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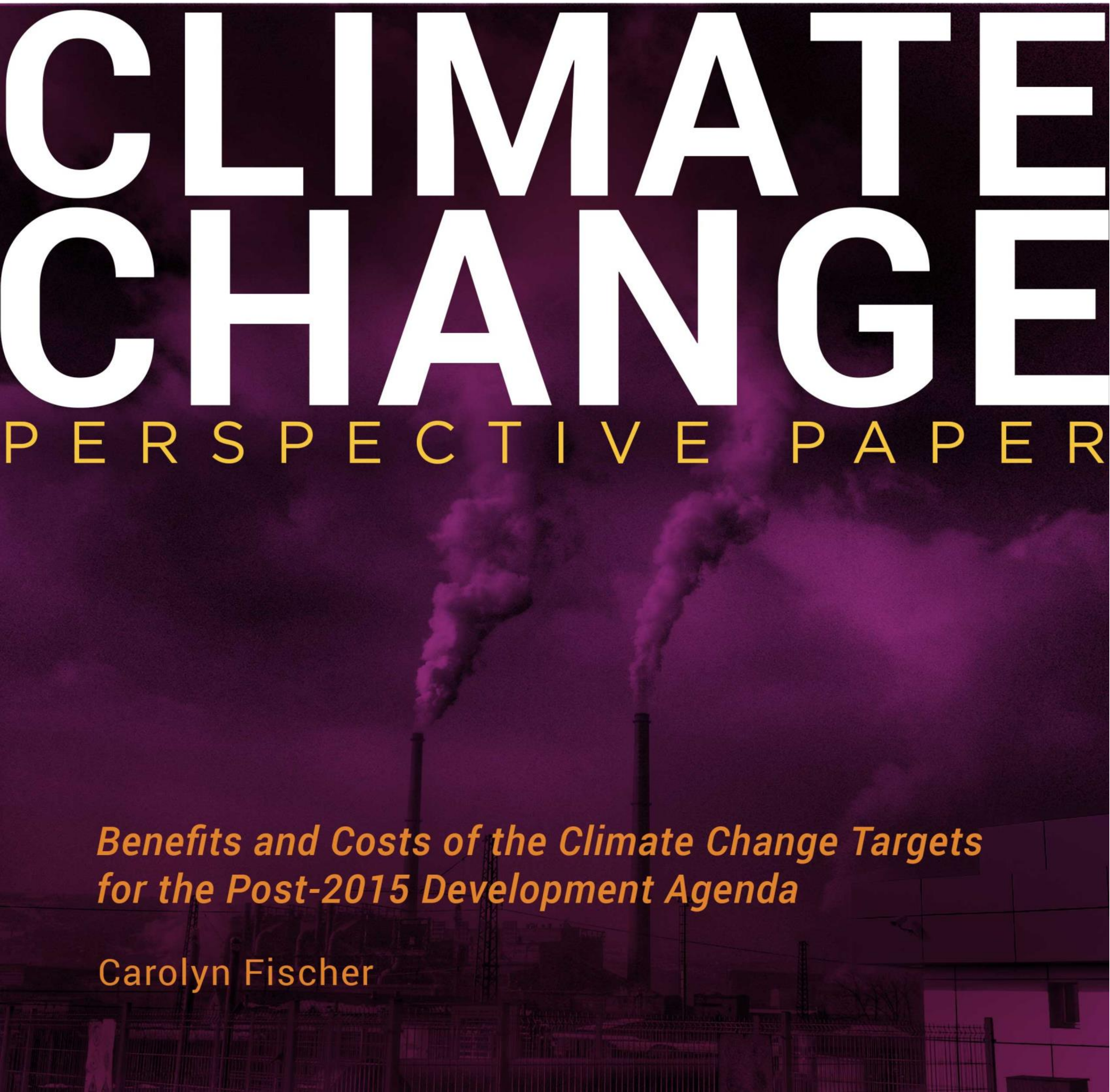

Benefits and Costs of the Climate Change Targets for the Post-2015 Development Agenda

Carolyn Fischer

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Post-2015 Consensus

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Resources for the Future

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Introduction

This paper reviews the challenge paper "Climate Change: Recommendations for a United Nations Post-2015 Development Agenda" and offers some alternative perspectives.

