Draft Conference Paper
(Please do not quote without permission)

'*De-Carbonizing The World*': Reviewing Recent Proposals on Positive Pricing of Carbon and Large-Scale Climate Finance

Dipak Dasgupta[1]
October 10, 2015
Paper prepared for Conference 'Exploring Positive Pricing Project', *Centro Brasil no Clima*, Rio de Janeiro on October 26-27

Summary: This paper reviews and evaluates the main propositions and institutional and investment practicality of some recent proposals to accelerate financing for carbon reduction investments. These proposals are contained, among others, in a paper by Hourcade and Aglietta with others (2015) hereafter referred to as the HA paper. Other recent papers include that by Bhattacharya, Oppenheim and Stern, hereafter referred to as the BOS (2015) paper, and a paper by Sirkis on positive pricing of carbon, hereafter referred to as the PPC (2015) paper. They all propose to enable very large targeted carbon reduction investments by reducing pricing and investment uncertainties. The details are different, but main directions broadly similar. At the heart of the proposals are social value attached to such carbon reducing investments, and incentivizing global institutional financial flows to jump-start such investments---including access to reimbursement of some costs, public guarantees and central banks supporting the financing of such investments. With the current scale of investments running at about only one-fifth of levels needed to achieve a safer de-carbonized world, a surplus of savings and available technology, something like these proposals will need collective action, soon. Transformative change now, as in history, requires no less---a calculated departure from the usual. The mobilization of large-scale climate finance through public support looks urgent and feasible.

(length: about 11,000 words)

(Key Words: Climate finance; climate negotiations; de-carbonization; low-carbon transition; 2 degrees world; fossil-fuels; renewables; disruptive technology; carbon pricing; carbon reduction; positive pricing of carbon; social cost of carbon; carbon tax; marginal abatement cost; willingness-to-pay; emissions trading system ETS; cap-and-pay; carbon offsets; stranded assets; risk and uncertainty; discount rate; free-riding; moral hazard; adverse selection; global finance; financial innovation; institutional finance; financial instability; public guarantees; loss compensating mechanisms; central banks; climate remediation assets; mitigation; MRV; quantitative easing; monetary policy; infrastructure; public debt; development banks; MDBs; UNFCCC; IPCC; CBDR; NAMAs; COP21; Green Climate Fund; G-20; OECD; IMF; ODA; climate clubs; credibility; political economy; international consensus)

[1] The views expressed in this paper are the author's alone and do not necessarily represent the views of any organization or institution with which the author may be affiliated with.

Abstract

This paper reviews and evaluates the main propositions and institutional and investment practicality of some recent proposals to accelerate financing for carbon reduction investments. These proposals are contained, among others, in a paper by Hourcade and Aglietta with others (2015), hereafter referred to as the HA paper[2]. Other recent papers include that by Bhattacharya, Oppenheim and Stern, hereafter referred to as the BOS (2015) paper[3], and a paper by Sirkis on positive pricing of carbon, hereafter referred to as the PPC (2015) paper[4]. They propose to enable very large targeted carbon reduction investments by reducing pricing and investment uncertainties through the agreed positive value attached to such carbon reduction investments, and allowing global institutional financial flows to jump-start such investments---including access to reimbursement of some costs, public guarantees and central banks swapping and refinancing some part of such assets and investments.

The HA (2015) paper proposes a novel approach to financing de-carbonization investments globally. The proposal essentially rest on four major planks: (1) creating a new class of bankable carbon reduction based assets, termed Climate Remediation Assets (CRAs); (2) CRAs assets to be certified and verified by an independent international Supervisory Body (similar to a CDM Board) to ensure both the environmental integrity of the investments (rules for attributing the CC, MRV process) and its developmental effectiveness (consistency with NAMAs selected by the countries to secure the alignment of mitigation actions with development policies); (3) a commitment by countries to back a large quantity of these CRAs at a given face value, which then allows banks, financial entities to finance such activity at much lower risk; and (4) central banks to finance and hold these assets as part of their quantitative easing and other heterodox monetary policy to stimulate real economic activity in such carbon reducing areas.

The BOS (2015) paper proposes similar but slightly different 'concerted action' approach to massively increase climate and sustainable development investments. It rests on the following proposals: (1) Over the coming 15 years, the world will need to invest around $90 trillion in sustainable infrastructure assets, with the bulk of it in developing countries; (2) The world appears to be caught in a vicious cycle of low investment and low growth and there is a persistence of infrastructure deficits despite an enormous available pool of global savings; (3) the capacity of national and international development banks to invest in infrastructure and agricultural productivity needs to be substantially augmented in order for them to support needed for better infrastructure; and (4) central banks and financial regulators should take further steps to support the redeployment of private investment capital from high- to low-carbon, better infrastructure, while official public funds (G-20, OECD and others) could also augment through standardized contracts, guarantees, taxation benefits and other ODA concessional financing of such investments---centered around a significant reduction in 'policy risks'.

Finally, yet a third strand of complementary proposals is a 'positive pricing of carbon' proposal, as outlined in Sirkis (2015). The idea is that a smaller number of important countries in 'Climate Clubs' such as in the G-20 might agree to the positive value of carbon reduction, and guarantee some portion (say ten percent) of the monetary value of these investments as internationally reimbursable—through future carbon taxation.

Our paper evaluates the practicality and operationalization of these proposals, focusing on the following questions:

(1) how do investors demonstrate credibly that carbon reduction (under the CRAs or similar instruments) equals value and what steps will legitimize this? Implicitly or explicitly, this will require international consensus. We know that reaching such a consensus has been very difficult. Different countries may attach different

[2]J-C. Hourcade (CIRED), M. Aglietta (Cepii), B. Perissin-Fabert (CIRED) with B. Leguet, I. Shishlov, C. Ferron, R. Morel, I. Cochran (CDC Climat), H. Chenet, D. Strauss, J. Thomae, A. Gorius, M. Coeslier, S. Dupré (2°II), R. Bibas, C. Cassen, A. Pottier (CIRED). Transition to a low-carbon society and sustainable economic recovery, A monetary-based financial device. CIRED. http://www.centre-cired.fr/IMG/pdf/concept_note.pdf

[3] A. Bhattacharya, J. Oppenheim and N. Stern, 2015.Driving Sustainable Development Through Better Infrastructure: Key elements of a transformation Program. Brookings, Grantham Institute and New Climate Economy Project.

[4] Alfredo Sirkis, 2015. Positive Pricing of Carbon Reduction: A Low Hanging Fruit. September. CEPII Blog. http://www.cepii.fr/BLOG/bi/post.asp?IDcommunique=405

social values. So, what are the possible routes out of this dilemma? UNFCCC and COP21 process, G20 agreement, carbon clubs, or something else?

(2) It will also require specific metrics of valuation, a price or value for such carbon reduction. Is this feasible, and can countries agree to such a common valuation, or are there other alternatives: should we settle for individual countries deciding a minimum price within a 'band' rather than a price or value, and why?

(3) The nature of the institutions that would best placed to refinance the "carbon remediation assets": individual central banks? A pool of central banks? The IMF? A fund linked to the GCF? A pool of development banks? National or international fiscal actions?

(4) Because there will be potential risks to the central banks and other refinance institutions of losses in such investments, there has to be a defined relationship of these CRAs to some public guarantees against such possible losses if some proportion of investments turn insolvent. Therefore, some kinds of guaranties would need to be given by governments. In addition, issues will arise on how credible these guarantees might be and the loss-compensating mechanisms and recovery in the context of high levels of existing public debt in many countries. Are future taxes credible?

This review paper looks at the advantages and disadvantages of the HA, BOS and PPC proposals over some others, such as the traditional proposals of public and private financing of climate change, and carbon taxation and cap-and-trade proposals in this light. The paper also briefly assesses their political economy feasibility. The review concludes that while there are some technical areas that may need fine-tuning, the proposals are right. With the current scale of investments running at about only one-fifth of levels needed to achieve a safer de-carbonized world, a surplus of savings and available new technology, something very much like these proposals---building on them---will need collective agreement and action, soon. We know what needs doing. Transformative change now, as in history, requires no less---a carefully calculated departure from the usual. The mobilization of large-scale climate finance, through enhanced public support, looks urgent and feasible.

