are the LAOs' current operations of household e-waste management in EEC by the Action Plan "Clean Province"? How?
22. Does household e-waste management impact the environment, such as water, air, soil, and people's health in EEC? How?

23. Does household e-waste management have both positive and negative social impacts in EEC? How?
24. Does household e-waste management have an economic impact on local people in EEC such as income, occupation? How?

Semi-Structured Interview Set 4

For Managers and Personnel of Private Companies, Producers, and Entrepreneurs in Electronic Waste Disposal in Industrial Estates in Chachoengsao, Chonburi, and Rayong

Name-Surname of Interviewed Person _____Position_____

Office Address_____

Telephone_____Email_____

Day/Month/Year_____Time_____

Place of Interview_____

Interviewer _____

1. Does the company or the industrial estate where the company is located have policies, strategies, laws, or measures relevant to e-waste? What are they? Are they successful or do they encounter problems and obstacles? How?
2. At present, are there many companies/factories with operation in sorting, recycling, and disposal of e-waste in the industrial estate where the company is located? What are they?
3. What is the company's technology for sorting, recycling, and disposal of e-waste?
4. What are the current and future laws and legal provisions on household e-waste management in EEC? How are they enforced?
5. Do local people have knowledge and understanding of household e-waste management in EEC? How?
6. In what process is the role of LAOs in EEC in household e-waste management? How is it operated?
7. In the company, are there plans and projects relevant to household e-waste management in the company? What are they?
8. Are there improvements or rectification of e-waste management in the company or the industrial estate where the company is located? How?
9. To improve and rectify e-waste management in the company or the industrial estate, are there responsible persons? Who are they?

10. How are the LAOs' current operations of household e-waste management in EEC?
11. Are the LAOs' current operations of household e-waste management in EEC by the Action Plan "Clean Province"? How?
12. Does household e-waste management impact the environment, such as water, air, soil, and people's health in EEC? How?
13. Does household e-waste management have both positive and negative social impacts in EEC? How?
14. Does household e-waste management have an economic impact on local people in EEC, such as income, occupation, etc.? How?

APPENDIX B

Non-Participant Observation Form

Observation area _____

Location _____

Day/Month/Year _____Time _____

Observer _____

Issues	Observation results
1. Location of the drop off points of household e-waste such as place, place owner, location (specify subdistrict, district, and province), installer of the drop off points	
2. Condition and utensil used to collect household e-waste include sound or damaged condition, garbage bin or sorting cabinet.	
3. Amount and types of e-waste found in the utensils that collect household e-waste such as light bulbs, batteries, and automotive batteries, electrical and electronic equipment	
4. Problems found around the drop-off points of e-waste include mixed with general waste, little usage, or no usage	
5. Areas to collect local e-waste, namely location (specify subdistrict, district, and province), location owner, equipment and tool, process of collection for disposal	

Other found observations ……

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APPENDIX C

Evaluation Form of the (Draft) Guideline of Household Electronic Waste Management for Eastern Economic Corridor in Chachoengsao, Chonburi, and Rayong

Explanations: This evaluation form is part of the dissertation of the candidate of the Doctor of Philosophy Program in Environmental Management, Graduate School of Environmental Development Administration, National Institute of Development Administration on the Model of Electronic Waste Management for Eastern Economic Corridor.

The objective is to evaluate the appropriateness of the **draft guideline of household electronic waste management in Chachoengsao, Chonburi, and Rayong.** The comments and recommendations of the assessor to improve it for appropriateness and recommend it in the model of household electronic waste management for EEC in the provinces of Chachoengsao, Chonburi, and Rayong province.

The evaluation form is divided into two parts as follows:

Part 1 General information of the assessor and definition

Part 2 Evaluation of the draft guideline of household electronic waste management for Eastern Economic Corridor in the provinces of Chachoengsao, Chonburi, and Rayong which will be recommended in the model

On this occasion, the researcher would like to thanks to all the assessors for filling in the complete evaluation form.

Chalida Nieobubpa
Candidate of the Doctor of Philosophy Program in Environmental Management
Graduate School of Environmental Development Administration
National Institute of Development Administration

Part 1 General information of the assessor and definition

1.1 General information of the assessor

Name-Surname. ..... Position.....

Name of agency or establishment.....

Home address Village .....No.....Road.....

Subdistrict.....District.....Province .....

Mobile phone number .....E-mail.....

Date of evaluation.....

1.2 Definitions

Household electronic waste (e-waste) means five types of household hazardous waste, namely 1) Fluorescent lamp 2) Dry cell and dry battery 3) Telephone and mobile phone 4) Computer, notebook, tablet, PC and 5) Television.

Eastern Economic Corridor (EEC) means the areas of Chachoengsao, Chonburi, and Rayong and some industrial estates in Chachoengsao, Chonburi, and Rayong following the Eastern Special Economic Development Zone Act B.E.2561 (2018).

Local administrative organization means the provincial administrative organization, city municipality, town municipality, and subdistrict municipality.

Model of household electronic waste management means pattern, principal component, and factor or relationship of pattern, component, and factor, including guideline of academically correct household e-waste management, with higher efficiency, and appropriate to the economic, social, and environmental conditions of Chachoengsao, Chonburi, and Rayong.

Part 2 Evaluation of the (draft) guideline of household e-waste management in the EEC in Chachoengsao, Chonburi, and Rayong

Tick ✓ in the appropriate and inappropriate space with recommendations to improve the guideline of operation

Appropriate means concrete implementation and impact on increased efficiency of household e-waste management in Chachoengsao, Chonburi, and Rayong

Inappropriate means no concrete implementation or no impact on increased efficiency of household e-waste management in Chachoengsao, Chonburi, and Rayong

***Your comments and recommendations are important and necessary to this study**

(Draft) Guideline of household e-waste management in Chachoengsao, Chonburi, and Rayong	Appropriate	Inappropriate	Additional comments*
1. Policy			
LAOs formulate the comprehensive and efficient action plan of household e-waste management in EEC under the EEC Development Plan and submit it to the Eastern Economic Corridor Office of Thailand (EECO)			
2. Economic conditions			
Relevant public agencies encourage electrical and electronic industries in EEC to produce environmentally-friendly EEE with easy recycling, energy-saving, resistant to usage, and reduce toxic substances in the production process.			
Relevant government agencies encourage electrical and electronic manufacturing plants within industrial estates in EEC to accept return of WEEE through trade-in of old items with new ones or purchase discount of EEE for people who return WEEE.			
3. Social conditions			
The people sector plans the purchase of household electrical and electronic devices for appropriate correct usage and to extend the working life of their products. If the products are damaged, they should repair them before buying new ones.			
LAOs and relevant government agencies promote the people sector to reduce the unnecessary purchase of households electrical and electronic appliances and choose to purchase them with caution, quality, and standards, and with environmentally-friendly labels or labels of Thai Industrial Standard (TIS) labels.			

