Clean energy technologies – global challenges for climate change mitigation

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Keywords: *Climate change, scenarios, IPCC, mitigation, renewable electricity, heating, cooling*

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As outlined throughout the Intergovernmental Panel on Climate Change 5th Assessment Report –Mitigation (IPCC, 2014)[1], reducing global greenhouse gas (GHG) emissions will be challenging.

To restrict global warming to below 2°C, a rapid transition to clean energy technologies will be needed, requiring investment in both development and deployment. The world's climate is changing[2], but it remains possible to slow down the speed and extent of change if all countries play their part. Rapidly deploying the many different types of mitigation technologies and measures available and developing effective policies to reduce greenhouse gas (GHG) emissions can also produce many additional benefits that offset the overall cost of mitigation. This was a key message from the Summary for Policy Makers of the 5th Assessment Report –Mitigation, of the Intergovernmental Panel on Climate Change (IPCC)[3]. It was released in May 2014 having been approved, sentence by sentence, by more than 140 government negotiating teams that gathered in Berlin for a week.

A carbon budget[2] (Fig. 1) shows the total giga-tonnes (Gt or billion tonnes) of carbon dioxide released to the atmosphere since 1870 has created a global temperature rise of almost 1°C above the global pre-industrial mean temperature (winter and summer, day and night, northern and southern hemisphere) of around 14.0°C.

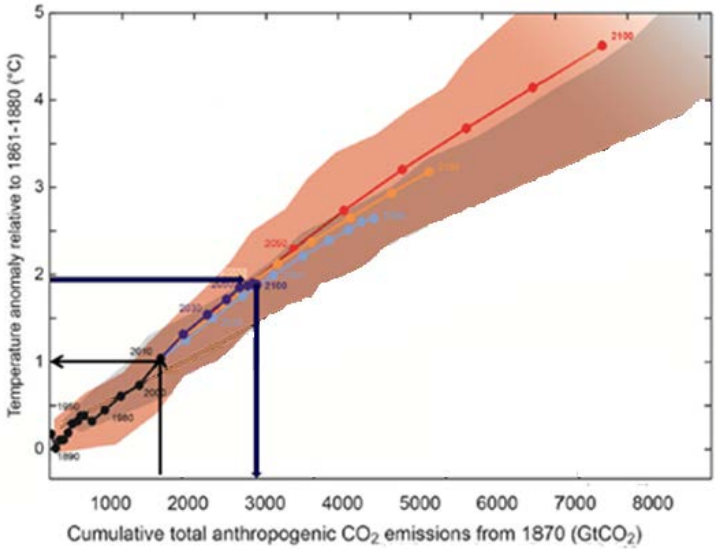

Fig. 1 Total CO_2 historic emissions to the atmosphere from 1870 until 2010 (black line) and four IPCC representative concentration pathways to 2100, with greater temperature anomaly responding

[1] http://mitigation2014.org/report/final-draft/
[2] http://www.ipcc.ch/report/ar5/wg1/
[3] http://report.mitigation2014.org/spm/ipcc_wg3_ar5_summary-for-policymakers_approved.pdf

to higher CO_2 emissions this century. To maintain global temperature rise below 2°C, only around a further 1500 Gt CO_2 can be released from fossil fuel combustion this century – far less than from combusting the known remaining fossil fuel reserves that would take us to 4-5^{o}C.

In spite of strong scientific evidence, the deployment of new low-carbon technologies and the implementation of regional, national, and local greenhouse gas emission reduction policies in many countries, annual global GHG emissions continue to increase. Despite mitigation efforts, anthropogenic GHG emissions grew more rapidly from 2000 to 2010 than in each of the previous three decades (Fig. 2). In the absence of additional mitigation efforts, economic and population growth, along with other driving forces, would raise GHG emissions and cause a median increase in global mean surface temperature of 3-5^{o}C relative to pre-industrial levels by 2100.