Although I concur with some of the broad conclusions—namely, that the traditional emissions target setting approach of the UNFCCC process is arguably flawed, and that international policy approaches need some rebalancing toward enhancing research, development, and demonstration (RD&D) in low-carbon energy technologies—I want to highlight other arguments that can be more compelling. Furthermore, I want to remind readers of the essential role of carbon pricing in meeting emissions reduction goals, whatever they may be, and in realizing the promise of RD&D investments.

Specifically, consider these points when assessing the challenge paper:

- There is no scientific consensus that emissions concentration targets in the 450 ppm range do not pass a cost-benefit test; in fact, broad political consensus already exists for limiting global temperature rise to 2.0°C, implying agreement that such emissions targets do meet a global cost-benefit test.
- Annual emissions targets (be they caps or intensity targets) are not inherently costly; their cost depends on their level of ambition over time and the policy instruments used to achieve them. The greater problem with targets in the UNFCCC process is that such an agreement is elusive. Although targets would create more certainty about future emissions, their costs are highly uncertain, and perceptions about burden sharing vary so widely that the larger uncertainty is when or even whether an agreement could be reached, resulting in costly delays in action while countries posture, positioning themselves for negotiations.
- Bringing fossil fuel prices more in line with their social costs necessarily entails benefits that are greater than the costs. With ancillary benefits and revenue opportunities, much of this alignment is in countries' self-interest. Negotiating for higher and converging carbon prices may hold more promise than negotiating quantity targets.
- Any policy portfolio that focuses primarily on R&D and/or renewable energy deployment is inherently more costly than one that incorporates a fundamental role for carbon pricing. Technology policies use only a subset of the abatement options in the toolkit, whereas carbon pricing encourages all options, including improving energy efficiency, reducing the emissions intensity of fossil-based energy, and adopting innovative low-carbon technologies. Overreliance on innovation necessarily postpones mitigation efforts, even though many cost-effective options are available today. The costs of delay in mitigation are well established.
- Knowledge spillovers and international spillovers make a stronger case for investing more in low-carbon technology R&D to make up for inadequate market incentives to do so, to address carbon leakage by making these technologies more competitive in countries that are reluctant to take on emissions targets, and

ultimately to make emissions targets and pricing more palatable, including in developing countries.

- Current renewable energy deployment subsidies often exceed cost-effective levels, even considering the value of fostering learning-by-doing. Developed economies and major emitters should rely first on carbon pricing—or at least better aligning the price of fossil fuels with their social costs—as the primary incentive for low-carbon technology deployment. Technology subsidies should be rebalanced away from current deployment in developed countries and toward a greater emphasis on R&D, as well as deployment financing for developing countries.

To avoid costly delay in taking action on mitigation while waiting for international agreement on emissions targets, we should immediately work toward aligning the prices of emitting energy sources with their social costs—removing fossil fuel subsidies, using market-based mechanisms to regulate conventional air pollutants, and pricing carbon. To a great extent it is in a country's self-interest to do so, thereby achieving local health and environmental benefits as well as tapping a more efficient revenue source by taxing "bads" rather than "goods" (like productive labor or capital). Coming to an agreement over carbon pricing convergence may therefore be more realistic than negotiating quantity-based emissions targets. At the same time, redirecting technology policy spending toward investments in R&D to bring down the global costs of low-carbon energy technologies will help enhance the effectiveness of those pricing policies and ultimately the feasibility of meeting the global targets that all parties agree are needed to limit climate change.