'*De-Carbonizing The World*': Reviewing Recent Proposals on Positive Pricing of Carbon and Large-Scale Climate Finance

A. The Question

In a recent paper[5], I argued that a shift to *massive climate finance*---trillions not billions---needs to be a crucial instrument of a successful shift towards a de-carbonized world. Without such a shift in institutional finance, the pace of change may not be fast enough to avoid the danger of tipping points.

The world is not short of savings, nor is it short of needed technological investments and opportunities to redirect it out of fossil fuels---if we are to avert the ongoing speed of global warming. Financial innovations, and the role of the state in fostering these shifts worldwide, is the challenge.

A rapid shift from a fossil-fuel dependent economy to a renewables based one requires a "*disruptive shift*": one that drastically displaces an established technology and shakes up the industry or creates a ground-breaking product that establishes a completely new industry. History of previous such technological shifts (from railroads in the 19th century to mobile telephony in the 21st) suggests that in order for this to happen, three things need to occur in a recursive loop: (1) dramatically falling costs of new technology (in this case, renewables from solar, wind and others); (2) increasing social and customer acceptance of the new technology as a vastly superior product (in this case, scale of renewables energy); and (3) financial innovation that causes a large shift in finance towards adoption of the new technology.

We know that this required shift in climate finance is not yet in place. Even central bankers are contemplating this change. Mark Carney, the Governor of the Bank of England, has (famously) recently gone on record to say: "Financing the de-carbonisation of our economy is a major opportunity for insurers as long-term investors. It implies a sweeping reallocation of resources and a technological revolution, with investment in long-term infrastructure assets at roughly quadruple the present rate. For this to happen, "green" finance cannot conceivably remain a niche interest over the medium term…. The more we invest with foresight; the less we will regret in hindsight[6]". Carney was speaking, of course, in assessing the contingent risk that were such a massive shift in climate finance to occur, out of fossil-fuels to renewables, there might be large-scale financial risks to 'stranded' fossil-fuel assets in the transition to a 2 degrees de-carbonized world.

---

[5]Dipak Dasgupta, 2015. Financial Innovation and The State: Lessons for 21st Century Climate Finance from the 19th Century Railways Era ENVIRONNEMENT & RESSOURCES NATURELLES Billet du 1er octobre 2015. CEPII Blog. http://www.cepii.fr/BLOG/bi/post.asp?IDcommunique=407

[6] Mark Carney, 2015. Breaking the tragedy of the horizon - climate change and financial stability. Speech to Lloyds, London. http://www.bankofengland.co.uk/publications/Pages/speeches/2015/844.aspx

But before we get to the risk of such financial instability, the prior question is what mix of public policy would trigger such a shift to massive climate to a low carbon economy? That is the fundamental question in this paper.

Several recent proposals, in the run up to the COP21 meetings in Paris, have started grappling with this question of financial innovation and the role of public policy. The urgency is clear. If we are to have a real successful outcome of the Paris meetings---of countries committing voluntarily committing towards such a transition to a 2 degree world---then those commitments have to be backed up by necessary technology and finance. Otherwise, COP21 would be an empty 'shell'. The need for large-scale financing is especially important for large developing countries such as India, but also everywhere. Households will not invest, companies cannot invest, financial intermediaries will hesitate in all settings---despite the promises. Without the means of implementation, technology and finance, the challenge of transition to a low-carbon world cannot be met.

The recent proposals to enable such financial innovation and public policy to enable such a massive shift in climate finance are therefore important and timely. The ones reviewed in this paper include: (1) a paper by Hourcade and Aglietta with others (2015), hereafter referred to as the HA paper[7]; (2) a paper by Bhattacharya, Oppenheim and Stern, hereafter referred to as the BOS (2015) paper[8]; and (3) a paper by Sirkis on positive pricing of carbon, hereafter referred to as the PPC (2015) paper[9]. These are not the only ones. In an earlier paper in 2013, I had proposed that an opportunity existed for using global bond markets and public sovereign guarantees to credibly back up global climate finance flows[10].

B. Finance in the Low-Carbon Transition---Three Approaches

Before we review the proposals for their feasibility, it might be useful to review first how we got here: to finance. The story begins with climate change negotiations, a collective effort to reach social and political consensus on the dangers and objectives. To get to that consensus on the importance of keeping global warming below 2 degrees, the first approach was not on finance, but on information, science, discussion, and agreements on targets and goals. Then follows the second approach, a discussion of how people should pay and how incentives might be set for achieving the targets and goals: through public taxation and transfers and optimal carbon prices

[7]J-C. Hourcade (CIRED), M. Aglietta (Cepii), B. Perissin-Fabert (CIRED) with B. Leguet, I. Shishlov, C. Ferron, R. Morel, I. Cochran (CDC Climat), H. Chenet, D. Strauss, J. Thomae, A. Gorius, M. Coeslier, S. Dupré (2°II), R. Bibas, C. Cassen, A. Pottier (CIRED). Transition to a low-carbon society and sustainable economic recovery, A monetary-based financial device. CIRED. http://www.centre-cired.fr/IMG/pdf/concept_note.pdf

[8] A. Bhattacharya, J. Oppenheim and N. Stern, 2015.Driving Sustainable Development Through Better Infrastructure: Key elements of a transformation Program. Brookings, Grantham Institute and New Climate Economy Project.

[9] Alfredo Sirkis, 2015. Positive Pricing of Carbon Reduction: A Low Hanging Fruit. September. CEPII Blog. http://www.cepii.fr/BLOG/bi/post.asp?IDcommunique=405

[10] Dipak Dasgupta, 2013. Fossil Fuel Subsidies: Three Questions, Evidence and Way Forward. Working Paper, Ministry of Finance, India. http://finmin.nic.in/workingpaper/FossilFueSubsdies.pdf

and taxes. It becomes evident that public pricing and taxation of the scale needed are going to be politically difficult. Then the time comes to look at the third option: finding the links between public policy to trigger large-scale transformative change through finance. These are the three sequential steps.

The Climate Negotiations Track (1). A first approach, the oldest one, the Climate Negotiations Track, rests on trying to achieve a global consensus and voluntary or otherwise pacts among countries to agree on how different countries might commit themselves to such a transition to lower carbon. Added up, if these commitments were possible, we might arrive at a safe global transition to a 2 degree world. Included within this, nevertheless, was the idea of a public financing scheme that would commit to transfer public resources from rich to poor countries, and/or from those who had contributed most to earlier carbon emissions to those who currently had the least per capita emissions of greenhouse gases (but in the future might grow so as they developed)---the case for equity in low-carbon transition globally. Equity also included the consequences of a globally warming world on countries who had contributed little but would face the worst effects of a warming world---through access to adaptation funds for developing countries and especially small islands and least developed countries.

This global Climate Negotiations Track approach is the familiar approach that countries have been negotiating under the United Nations Framework Convention on Climate Change (UNFCCC) approach ever since the Earth Summit in Rio in 1992. The problem with such treaty based negotiating process is that they contain no legally binding agreements nor any mechanisms for enforcement. In addition, reaching a consensus among some 190 plus members has never been easy. The annual Conference of Parties meetings assess progress and try and sign new protocols and processes[11].

On the other hand, the UNFCCC negotiations process have yielded some crucial gains: (a) a political and social process of global engagement, negotiations and targets; (b) an universality of such agreement at a multilateral forum which ensures wide global ownership among countries; (c) much greater information, tools, specialized institutions and processes, including most importantly, the periodic scientific assessment of global warming and climate change risks under the Intergovernmental Panel on Climate Change (IPCC); (d) a principle of Common but Differentiated Responsibility (CBDR) and equity; and (e) some funding agreements, including establishing the Global Environment Facility, special climate funds, the Global Adaptation Fund, and more recently, the global Green Climate Fund, as well as other national and bilateral channels---with an overarching agreement that developed countries Parties would commit to provide US$100 billion annually of funds for mitigation and adaptation of developing country Parties by 2020, even though we remain far from that goal and with no means or even an agreement on firm parameters to measure and verify the accuracy of the stated funding (is it

[11] After the initial inking of the Treaty, these have included the Kyoto Protocol (1997), the Bali Action Plan (2007), the Copenhagen Accord (2009), the Cancun agreements (2010), and the Durban Platform for Enhanced Action (2012)

public or private? Is it grants or loans? Is it to be converted to grant-equivalent terms? How will burden-sharing be enforced?).