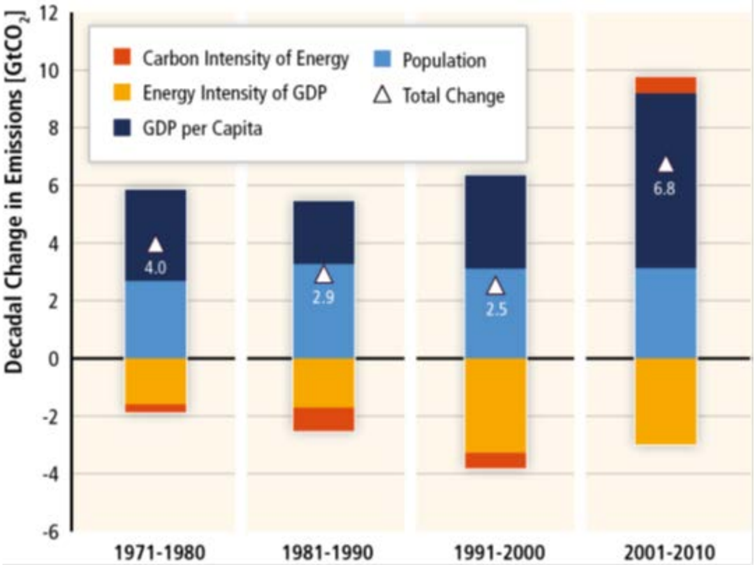

Fig. 2 Decomposition of the change in total global CO2 emissions from fossil fuel combustion shows the long standing trend of decarbonising the energy supply (reducing the carbon intensity of energy - red bars) has reversed mainly due to increased use of coal.

Only rapid, stark institutional and technological change can preserve a chance to limit global warming to the internationally agreed 2^{o}C above the pre-industrial level. Further delays in taking strong actions will increase the mitigation challenge, the costs, and the risks of exceeding this temperature threshold. Adapting to climate change impacts in parallel with mitigation is inevitable.

Direct emissions of carbon dioxide from the energy supply sector that generates heat and electricity mainly from the combustion of fossil fuels, can be allocated to the industry, buildings, transport and agriculture, forests and other land use (AFOLU) sectors that use these energy services (Fig. 3). The various technological and social means of reducing sectoral emissions of CO_2 and all other GHGs are clearly outlined in the IPCC Mitigation report. Many mitigation solutions provide major additional co-benefits such as lower local air pollution, improved health, reduced traffic congestion, more employment, and can actually save money for businesses and consumers. These can lead to a better "green economy". A country example of how to achieve this is in New Zealand as outlined in a recent Royal Society of New Zealand report [4].

Stabilizing GHG concentrations in the atmosphere at low levels requires mitigation throughout the global economy. Successful efforts in one sector (such as electricity generation) will determine the

[4] https://zen.nzherald.co.nz/media/webcontent/document/pdf/201412/infographic.pdf and http://assets.royalsociety.org.nz/media/2014/05/Facing-the-future-towards-a-green-economy-for-NZ.pdf

need for mitigation efforts in other sectors. Low-stabilization scenarios are dependent upon a full decarbonization of energy supply in the long term, with electricity generation potentially becoming zero-carbon by around 2050. Reductions in energy demand through efficiency and behavioural change

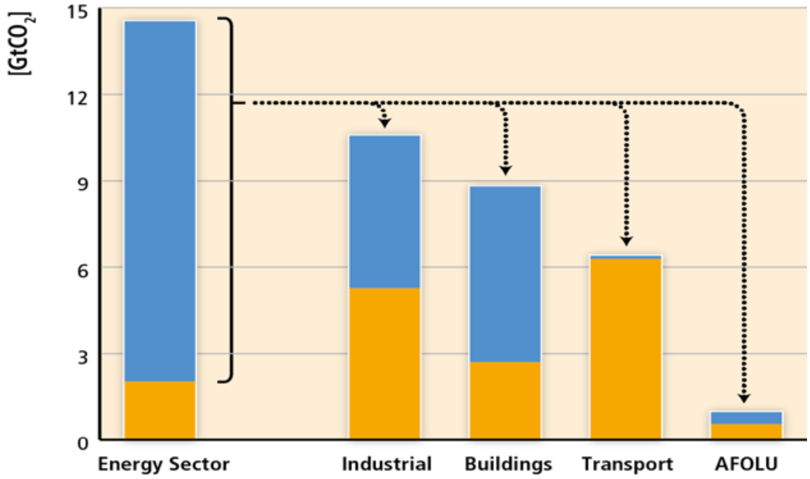

Fig. 3 Global CO_2 emissions in 2010 for each sector with allocation of emissions from the centralized generation of heat and electricity to the industrial, buildings, transport and agriculture, forests and other land use (AFOLU) sectors.

can limit the mitigation risks and provide flexibility in the up-scaling of energy supply technologies. Reductions can also be achieved by avoiding lock-in to carbon-intensive infrastructure and this can increase the cost effectiveness of mitigation scenarios. For low- and middle-income countries, the challenge is for residents to achieve sustainable development, improve lifestyles and enhance food security, without reliance on fossil fuel inputs and deforestation. This will require considerable support from higher-income countries, including knowledge transfer, finance, capacity building etc.