(Draft) Guideline of household e-waste management in Chachoengsao, Chonburi, and Rayong	Appropriate	Inappropriate	Additional comments*
4. Technology			
Relevant government agencies drive factories operating treatment or disposal of household e-waste to apply more technology in new usage.			
Relevant government agencies promote and support research and development in technology or application of advanced technology with quality sorting, recycling, and disposal of e-waste in the e-waste treatment or disposal plants in EEC.			
5. Laws			
The relevant public sector accelerates the drive of Electronic Waste Management Act or the Draft of the Waste from Electrical and Electronic Equipment Management Act B.E. .... for enforcement.			
Relevant public sector should amend laws and improve rules and regulations on household e-waste management for clarity and more accommodations for the operation of LAOs, such as Municipal law on household e-waste management separated by types.			
6. Environment			
Agencies receiving complaints within the provinces prepare to receive complaints and solve the problems of the complaints all the time in terms of personnel, channels to receive complaints, monitoring and investigation of facts, and reporting of the results of the solutions to the problems.			
LAOs monitor the landfill within the solid waste disposal sites based on academically correct methods to prevent the problems of leachate from e-waste mixed with general solid waste and contaminated environment, such as surface water sources, groundwater sources, and soil.			
LAOs arrange space to correctly and safely install bins for hazardous waste and storing cupboards of household e-waste to reduce risks of stormwater runoff, leachate, and contaminating the environment, such as surface water sources, groundwater sources, and soil.			
7. LAO personnel and people sector			
LAOs hold training for their personnel to acquire academic knowledge and understanding on household e-waste management at upstream, midstream, and downstream, including the relevant laws, and promote skills in the			

(Draft) Guideline of household e-waste management in Chachoengsao, Chonburi, and Rayong	Appropriate	Inappropriate	Additional comments*
operation of household e-waste management with correctness, appropriateness, and efficiency.			
LAOs promote and support Regional Environment Office (REO)13 (Chonburi) and Provincial Office of Natural Resources and Environment (PONRE) to serve as coaching in the operation of projects/activities related to household e-waste management to ensure learning and development of the potential of LAOs' personnel.			
Provinces and LAOs organize activities to forge awareness, provide knowledge, and advice people in e-waste management at source. Those are e-waste reduction, sorting e-waste in households, and separating the types of e-waste before disposal at drop-off points of household e-waste designated by LAOs.			
8. Budget			
LAOs in collaboration with relevant agencies in EEC , such as REO 13 (Chonburi), PONRE, and Provincial Office for Local Administration formulate and prepare the budget to drive and operate action plans/projects on household e-waste management based on the principles of 3Rs.			
LAOs prepare the budget for procurement, repair, or improvement of the trucks collecting household hazardous waste, and hazardous waste storage sites for appropriateness and hygiene based on relevant laws.			
PAOs prepare the budget as expenses for transferring household e-waste for disposal to the private sector's disposal location.			
9. Household e-waste management			
People schedule the date and time for LAOs to pick up large-sized e-waste from people's households such as computers, television, refrigerator, and air conditioner.			
PAOs prepare the list of private companies operating treatment or disposal of household e-waste which are efficient, based on academically correct methods, legal, and located in the provinces and EEC both in and outside industrial estates			
LAOs collecting and sending for disposal household e-waste by themselves determine the time of sending household e-waste to the private sector's disposal facilities			

(Draft) Guideline of household e-waste management in Chachoengsao, Chonburi, and Rayong	Appropriate	Inappropriate	Additional comments*
at least twice a year.			
10. Tools and equipment			
PAOs establish the provincial hazardous waste storage centers to collect household e-waste and transfer it for academically correct disposal.			
LAOs improve the size of containers for household hazardous waste for more appropriateness and convenience to accommodate household e-waste, which tends to be of large quantity such as computer, notebook, tablet, PC, smartphone, and television.			
LAOs should improve the household e-waste storage site sites to closed buildings with sufficient space and correctly arrange the boxes for storing household e-waste collected during the year and prevent the leak of hazardous substances into the environment outside.			
LAOs should arrange for boxes to correctly store household e-waste in the trucks collecting household hazardous waste to prevent the leak of hazardous substances during transport.			
11. Planning of work or projects			
LAOs formulate the plan of household e-waste management integrated with the 4-Year Government Action Plan for Local Administrative Organization to cover the three processes for household e-waste management, namely management at upstream, midstream, and downstream.			
LAOs who collect and send household e-waste for disposal by themselves formulate the action plan of clusters in each province to send household e-waste of other LAOs to disposal by considering the Provincial Sewage and Solid Waste Management Committee of each province.			
12. Operation of projects or activities			
Provinces promote, applaud, and make public relations of the LAOs who received Clean LAO Awards with the performance of household e-waste management which is in line with the Action Plan “Clean Province” to serve as a role model for other LAOs.			
LAOs construct a community model in household e-waste management at origin to enable people and officers of other LAOs in the province to conduct study			

