Editorial

The Greenhouse Gas Gap

The threat to global climate posed by greenhouse gases (GHG) and the role of humans in it is now clearer than when these concerns first gained prominence in the 1980s. In its 2013 Summary for Policy Makers the Intergovernmental Panel on Climate Change (IPCC) spells out the underlying physical basis of the threat.[1] Calls for quickly curbing GHG emissions can be heard not just from environmental groups but also from many business communities and national governments. Yet, as discussed below, global trends show little progress. There remains a large gap between the targeted reductions in GHG emissions and those achieved or pledged by nations, chiefly because the energy needed to alleviate poverty is huge and cannot be met by renewable power sources like wind and solar.

Since 2006, the year for which the data were used in the writing of *A Cubic Mile of Oil*,[2] global energy use has increased from 3.19 cmo to 3.74 cmo.[3] Renewable resources like wind and solar increased four-fold, but since they were starting at a low base (0.02 cmo) the net contribution was still small (0.08 cmo). Most of 0.55-cmo increase in energy consumption since 2006 has come from increased use of coal (0.23 cmo), natural gas (0.14 cmo), and oil (0.10 cmo), and not surprisingly, the global emission of CO_2 from energy use increased from 31.2 $GtCO_2$ in 2006 to 36 $GtCO_2$ in 2014.

Given the threat to climate change posed by greenhouse gas (GHG) emissions, there has been increasing pressure on the world's largest emitter, China, and the largest per capita emitter, the US, to curb emissions of CO_2, the major GHG. US and China emissions of CO_2 in 2006 were 6.4 and 6.9 Gt respectively. In 2014, the US emissions were down to 6.0 Gt, but China's emissions had risen to 9.8 Gt. On a per capita basis, US emissions still far exceed those of China—18 metric tons per capita in the US versus 8.2 metric tons in China. In Nov. 2014 presidents Obama and Xi Jinping signed an accord under which the US would reduce its GHG emissions to 28% below

[1] *Climate Change 2013: The Physical Science Basis*, Fifth Assessment Report of the IPCC. www.climatechange2013.org.

[2] *A Cubic Mile of Oil* by H. D. Crane, E. M. Kinderman, and R. Malhotra, Oxford University Press, New York, NY, 2010.

[3] A cmo is the energy released during combustion of a cubic mile of oil (26.2 billion barrels) and is equivalent to 153 x 10^{15} Btu or 162 EJ.

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the 2005 level by 2025, and China would peak its emissions by 2030, after which it would reduce them. President Obama followed up that pledge by issuing the Clean Power Plan (CPP) in August 2015, under which there would be a federal standard for reducing CO_2 emissions from power generation by 32% over 2005 levels by 2030, but it would be up to individual states to determine the mix of technologies to achieve those goals.[4]

With the aim of promoting the installation of power sources with near-zero CO_2 emissions, the CPP provides incentives (investment tax credit and production tax credit) for early deployment of renewables and efficiency measures benefiting low-income communities. New nuclear plants also get this incentive, but existing plants do not. Without this credit many existing plants are likely to be shut down for economic reasons instead of having their licenses renewed for another twenty years. Renewables are unlikely to replace the hundreds of TWh of electricity generation from those lost nuclear plants—the amounts generated by wind and solar are too small, with the result that there will be increased electricity generation from natural gas plants, and a net increase in CO_2 emissions.

It is not clear how successful CPP will be in cutting down GHG emissions. Market forces have already led to a substantial reduction of emissions in the US by the switch from coal to natural gas, and perhaps more could be achieved with further decline in the cost of wind and solar power. Politically, the CPP has not garnered much support. Many state governors have already announced their opposition to the CPP. Nevertheless, the joint agreement with China and the CPP helped pave the way for the COP21 Climate Talks in December.

The Papal Encyclical issued in July, 2015 also drew attention to the growing threat of climate change and its disproportionate impact on the impoverished.[5] Pope Francis called for "changes of lifestyle, production and consumption, in order to combat this warming or at least the human causes which produce or aggravate it." His statements about combating climate change received much attention, but there was another deeper message in his statement, the one about consumerism and social injustice it engenders. The pope recognized the need for vastly expanding renewable energy sources, but also noted that, "(f)or poor countries, the priorities must be to eliminate extreme poverty and to promote the social development of their people."

Around the same time as the Pope's Encyclical, the World Bank also issued *Sustainable Development Goals* for the world which lists goals and targets in 17 areas: eradicating poverty, providing adequate food and clean water, reducing gender inequality, taking urgent action to combat climate change, and ensuring access to affordable reliable energy is listed among the goals. Achieving most of these goals requires increasing global energy supply. Speaking about the enormous progress the world already made Dr. Jim Yong Kim, president of World Bank (WB) noted that

[4] "Fact Sheet: Energy efficiency in the Clean Power Plan," US Environmental Protection Agency, 2015. http://www.epa.gov/cleanpowerplan/fact-sheet-energy-efficiency-clean-power-plan

[5] Pope Francis, "Encyclical Letter *Laudato Si"* July 2015. *https://laudatosi.com/watch*

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over a billion people have been lifted out of poverty in the last 25 years, and he could foresee lifting another billion in the not too distant future.