On Emissions Targets

In some sense, there is already consensus about emissions targets, at least for the globe. In 2010 in Cancún, the Parties agreed to the objective of limiting future global warming to 2.0°C (3.6°F) relative to the preindustrial level. According to the Fourth Assessment report of the Intergovernmental Panel on Climate Change (IPCC), this target requires stabilizing atmospheric greenhouse gas (GHG) concentrations in a range of 445 to 490 parts per million (ppm) CO2-equivalents (or about 400 ppm CO2 alone, accounting for other gases). Galiana (2014) cites a few studies (most notably Tol 2013) that find even less ambitious stabilization targets are unlikely to pass a conventional cost-benefit test. However, even using available data and plausible assumptions, integrated assessment models are naturally limited in their ability to estimate the full range of the potential costs of climate change. For example, it is difficult to place a reasonable value on market effects unrelated to agriculture or energy use, much less calculate the myriad nonmarket costs of climate change (including the loss of species and cultural heritage), damages unrelated to temperature (such as ocean acidification), or the uncertain but potentially catastrophic damages that may occur with an out-of-sample change to the climate. Nor can modeling address the ethical and distributional effects of climate change: utilitarian estimates of global costs can mask the disproportionate negative effects on poor inhabitants of developing nations (points made by Tol himself). Indeed, environmental justice advocates vociferously argue for even lower limits: the small island states, whose very existence is threatened by sea level rise, have long been seeking a 1.5°C target, and NASA Chief Scientist James Hansen believes that the concentration of carbon dioxide in the atmosphere should be reduced to 350 ppm "to preserve a planet similar to that on which civilization developed and to which life on Earth is adapted."[1] Thus, weighing all the factors, reasonable people can still agree that the Cancún target passes the cost-benefit test.

Of course, even agreement on a global target does not mean agreement on each nation's contribution toward that goal. A second international agreement based on country-level emissions targets is too fraught with different perspectives on responsibility, equity, and costs; consensus will likely continue to be elusive. In the meantime, as countries posture in negotiations, even modest mitigation actions are delayed. Pessimism about the UNFCCC process thus suggests a search for alternatives, including technology-based ones.

Regardless of opinions about the cost-effectiveness of global emissions targets, they should not be conflated with the cost-effectiveness of specific policies that use emissions caps or intensity targets to meet reduction goals. Emissions trading can be a highly cost-effective mechanism for meeting emissions reduction targets. The principle holds even if low-cost technologies are not immediately available. For example, one can easily adjust the time profile of ambition by phasing in the targets or by allowing banking and borrowing of credits over time. But even the challenge paper's premise of a lack of technological options is contested in the literature: IEA (2013) emphasizes the feasibility of meeting climate goals cost-effectively with existing technologies. Innovation can obviously lower costs further, but that does not obviate the usefulness of emissions targets or other pricing policies.

On Doubling Renewable Energy Shares

After noting that current deployment policies are highly cost-ineffective, the challenge paper recommends doubling the share of renewable energy. Some nuance is useful for interpreting this conclusion.

Deploying renewable energy is one mode of decarbonization—an important one, but one among many. Its effectiveness in reducing emissions depends notably on what energy source it replaces: coal-fired generation, natural gas, nuclear, or energy efficiency measures, for example, have vastly different emissions factors. The emissions reductions can also depend on what energy source is used to backstop the intermittency of renewables. In general, because of relatively high technology costs (and, arguably, overly generous subsidies that are ultimately paid by ratepayers or taxpayers), as well as the indirect effect on emissions, currently the large-scale deployment of renewables is a cost-ineffective strategy for emissions mitigation.

Fischer and Newell (2008), in a study of the electricity sector, found that relying on renewable energy targets alone would be roughly twice as expensive as a carbon price alone for meeting a modest emissions reduction target. And this study does take into account significant spillover benefits that may occur from learning-by-doing as cumulative experience with renewable energy expands. Fischer et al. (2014) extend and update this

[1] http://350.org/about/science/ (accessed August, 2014)

analysis with qualitatively similar results; despite some learning benefit from supporting renewable energy deployment (i.e., through production subsidies), optimal levels of support are quite modest and arguably lower than we observe in practice in many countries with generous feed-in tariffs.