(Draft) Guideline of household e-waste management in Chachoengsao, Chonburi, and Rayong	Appropriate	Inappropriate	Additional comments*
tours, exchange experiences in household e-waste management, and apply to their areas for appropriateness.			
LAOs cooperate with relevant agencies such as REO 13 (Chonburi), PONRE, PCD, DEQP, and Provincial Office for Local Administration to operate projects or campaign activities of household e-waste to local people and young people. They should regularly promote, provide knowledge, and conduct public relations on e-waste reduction, sorting, collection, and management at least twice a year.			
LAOs conduct public relations on the locations of drop-off points of household e-waste, schedule the date and time of LAOs' collection to all local people through various media (e.g., local radio and television, information board, people handbook for e-waste sorting, door knocking at least twice a year.			
13. Monitoring and inspection			
LAOs monitor and inspect the monthly recording of the information on e-waste management according to the "Mor Phor 2 Form" for up-to-date and completeness.			
LAOs cooperate and assist in solving problems of complaints on household e-waste from the local agencies receiving complaints.			
The local agencies receiving complaints notify the investigation results on the complaints of e-waste problems to their agencies who made a joint investigation and the complainants for acknowledgment.			
14. Improvement and rectification for appropriate operation			
LAOs encourage private entrepreneurs to participate in public relations and determine the areas to install the drop-off points of household e-waste in the establishments of the entrepreneurs themselves, which are interesting, easily observable, and accessible. Those locations are gas stations, convenience stores, construction material centers, department stores, and academic institutions.			
LAOs collaborate with relevant government agencies (e.g., REO 13 (Chonburi), PONRE, PCD, and DEQP to develop the public relation of household e-waste management to draw interest and easy access of people of all ages. That is the use of role models to make public relations via social			

(Draft) Guideline of household e-waste management in Chachoengsao, Chonburi, and Rayong	Appropriate	Inappropriate	Additional comments*
media for clear pictures such as television, YouTube, Facebook.			
LAOs survey and monitor the conditions of all drop-off points in their areas to evaluate the conditions and the amount of e-waste by type, and prepare or improve the appropriate size of containers for e-waste which will be ready to use.			
Department of Local Administration and PCD develop the system and record and report the information on household e-waste management for clarity, easy understanding, convenient use, and more speed.			
15. Results from household e-waste management			
LAOs add good drop-off points for household e-waste with signs or messages showing "drop-off point for household e-waste" and information on hazardous substances, impact on health, and environment attached to the container of household e-waste to cover all areas. The locations include the areas of private establishments (e.g., convenience stores, Big C, Lotus, gas stations, tool and equipment centers, academic institutions), government buildings, and communities (e.g., town halls, village town halls.)			
LAOs add bins for hazardous waste (in orange) side by side the storing cupboards of household hazardous waste covering government buildings, private establishments, and academic institutions to accommodate more household e-waste.			
PAOs accelerate the preparation of the Memorandum of agreement on the cooperation of household hazardous waste management (MOU) with municipalities and SAOs in the provinces.			
LAOs collecting and transferring household e-waste by themselves should consider sending household e-waste for treatment or disposal at factories with permits and efficiency in treatment or disposal of household hazardous waste within the provinces and EEC as a priority.			

(Draft) Guideline of household e-waste management in Chachoengsao, Chonburi, and Rayong	Appropriate	Inappropriate	Additional comments*
16. Economic, social, and environmental impacts			
Provincial Industry Office strictly inspects factories and place the announcement for receiving comments from the public on household e-waste treatment and disposal factories before issuing factory permits.			
Electrical and electronic manufacturing plants and e-waste treatment and disposal factories in EEC must regularly monitor air pollution treatment system and wastewater treatment system for good condition and function during the whole time of the factories' operation.			
LAOs coordinate and cooperate with Natural Resources and Environmental Protection Volunteers (NEV) in monitoring and reporting the local situations of household e-waste management to LAOs and agencies receiving complaints continuously.			
LAOs coordinate with local junk shops in pricing WEEE types for the same standards to ensure people's equality in compensation and selling prices and motivate people to sort e-waste and separate correct types of e-waste.			
LAOs support local junk shops and small entrepreneurs who disassemble e-waste to register and receive permit operation licenses for health-hazardous businesses. That leads to upgrading the local junk shops and small entrepreneurs' standards and having a hygienic workplace and safe workers' health.			

Additional recommendations*.....

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Thanks to all the assessors for filling in the complete evaluation form

APPENDIX D

Index of Item-Objective Congruence (IOC) Results of the Questions

Questions	Experts Opinions Scores			Average Scores of IOC
	+1	0	-1	
Does the agency formulate strategies, policies, plans, or measures on electronic waste management? Are they successful? Are there problems or obstacles?	8	1	1	0.70
At present, are there a lot of companies/factories to sort, recycle, and dispose of electronic waste in EEC? Which are they?	8	2	0	0.80
What is the technology to sort, recycle, and dispose of electronic waste in factories in EEC?	8	2	0	0.80
What are the laws and legal measures on household electronic waste management in EEC at present and in the future? How are they enforced?	10	0	0	1.00
In EEC, are there agencies responsible for household e-waste management? Do those agencies have sufficient human resources with knowledge and expertise in e-waste management? How can the operation of the agencies responsible for household e-waste management be efficient?	8	2	0	0.80
What is the knowledge and understanding of household e-waste management of local people in EEC?	7	3	0	0.70
Is the budget for household e-waste management in EEC appropriate? How is it operated?	9	1	0	0.90
Are the areas receiving budget support from relevant sector for e-waste management more efficient? How?	10	0	0	1.00
What are the methods of household e-waste	8	2	0	0.80

Questions	Experts Opinions Scores			Average Scores of IOC
	+1	0	-1	
management of sorting, collection, transferring, and storing of electronic waste in the three provinces of EEC? What are the main tools and equipment?				
In what process is the role of local administrative organizations in e-waste management? How is it operated?	9	1	0	0.90
Are the sorting, collection, transfer, recycling, and disposal of e-waste in EEC academically correct? How? Can they reduce the amount of electronic waste?	9	1	0	0.90
Are there planning and project related to household e-waste management in EEC? How?	9	1	0	0.90
Are there activities held in accordance with the plan or project on household e-waste management in EEC in the agency? How?	10	0	0	1.00
Are there projects or activities promoting and supporting knowledge, understanding and awareness of household e-waste management from upstream, midstream, and downstream for the community in the agency? How?	8	1	1	0.70
Are there campaign and public relations for local communities to understand and realize the importance of correct e-waste management in the agency? Through which channels? Are the channels sufficient and easily accessible? How?	8	1	1	0.70
Are there monitoring and evaluation of the success of e-waste management in the agency? How?	8	2	0	0.80
Are there channels for complaint and follow-up the complaints from household e-waste management in the areas? How?	9	1	0	0.90
Is there improvement or rectification of household electronic waste management in the agency? If yes, how is it operated?	8	1	1	0.70
Are there responsible persons in the improvement	8	2	0	0.80