Almost by definition, the Climate Negotiations Track has been slow. Some 23 years later, outside observers have even termed it as a 'theatre of the absurd'[12]. Yet others have pointed to significant achievements, despite the 'despair with outcomes': the setting and measurement of goals, political engagement, and credible progress on the ground with renewables technologies, slowing deforestation and at least a start on climate finance.[13]

As we approach the Paris COP21 process, two areas of crucial importance have become clearer: a universal agreement to produce credible progress through INDCs and national plans and goals, and the means of implementation including finance. The INDCs are making progress, although there is still need to make them much more ambitious to reach a 2 degree world. The finance issues remain unresolved---and painfully inadequate to reach the outcomes. For example, the Green Climate Fund has only raised some US$10 billion in commitments to public finance after three years of being established as the main multilateral fund for climate finance, while others are still struggling, such as the global Adaptation Fund. We remain far from the US$100 billion annual commitment of funding target, even as the actual amounts needed for climate finance are conservatively four times larger for developing countries. Globally, the need for investments to reach a 2 degree target are in the order of about US$1 trillion a year or more, whereas the actual investments are some one-fifth or less, counting all finance, public and private.

The Carbon Pricing and Taxation Track, and the Social Cost of Carbon (2). There are two reasons why the second---carbon pricing and taxation track---has become important. The first is that as countries begin to think about implementing a low-carbon transition goal, it makes sense to set a social value to the costs of emitting carbon: the price of carbon emissions. Once set, it establishes a benchmark for governments to reduce such emissions say by imposing tight standards and regulations on such emissions, and incentives for companies to avoid such carbon emissions. The second is equally important: since markets left to themselves will not price the costs, the economic price of carbon can only be set by effectively imposing a tax on emissions. Revenues from such Pigouvian taxes help directly pay for the investments needed[14]. This 'doubly' beneficial effect of taxing a negative externality---setting incentives and collecting public revenues---makes it attractive. There were some early attempts to propose some international sector specific taxes, such as on aviation and maritime bunker fuels. But these attracted much criticism as being highly distortionary to specific sectors, and grave imbalances in their incidence.

[12] The Economist, 2012. Theatre of the Absurd. http://www.economist.com/news/21567342-after-three-failures-years-un-climate-summit-has-only-modest-aims-theatre-absurd

[13] Tove Ryding, 2012. Climate Protection between hope an despair: 20 years of UNFCCC, Greenpeace International. http://www.greenpeace.org/international/Global/international/publications/RioPlus20/20-Years-of-UNFCCC.pdf

[14] Dipak Dasgupta, Rajasree Ray and Nikhila Menon, 2011. International Taxes to Finance Global Green Climate Fund---An Analytical Review. Working Paper, Ministry of Finance, India. http://finmin.nic.in/workingpaper/Inter_Finance_TaxGreen.pdf

The larger problem with a carbon tax, however, is its political economy costs (broader class of consumers), the intense lobbying by the carbon-emitting established industries (narrower and well-organized producers), and the differences between countries in different circumstances (fossil-fuel abundant versus scarce countries, and rich versus poor countries in terms of capacity and willingness to pay).

The case made against such general carbon tax are familiar[15]: how do we know what the damages really are from future climate change (information difficulties) based as they are on 'models', even a revenue-neutral carbon tax might be distortionary (hurt some producers more and lower aggregate growth), and finally, the actual 'failure' of carbon taxes in many countries. Numerous articles and papers reflect intense lobbying exercises against carbon taxes. However, of late, even the more conservative ones are beginning to suggest that it may be better to go with a general carbon tax than tighter and deepening emissions control[16]; the Congressional Budget Office in the USA has also recommended such a carbon tax (starting at US$20 per ton of CO2, 2013) as desirable---equivalent to just a few cents per gallon of gasoline.

A more neutral and better assessment comes from 'willingness to pay' studies. In the USA, such studies have found significant willingness to pay (US$60-100 per year per consumer per ton of CO2), without much distinction between types of instruments chosen (a straight carbon tax versus a cap-and-trade system or a GHG emission regulation). In Europe, the willingness to pay is up to 4 times higher[17]. Not unexpectedly, the opposition to carbon taxes is generally greater among older citizens, and finds more favor among younger generation, more educated households and higher income classes.[18] Numerous other studies now show a range of relatively high willingness-to-pay for carbon reductions across countries and regions, including in developing Asia.

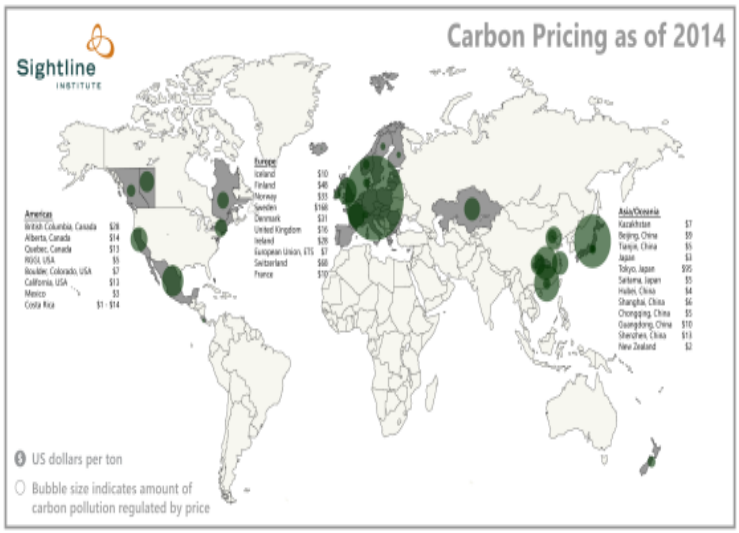
Partly because of the formidable political economy constraints to carbon taxes, many have advocated an alternative **emissions trading system (ETS)** or cap-and-pay systems. Under such an ETS scheme, carbon emissions regulations are set to cap the level of emissions of particular industries, and then trade is permitted which effectively ends up with a 'market' price for carbon. It is of course an artificial market that depends entirely on public policy. When policy is lax, prices can collapse (as currently is the case). The advantage of the system is that it is more flexible and more directly linked to emissions reduction than are straight carbon taxes.

The World Bank, a key proponent of this idea, reports that the total value of the emissions trading schemes (ETSs)[19] globally in 2014 was about US$32 billion---a miniscule fraction of costs. Despite

[15] Robert P. Murphy Patrick J. Michaels Paul C. Knappenberger, 2015. The Case Against a Carbon Tax, Cato Institute, Working Paper No. 33. http://object.cato.org/sites/cato.org/files/pubs/pdf/cato-working-paper-33.pdf
[16] Jerry Taylor, 2015. The Conservative Case for a Carbon Tax. Niskanen Centre Working Paper. http://niskanencenter.org/wp-content/uploads/2015/03/The-Conservative-Case-for-a-Carbon-Tax1.pdf
[17] Flavia Tsang, Peter Burge, 2011. Paying for carbon emissions reduction. Rand Europe Occasional paper. http://www.rand.org/content/dam/rand/pubs/occasional_papers/2011/RAND_OP312.pdf
[18] Kotchen, M., K. Boyle, and A. Leiserowitz, 2011. Willingness to pay and policy-instrument choice for climate change policy in the United States. NBER Working Paper. http://www.nber.org/papers/w17539
[19] World Bank, 2014. State and Trends of Carbon Pricing, Washington DC.

the repeal of Australia's Carbon Pricing Mechanism in July 2014, and mainly due to the launch of the Korean ETS and the expansion of GHG emissions coverage in the California and Quebec ETSs, the value of global ETSs as of April 1, 2015 increased slightly. The International Energy Agency reported that Carbon markets covered just 11% of global energy-related emissions in 2014 and the average price was only $7 per ton of CO2. (In contrast, 13% of CO2 emissions were linked to fossil-fuel use supported by consumption subsidies, equivalent to an implicit subsidy of $115 per ton of CO2). In addition, carbon taxes around the world, valued for the first time in this report, are reported to be about US$14 billion.

