Global Climate Change & the Challenges to Long Term Sustainability *(Extended Abstract)*

By Frank Princiotta

Director, Air Pollution Prevention and Control Division

National Risk Management Research Laboratory

Office of Research and Development

U.S. Environmental Protection Agency

INRODUCTION

In February, 2007, the Intergovernmental Panel on Climate Change (IPCC) (**1**) concluded:

- Warming of the climate system is unequivocal, as is now evident from observations of increases in global average air and ocean temperatures, widespread melting of snow and ice, and rising global average sea level.
- Most of the observed increase in globally averaged temperatures since the mid-20th century is very likely due to the observed increase in anthropogenic greenhouse gas concentrations.
- The combined radiative forcing due to increases in carbon dioxide, is very likely to have been unprecedented in more than 10,000 years.
- Depending on the assumed greenhouse gas emission, warming in 2095, relative to pre-industrial levels, is projected to be 1.6 to 6.4 ºC.

Given these findings, this chapter will examine the key factors driving emissions of Carbon Dioxide from the energy sector: & the mitigative options for reducing such emissions.

OVERVIEW

It is noteworthy that in addition to the emission of greenhouse gases, there are a number of other anthropogenic activities that can lead to potential impacts that can yield unacceptable global impacts. Individually and certainly collectively, such impacts may be inconsistent with the long-term viability of humanity. In other words, they may be incompatible with long-term sustainability. Long-term sustainability can be defined as the ability of humanity to indefinitely live compatibly with the Earth. Sustainable development refers to a systematic approach to achieving human development in a way that sustains planetary resources, based on the recognition that human consumption is currently occurring at a rate that is beyond Earth's capacity to support it. Population growth and the developmental pressures spawned by an increasing demand for resource intensive goods, foods and services are altering the planet in ways that threaten the long-term well being of humans and other species.

Figure 1 illustrates the role that climate change plays in challenging long-term sustainability. It also indicates the factors that are responsible for potentially unsustainable global impacts, including climate change. Such impacts have the potential to modify the home planet so that it is inhospitable to the needs of the growing population, expected to pass 10 billion later this century **(1).**

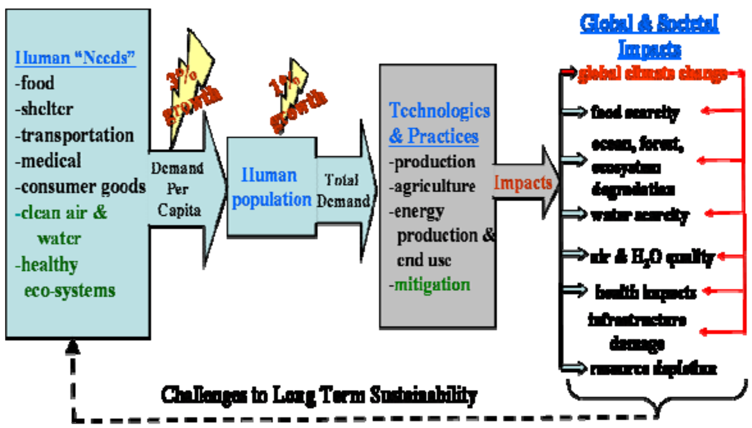

Figure 1 Global Climate Change one of the key challenges to long term sustainability

The following discusses the implications of Figure 1, from left to right. The root cause of potential deleterious impacts is the technological challenge of meeting human needs, which are growing dramatically, especially in developing nations. Over time the developed nations have expanded their list of "needs" to include personal transportation, a diet heavily oriented toward meat production and a growing array of consumer goods. Developing countries such as China and India, with large populations, are moving in the same direction. Although it is difficult to quantify the growth rate of such per capita "needs," the author deems it reasonable to roughly relate it to per capita annual economic growth, been over 3% in recent years **(2).** The problem is further magnified by the fact that population is growing at roughly 1% per year **(2).** At these growth rates, the overall demand for such needs will double in less than 20 years.

The middle of the figure indicates that these human needs are met by means of a large array of industrial, agricultural, and energy technologies and practices. A few technologies designated as "mitigation" are add-ons to existing technologies to reduce their environmental impacts. One example is the use of flue gas cleaning technology to reduce criteria air pollutants & potentially CO2 from the combustion of coal. They can reduce air pollutant emissions but yield potential land & water impacts.

On the right hand side of the figure is a listing of key impacts to the Earth associated with the technology and practices currently used to meet human needs. As indicated by the red return arrows, climate change has the potential to exacerbate certain global impacts associated with non-energy related technologies. Ocean and forest degradation are examples of such amplification. Climate change can also yield unique impacts, e.g., infrastructure damage, due to sea water rise. As indicated by the return flow at the bottom of the graphic, in a business as usual scenario, these impacts will challenge the ability of humanity to meet its needs over the long term, challenging long-term sustainability.