Questions	Experts Opinions Scores			Average Scores of IOC
	+1	0	-1	
and rectification of household e-waste management? Who are they?				
At present, how is the operation of household e-waste management of local administrative organizations in EEC?	6	4	0	0.60
Does the current household e-waste management of local administrative organizations in EEC align with the Action Plan “Clean Province”? How?	8	2	0	0.80
Does household e-waste management impact environment, such as water, air, soil, and local people’s health in EEC? How?	8	1	1	0.70
Does household e-waste management impact society in EEC? How?	7	3	0	0.70
Does household e-waste management impact community economy in EEC, such as occupation and income? How?	6	4	0	0.60

Note: +1 = Congruent

0 = Not certain

-1 = Not congruent

APPENDIX E

Collection of Data on Household Electronic Waste Management from Local Administrative Organizations

Name_____Position_____

Office address_____

Telephone_____Email_____

Day/Month/Year _____Time_____

Collector of data_____

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1. Projects or activities related to electronic waste (e-waste) management, target groups, number of participants, budget for the past three years, budget years 2017-2019, and performance of projects or activities with accompanying pictures.
2. Agencies providing cooperation or support of the projects or activities in item 1.
3. Examples of media or public relation documents used in the projects or activities in item 1 with accompanying pictures or documents, such as brochure, public guide, drop-off point of e-waste, public relation board.
4. Amount of collected household e-waste classified by type in the budget years 2017-2019 with the name and location of the factories of e-waste disposal or recycling that the e-waste was sent to for disposal as shown in the accompanying Table.
5. E-waste management in the areas (location of the drop-off point in community, date, time, and collection of waste, storage and disposal sites, and accompanying pictures, such as garbage trucks, building for e-waste collection, a bin for e-waste).
6. Methods of household e-waste management in the areas after collection.
7. Impact on environment, health, society, and economy from e-waste management in the areas.
8. Complaints on e-waste management in the areas.

Table of Record of the Amount of Household Hazardous Waste Classified by Types in Municipality of ..... **during the budget years 2017-2019**

From the drop off point of household hazardous waste .....number of drop off point/community

Types	Amount of Household Hazardous Waste (Kg.) (2-Digit Decimal)					
	Collection			Disposal		
	Budget year 2017	Budget year 2018	Budget year 2019	Budget year 2017	Budget year 2018	Budget year 2019
1. Lamps						
2. Spray can						
3. Dry battery						
4. Battery						
5. Electrical and electronic equipment such as						
6. Other contaminated materials such as bathroom cleaner bottle, expired medicine bottle, lubricant packaging, or materials contaminated with used lubricant						
Total from all local administrative organizations (number)						
Total of all household hazardous waste (kg.)						
Name of companies for waste disposal						
Waste sent for disposal at (province)						

Note: Budget year 2017 (1 Oct 2016 - 30 Sep 2017)
Budget year 2018 (1 Oct 2017 - 30 Sep 2018)
Budget year 2019 (1 Oct 2018 - 30 Sep 2019)

APPENDIX F

Certificate of Exemption

COE No. 2019/0012 Protocol ID No. ECNIDA 2019/0035

NIDA
WISDOM for Change

เอกสารรับรองการยกเว้นการพิจารณาจริยธรรมการวิจัยในมนุษย์

Certificate of Exemption

คณะกรรมการจริยธรรมการวิจัยในมนุษย์ สถาบันบัณฑิตพัฒนบริหารศาสตร์ ขอรับรองว่าโครงการวิจัยตามที่ระบุด้านล่างได้ผ่านการพิจารณาจริยธรรมการวิจัย และได้รับการยกเว้นการพิจารณาจริยธรรมการวิจัยตามแนวทางหลักจริยธรรมการวิจัยในมนุษย์ที่เป็นมาตรฐานสากล ได้แก่ ประกาศเฮลซิงกิ แนวทางการปฏิบัติการวิจัยทางคลินิกที่ดี และรายงานเบลมองต์

This is to certify that the research project identified below has been successfully reviewed and granted an exemption on human research protection by the Ethics Committee in Human Research, National Institute of Development Administration, which is in full compliance with international guidelines of human research protection such as Declaration of Helsinki, CIOMS Guidelines, and the Belmont Report.

ชื่อโครงการ:	ตัวแบบการจัดการขยะอิเล็กทรอนิกส์ในเขตพัฒนาพิเศษภาคตะวันออก
Project Title:	Model of Electronic Waste Management for Eastern Economic Corridor
ผู้วิจัยหลัก:	นางชลิดา เหนี่ยวบุบผา
Principal Investigator:	Mrs. Chalida Nieobubpa
อาจารย์ที่ปรึกษา:	ศาสตราจารย์ ดร.วิสาขา ภู่จินดา
Advisor:	Professor Dr.Wisakha Phoochinda
สังกัด:	คณะบริหารการพัฒนาสิ่งแวดล้อม สถาบันบัณฑิตพัฒนบริหารศาสตร์
Affiliation:	Graduate School of Environmental Development, National Institute of Development Administration

(ศาสตราจารย์ ดร.ก้ลยาณี เสนาสุ)
ประธานคณะกรรมการจริยธรรมการวิจัยในมนุษย์ สถาบันบัณฑิตพัฒนบริหารศาสตร์
Chairperson of the Ethics Committee in Human Research,
National Institute of Development Administration

วันที่รับรอง: 29 ตุลาคม 2562
Approval Date: October 29th, 2019

โครงการวิจัยนี้ได้รับการรับรองจริยธรรมการวิจัยในมนุษย์จากคณะกรรมการจริยธรรมการวิจัยในมนุษย์ สถาบันบัณฑิตพัฒนบริหารศาสตร์ แล้ว

หากผู้วิจัยต้องการปรับเปลี่ยนรายละเอียดบางส่วนของโครงการวิจัย ขอให้ผู้วิจัยแจ้งมายังศูนย์ประสานคณะกรรมการจริยธรรมการวิจัยในมนุษย์ สถาบันบัณฑิตพัฒนบริหารศาสตร์ โดยกรอกแบบฟอร์ม "แบบขอปรับเปลี่ยนรายละเอียดโครงการวิจัยที่ได้รับการรับรองจากคณะกรรมการจริยธรรมการวิจัยในมนุษย์ สถาบันบัณฑิตพัฒนบริหารศาสตร์ แล้ว (Approved Protocol Amendment Request Form)" เพื่อขอรับการพิจารณารับรองก่อนเริ่มดำเนินการวิจัย เมื่อคณะกรรมการจริยธรรมการวิจัยในมนุษย์พิจารณารับรองแล้ว จะมีหนังสือตอบรับแจ้งไปยังผู้วิจัย โดยระบุวันที่รับรอง ผู้วิจัยจึงสามารถเริ่มดำเนินการวิจัยต่อไปได้

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This research project has been certified by the Ethics Committee in Human Research, National Institute of Development Administration.