Combined, the value of the carbon pricing mechanisms globally in 2015 is estimated to be just under US$50 billion.[20] Overall, "… there are 39 different programs that collectively put a price on 12 percent of all the greenhouse gas (GHG) emissions in the world. And when China's national program starts in 2016, almost a quarter of global GHG pollution will carry a price tag to speed the changeover to clean energy". The map below shows carbon pricing programs around the world (with the size of the bubbles indicating the amount of pollution priced)[21]. Note that the map and coverage omits some significant countries such as India, which also has introduced significant carbon taxes, such as on coal.



Source: Sightline Institute.

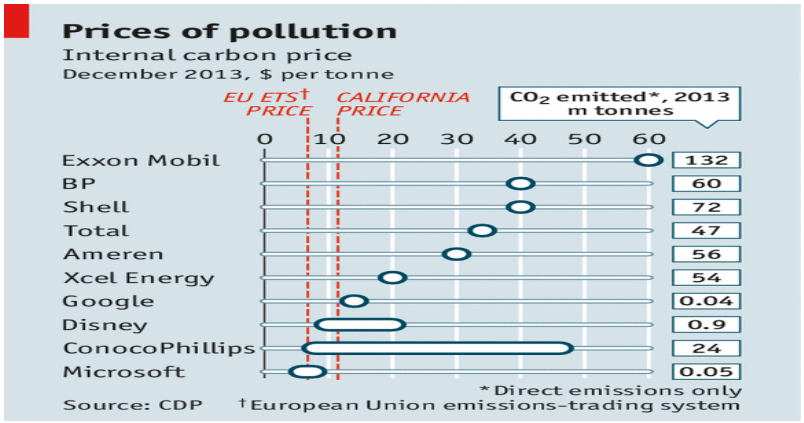
The next stage in the carbon tax initiative by some proponents is for countries to agree to a minimum global carbon tax, which would avoid the problem of 'free-riding'. Joseph Stiglitz, the

[20] International Energy Agency, 2015. Special Report on Energy and Climate Change. http://www.iea.org/publications/freepublications/publication/WEO2015SpecialReportonEnergyandClimateC hange.pdf

[21] Kristin Eberhard (@KristinEberhard) on November 17, 2014 at 6:30 am **SightLine Daily**. http://daily.sightline.org/2014/11/17/all-the-worlds-carbon-pricing-systems-in-one-animated-map/

Nobel laureate, has argued that it would involve say 'a commitment by each country to raise the price of emissions (whether through a carbon tax or emissions caps) to an agreed level, say, $80 per ton'. Each country could decide to make it revenue-neutral, raising these taxes and reducing taxes on capital or labor. Some significant part would also be transferred to developing countries to make sure that equity is preserved[22].

It is interesting to note that large private corporations, some heavily engaged in fossil-fuel economy, already use shadow carbon prices in their own internal assessments. According to the Global Price on Carbon report 2014, at least 150 companies are using an internal price on carbon ranging from $6 to $80 per ton with one outlier at $324. These companies represent diverse sectors, including consumer goods, energy, finance, industry, manufacturing, and utilities. Six of Europe's largest oil producers have recently announced a call for a plan to price planet-warming greenhouse gas emissions, citing climate change as "a critical challenge for our world."[23]



Source: The Economist[24]

Although different in concept from a price on carbon, it is also important to note that some governments have been making use of the 'social cost of carbon' (SCC), in deciding when and where to set regulations and standards on curbing GHG emissions. The Stern review, estimated the social cost of carbon at $86 in 2006. Much of the variation between estimates is driven by the discount rate applied but other factors are also relevant, such as the climate model used and the approach to valuing damages[25]. From 2002 to 2009, the UK used a SCC approach. The EPA in

[22] Joseph Stiglitz, Carbon-pricing. http://carbon-price.com/joseph-stiglitz/

[23] Matt Ramos, 2015. Europe's Oil Giants Call For Carbon Pricing. The Huffington Post.

[24] The Economist, 2013. Some firms are preparing for a carbon price that would make a big difference. December 14.

[25] Will Evison and Jonathan Grant, 2015. How should we calculate the cost of carbon? PWC. http://pwc.blogs.com/sustainability/2015/01/how-should-we-calculate-the-cost-of-carbon.html

the United States and other federal agencies have used the SCC approach---estimating the economic damages associated with a small increase in CO2 emissions, conventionally one metric ton, to estimate the benefits of new rules: about US$37 per ton in 2013 as the mean cost estimate. A key issue in making such calculations is the discount rate to discount the effect of future damages. Using a low discount factor (valuing the future more) would raise costs, and vice-versa when a high discount rate is used. Apart from this sensitivity is also the counting of true costs of climate change. Stanford researchers have recently estimated that the EPA's use of US$37 per ton was a serious underestimate of the true SCC which should be as high as US$220 per ton. The reason: there are persistent economic damages from higher carbon emissions that were not factored in.[26] [27] Extreme weather changes, for example, would cause serious damage necessitating rebuilding of assets to return to past growth and which would raise the social costs far higher than the conventional model estimates used by the EPA.

However, in conclusion, the political economy opposition against such carbon taxes (and social costs of carbon) remains formidable---from concentrated industrial owners of assets which would lose value to concerted public action against such taxes, and from the general reluctance of consumers to pay taxes as levels of such taxes start to rise---reducing these politically feasible taxes to much lower levels.[28] The collapse of Australia's carbon tax is also seen as evidence why such opposition can mount quickly as carbon taxes are imposed. The collapse of the European carbon market EU-ETS is also similar pointer: carbon prices are now far lower than the expected Euro 30 per ton. Therefore, despite such a growing move towards carbon pricing, whether in taxes or ETS or in internal pricing, the political economy issues remain formidable. The argument now is that second-best approaches might work better than outright first-best carbon prices or taxes: starting with low taxes, slowly increasing them over time, targeting the uses towards generating more employment and production, and showing the 'co-benefits' of such taxes or pricing. The differences in willingness to pay and differences in country settings and the political economy constraints are seen to be such that only progressive increases in a second-best policies may appear to make the most sense.

The Transformative Track: Finance-cum-Technology-cum-Public Policy (3). A third approach to dealing with climate change takes the argument, I believe, to large-scale financing of the costs of adopting new technology: mitigation of GHG emissions will need massive shifts in investment, and providing public support for such investments is a key issue.

What factors would justify such a potential role for public policy support? After all, the use of public monies or backing carries its own problems: governance failures, potential losses, and policy mistakes. Three factors are probably important. The first is the size and scale of threat

[26] Ker Than, 2015. Estimated social costs of carbon not accurate, Stanford scientists say.
[27] Frances C. Moore & Delavane B. Diaz, 2015. Temperature impacts on economic growth warrant stringent mitigation policy. *Nature Climate Change* 5,127–131 (2015)

[28] Jesse D. Jenkins, 2014. Political economy constraints on carbon pricing policies: What are the implications for economic efficiency, environmental efficacy, and climate policy design? Energy Policy. Volume 69, June 2014, pp 467-477.

from the negative externality of continued reliance on carbon-based fossil-fuel economies. The second is the risk of imminent permanent negative effects without public policy action---and the absence of near-term forward risk and insurance markets. And the third is the need for 'coordinated' public policy action, since the negative externality crosses borders.