A wide range of options for decarbonizing energy supply is available including renewable energy systems, nuclear power and carbon dioxide capture and storage (CCS). These can provide some flexibility in technology choice for a country depending on circumstances and resources. Decarbonization of the electricity sector is projected to proceed faster than the switch to other low-GHG energy carriers in the end-use sectors. Each set of energy supply technologies is associated with its own set of co-benefits and adverse side-effects and implementation challenges.

In the transport, buildings and industry sectors, the wide-scale application of best-practice low-GHG technologies, complemented by behavioural changes and energy efficiency measures, can lead to substantial emission reductions[5]. The next two decades represent a window of opportunity for mitigation, as a large portion of the world's urban areas will be newly developed during this period, and spatial planning can help avoid lock-in to carbon intensive patterns of infrastructure and urban form. In established cities, the potential lies in retrofitting existing urban forms and infrastructure. Mitigation in urban areas is most effective when planning strategies and cross-sectoral policy instruments are aligned to increase accessibility, promote land-use mix, and reduce urban sprawl.

The AFOLU sector plays a key role in low-stabilization scenarios because it provides options to remove carbon dioxide from the atmosphere through increasing soil carbon or linking biomass production with CCS. Applied at scale, land-based mitigation can increase competition between

[5] Details are provided in the sector chapters 7 to 11 in the IPCC 5th Assessment Report- Mitigation.

different land-uses for food, livelihoods, afforestation, reforestation, bioenergy, human settlements, and other economic sectors. Land management and multi-functional uses of land might help to reduce the associated risks and provide synergies between mitigation and other societal goals.
Policy-making for climate change raises issues of risk and uncertainty, of ethics, of social and economic goals and of sustainability. Analytical methods, along with insights from behavioural research, are available to inform policy-makers when attempting to manage these issues. Financial and institutional barriers may be overcome by packages of complementary policies. Overall, co-benefits for energy end-use measures that take regional specificities into account outweigh any adverse side-effects whereas the evidence suggests this is not the case for all supply side measures. Many sectoral policies are available and some have already successfully reduced emissions at net negative social cost.

The number of national and sub-national mitigation policies to reduce GHG emissions or to support clean energy technologies has continued to increase. In many countries such policies have helped to reduce emission intensity but ambitious mitigation will require policies sufficiently effective to induce a fundamental shift in investment flows. There is an increasing focus on policy design to integrate climate change mitigation strategies with other economic, environmental and social objectives.

As a global commons problem, effective climate change mitigation requires international co-operation. The United Nations Framework Convention on Climate Change (UNFCCC) has provided a platform for coordinating efforts across nations. Other increasingly diverse forms of international cooperation have developed over the past decade including including linkages among regional, national and sub-national policies, and the inclusion of climate change issues in other policy arenas. The Kyoto Protocol was the first binding step toward implementing principles and mitigation goals but it failed to significantly reduce global emissions because some countries did not ratify; some did not meet their commitments; and those commitments applied to only a small portion of the global economy by not including developing countries whose emissions have grown rapidly over the past decade.

Recent international negotiations have sought to include more ambitious commitments from all countries by November 2015 and pledge emission reductions by 2020 through their intended nationally determined contributions (INDCs). The distributional impact of future international agreements will depend in part on the magnitude and sources of evolving financing. In the absence of a future binding, international agreement on climate change, linkages among existing and other international, regional, national, and sub-national climate policies offer potential climate mitigation benefits. Such linkages can be established through regional co-operation, such as embodying mitigation objectives in trade agreements or the joint construction of infrastructures that facilitate reduction in carbon emissions. Linkages between carbon markets to improve market efficiency can be stimulated by competition between and among public and private governance regimes, accountability measures.

Deep cuts in GHG emissions will be needed to limit warming to 2°C relative to pre-industrial levels. This remains possible, yet will entail the challenging transition to clean energy technologies, together with economic, institutional, and behavioural changes. Similar challenges would have to be faced for less ambitious mitigation targets over a longer period of time, but the total costs are then likely to be higher.

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