If the principal investigator needs to amend some details of the research project, he/she has to inform the Center of the Ethics Committee in Human Research, National Institute of Development Administration (CECNIDA) by completing the Approved Protocol Amendment Request Form for ECNIDA consideration before carrying out the research project. After the amendment is reviewed, the acceptance letter with the approval date will be sent to the principal investigator. Then the research project can be continued.

ศูนย์ประสานคณะกรรมการจริยธรรมการวิจัยในมนุษย์ สถาบันบัณฑิตพัฒนบริหารศาสตร์
เลขที่ 118 หมู่ 3 ถนนเสรีไทย แขวงคลองจั่น เขตบางกะปิ กรุงเทพมหานคร 10240

Center of the Ethics Committee in Human Research, National Institute of Development Administration
118 Moo 3, Serithai Road, Klong-Chan, Bangkapi, Bangkok THAILAND 10240
Tel. (+66) 2-727-3313 Website: http://ecnida.nida.ac.th/th/
E-mail: nidaec@nida.ac.th, ecnida@gmail.com

APPENDIX G

Results of the Testing of the Draft Model of Household E-Waste Management for EEC

The Draft Model	Appropriate*		Additional comments and recommendations
	Number (persons)	Percentage	
Context			
1. Policy			
1.1 LAOs formulate the comprehensive and efficient action plan of household e-waste management in EEC under the EEC Development Plan and submit it to the Eastern Economic Corridor Office of Thailand (EECO)	49	89.09	- LAO model should prepare the plan. Because in the case of operation in all local communities, it would need time. - The plan should be holistically formulated at the provincial level. - LAOs are not likely to have potential and cannot operate comprehensive e-waste management - LAOs should propose plans/projects to request for the integrated budget of the EECO. - In formulating the plan, consideration should be made on the Draft of the Waste from Electrical and Electronic Equipment Management Act B.E. .... as a guideline for accordance and actual implementation with the enforcement of the law soon.
2. Economic conditions			
2.1 Relevant public agencies encourage electrical and electronic industries in EEC to produce environmentally-friendly EEE with easy recycling, energy-saving, resistant to usage, and reduce toxic substances in the production process.	52	94.55	- Support the attachment of symbol of e-waste Management on goods/products - Support the design of EEE

The Draft Model	Appropriate*		Additional comments and recommendations
	Number (persons)	Percentage	
2. Economic conditions			
2.2 Relevant government agencies encourage electrical and electronic manufacturing plants within industrial estates in EEC to accept return of WEEE through trade-in of old items with new ones or purchase discount of EEE for people who return WEEE.	50	90.91	- As for the guideline to return the WEEE, the study should be conducted on the Draft of the Waste from Electrical and Electronic Equipment Management Act B.E. .... as already stipulated on this issue for uniform practical guideline.
3. Social conditions			
3.1 The people sector plans the purchase of household electrical and electronic devices for appropriate correct usage and to extend the working life of their products. If the products are damaged, they should repair them before buying new ones	53	96.36	- There should be public relations and provision of locations for the repair of EEE to people in each area, such as LAOs set up service centers within communities. - Public relations should provide knowledge to people on correct usage, as well as correct disposal of damaged EEE - Entrepreneurs of EEE repair must receive knowledge and must be under the supervision of LAOs to ensure that the repair and the e-waste generated from the repair do not impact the environment and health and hygiene of those who repair.
3.2 LAOs and relevant government agencies promote the people sector to reduce the unnecessary purchase of households electrical and electronic appliances and choose to purchase them with caution, quality, and standards, and with environmentally-friendly labels or labels of Thai Industrial Standard (TIS) labels.	52	94.55	- Knowledge should promote the people sector to plan and reduce the purchase of EEE in households. - Focus should be on the promoting of quality production and promotion of marketing to encourage consumers' interest in using environmentally-friendly products.

The Draft Model	Appropriate*		Additional comments and recommendations
	Number (persons)	Percentage	
4. Technology			
4.1 Relevant government agencies drive factories operating treatment or disposal of household e-waste to apply more technology in new usage.	53	96.36	- The establishment of comprehensive e-waste treatment or disposal plants or the use of technology requires high investment for entrepreneurs. Therefore, the government must support knowledge transfer and budget or tax reduction measures.
4.2 Relevant government agencies promote and support research and development in technology or application of advanced technology with quality sorting, recycling, and disposal of e-waste in the e-waste treatment or disposal plants in EEC.	52	94.55	- Incentives should be offered, such as tax for motivation. The operation of factories must be strictly controlled because hazardous substances may impact the environment and people's health around the factories. - It will create efficient disposal of household e-waste and reduce pollution to the environment. - It will develop technology for maximum benefit.
5. Law			
5.1 The relevant public sector accelerates the drive of Electronic Waste Management Act or the Draft of the Waste from Electrical and Electronic Equipment Management Act B.E. .... for enforcement.	50	90.91	- Public relations should be conducted on the draft of the Waste from Electrical and Electronic Equipment Management Act B.E. .... for people's acknowledgment before enforcement of the law. - Companies producing and selling electrical and electronic equipment must be responsible for the disposal of e-waste so that more e-waste will be in the system and reduction.
5.2 Relevant public sector should amend laws and improve rules and regulations on household e-waste management for clarity and more accommodations for the operation of LAOs, such as Municipal law on household e-waste management separated by types.	51	92.73	- Responsible officers or personnel in local administration must strictly enforce laws and must strictly comply with the law.