Are these three factors compelling enough to justify such action? The narrow 'technical' answer lies ultimately in the calculus of balance of costs versus benefits. If the scale of public monies that might have a sufficiently positive effect is, say, 'X', and the probable inherent or unavoidable inefficiency losses of use of public monies is say 'å', those are the associated costs of public action. The benefit, on the other hand, is the positive effect of inducing say the expected 'Y', the anticipated necessary scale of private institutional finance flows to new carbon reducing investments and technology, to avoid the cost of inaction, say 'Z' (an event with a rising probability, converted to certainty equivalent value, discounted to present value terms). Then, public action is justified, if:

$$å.X \leq Z \text{ ------- (1)}$$

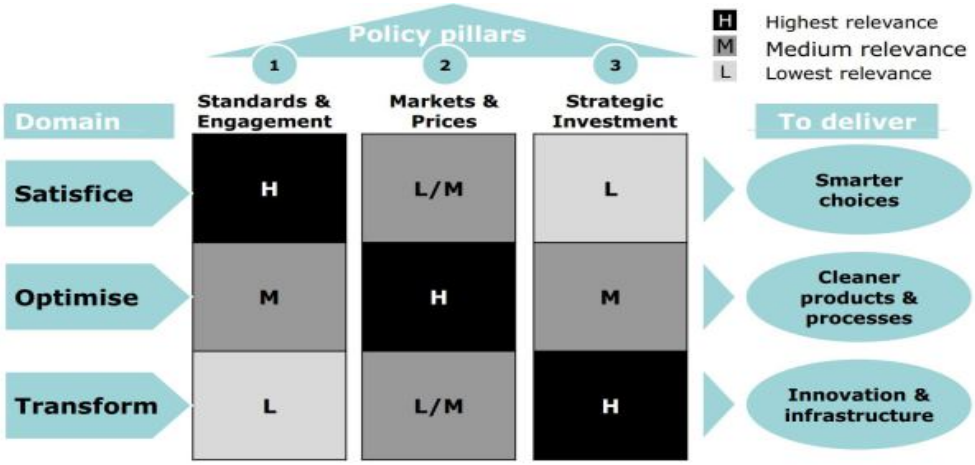
Let's try to put some possible numbers behind this calculus. Suppose the stream of additional investments 'Y' over the next decade supported by institutional finance needed to avert the risk of exceeding 2 degrees warming is some US$10 trillion (US$1 trillion additional a year). Say, on the other hand, that this sum would be forthcoming if it were to require committing 'X' of US$2 trillion (US$200 billion annually) in public guarantees (20% public guarantees, to offset expected institutional risk-aversion and uncertainty)---of which the expected losses, 'å', may amount to one-fifth, and the size of the loss, 'å.X' is therefore some US$400 billion (or US$40 billion a year at some future point of time). Then, so long as the size of 'Z', the expected net present value of losses from global warming exceeding 2 degrees, is higher than the loss, then the benefit-cost calculus justifies such public action. There is also an additional public finance consideration: how to pay for the expected losses, which because it will occur at a future time, requires a credible commitment now to raise future carbon taxes to fund these losses. Since future generations benefit more than current generation, this transformation of committing present generation public funds to avert losses in the future, and taxing future generations to pay for expected losses, may make sense.

By any yardstick, the value of 'Z' far exceeds the cost 'å.X' as calculated from these numbers, since the size of global losses from a more than 2.5 degrees world are at least 2 percent of world GDP annually[29], and rising catastrophically higher as the temperature exceed that threshold, and the probabilities are climbing. As far as the funding of losses through future carbon taxes are concerned, the implicit tax burden is relatively small. The benefit-cost ratios of public policy to encourage accelerated institutional climate finance remain overwhelmingly positive, and the

[29] Current size of world GDP is about US$75 trillion, and expected rise much further by 2050. With a conservative cost of 2% of world GDP, the annual losses alone from global warming using current world GDP would amount to at least US$1.5 trillion a year. Over ten years, even with discounting, the sums of 'Z' are massive, compared to the expected costs of public action.

main issue is of governance (to keep actual public finance losses from the call on guarantees well defined and limited to publicly tolerable levels from the public risk and fiduciary perspectives) and the political willingness to act, as in many other areas of public decision.

Michael Grubb at Cambridge, along with Jean-Charles Hourcade and Karsten Neuhoff, in this context, argue that there are three distinct domains of human decision-making. No one domain as a centre of attention is right or wrong. But excessive attention to only one or two domains such as 'optimal market pricing' and new 'standards and regulations' has ignored a third key pillar of behavioral change in climate change: how to induce rapid large-scale technological change[30].



Source: Adam Whitmore, 2014. A new framework for climate policy. Why carbon pricing is not enough.[31]

Grubb and his colleagues base their book on three pillars of change or domain, each affecting outcomes differently. In the first domain people seek to satisfice their needs, and do not necessarily go much further. This is akin to the Climate Negotiations Track (1) outcome that we described, as well other national measures such as energy efficiency standards and information campaigns: it is slow, takes time, usually starts unambitious and will settle for the minimum change that is needed. The design of policies here is informed by disciplines such as psychology, the study of social interactions, and behavioral economics. A second domain looks at what Grubb and colleagues describe as 'optimising behavior', where companies and individuals will respond most to market incentives and instruments, and prices and neo-classical economics matter. This is akin to our second track on Carbon Pricing and Taxation. Yet a third domain they suggest needs to look at transformative change that warrants a much larger role for government to drive change. The shift to large-scale finance possibly plays a critical role, to enable new investments, technology, and other wholesale changes that draws on governance, technology and industrial

[30] Michael Grubb, with Jean-Charles Hourcade and Karsten Neuhoff, 2014. Planetary Economics: Energy, climate change and the three domains of sustainable development. Routledge.

[31] Adam Whitmore, 2014. A new framework for climate policy. Why carbon pricing is not enough. March 26, Energy Post. http://www.energypost.eu/new-framework-climate-policy-carbon-pricing-enough/

policy, and institutional economics. Why? Because there are considerable uncertainty and risks, much larger impacts than the market can handle, and bigger shifts that are required than can be accommodated by the other two domains. Finance is particularly crucial as an enabler.

Having set out what I believe are the 3 main approaches to thinking about finance for climate change, we can now turn to the specific review of the proposals.

C. Recent Proposals on Large-Scale Climate Finance

Some recent proposals have been made to dramatically accelerate financing for carbon reduction investments (summary in Table 1). These proposals are contained, among others, in a paper by Hourcade and Aglietta with others (2015), referred to as the HA paper.[32] Other recent papers include that by Bhattacharya, Oppenheim and Stern, referred to as the BOS (2015) paper, and a paper by Sirkis on positive pricing of carbon, referred to as the PPC (2015) paper. They propose to enable very large targeted carbon reduction investments by reducing pricing and investment uncertainties, and allowing global financial flows to jump-start such investments---including central banks swapping and refinancing such assets and investments. Of all three proposals, the most carefully thought-out one is the HA paper---dealing extensively with the possible downsides and questions on the design of governance and risk management. The BOS paper is much more reliant on mainstream mechanisms and internalization of scheme management (for example, advocating use of MDBs and development banks), so that risk and governance issues are given relatively light attention. The PPC proposal, on the other hand, is the simplest, arguing for a social valuation and a very modest level of public resource transfer.

The HA (2015) paper proposes a novel approach to financing de-carbonization investments globally. The proposal essentially rest on four major planks: (1) creating a new class of bankable carbon reduction based assets, termed Climate Remediation Assets (CRAs); (2) CRAs assets to be certified and verified by an independent international Supervisory Body (similar to a CDM Board) to ensure both the environmental integrity of the investments (rules for attributing the CC, MRV process) and its developmental effectiveness (consistency with NAMAs selected by the countries to secure the alignment of mitigation actions with development policies); (3) a commitment by countries to back a large quantity of these CRAs at a given face value, which then allows banks, financial entities to finance such activity at much lower risk; and (4) central banks to finance and hold these assets as part of their quantitative easing and other heterodox monetary policy to stimulate real economic activity in such carbon reducing areas.