Importantly, the value of renewable energy deployment support depends on the policy context. For example, in the presence of an emissions cap-and-trade system, additional support for deployment has no incremental effect on emissions, which are regulated by the cap. Rather, it can have counterproductive effects: by driving down emissions prices, it allows cheaper expansion of relatively dirty sources like coal (Böhringer and Rosendahl 2010), and by driving down electricity prices, it discourages conservation and investments in energy efficiency (Fischer and Preonas 2010). Therefore, in the presence of a cap, the benefits of deployment support relate solely to ancillary effects, such as learning spillovers, changes in conventional air pollutants, or energy security. If these ancillary benefits are not valued, renewable energy targets will only increase the costs of an emissions trading system. Hence, economists have found that the European Union's 20-20-20 policy likely doubled the cost of meeting the emissions cap (e.g., Tol 2012). Even with learning benefits, however, Fischer et al. (2014) warn of the greater cost of overly ambitious deployment strategies: no additional support is often more cost-effective than too much.

Therefore, an important nuance to the recommendation of doubling renewable energy is asking where and how. Developed countries would be better off relying on carbon pricing to encourage renewable energy deployment (and discourage fossil energy capacity) while targeting supplemental policies at the ancillary benefits (e.g., modest and temporary production-based support for renewable technologies that are innovating and scaling up rapidly). Even more important may be enabling investments to deal with necessary grid enhancements, addressing financial and regulatory barriers, and fostering greater certainty for investors (IEA 2014). Together, these policies would likely more than double renewable energy without additional deployment support. (In the US EIA's 2013 Annual Energy Outlook scenario with a $25 per metric ton CO2 GHG concern, renewable energy in the United States doubles within 15 years; without any GHG concern, with currently legislated energy policies, by 2040 renewable energy would be only 50 percent above 2012 levels.)

Developing countries, on the other hand, are less likely to be willing or expected to price carbon in the near term or, more generally, adopt policies that increase their energy costs when they are still trying to expand energy access for development purposes. Thus, innovative financing methods that support low-carbon energy deployment are needed to keep developing countries from tying their growth to carbon-intensive sources—a path that would be more costly to mitigate in the long run.

On RD&D as the Alternative

Bringing down the cost of low-carbon technologies—or even finding breakthrough technologies—has many advantages, particularly in a world reluctant to take costly measures to reduce emissions. If low-carbon energy sources can become cost-competitive on their own, they will naturally displace fossil-based sources. This objective may be most attractive for developing countries, which can then decarbonize without sacrificing growth. More generally, innovation policies—if the fruits are widely disseminated—align with the principles of common but differentiated responsibilities.

Other market failures, like knowledge spillovers, also call for public support for RD&D. Society generally reaps more gains from private innovation than accrues to the innovators; in that sense, they do not have sufficient incentive to invest in R&D. Taking into account substantial knowledge market failures—that the social benefits of R&D are roughly twice the private benefits, as estimated in prior literature—Fischer et al. (2014) find that plausible optimal annual public spending levels on RD&D and deployment fall in the range of 50 to 100 percent of market generation revenues for solar and 15 to 30 percent for wind and other more commercial renewables. Furthermore, unless one believes that learning is a much more important driver of innovation than R&D, the ratio of deployment spending to R&D spending is unlikely to exceed 1 for conventional renewables like wind and 2 times for solar. By contrast, current practice is much more skewed toward subsidizing deployment: in an analysis of six EU countries, Zachmann et al. (2014) find a ratio of deployment to R&D spending of more than 150-to-1. Thus a rebalancing of technology policy spending does seem in order.