The Draft Model	Appropriate*		Additional comments and recommendations
	Number (persons)	Percentage	
6. Environment			
6.1 Agencies receiving complaints within the provinces prepare to receive complaints and solve the problems of the complaints all the time in terms of personnel, channels to receive complaints, monitoring and investigation of facts, and reporting of the results of the solutions to the problems.	51	92.73	- Specific complaints should be identified, such as complaints on environmental impact from any action. - Solutions to problems should be in parallel with receiving complaints. - Ad hoc task force should be set up because e-waste management involves many agencies and requires sufficient human resources, budget, and monitoring tools.
6.2 LAOs monitor the landfill within the solid waste disposal sites based on academically correct methods to prevent the problems of leachate from e-waste mixed with general solid waste and contaminated environment, such as surface water sources, groundwater sources, and soil.	46	83.64	-There should be the registration of e-waste disposal sites and the establishment of an environmental buffer zone because. In some provinces, LAOs will send e-waste for disposal in other areas, not under their responsibilities. - Agencies from the central government should advise on e-waste management to LAOs. - Some LAOs are limited by budget and personnel with specific knowledge. - E-waste should be collected for disposal in an incinerator with high temperature or secure landfill. - New solid waste disposal sites must start from the design of landfills based on the principles of sanitary landfills. Most are still in piles without a landfill lining system to prevent contamination into the soil and groundwater source.

The Draft Model	Appropriate*		Additional comments and recommendations
	Number (persons)	Percentage	
6.3 LAOs arrange space to correctly and safely install bins for hazardous waste and storing cupboards of household e-waste to reduce risks of stormwater runoff, leachate, and contaminating the environment, such as surface water sources, groundwater sources, and soil.	54	98.18	- There should be an agency inspecting the operation of LAOs on the location of bins for e-waste. - Bins or containers for the collecting of waste should be located in the shade and prohibited to be in the sun to reduce the leak of chemicals.
Input			
7. LOA personnel and people sector			
7.1 LAOs hold training for their personnel to acquire academic knowledge and understanding on household e-waste management at upstream, midstream, and downstream, including the relevant laws, and promote skills in the operation of household e-waste management with correctness, appropriateness, and efficiency.	53	96.36	- Some LAOs have limited budget and personnel with specific knowledge. - LAO personnel should be provided with knowledge on correct e-waste management and increase knowledge for people on correct methods of e-waste management and disposal.
7.2 LAOs promote and support Regional Environment Office (REO)13 (Chonburi) and Provincial Office of Natural Resources and Environment (PONRE) to serve as coaching in the operation of projects/activities related to household e-waste management to ensure learning and development of the potential of LAOs' personnel.	52	94.55	- Coaching agency cannot provide advice or support activities that cover all LAOs. - With Coaching and the project, people will understand more easily.
7.3 Provinces and LAOs organize activities to forge awareness, provide knowledge, and advice people in e-waste management at source. Those are e-waste reduction, sorting e-waste in households, and separating the types of e-waste before disposal at drop-off points of household e-waste designated by LAOs.	54	98.18	- Community residents should receive correctly knowledge before actual implementation. - There should be regular public relations, activities, or household e-waste management training to the local youth. It provides knowledge, understanding, and awareness to the youth correct household e-waste management or communities.

The Draft Model	Appropriate*		Additional comments and recommendations
	Number (persons)	Percentage	
8. Budget			
8.1 LAOs in collaboration with relevant agencies in EEC , such as REO 13 (Chonburi), PONRE, and Provincial Office for Local Administration formulate and prepare the budget to drive and operate action plans/projects on household e-waste management based on the principles of 3Rs.	54	98.18	- Some LAOs have a limited budget. - Participation should include agencies from the Ministry of Industry.
8.2 LAOs prepare the budget for procurement, repair, or improvement of the trucks collecting household hazardous waste, and hazardous waste storage sites for appropriateness and hygiene based on relevant laws.	51	92.73	- The potential of each LAO is different. Therefore, the preparation of the budget for procurement, repair, and improvement of transporting trucks of household hazardous waste and household hazardous waste storage sites cannot be conducted in all LAOs. - Experts in specific e-waste management are also required.
8.3 PAOs prepare the budget as expenses for transferring household e-waste for disposal to the private sector's disposal location.	50	90.91	- There should be hosts in overall household e-waste disposal of the entire province, such as PAO, to reduce the budget for household e-waste disposal of each LAO. - Rules and regulations should be improved on flexible management, such as financial and supply regulations. A handbook should be produced to hire private companies for correct e-waste disposal to be in the same direction and not violating the government regulations. - Producers or sellers of products should participate in expenses - Household e-waste should be sent to legal disposal sites with academically correct methods.

The Draft Model	Appropriate*		Additional comments and recommendations
	Number (persons)	Percentage	
9. Household e-waste management			
9.1 People schedule the date and time for LAOs to pick up large-sized e-waste from people's households such as computers, television, refrigerator, and air conditioner.	48	87.27	- Many LAOs are limited budget and personnel. - Appointment by telephone should be made as convenient and work should be done on weekends. - LAOs provide the service of picking up waste at people's households and prepare the location for people to bring in large-sized e-waste themselves if it is convenient for them. - LAOs should schedule specific dates and should not let people make appointments because, in each LAO, there are many communities. - LAOs should set the dates and notify communities for acknowledgment, such as the third Wednesday of the month, the first Saturday of the month, and continuous public relations.
9.2 PAOs prepare the list of private companies operating treatment or disposal of household e-waste which are efficient, based on academically correct methods, legal, and located in the provinces and EEC both in and outside industrial estates.	50	90.91	-Government agencies such as the PCD, and the Department of Industrial Works should act as hosts in preparing the list of private companies operating e-waste treatment or disposal and disseminate the list for the public's acknowledgment.
9.3 LAOs collecting and sending for disposal household e-waste by themselves determine the time of sending household e-waste to the private sector's disposal facilities at least twice a year.	43	78.18	- If insufficiently large quantity, the disposal should be done immediately. - It should depend on the amount of e-waste collected from communities.

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	Number (persons)	Percentage	
9.3 (continued)	43	78.18	- Entrepreneurs may not be interested in investing. It should be done quarterly due to the unequal amount of e-waste in each area. Therefore, collection and transfer for disposal cannot be specifically identified as the number of times in each year. It depends on the household e-waste generated or the cost-benefit of private companies in collecting household e-waste. - The number should not be set as at least per year because consideration should be made on the actual amount of waste. A study on EEE using tendency in the community of municipalities should be conducted due to the different behaviors of each community.
10. Tools and equipment			
10.1 PAOs establish the provincial hazardous waste storage centers to collect household e-waste and transfer it for academically correct disposal.	52	94.55	- PAO in each province may set up a household e-waste disposal center based on the Polluter Pays Principles (PPP). In terms of the area-based operation, e-waste disposal should not be transferred across provinces (The pollution generating areas should have their measures). - As it is difficult to find a responsible person for the managing of household hazardous waste collection center , LAO should operate the collection. - Survey must also be conducted on the acceptance of local people on the establishment of the household hazardous waste collection center.