So what are the potential remedies? Figure 1 suggests the following mitigative possibilities. *First*, humanity could downscale its "needs" to reduce the demand on production technology with its associated environmental impacts. Examples would include a transition to smaller houses, more mass transit and fewer cars, and a modification of our resource intensive diets. It should be noted that to the extent we scale back our needs; in addition to reducinge greenhouse gas emissions we would also reduce the impact associated with other environmental insults, such as air and water pollution and ocean and forest degradation. *Second*, humanity could consider a move toward population stabilization. *Third*, we could fundamentally change the technology we use. This can be achieved by a major transition to low carbon energy production, more efficient end use technologies, pollution prevention, renewables and reuse/recycling, to minimize environmental impact per unit of production.

The balance of extended abstract will focus on the *third* option, applied more narrowly to energy production and use, with the aim of mitigating climate change and its potential to yield planetary impacts inconsistent with long-term sustainability. However, it should be noted that downscaling human needs needs and reducing population growth, can ease the role that new technologies and practices must play to prevent unacceptable climate change.

Figure 2 illustrates the energy sector implications of two global mitigation scenarios compared with projected baseline emissions up to the year 2050 **(3)**. For the less aggressive ACT scenario, major savings are achieved in the power generation sector. However, for the Blue scenario, major reductions are required in every energy sector.

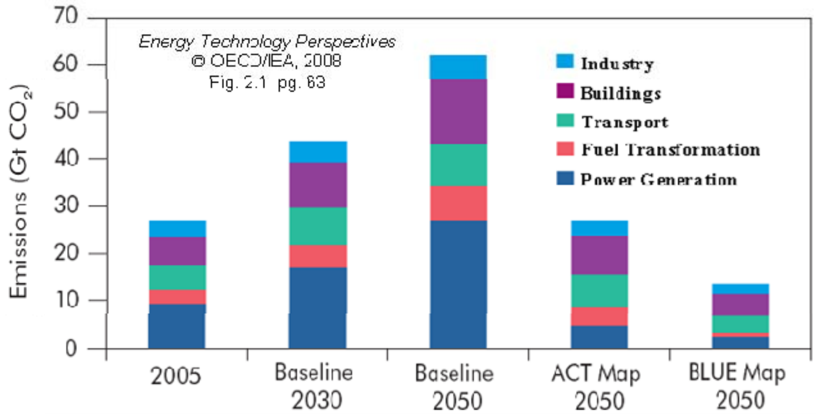

Figure 2. Emissions by sector for Baseline, ACT, and Blue Scenarios to 2050 in Gt CO_2

Figure 3 summarizes the results of the IEA analysis by identifying technologies contributing to the CO_2 avoidance of both the ACT and Blue Map scenarios to 2050. The sum of all the bars yields the 35 and 48 Gt avoidance goals for the ACT and Blue scenarios, respectively. The figure illustrates the projected avoidance by technology in the key sectors. As can be seen, a diverse array of technologies in all energy sectors will be needed if these avoidance goals are to be met, especially for the Blue scenario. Of particular importance are end use technologies in the building, transport, and power generation sectors; and carbon storage technologies in the power generation and industrial sectors. It is important to note that the IEA (7) has characterized the technological changes that would be necessary to achieve carbon reductions consistent with these scenarios: as "A global revolution …. in ways that energy is supplied and used".

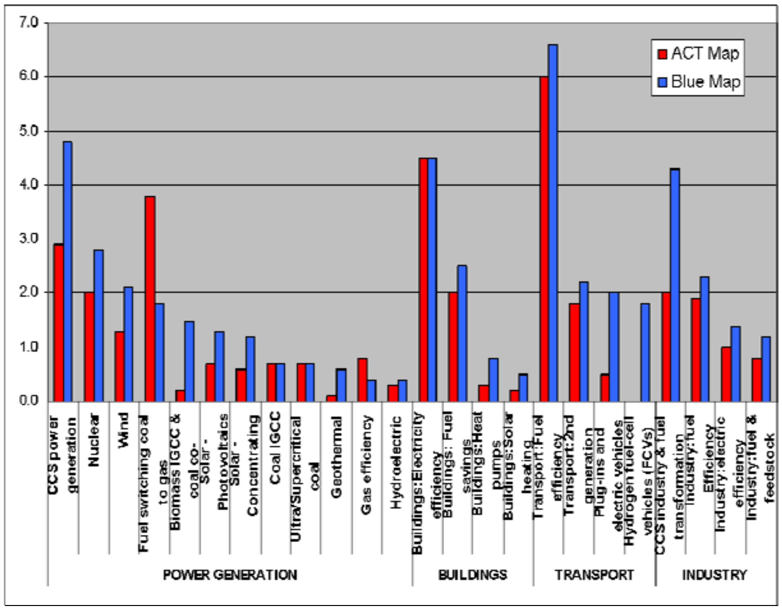

Figure 3 Technologies needed to meet ACT and Blue Map Scenarios Avoidance Goal of 35 and 48 Gt CO_2 in 2050, respectively.