Is 0.5 percent of gross domestic product the right amount? To put this in perspective, public spending on all energy-related RD&D (energy efficiency, fossil energy, etc.) averaged 0.04 percent in the countries of the Organisation for Economic Co-operation and Development (IEA and OECD data, 2014), so the challenge paper calls for an order of magnitude increase. Total R&D spending, economywide (i.e., both public and private), was 2.4 percent of GDP in the OECD in 2010; thus, this target would mean shifting a fifth of total R&D spending toward clean energy technologies. Whether scientists are retrained or added to the labor pool, such a reallocation could not be done quickly without markedly driving up the costs of R&D (Markandya 2012). Since this technology strategy could be considered a development aid strategy, another useful comparison is with the magnitude of spending on overseas development assistance (ODA): in fact, this annual target would exceed the total ODA spending rates of OECD countries (0.31 percent of gross national income in 2011).[2] Thus, we can consider this target highly ambitious, if not unrealistic. Furthermore, one must consider where the funding would come from, particularly absent a carbon price to drive private sector incentives toward clean energy and raise revenues to fund public efforts.

The cost-benefit ratio cited in the challenge paper for the 0.5 percent RD&D target is based in large part on IEA (2014), which finds that "an additional global investment of USD 44 trillion could decarbonise the energy system sufficiently to meet the 2° target by 2050. Moreover, this expenditure is more than offset by over USD 115 trillion in fuel savings—resulting in net savings of USD 71 trillion" (Galiana 2014). However, the IEA recommendation is not primarily for RD&D but for a broad expansion of capacity

[2] http://www.oecd.org/newsroom/developmentaidtodevelopingcountriesfallsbecauseofglobalrecession.htm (accessed 25 August 2014).

(deployment) in low-carbon energy sources and energy efficiency. Indeed, many of the excess fuel cost savings likely arise from energy efficiency investments (which are typically assumed to be privately undervalued), as well as terms-of-trade improvements among fossil fuel–importing countries. Perhaps the challenge paper's spending target would be better characterized as a RD&D & Deployment target for a broad range of both energy- and efficiency-related investments.

Finally, relying too heavily on innovation as a mitigation policy creates several problems. The first is delay: waiting until low-carbon technologies become competitive on their own means that many cost-effective options available today are ignored, raising the future mitigation burden. The second relates to the lack of incentive for other abatement options: not only are they ignored while we await low-cost breakthroughs, but they are also ignored afterward, further increasing the mitigation burden borne by the new technologies. Fischer and Newell (2008) find that relying on an R&D policy alone for emissions reductions increases the cost of mitigation by an order of magnitude (more than a factor of 10), relative to using an emissions price alone.[3] Finally, there is also uncertainty over the success of RD&D, which can further increase the costs of delay.

The costs of delay in taking global action on mitigation are substantial (Kriegler et al. 2013). According to the IPCC Working Group III (2014), delaying additional mitigation until 2030 would increase the costs of meeting the 2.0°C target by 14 to 50 percent in the subsequent two decades. These cost increases exceed those of a scenario with limited renewable generation (a 2 to 29 percent increase).

Developing backstop technologies—options that could be scaled up quickly without driving up their prices—would have added value in an uncertain future, given that we cannot be sure today how deep an emissions reduction target we will ultimately need to avoid serious climate change (Fischer and Sterner 2012). The same IPCC study found that commercialization of one low-carbon technology—carbon capture and sequestration (CCS)—could make a big difference in the expected costs of mitigation. Not having CCS available would increase total discounted mitigation costs by 29 to 297 percent. Thus, CCS (or technologies with similar backstop values) would be a likely candidate for greater investment in R&D. However, since CCS involves an energy penalty that raises generation costs, even if it becomes inexpensive, it will not be deployed without the additional incentives provided by carbon pricing or other regulation (Fischer 2008). Galiana (2014) notes appropriately, "It will be necessary to use [RD&D targets] in conjunction with incentives (intensity targets/standards, carbon pricing) to adopt technologies when they become available"—a point that cannot be emphasized enough.

[3] This paper assumes an initial "innovation stage" of 5 years, followed by a "knowledge application stage," benefiting from the fruits of innovation, of 20 years. Even when the application stage is lengthened to 80 years, the costs are still eight times that of the carbon price alone. In addition to the above reasons, discounting means that costs incurred early on are more important than benefits reaped in the far future.

