

ห้องสมุดงานวิจัย สำนักงานคณะกรรมการวิจัยแห่งชาติ



E46247

**ASSESSMENT AND MODELING OF LUMINOUS EFFICACY OF THE DAYLIGHT
IN TROPICAL CLIMATE**

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ID: 52916419

**A THESIS SUBMITTED AS A PART OF THE REQUIREMENTS
FOR THE DEGREE OF MASTER OF ENGINEERING
IN ENERGY TECHNOLOGY AND MANAGEMENT**

**THE JOINT GRADUATE SCHOOL OF ENERGY AND ENVIRONMENT
AT KING MONKUT'S UNIVERSITY OF TECHNOLOGY THONBURI**

2ND SEMESTER 2010

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Assessment and Modeling of Luminous Efficacy of the Daylight in Tropical Climate


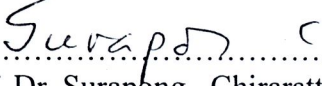

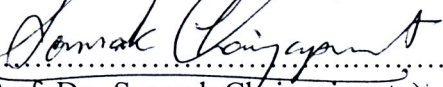
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at King Mongkut's University of Technology Thonburi

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ABSTRACT

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This thesis aims to study the characteristics of daylight efficacy in a tropical climate. With solar irradiance and daylight illuminance measurements at a station in Thailand, the statistical data of the hourly mean values and the standard deviations of the efficacy of global, diffuse horizontal and beam normal components were derived. This study explores the variations of daylight efficacy with climate conditions as well as the correlations with some insolation parameters of Perez's clearness (ε), brightness index (Δ), and Solar zenith angle (ϕ_s). The Mean Bias Difference (MBD) and Root Mean Square Difference (RMSD) are used for evaluation of prediction performances of the efficacy models proposed by various authors. The results of MBD and RMSD illustrated that no model is suitable for tropical climates. In this study, two models were proposed for global efficacy and diffuse efficacy. The models are capable of determining the efficacy for all sky conditions. As observed from a number of plots of variations of the efficacy with sky conditions, the models chose Perez's clearness (ε) for the model input. The less effective brightness index (Δ) was excluded from the models. Solar zenith angle (ϕ_s) in radian is also the input of the models. Therefore, this thesis proposes new efficacy models for tropical climates and the models are obtained by fitting the values of the relative luminous efficacy as a function of Perez's clearness (ε) and Solar zenith angle (ϕ_s), which are expressed as follows:

$$\text{Global efficacy: } K_{G_{eff}} = (101.65 + 13.92\varepsilon^{-3.49})(\cos\phi_s)^{(-0.18 + 0.19\varepsilon^{-1.25})}$$

$$\text{Diffuse efficacy: } K_{D_{eff}} = (107.14 + 12.59\varepsilon^{0.24}) + (30.35 - \frac{30.1}{\varepsilon^{1.5}})\phi_s$$

Keywords: Global efficacy, diffuse efficacy, Mean Bias Difference (MBD), Root Mean Square Difference (RMSD), Clearness index and Brightness index.

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NOMENCLATURES

SYMBOL	DESCRIPTION	UNIT
a_i, b_i	Coefficients in the Perez model.	
c_i, d_i	Coefficients in the Perez model.	
c_1	First plank's constant ($3.7405 \times 10^{-16} \text{ W.m}^2$)	
c_2	Second Plank's constant (0.0143879 m.K)	
D	Cloud ratio (ratio of diffuse to global irradiance)	
E	Horizontal global illuminance	lux
E_b	Horizontal beam illuminance	lux
E_d	Horizontal diffuse illuminance	lux
E_λ	Solar spectral sensitivity of the eye	
E_{eo}	Extraterrestrial irradiance	
G	Horizontal global irradiance	W m^{-2}
G_b	Normal beam or direct irradiance	W m^{-2}
G_d	Diffuse horizontal irradiation	W m^{-2}
K_m	Maximum luminous efficacy	lmW^{-1}
K	Luminous efficacy	lmW^{-1}
K_g	Global Luminous efficacy	lmW^{-1}
K_d	Diffuse Luminous efficacy	lmW^{-1}
K_b	Beam Luminous efficacy	lmW^{-1}
k_t	Clearness index	
m	Optical air mass	
T	Temperature of the emitting surface	K
$V(\lambda)$	C.I.E photopic spectral sensitivity of the eye.	
W	Precipitable water	cm
ε	Clearness index of Perez model	
\square_s	Solar zenith angle	radian
Δ	Brightness index	
λ	Wavelength	nm
α_s	Solar altitude angle	radian

ABBREVIATIONS

AIT	:	Asian Institute of Technology
CIE	:	Commission Internationale de l’Eclairage
DEDP	:	Department of Energy Development and Promotion
JGSEE	:	Joint Graduated School of Energy and Environment
KMUTT	:	King Mongkut’s University of Technology Thonburi
MBD	:	Mean Bias Deviation
RMSD	:	Root Mean Square Deviation
TICA	:	Thailand International Development Cooperation Agency