It is instructive to examine the implications of an aggressive energy technology mitigation program. The Blue scenario is an ideal option to examine, since it involves early and deep carbon reductions across all energy sectors. Figure 4 illustrates the role that new technology will have to play in order to control emissions consistent with the Blue scenario. The author has used engineering judgment to divide the technologies into *existing* and *new* categories. Also, best guess equilibrium warming using the MAGICC model **(4)** is included as a function of the Gt of CO_2 mitigated in 2050. As can be seen, new technology is projected to play a major role. Also note, in the absence of new technologies, it will be difficult to constrain ultimate warming below about 4 ºC, +/- the uncertainties!

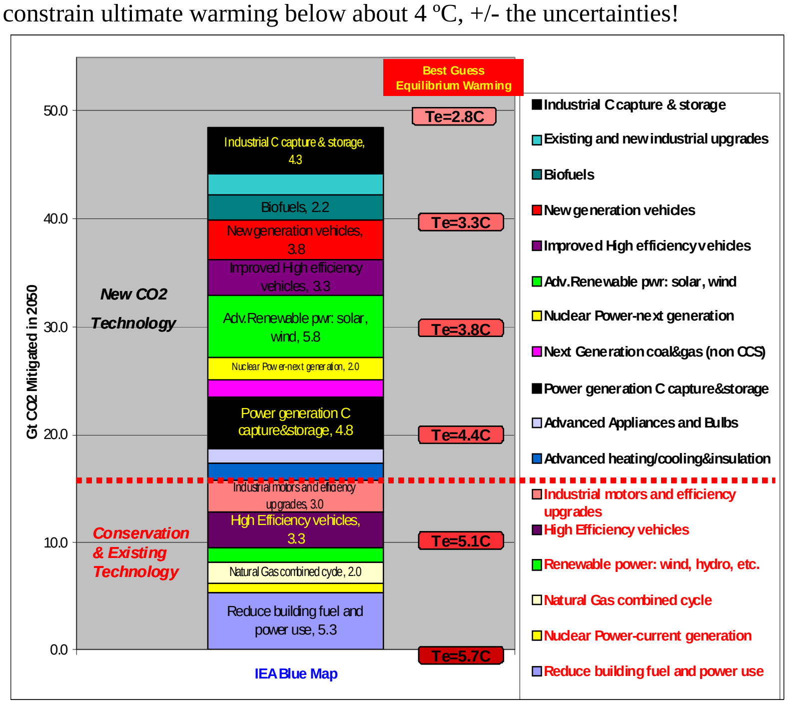

Figure 4 . Existing and new technologies needed for the Blue Scenario

SUMMARY

Long term sustainability of human settlements is challenged by the environmental & resource impacts of a growing demand for goods & services by a growing population. In the absence of fundamental changes to our life styles & historical population growth patterns, it will be necessary to make major changes in the technology & practices we use to meet these human needs. In order to mitigate global climate change & all of its potential deleterious impacts, it will be necessary to revolutionize the way we generate & use energy. An examination of the technology requirements for a major CO2 mitigation program, suggests that in addition to aggressive utilization of existing conservation & low carbon technologies, new generations of low Carbon technologies will have to be developed & utilized at an accelerated rate.

REFERENCES

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(2) Raupach, M.R., et al., *Global and Regional Drivers of Accelerating CO_2 Emissions*, Proceedings of the National Academy of Sciences of the United States of America, available at www.pnas.orgcgidoi10.1073pnas.0700609104 (May 22, **2007**)

(3) International Energy Agency, Energy Technology Perspectives 2008, Organization for Economic Cooperation and Development, IEA, Paris, France, **(2008)**

(4) Wigley, T.M.L. "MAGICC/SCENGEN 5.3 User Manual"; MAGICC (Model for the Assessment of Greenhouse gas Induced Climate Change) can be downloaded from www.cgd.ucar.edu/cas/wigley/magicc/index.htm (**2008**)