The BOS (2015) paper proposes similar but slightly different 'concerted action' approach to massively increase climate and sustainable development investments. The proposal is not exclusively about climate finance, but much of its proposals would apply. It rests on the following

[32] See also, Jean-Charles Hourcade & Priyadarshi Shukla, 2013. Triggering the low-carbon transition in the aftermath of the global financial crisis. Climate Policy. Volume 13, Supplement 01, 2013.

proposals: (1) Over the coming 15 years, the world will need to invest around $90 trillion in sustainable infrastructure assets, with the bulk of it in developing countries; (2) The world appears to be caught in a vicious cycle of low investment and low growth and there is a persistence of infrastructure deficits despite an enormous available pool of global savings; (3) the capacity of national and international development banks to invest in infrastructure and agricultural productivity needs to be substantially augmented in order for them to support needed for better infrastructure; and (4) central banks and financial regulators should take further steps to support the redeployment of private investment capital from high- to low-carbon, better infrastructure, while official public funds (G-20, OECD and others) could also augment through standardized contracts, guarantees, taxation benefits and other ODA concessional financing of such investments---centered around a significant reduction in 'policy risks'.

Table 1: The Three Proposals, in Summary

Proposals /Characteristics	***Carbon Rem. Asset (CRA) /Positive Value of Carbon***	***CRA Verification.***	***Large Scale Financial Backing to Climate Projects /Refinance of CRAs***	***Agency***	***Role of Central Banks***	***Other Policy Actions***
HA (2015)	Yes.	Yes. Independent Supervisory Board.	Yes	Central banks. Monetary Authorities. Public Finance.	Yes	Future Carbon taxes to back up fiscal guarantees.
BOS (2015	No. National strategy for sustainable infrastructure. Targeted climate finance, scaled up, through GCF.	No. Norms for sustainable infrastructure.	Yes	G-20. Development Banks MDBs	Yes	Standard contracts, govt. guarantees, other,
PPC (2015)	Yes. Agreed positive price of Carbon. 10% of monetary value of investments internationally reimbursable.	Yes	Yes	G-20. 'Climate Clubs'	Yes	Agreed Social Price of Carbon. 10% of value to be guarantee provided to projects.

Finally, yet a third strand of complementary proposals is a 'positive pricing of carbon' PPC proposal, as outlined in Sirkis (2015). The idea is that a smaller number of important countries in

'Climate Clubs' such as in the G-20 might agree to the positive value of carbon reduction, and guarantee some portion (say ten percent) of the monetary value of these investments as internationally reimbursable—through future carbon taxation.

D. Assessing their Practicality and Feasibility

We consider in this section some elected issues for examination of the practicality and feasibility of the proposals. These are by no means exhaustive, but point to some of the issues that arise.

Establishing the Credibility of Carbon Reduction Under Investments Financed (1). How do investors demonstrate credibly that carbon reduction (under the CRAs or similar instruments) proposed to be financed equals value and what steps will legitimize this? Implicitly or explicitly, this will require international consensus. We know that reaching such a consensus has been very difficult in many areas. Different countries may attach different social values. So, what are the possible routes out of this dilemma? UNFCCC and COP21 process, G20 agreement, carbon clubs, or something else?

The carbon offsets market is the closest we can get to the real-life credibility and certification process for investments that reduce carbon. However, the size of the current market is very small. Over the past decade, voluntary offsets totaled some US$4.5 billion.[33] The largest part originated in the USA, followed by Brazil, Turkey, India, Kenya and China. Some 87 million tons of CO2 were traded in 2014---only a fraction of 1% of global GHG emissions---with an average price of US$3.8 per ton (a new low). Avoided deforestation and land-fill methane use accounted for half, while renewable wind energy, clean cook stoves, and water were some of the most popular uses. There were 4 major voluntary standards that were applied, accounting for about a third of all transactions. The highest prices were paid for the two biggest, 'VCS' and the 'Gold Standard' (US$4.4/ton) suggestive of the 'credibility' premium to these standards. Virtually all were project-based, with third party verification---based on project proposed baseline, with third-party validation at that baseline and verification afterwards once project is functioning. Offset project registries then issue the tradeable certificates which are resold before being retired. Brokers and retailers bring buyers and sellers together, while some direct buyer-seller transactions are also done. An exchange traded system in the USA (CCX) collapsed in 2010 because of little demand and no cap-and-trade system. A government-to-government 'pay for performance' system was initiated recently (REDD) for avoided deforestation between Germany and Brazil, which Norway has joined on the donor side, and Colombia and Ecuador on the contributor side. Generally, voluntary demand has stagnated. Finally, most transactions dealt with projects already in stream, with very little going to new starts.

More formal or regulated offset markets—such as under the UNFCCC and the European EU ETS---require much more stringent technical standards for certification. Under the CDM mechanism of the UNFCCC, projects generate certified emissions reductions (CERs) or certified emission units

[33] Ecosystems Marketplace, 2015. Ahead of the Curve: State of the Voluntary Carbon Markets 2015.

(CEUs). Under the EU ETS, similar arrangements apply. Validation is done by certified third parties, as well as monitoring. Both the CDM and EU ETS has been under considerable stress and prices have fallen sharply.

There are several broad lessons: (1) relatively proven methods exist to certify emission reductions, by using third-party validation and monitoring, with considerable experience having been built up over time; (2) the process can however be quite cumbersome and costly, making sense only for larger and more middle-income settings, with the capability to bear the costs; (3) because all current systems tend to be project-based, moving to much larger volumes of financing as anticipated will inevitably require the entry of 'aggregators' or financial intermediaries that consolidate and package, otherwise the system will be unworkable; (4) Compliance with high standards has to move away from 100% project-based verification and third-party audits, towards more risk-based systems and ex-post random compliance and performance audits, and strong financial penalties for non-performance; (5) it is inevitable by the very nature of such regulatory systems of compliance, as we have seen in the financial system, that some significant defaults in credible performance will tend to occur; therefore, the credibility of the whole system will depend greatly on how well the compliance system is regulated by an official body, and how swiftly any deviation is found and penalized so that such credibility is quickly established and maintained over time; and (6) there is no experience of international regulation of this size and order that is anticipated with massive climate financing; only the global financial system and its regulation is analogous, and there, the regulatory structure depends fundamentally on national regulatory systems with strong cross-border standards and sharing of information. In sum, the move to a credible carbon reduction system will require enormous national and cross-border regulatory arrangements----inevitably requiring central bank and financial system regulation and supervision by national entities. Since we do not have such an architecture in place, it is likely that progress will be slow and credibility only established carefully over time, with pilots starting with a few large countries with the capability to manage the system, and ratings systems that regularly assess compliance and capability of such national systems with international standards.

It is certain, conversely, that neither the current voluntary offsets market nor the regulated markets will prove to be robust enough to handle the challenges of massive carbon financing envisaged under the HA system. To be feasible, more thought may have to be given to the design of the system to establish the credibility of carbon reductions. The HA proposal explicitly acknowledges this and suggests that the reliability of the certifying system is critical, yet it must do so without imposing very high or impossible transaction costs. Too much accuracy and the system would grind to a halt; too little, and the system would lose credibility. A 'learning by doing' process to navigate between the two is envisaged, with elaborate technical proposals. Our discussion above points to similar issues, but proposes that more discussion may be needed (for example, risk-based systems and ex-post audits) to arrive at the best solution. It is possible to improve on these suggestions?

The BOS scheme is less likely to create such a problem, because it relies much more heavily on large-scale 'infrastructure' projects and financed primarily by large financial entities such as

development banks nationally and MDBs globally. As such, they can 'internalize' the credibility of these investments much more than can the HA system and seem more acceptable.

Finally, the PPC system is also likely to be much more easily implementable, as it would rely primarily on a G-to-G system to be organized among a smaller group of countries under the Climate Clubs envisaged, and reasonably amenable to forums such as the G-20 and OECD. Equally, only the largest and more middle-income countries would be able to comply with the requirements of credibility of carbon reduction investments under all three of the proposals. It is highly unlikely therefore that the UNFCCC or COP process would apply to these schemes; instead, it would be a smaller and more tractable group working under the G-20 or similar current arrangements.

Establishing the value of Carbon Reduction (2). How will the specific metrics of valuation, a price or value for such carbon reduction be determined? Is this feasible, and can countries agree to such a common valuation, or are there other alternatives: should we settle for individual countries deciding a minimum price within a 'band' rather than a price or value, and why?

