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2015 Environ. Res. Lett. 10 101003

(http://iopscience.iop.org/1748-9326/10/10/101003)

Environmental Research Letters

PERSPECTIVE

A 'fair and ambitious' climate agreement is not nearly enough: Paris 2015 take heed!

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Keywords: climate agreement, energy technologies, Paris 2015

OPEN ACCESS

RECEIVED
1 October 2015

ACCEPTED FOR PUBLICATION
5 October 2015

PUBLISHED
23 October 2015

Abstract

Peters *et al* (2015 *Environ. Res. Lett.* **10** 105004) find that the INDCs submitted prior to the upcoming UNFCCC meetings in Paris are not nearly 'fair and ambitious' enough to achieve the goal of limiting global warming to <2 °C and that much greater attention needs to be paid to advanced energy technologies, without which climate goals are unattainable.

Perspective

In December, national delegations from almost 200 nations will meet in Paris to hammer out an agreement on greenhouse gas emission (GHG) reductions. Like Kyoto (1997) and Copenhagen (2009) before it, Paris 2015 will rely on GHG emission reduction pledges to achieve their climate goals, this time to limit global warming to less than 2 °C.

An important letter by Peters *et al* (2015) uses a cumulative emission approach to assess whether national emission reduction intentions (INDCs) submitted in advance of the Paris meetings are both 'fair and ambitious' enough to put the world on a path that would limit global warming to 2 °C, with at least 66% probability. The findings are a potential deal-breaker. Even if the EU, USA, and China achieve their 2030 emission reduction pledges and go on to make very deep emission reductions by 2050, little or nothing is left over in the 2 °C global emission budget for the rest of the world (ROW) to emit.

The EU and USA pledges are substantial: 40% and 28% reductions by 2030 and 2025, respectively; and 80 and 83% by 2050. In the meantime, China's emissions peak by 2030 at about current levels and sharply decline thereafter. But their pledges are neither fair enough nor ambitious enough to seal the deal in Paris. Yet there is no reason to believe even more ambitious pledges would be credible.

The Peters *et al* analysis is the clearest I have seen why the probability of meeting the 2 °C warming limit is exceedingly low (if not $\sim$ zero)—at least if pursued via emission reduction commitments. It has long been clear that the 'clean' energy technology gap is so large (Hoffert *et al* 1998) that policies focusing on emission reductions rather than technologies required to achieve them can do little to reduce *global* emissions—with or without carbon pricing. Setting ambitious targets without the means to achieve them is a recipe for failure.

Peters *et al* (2015) are aware that more is needed than 'fairness and ambition'. According to the authors, 'a critical ingredient that is missing from current negotiations is the need for a greatly increased focus on advancing research and development on low, zero or negative-carbon energy sources'. The authors are on the mark when they say 'fair and ambitious' mitigation needs to be accompanied by 'a new diplomatic effort directed at ensuring that the necessary technologies become available in the near future'. Paris 2015 should take note!

Yet I fear these wise words will be ignored. There is afoot a widely held view that renewable energies and energy efficiency will do the trick. But energy statistics (British Petroleum, hereafter BP 2015) tell quite another story. The share of carbon fuels in total energy consumption has remained steady at about 86–87% since 2000—it was 86.3% in 2014. While the share of non-hydro renewable energies (NHREs) rose from 0.55% in 2000 to 2.45% in 2014, that rise has been offset by a 1.8 percentage point decline in the share contributed by nuclear energy—also a low carbon energy source.

One likely reason for the small, albeit currently fast growing, share of NHREs is their low 'capacity factor', the average use of capacity, calculated here as the ratio of production to capacity output. Using BP energy statistics (2015), I calculate the global capacity factor for solar energy at 11.75% —or the equivalent of 2.8 h per day. Wind energy had a better, but still low, capacity factor of 21.6%, or 5.2 h per day. These figures largely reflect the intermittency and variability of these renewables. Without storage at a utility-level scale, their penetration of the energy mix is likely to remain small.

While the cost of solar and wind energy has declined (aided by substantial subsidies to their manufacture and deployment) little has yet been achieved that improves their reliability as base load energy sources. As a result fossil fuels, although inferior to renewables in terms of air quality and climate impacts, remain otherwise superior deliverers of energy because they are areally concentrated, dense, storable and thus available (dispatchable) on demand, and are technologically scalable in meeting global energy needs.

Although important, increased energy efficiency is no panacea. On a century-long basis, *global* energy intensity decline is unlikely to substantially exceed its long term average of about 1.1% (Baksi-Green 2007). The approximately 5% average annual rate of decline required to eliminate carbon emissions by the end of the century must rely mainly on de-carbonization of the energy supply.

Is then the $<2\,^{\circ}$C goal unachievable? Not necessarily! We could of course luck out if climate sensitivity is lower than expected. But we should not rely on luck. It is crucial to get mitigation strategy right. The energy technology challenge to climate stabilization is huge (tens of terawatts of carbon-free power); no energy sources or technologies, or combination thereof, is yet up to the task (Hoffert *et al* 2002, Barrett 2009, Myhrvold and Caldeira 2012, Edmonds *et al* 2012, Davis *et al* 2013, IPCC 2014, ch 6) .

Galiana and Green (2009) suggested a technology-led climate strategy financed by a low, slowly rising carbon tax. The focus would be on science driven, basic R&D, followed by testing and demonstration at scale. These are essentially public good in nature and thus severely under-funded by the private sector. Instead there is a rising tide of government subsidies 'downstream' to manufacture and deployment of renewable energies rather than 'up-stream' support where fundamental technological breakthroughs occur.

The current strategy lacks balance. Globally, in 2014, the heavily subsidized NHREs accounted for only 13.2 EJ/yr or 0.4 Tw of 17.1 Tw consumed. (BP 2015 with millions of toe converted to metric energy and power.) If Paris 2015 is serious about the $<2\,^{\circ}$C goal it will heed Peters *et al* (2015) and open a new, technology-oriented front in the war on global warming.

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