The progress Dr. Kim noted was made on the backs of coal and oil. Can we afford to do the same to help the next billion? The SDG of removing poverty runs up against the need to curb CO_2 emissions. The WB used to support the development of large hydroelectric facilities, but as these projects have many undesirable environmental and social impacts, the WB has curtailed that program. Currently the WB provides assistance for installing renewable energy sources like wind and solar power, but they alone are unable to meet the growing electricity needs of the developing countries, where reducing poverty remains a top priority. Unfortunately, the one CO_2-free energy source that is capable of generating the required scale of power, nuclear, is something that the World Bank does not support developing. In view of its policy of not funding nuclear power, I have to wonder how serious the World Bank is about the SDGs.

In early December 2015, with much fanfare, 195 nations signed the COP21 Agreement to curb global GHG emissions.[6] It was an unprecedented achievement given the previous failed attempts. All nations acknowledged the peril the world faces from climate change being engendered by continued emission of GHG, principally from the use of fossil fuels. The countries pledged to cut down their GHG emissions either in absolute numbers or relative to an expected business-as-usual (BAU) scenario. The individual countries determine the GHG reductions they pledge to make. However, there is no mechanism of punitive action to force the countries to stick to the pledged contributions except a public shame. The intended nationally determined contributions (INDCs) are reported to the UN and the emissions of each country are measured and reported in an agreed-upon standard way, and both these reports are made public. The lack of enforcement is a recognition of political realities; any Agreement that had forced compliance would not have had the support of many countries.

The COP21 Agreement sets a goal of limiting the rise in global to temperature to 2 °C above the pre-industrialization level, with a stretch goal of limiting the rise to 1.5 °C.[6] Even achieving the 2 °C target is a daunting challenge, and requires a major upheaval of the global energy system. It would require achieving a net zero emissions by 2050, and limiting total emissions to about 350 Gt CO_2, from an estimated 1200 Gt CO_2 under BAU, between 2014 and 2050. The aggregate of INDCs submitted curtail emissions by only about 120 Gt by 2025.[7] If no further measures are taken, this trajectory will lead to avoiding emissions of perhaps 300 Gt CO_2 by 2050, instead of the required 1200 Gt CO_2. While we can expect more pledges will follow, the current pledges are woefully inadequate to meet the stated goal.

[6] *UN Framework Convention on Climate Change, Adoption of the Paris Agreement.* http://unfccc.int/documentation/documents/advanced_search/items/6911.php?priref=600008831

[7] "*Synthesis Report on the Aggregate Effect of the Intended Nationally Determined Contributions*," UN Conference of Parties, Paris, 2015.

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The world currently consumes about 3.6 cubic miles of oil equivalent (cmo) of primary energy and emits over 36 Gt CO_2 from energy use.[8] Under BAU the annual energy consumption is expected to rise to more than 6 cmo by 2050. Burning of each cubic mile of oil releases 12 Gt CO_2, about 17 Gt if it is from coal and about 8 Gt CO_2 if natural gas is the source of the energy. Even under an all-renewable, all-electric scenario, which could conceivably avoid two-thirds of the primary energy, an energy consumption of 6 cmo/yr would lead to a requirement of generating 82,000 TWh[9] of electricity, relative to 24,000 TWh in 2014, in other words, more than tripling the current global electricity production.

As mentioned above, discussions of emissions reductions to combat climate change often take place without consideration of energy needs. I find it appalling that the word *energy* appears only three times in the 31-page Agreement.[10] The word appears twice on page two where the Conference of Parties "acknowledges the need to promote universal access to sustainable energy in developing countries, in particular in Africa, through the enhanced deployment of renewable energy." The third time the word is used is on page 31 as part of the name of UN's IAEA: International Atomic Energy Agency. No wonder then that there is such huge chasm between the target reductions in CO_2 and the pledged INDCs.

I paint a rather dreary picture, but I would like to end on a more hopeful note. Perhaps the most important outcome of COP21 was the formation of the Mission Innovation fund by many prominent philanthropists like Bill Gates, Richard Branson, Jeff Bezos, Mark Zuckerberg, and others to help innovative solutions cross the "valley of death" and transition to commercialization. They have been joined by 20 governments to double the collective annual budget of energy research from $10 B to $20 B. It may be too little too late, but I can only hope some of the Mission Innovation funds will provide the necessary support to bring the nascent nuclear power technologies that are inherently safe and scalable to market. I dread the thought that *despair* may become the new *hope*.

Ripudaman Malhotra
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[8] *BP Statistical Review of World Energy*, 2015. http://www.bp.com/en/global/corporate/energy-economics/statistical-review-of-world-energy.html

[9] Calculated using a heat rate of 10,000 Btu/kWh instead of the simple energy equivalence of 3412 Btu/kWh. This method accounts for efficiency gains to be realized from the electricity generation from sources like PV and wind instead of coal or natural gas.

[10] I thank Dr. Morgan Bazilius of the World Bank for bringing it to my attention.

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