As we have already discussed, there can be a very wide range of social value of carbon reduction. There is virtually no current agreement on the appropriate social price of carbon, with enormous variation across countries, from Sweden which has valuation of over US$150 per ton to as little as US$3.5 per ton in some large developing countries (such as Mexico). The calculations in the USA for the social cost of carbon similarly range from US$16-150 for the year 2025, depending on the discount rate used from 5% to 2.5% (the lower the discount rate, the higher the social cost), and not all costs have been factored in. Agreement on a common price will therefore be politically very difficult, if not impossible. Instead, the most feasible approach may be to agree to set values within a band. Political economy second-best considerations suggest that such a band may have to start with relatively low initial values---probably about US$25-50 per ton, and then move upwards over time as the investments financed gain more traction and demonstrate their use for growth and jobs and a substantial fall in carbon emissions.

The key question is whether such a social value to carbon attached to investments that reduce GHG emissions will be sufficient incentive to attract large-scale new investments in renewables and related infrastructure (energy efficiency projects, clean transport, smart cities and the like). It is likely that the near-term marginal costs of abatement (MCA) for some large projects may be well within this range. However, there are trade-offs. One recent article suggests that because measures required to implement ambitious targets for carbon reduction may need time to implement, choosing the cheapest carbon abatement projects can be sub-optimal. Instead, the best strategy, for example in Europe, may be to implement some expensive, high-potential and long-to-implement options to reach more ambitious medium-term targets.[34] Therefore, some

[34]Adrien Vogt-Schilb and Stéphane Hallegatte, 2014. Marginal abatement cost curves and the optimal timing of mitigation measures. Energy Policy, Volume 66, March 2014, Pages 645–653

flexibility may well be required in setting a wider band or a sufficiently high minimum value for valuing specific projects which have the highest long-term potential and impact rather than the least-cost short term options which can 'lock-in' options.

As far as the different proposals are concerned, there is little to choose between the HA proposal versus the BOS proposal in this regard. Both will demand relatively similar and high valuations, although the BOS proposal will probably demand higher values given the envisaged longer gestation and larger size of projects. There is an explicit valuation requirement for the HA proposal, but none for the BOS proposal. How the latter will value investments from a carbon reduction potential is mainly through development of agreed 'norms' at G-20, which are not yet detailed.

For the PPC proposal, however, because the proposal starts out with a transfer/reimbursement of just 10 percent of the agreed social value of carbon reduction---or about US$2.5-5 per ton benefit for cross-border investments if we use our likely initial rates---is perhaps unlikely to attract substantial investments in carbon mitigation projects, except those that are the cheapest 'low-hanging' fruits. Remember, that a substantial part of these receipts will also have to reimburse the risks of financial intermediaries. Therefore, the lower the valuation attached to carbon, the lower the incentive to investors and a 10 percent share may be too small---except for a G-to-G transfer mechanism rather than project specific mechanism. One solution would be obvious; raise the share of transfers much higher, to say at least 30 percent under the PPC scheme. By contrast, under the HA proposal, the entire carbon assets is reimbursable or refinanced by the central banks at 100% of value set. This makes it far more attractive for the investor, and especially is relatively neutral in terms of size and may even favor larger size but high-impact projects---as opposed to business as usual risk profiles that would favor lower up-front capital costs even if more, limited in terms of carbon remediation.

Institutions best placed to refinance the "carbon remediation assets" (3). What institution should refinance the carbon assets being financed? Individual central banks? A pool of central banks? The IMF? A fund linked to the GCF? A pool of development banks? National or international fiscal institutions?

The idea under all three schemes, but most prominent under the HA proposal and less so for the other two proposals, is that the carbon mitigation investments being financed should be 'refinanced' or guaranteed by some financial institution, so that the first-line banks and other long-term financing intermediaries can reduce their risk and uncertainty of holding on to these assets. The HA proposal is also explicit that central banks are envisaged to play the most prominent role, by using their monetary policies to acquire such long-term assets (the CRAs) on their balance sheets---even using it as part of their quantitative easing or similar policies to encourage revival of real economic activity.

To the extent that most of the investments fall within national boundaries, central banks can do so. Two problems arise. First, will central banks be willing to do so? And second, will central banks take on obligations outside national boundaries? The answer to the first is unknown. Several

central banks, mostly in developing countries, have been far more willing to enter into such selective prioritization of assets that banks can lend against, and the treatment of what constitutes priority lending and/or reserve assets. We don't know whether central banks will be willing to do in the case of developed countries. The most likely scenario is experimentation. The quantitative easing policies of the US Fed is one recent example that if persuaded by the merits of the case, central banks can do much. On the second question, however, it is highly improbable and politically infeasible that central banks will want to take on such assets outside of their national jurisdictions. For that, the International Monetary Fund is a better option and can do so by issuing SDRs and acquiring such assets as part of a move to provide greater global liquidity. But it is clear then that the mandate of the IMF would have to change---no easy task given what we know from past history. The GCF or similar multilateral institution such as the World Bank can also do so, but are less likely, because this ties up their expensive capital base which has probably far more immediate uses. National development banks have similar problems. Fiscal institutions can also play a role, by providing judicious guarantees?

Covering the Risks of Losses to Public Guarantee Agencies and Central Bank Refinance Institutions (4)**.** Inevitably, there will be potential risks to the central banks and other refinance institutions of losses in such carbon remediation assets (CRAs) investments. Since no central banks or other refinance institutions will want to take these risks on their balance sheets, there has to be a defined relationship of these CRAs to some public guarantees against such possible losses, if some proportion of investments turn insolvent. Therefore, some kinds of counter-guaranties would need to be given by governments. In addition, issues will arise on how credible these guarantees might be and the loss-compensating mechanisms and recovery in the context of high levels of existing public debt in many countries. Future carbon taxes are an obvious possibility. But can future taxes be credible? How will the market value these guarantees?

This is the most difficult and contentious of all the issues. The idea that some proportion of (strictly, some projects that comprise such) CRAs will default raises some serious 'moral hazard' problems, first of all. Moral hazard will be likely because some other party is carrying the risk of default. Adverse selection (rigged trades) is also likely because of asymmetric information---first line banks and financiers will be tempted to dump more of the risky projects to refinancers. Careful design of refinancing of such CRAs will therefore be essential. There is no easy way to avoid these problems, because the tighter the refinancing options to guard against such risks, the less likely it is that more such projects will be financed. The likely answer is that the asset build-up has to be done gradually, and refinancing only done for the best projects (relying on ratings by third parties) and only for some part of the assets. Nevertheless, there will be inevitably some risks remaining on the balance sheets of the central banks or others who refinance the assets. That also means that some funds will need to be created to guard against the risk-based likelihood of such losses by some fiscal agency---presumably collected by some carbon taxes. Future carbon taxes for this purpose raises problems of credibility, and it is better that some amount of carbon taxes be started immediately and pooled into such funds now. As experience is gained and the pool of such funds grow, more lending and 'safer' refinancing can then proceed.

Tackling the Problem of 'Free-Riding' (5). A big problem in global schemes is the chilling effect of countries, particularly large ones, which may decide not to participate, partly for their particular political economy reasons at home. This has bedeviled earlier agreements in climate negotiations, such as the Kyoto protocol. This problem is skirted by all three proposals. None of them considers the problem of free-riding if one or more large countries decided they would not wish to participate in the scheme. It is free-riding, only because the benefits of any significant carbon reduction investments are global, so that others in effect may end up paying for someone else who does not participate.