On Emissions Pricing as a Focus for Agreement

For all those reasons, it is difficult to avoid making emissions pricing a central piece of mitigation policy. Technology policies use only a subset of abatement options in the toolkit, whereas carbon pricing encourages all options, including improving energy efficiency, reducing the emissions intensity of fossil-based energy, and creating and adopting innovative low-carbon technologies. Thus, any policy portfolio that focuses primarily on R&D and/or renewable energy deployment is inherently more costly than one that incorporates a fundamental role for carbon pricing. Indeed, the EU 20-20-20 policy was criticized for not relying enough on the cap portion and allowing carbon prices to collapse as the focus shifted to mandating other—more expensive—mitigation technologies.

There is a strong consensus that the social cost of carbon (SCC) is significant. Tol (2013), surveying 75 prior studies, finds a median estimate of $37 per metric ton of CO2 (in 2010 dollars), but uncertainty is quite large and highly sensitive to the discount rate used.[4] The US Interagency Working Group on the Social Cost of Carbon uses a central value that starts at $39/tCO2 in 2015 and rises thereafter.[5] Very few jurisdictions have carbon prices (from either taxes or emissions trading) that approach these levels (the primary exception being Sweden). Meanwhile, others observe that the models omit a variety of climate impacts identified by the IPCC and argue that the SCC should therefore be much higher (Howard 2014).

By definition, then, any reasonable policy that moves carbon prices toward the SCC will increase welfare and produce benefits that exceed the costs. Benefits can be further enhanced by ancillary benefits from reduced conventional pollutants that are not already regulated with market-based mechanisms. In the United States, the costs of near-term climate policies are expected to be more than outweighed by the ancillary health benefits alone (Thompson et al. 2014). More generally, aligning energy prices with their fully loaded social costs reduces emissions, improves health, and provides positive net benefits.

The first step toward this alignment should be the removal of fossil fuel subsidies, which could be the basis of an international agreement in itself (Whitley 2013). Fossil fuel subsidies unnecessarily encourage emissions-intensive behaviors, making it hard for low-carbon technologies to compete; they also drain public coffers while doing little to help the poor or to promote economic development (IMF 2013; Sterner 2012). Phasing out fossil fuel consumption subsidies would, by itself, cut growth in CO2 emissions by 1.7 Gt (IEA 2011).

The next step, particularly relevant for developing countries, is to align fossil fuel prices at least with the cost burdens they impose locally, including the health and environmental damages from conventional pollutants. These two steps are in any country's self-interest—although political sensitivities will require careful navigation of the transition—and they can also significantly reduce carbon emissions.

[4] He finds a standard deviation of $88, a modal estimate of $13, and a mean of $53.

[5] With a 3 percent discount rate, this value is significantly higher than those based on similar rates found by Tol's survey of earlier studies, and a significant upward revision from the Interagency Working Group's 2010 finding of $24/t$CO_2$.

The final step is to add a price on carbon, through either a carbon tax or emissions trading mechanisms. Under the principle of common but differentiated responsibilities, we may expect these prices to be higher among developed countries for a time. In the meantime, concerns about carbon leakage can be alleviated by other, complementary mechanisms and by negotiating the convergence of carbon pricing, particularly in trade-intensive sectors. Even in jurisdictions without explicit carbon pricing, the financing of energy investments, particularly from public sources, can still incorporate values for the costs of carbon, encouraging the development of capacity in low-carbon sources. Thus, the principle of social cost pricing can be gradually introduced into economies of all levels of development.