The Draft Model	Appropriate*		Additional comments and recommendations
	Number (persons)	Percentage	
10.2 LAOs improve the size of containers for household hazardous waste for more appropriateness and convenience to accommodate household e-waste, which tends to be of large quantity such as computer, notebook, tablet, PC, smartphone, and television.	50	90.91	- Hazardous waste and e-waste should be separated for easy collection. Hazardous waste can be collected in bins. As for e-waste, a container or large room may be required as it needs a lot of space. The containers must also be placed in the shade and not in the sun to reduce the leak of chemicals.
10.3 LAOs should improve the household e-waste storage site sites to closed buildings with sufficient space and correctly arrange the boxes for storing household e-waste collected during the year and prevent the leak of hazardous substances into the environment outside.	53	96.36	- Many LAOs are limited by budget and personnel with specific knowledge for hygienic operation. - Some types of e-waste have large sizes and require relatively large space. LAOs in urban areas may not have the collection area as the installation of drop-off points requires a lot of space, large containers, and large rooms with a theft prevention system as most of the waste are sellable.
10.4 LAOs should arrange for boxes to correctly store household e-waste in the trucks collecting household hazardous waste to prevent the leak of hazardous substances during transport.	53	96.36	- Trucks transporting household e-waste should be separately provided.
Process			
11. Planning of work or projects			
11.1 LAOs formulate the plan of household e-waste management integrated with the 4-Year Government Action Plan for Local Administrative Organization to cover the three processes for household e-waste management, namely management at upstream, midstream, and downstream.	54	98.18	- Most LAOs do not specifically identify e-waste management but rather generally. It should also be by the plans at the provincial level. - E-waste should be managed from upstream to downstream in their province to prevent complaints from other provinces.

The Draft Model	Appropriate*		Additional comments and recommendations
	Number (persons)	Percentage	
11.2 LAOs who collect and send household e-waste for disposal by themselves formulate the action plan of clusters in each province to send household e-waste of other LAOs to disposal by considering the Provincial Sewage and Solid Waste Management Committee of each province.	52	94.55	-Operation in clusters may cause delay as operation and considerations require the committee's approval from each LAO.
12. Operation of projects or activities			
12.1 Provinces promote, applaud, and make public relations of the LAOs who received Clean LAO Awards with the performance of household e-waste management which is in line with the Action Plan "Clean Province" to serve as a role model for other LAOs.	54	98.18	-Other additional guidelines should also focused on the budget for municipal solid waste management and motivation for strict compliance.
12.2 LAOs construct a community model in household e-waste management at origin to enable people and officers of other LAOs in the province to conduct study tours, exchange experiences in household e-waste management, and apply to their areas for appropriateness.	54	98.18	-The community model creates the experience in various areas to adapt to own areas and apply knowledge for actual implementation. - There should be a community model at least one community in each province.
12.3 LAOs cooperate with relevant agencies such as REO 13 (Chonburi), PONRE, PCD, DEQP, and Provincial Office for Local Administration to operate projects or campaign activities of household e-waste to local people and young people. They should regularly promote, provide knowledge, and conduct public relations on e-waste reduction, sorting, collection, and management at least twice a year.	52	94.55	- LAOs may operate the "Sister Cities " project with foreign LAOs or LAOs in the countries with high potential in e-waste management to foster cooperation and exchange of knowledge on e-waste management. - Operation should be conducted every three months and there should be an exciting form of campaign. The operation should not end after training. - Participation of agency from Ministry of Industry should include.

The Draft Model	Appropriate*		Additional comments and recommendations
	Number (persons)	**Percentage**	
12.4 LAOs conduct public relations on the locations of drop off points of household e-waste, schedule the date and time of LAOs' collection to all local people through various media (e.g., local radio and television, information board, people handbook for e-waste sorting, door knocking at least twice a year.	52	94.55	- Public relations should be determined, but frequencies of public relations must increase.
13. Monitoring and inspection			
13.1 LAOs monitor and inspect the monthly recording of the information on e-waste management according to the "Mor Phor 2 Form" for up-to-date and completeness.	55	100.00	- To serve as information in operation and summary of results.
13.2 LAOs cooperate and assist in solving problems of complaints on household e-waste from the local agencies receiving complaints.	54	98.18	- Solutions to the complaint's problems must integrate all relevant agencies to solve all the processes thoroughly. - Many agencies receiving complaints both in communities and the regional government agencies.
13.3 The local agencies receiving complaints notify the investigation results on the complaints of e-waste problems to their agencies who made a joint investigation and the complainants for acknowledgment.	52	94.55	- Coordination between agencies is quite complicated and follow-up of the results is quite slow.
14. Improvement and rectification for appropriate operation			
14.1 LAOs encourage private entrepreneurs to participate in public relations and determine the areas to install the drop-off points of household e-waste in the establishments of the entrepreneurs themselves, which are interesting, easily observable, and accessible. Those locations are gas stations,	53	96.36	- The private sector should provide containers for household e-waste and conduct public relations together with LAOs, promote and support LAOs, or jointly sign MOU.