Carbon pricing has the additional benefit of having the potential to raise revenues while also improving market incentives. This can be a valuable and powerful tool, particularly during a time of fiscal austerity, since the revenues can be used not only to fund R&D, adaptation, and international finance commitments, but also to lower tax burdens that are far more distorting to economies. In developed countries, this can mean a shift from costly payroll and capital taxes toward a "greener" tax system. In developing countries, the marginal value of public investments (e.g., in education or infrastructure) can be high, given constraints in their capacity to raise revenues. Furthermore, collecting taxes based on energy consumption—with its limited points of entry into the economy—can frankly be easier to implement effectively than broad-based tax systems that require substantial administration, compliance, and enforcement costs. Thus, revenues from this feasible source could fund public goods of much higher value, with a portion reserved to offset any negative impacts on the poorest segments of society. At a minimum, eliminating wasteful subsidies can free up valuable public resources. A recent IMF study finds that "At a global level, implementing efficient energy prices would reduce carbon emissions by an estimated 23 percent and fossil-fuel air pollution deaths by 63 percent, while raising revenues (badly needed for fiscal consolidation and reducing other burdensome taxes) averaging 2.6 percent of GDP" (Parry et al. 2014, abstract).

Given that the national benefits of a green tax shift can be more transparent than those of an emissions target, finding agreement on prices may well be more feasible than an agreement on quantities. Prices also offer a greater amount of certainty about the costs of commitments and more perceived leeway for economic growth, when development paths are uncertain. Price-based commitments can help achieve and document compliance, and they allow a transparent comparison of efforts (Morris et al. 2013). Although carbon prices do not offer certainty about global emissions, emissions targets may not offer that either, as long as they can (or must) be renegotiated. An agreement on climate pricing could allow measures to begin today while planning for the long-term achievement of the consensus climate targets (OECD 2013).

On Cost-Benefit Ratios for Global Climate Policy

I am a skeptical environmental economist when it comes to assigning cost-benefit ratios for broad policy goals, since so much depends on how they are implemented. For me, the challenge paper's presentation of cost-benefit ratios is at best uninformative and at worst misleading.

As previously discussed, the chosen cost-benefit ratios for each policy option rely on particular studies with particular assumptions and should not be interpreted as representing a scientific consensus. Furthermore, for global emissions targets, the point is rather moot: broad political consensus has already been reached for limiting global temperature rise to 2.0°C. The much bigger question is how to get there.

It was thus initially perplexing to me that policy instruments known to be much more cost-ineffective at meeting a given emissions reduction target (compared with carbon pricing or cap-and-trade) are awarded much higher benefit-cost ratios in the challenge paper. These policies are not held to meeting an equivalent standard of emissions.

A far more genuine exercise would be to compare policy options that are capable of achieving similar goals (essentially, a cost-effectiveness analysis). Here we can have greater confidence about how they may rank. Economists have demonstrated time and again that the single most cost-effective policy for reducing emissions is to price them. In some situations that is not enough, and supplemental technology policies are useful to address other failures in the market. When emissions pricing is not available as a tool, then technology policies can indeed still meet emissions reduction goals, but at significantly higher costs. In particular, policies that delay mitigation action until a future date, such as when technology costs come down, raise the future mitigation cost burden tremendously while also requiring much greater current spending on innovation.

A robust policy for ensuring a positive cost-benefit ratio is to align the prices of fossil fuels more closely with their social costs. Meanwhile, a rebalancing of technology policy spending toward investments in R&D to bring down the global costs of low-carbon energy technologies will help enhance the effectiveness of those pricing policies and ultimately the feasibility of meeting the global targets that all parties agree are needed to limit climate change.

References

Böhringer, Christoph, and Knut-Einar Rosendahl. 2010. Green promotes the dirtiest: On the interaction between black and green quotas in energy markets. Journal of Regulatory Economics 37(3): 316–25.

EIA. 2013. Annual Energy Outlook 2013. DOE/EIA-0383(2013). Washington, DC: Energy Information Administration. http://www.eia.gov/forecasts/aeo/pdf/0383(2013).pdf.

Fischer, Carolyn. 2008. Emissions pricing, spillovers, and public investment in environmentally friendly technologies. Energy Economics 30(2): 487–502.

Fischer, Carolyn, and Richard G. Newell. 2008. Environmental and technology policies for climate mitigation. Journal of Environmental Economics and Management 55(2): 142–62.

Fischer, Carolyn, and Louis Preonas. 2010. Combining policies for renewable energy: Is the whole less than the sum of its parts? International Review of Energy and Resource Economics 4(1): 51–92.

Fischer, Carolyn, and Thomas Sterner. 2012. Climate policy, uncertainty, and the role of technological innovation. Journal of Public Economic Theory 14(2): 285–309.

Fischer, Carolyn, Richard G. Newell, and Louis Preonas. 2014. Environmental and technology policy options in the electricity sector: Interactions and outcomes. CESifo Group Munich (RFF Discussion Paper 13-20, Washington, DC: Resources for the Future).

Galiana. 2014, Climate Change Assessment Paper for the Post-2015 Consensus, Copenhagen Consensus Center

Howard, Peter. 2014. Omitted damages: What's missing from the social cost of carbon. Report of The Cost of Carbon Project. New York: Environmental Defense Fund, the Institute for Policy Integrity, and the Natural Resources Defense Council.

IEA. 2011. IEA analysis of fossil-fuel subsidies. World Energy Outlook. Paris: International Energy Agency.

IEA. 2013. Redrawing the energy-climate map. World Energy Outlook Special Report. Paris: International Energy Agency.

IEA. 2014. Energy technology perspectives 2014. Paris: International Energy Agency.

IMF. 2013. Energy subsidy reform: Lessons and implications. Washington, DC: International Monetary Fund.

IPCC Working Group III. 2014. Mitigation of climate change. Fifth Assessment Report. Intergovernmental Panel on Climate Change.

Kriegler, Elmar, Massimo Tavoni, Tino Aboumahboub, Gunnar Luderer, Katherine Calvin, Gauthier De Maere, Volker Krey, Keywan Riahi, Hilke Rosler, Michiel Schaeffer, Detlef van Vuuren. 2013. What does the 2°C target imply for a global climate agreement in 2020? The LIMITS study on Durban Platform scenarios. Climate Change Economics 4(4): 1340008 [30 pages]

Markandya, Anil. 2012. Climate change perspective paper for the Third Copenhagen Consensus, Copenhagen Consensus Center.

Morris, Adele C., Warwick J. McKibbin, and Peter J. Wilcoxen. 2013. A climate diplomacy proposal: Carbon pricing consultations. Policy Brief, Harvard Project on Climate Agreements, Belfer Center for Science and International Affairs, Harvard Kennedy School, February.

OECD. 2013. Climate and carbon: Aligning prices and policies. OECD Environment Policy Paper 1 (October 9). Paris: Organisation for Economic Co-operation and Development. doi: 10.1787/5k3z11hjg6r7-en.

Parry, Ian, Dirk Heine, Eliza Lis, and Shanjun Li. 2014. Getting Energy Prices Right: From Principle to Practice. Washington, DC: International Monetary Fund.

Sterner, Thomas (ed.). 2012. Fuel taxes and the poor: The distributional effects of gasoline taxation and their implications for climate policy (Washington, DC: RFF Press).

Thompson, Tammy M., Sebastian Rausch, Rebecca K. Saari, and Noelle E. Selin. 2014. A systems approach to evaluating the air quality co-benefits of US carbon policies. Nature Climate Change. doi:10.1038/nclimate2342.

Tol, Richard S. 2012. A cost–benefit analysis of the EU 20/20/2020 package. Energy Policy 49: 288–95.

Tol, Richard S. 2013. Targets for global climate policy: An overview. Journal of Economic Dynamics and Control 37(5): 911–28.

Whitley, Shelagh. 2013. Time to change the game: Fossil fuel subsidies and climate. London: Overseas Development Institute.

Zachmann, Georg, Amma Serwaah and Michele Peruzzi. 2014. When and how to support renewables? Letting the data speak. Brussels: Bruegel (February 5).

This paper was written by Carolyn Fischer, Senior Fellow and Associate Director of the Center for Climate and Electricity Policy at Resources for the Future. The project brings together 62 teams of economists with NGOs, international agencies and businesses to identify the targets with the greatest benefit-to-cost ratio for the UN's post-2015 development goals.

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