The Draft Model	Appropriate*		Additional comments and recommendations
	Number (persons)	**Percentage**	
14.1 (continued) convenience stores, construction material centers, department stores, and academic institutions.			
14.2 LAOs collaborate with relevant government agencies (e.g., REO 13 (Chonburi), PONRE, PCD, and DEQP to develop the public relation of household e-waste management to draw interest and easy access of people of all ages. That is the use of role models to make public relations via social media for clear pictures such as television, YouTube, Facebook	53	96.36	- Add local academic institutions to organize activities of a contest of public relation media, forge cooperation in the campaign, and raise awareness.
14.3 LAOs survey and monitor the conditions of all drop-off points in their areas to evaluate the conditions and the amount of e-waste by type, and prepare or improve the appropriate size of containers for e-waste which will be ready to use.	54	98.18	- Develop an application for the public to search for the household e-waste collection sites, the position and distance of which can be identified from households.
14.4 Department of Local Administration and PCD develop the system and record and report the information on household e-waste management for clarity, easy understanding, convenient use, and more speed.	54	98.18	- It is an application on Smartphones.
Product			
15. Results from household e-waste			
15.1 LAOs add bins for hazardous waste (in orange) side by side the storing cupboards of household hazardous waste covering government buildings, private establishments, and academic institutions to accommodate more household e-waste.	52	94.55	- People may be confused between hazardous waste and e-waste. Some communities may collect them in the same bin. - Date and time should be scheduled for specific disposal of e-waste similarly, the large-sized waste scheduled dates

The Draft Model	Appropriate*		Additional comments and recommendations
	Number (persons)	Percentage	
15.2 LAOs add good drop-off points for household e-waste with signs or messages showing "drop-off point for household e-waste" and information on hazardous substances, impact on health, and environment attached to the container of household e-waste to cover all areas. The locations include the areas of private establishments (e.g., convenience stores, Big C, Lotus, gas stations, tool and equipment centers, academic institutions), government buildings, and communities (e.g., town halls, village town halls).	53	96.36	- Add more installation of drop-off points of household e-waste at hospitals.
15.3 PAOs accelerate the preparation of the Memorandum of agreement on the cooperation of household hazardous waste management (MOU) with municipalities and SAOs in the provinces.	53	96.36	- PAOs must be ready to deal with hazardous waste and household e-waste from all LAOs.
15.4 LAOs collecting and transferring household e-waste by themselves should consider sending household e-waste for treatment or disposal at factories with permits and efficiency in treatment or disposal of household hazardous waste within the provinces and EEC as a priority.	54	98.18	Cost-saving

The Draft Model	Appropriate*		Additional comments and recommendations
	Number (persons)	**Percentage**	
Impact			
16. Economic, social, and environmental impacts			
16.1 Provincial Industry Office strictly inspects factories and place the announcement for receiving comments from the public on household e-waste treatment and disposal factories before issuing factory permits.	52	94.55	- E-waste treatment or disposal plants should be stipulated to be located in industrial estates and not scattered everywhere. - Supervision from government agencies is limited, especially by cooperation and budget.
16.2 Electrical and electronic manufacturing plants and e-waste treatment and disposal factories in EEC must regularly monitor air pollution treatment system and wastewater treatment system for good condition and function during the whole time of the factories' operation.	52	94.55	- The addition should be made to recording the inspection results, solutions to problems and reporting of the problems in case air quality and wastewater quality exceed the standards and discharge from factories to communities. Monitoring and inspection should also be conducted regularly.
16.3 LAOs coordinate and cooperate with Natural Resources and Environmental Protection Volunteers (NEV) in monitoring and reporting the local situations of household e-waste management to LAOs and agencies receiving complaints continuously.	53	96.36	- Only a few Natural Resources and Environmental Protection Volunteer Network (NEV-Net) in the voluntary network can perform tasks. - LAOs have the "Local Environment Volunteer Network" or "LEV-Net" with missions quite similar to the NEV-Net.
16.4 LAOs coordinate with local junk shops in pricing WEEE types for the same standards to ensure people's equality in compensation and selling prices and motivate people to sort e-waste and separate correct types of e-waste.	51	92.73	- For the sake of fairness.

The Draft Model	Appropriate*		Additional comments and recommendations
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16.5 LAOs support local junk shops and small entrepreneurs who disassemble e-waste to register and receive permit operation licenses for health-hazardous businesses. That leads to upgrading the local junk shops and small entrepreneurs' standards and having a hygienic workplace and safe workers' health.	53	96.36	- Local junk shops must register and receive training on correct management. - Small entrepreneurs who disassemble parts should not be allowed. - Focus should be on safety and e-waste management based on correct methods. - The number of sidecar buyers of old items can come down.

Other recommendations

Cooperation

1. LAOs should coordinate with Thailand Post to enable people to ask the postman to take small e-waste to collection location in each province to facilitate people as the Post Office already has access to all households. (At present, the Post Office cooperates with AIS in receiving e-waste and sending it to recycle).
2. Household e-waste management requires cooperation from all sectors as follows:

Government agencies such as

1) Executives must realize the importance to formulating policies, prepare the budget, and be ready to provide locations and personnel to drive the activities of household e-waste management.
2) Accelerate the creation of acknowledgment and understanding for people through all channels.
3) Devise measures to motivate the people sector to realize the importance and cooperate.
4) More enforcement of relevant laws.

Private sector/people sector such as Follow-up of information and news, realization and awareness, and cooperation in strict compliance with local regulations

Management

1. E-waste management requires cooperation from many agencies. Regulations and responsibilities may limit each agency. With the coordination of cooperation and precise determination of responsibilities, the solutions of the problems will be more concrete.
2. For the LAOs to have potential in household e-waste management, it requires support, promotion, development of responsibilities, budget, and personnel for more consistency.
3. Stipulate that entrepreneurs must buy back their product waste at appropriate ratio through dealers or communal shops covering all areas.
4. Stipulate that companies producing goods can change devices without having to discard all the devices.

Note: * Appropriate = Can be implemented and impact on the increased efficiency of household e-waste management in Chachoengsao, Chonburi, and Rayong provinces

BIOGRAPHY

Name-Surname	Mrs. Chalida Nieobubpa
Academic Background	- M.Sc. (Aquaculture) Kasetsart University, Thailand, 1995 - B.Sc. (Agriculture, Second class honors) Major Animal Science, King Mongkut's Institute of Technology, Thailand, 1989 - B.P.H. (Occupational Health and Safety), Sukhothai Thammathiraj Open University, 2013
Experience	TEAM Consulting Engineering and Management Public Company Limited Senior Environmental Scientist/Project Manager - Twenty-eight (28) years of experience in Strategic Environmental Assessment (SEA) for Transit-Oriented Development (TOD) in Thailand, Environmental Impact Assessment (EIA), Initial Environmental Explanation (IEE), and Environmental Management Plan (EMP) of various kinds of international (e.g., Laos PDR, Cambodia, Myanmar (road, building, hydropower, and power plant) and Timor-Leste (refinery, condensate pipeline, water supply system and new town) and domestic projects especially for power plant (hydro, coal-fired and biomass), oil and gas, jetty and port, and some infrastructure projects (e.g., highway, transmission line).