There is a need to carefully consider how to deal with such possible 'free-riding'. One answer is to make sure that every large country has an incentive to join. This may be partly possible in the proposals, by setting up the schemes such that institutions in non-participating countries would (by definition) not be eligible to participate. Their financial institutions would not be able to participate, nor would their investments at home be eligible for cross-border financing from the scheme. In other words, it would be a 'closed club' of participating countries. Characteristically, the prospective losses both to business and to investments, and hence to jobs and incomes, would be such as to crowd-in more countries which may be otherwise hesitant to join---which is a good incentive. However, the world is more complicated. Strategic reasons suggest that conversely, it might be difficult for such schemes to get off the ground if there were 'blocking' tactics of some prospective big country participants. The G-20 and IMF therefore has to play a significant role to smooth over these issues and to make sure that all large players can be brought on board. Even more crucial is perhaps the lobbying power of major global financial firms and corporations, who stand to benefit from the scheme. At one extreme, a small 'club' to start with might become essential to start the scheme and demonstrate the value of membership benefits. However, the smaller such clubs, the less impact on the global carbon economy, so that in the end, it is better to have as many of the large countries and emitters participate in the schemes.

Political Feasibility (6). Finally, the larger question to assess is whether the political economy of public support generally to carbon remediation of the scale suggested under all three proposals will be supported and under what conditions. Here, the biggest hurdle is that public support will be lukewarm to the extent that the risks of climate change are seen to be modest and far into the future---not enough to worry the present generation of electors and tax-payers. There is no avoiding this problem. To the extent that climate change is seen to be a risk for future generations, the present generation will not want to share in the costs.[35] Then, under what circumstances can a change happen? To the extent that the burden of risks start to shift to the present generation---for example, through a larger series of natural disasters that are at least in some way commonly ascribable to ongoing global warming---we might see greater political feasibility of more decisive collective action as envisaged in the three proposals. In a sad way, we may probably have to wait for some more disasters before there is a political impetus to act more wilfully. 'Fortunately' for the proponents of the proposals, there is growing evidence of such

[35] Stephen M. Gardiner, 2006. A Perfect Moral Storm: Climate Change, Intergenerational Ethics and the Problem of Moral Corruption. Environmental Values, Vol. 15, No. 3, Perspectives on Environmental Values: The Princeton Workshop (August 2006), pp. 397-413

larger scale of disasters happening, everything from the warmest summer temperatures to ice-map melt, droughts and wildfires, storms and hurricanes, and growing insurance losses. These might turn the tide.

Going back in history, the few times that large scale investments, backed by public finance, were carried out decisively to seize opportunities were typically something like the railroads construction boom of the 1840-70 period. We have looked at that episode in another study. Characteristically, it was the transformative impact of that technology---opening up the transport corridors of nations---that paved the way for large-scale public support to the investments needed. In this case too, the political support that may emerge for large-scale investments in carbon remediation in all three proposals might well also rest on whether the technological improvements that are ongoing---in solar, wind, energy storage, smart grids and other technologies---manages to excite the imagination of the public, policy-makers and investors. Then, public policy might well be able to pick up the slack and lean with rather than against the global winds of change.

Conclusions

Finance has to play a much bigger role if large-scale and faster de-carbonization is to occur.[36] The scale of climate investments needed is simply too large a transformation that can be achieved by the two tools currently in play: slow, protracted climate negotiations, limited public monies and hesitant carbon pricing. There is no shortage of savings to finance the needed investments, nor a paucity of technologies. Private investors are waiting for the announcement of some bold public policy frameworks to mitigate private risks and uncertainty. The three proposals reviewed in the paper are all in that direction: how to enable massive climate finances.

The specific ideas in the proposals are the right ones---attaching social or public value to these carbon remediation assets, backing up the financing of these assets with some public guarantees and refinancing, future carbon pricing to make these guarantees and financing credible, and central banks and financial regulators directly 'nudging' investors to take the plunge with new investments. Transformative change cannot happen by relying only on attempts at 'optimal' prices and cap-and-trade markets or on unenforceable and unimplementable promises at climate negotiations.

We conclude that while there are some technical areas that may need fine-tuning, the proposals are firmly in the right direction. The areas that may need more attention are all doable: re-working the credibility of certifying the climate remediation investments, agreeing decisively on the starting 'social' value of carbon reduction that must be a minimum level, raising the share of global reimbursements (from 10% proposed to more like 30%) from such investments, a decisive role for central banks and the IMF (in the case of cross-border investments) in refinancing some

[36] Jean Pisani-Ferry, 2015. Why Finance can Save the Planet, Project Syndicate commentary. http://www.project-syndicate.org/commentary/why-finance-can-save-the-planet-by-jean-pisani-ferry-2015-09

part of the assets being financed, credible public guarantees against the risk of some failures that will be inevitable, with some starting public funds from a minimum levels of carbon taxes, tackling the problem of free-riding and incentivizing all large countries to join the scheme, and finally, building the political support needed by pointing to the rising enormous scale of immediate costs of inaction.

With the current scale of climate investments running at about only one-fifth of levels needed to achieve a safer de-carbonized world, a surplus of savings and available technology, something like these proposals---building on them---will need collective agreement and action, soon.

We know what needs doing. Transformative change, as in history, requires no less---a calculated departure in public policies from the usual. The mobilization of large-scale climate finance, through enhanced public support, looks urgent and feasible.

References

A. Bhattacharya, J. Oppenheim and N. Stern, 2015.Driving Sustainable Development Through Better Infrastructure: Key elements of a transformation Program. Brookings, Grantham Institute and New Climate Economy Project.

Alfredo Sirkis, 2015. Positive Pricing of Carbon Reduction: A Low Hanging Fruit. September. CEPII Blog. http://www.cepii.fr/BLOG/bi/post.asp?IDcommunique=405

Adam Whitmore, 2014. A new framework for climate policy. Why carbon pricing is not enough. March 26, Energy Post. http://www.energypost.eu/new-framework-climate-policy-carbon-pricing-enough/

Adrien Vogt-Schilb and Stéphane Hallegatte, 2014. Marginal abatement cost curves and the optimal timing of mitigation measures. Energy Policy, Volume 66, March 2014, Pages 645–653

Dipak Dasgupta, Rajasree Ray and Nikhila Menon, 2011. International Taxes to Finance Global Green Climate Fund---An Analytical Review. Working Paper, Ministry of Finance, India. http://finmin.nic.in/workingpaper/Inter_Finance_TaxGreen.pdf

Dipak Dasgupta, 2013. Fossil Fuel Subsidies: Three Questions, Evidence and Way Forward. Working Paper, Ministry of Finance, India. http://finmin.nic.in/workingpaper/FossilFueSubsdies.pdf

Dipak Dasgupta, 2015. Financial Innovation and The State: Lessons for 21st Century Climate Finance from the 19th Century Railways Era ENVIRONNEMENT & RESSOURCES NATURELLES Billet du 1er octobre 2015. CEPII Blog. http://www.cepii.fr/BLOG/bi/post.asp?IDcommunique=407

Ecosystems Marketplace, 2015. Ahead of the Curve: State of the Voluntary Carbon Markets 2015.

Flavia Tsang, Peter Burge, 2011. Paying for carbon emissions reduction. Rand Europe Occasional paper. http://www.rand.org/content/dam/rand/pubs/occasional_papers/2011/RAND_OP312.pdf

Frances C. Moore & Delavane B. Diaz, 2015. Temperature impacts on economic growth warrant stringent mitigation policy. *Nature Climate Change* 5,127–131 (2015)

International Energy Agency, 2015. Special Report on Energy and Climate Change. http://www.iea.org/publications/freepublications/publication/WEO2015SpecialReportonEnergyandClimateC hange.pdf

J-C. Hourcade (CIRED), M. Aglietta (Cepii), B. Perissin-Fabert (CIRED) with B. Leguet, I. Shishlov, C. Ferron, R. Morel, I. Cochran (CDC Climat), H. Chenet, D. Strauss, J. Thomae, A. Gorius, M. Coeslier, S. Dupré (2°II), R. Bibas, C. Cassen, A. Pottier (CIRED). Transition to a low-carbon society and sustainable economic recovery, A monetary-based financial device. CIRED. http://www.centre-cired.fr/IMG/pdf/concept_note.pdf

Jean-Charles Hourcade & Priyadarshi Shukla, 2013. Triggering the low-carbon transition in the aftermath of the global financial crisis. Climate Policy. Volume 13, Supplement 01, 2013

Jean Pisani-Ferry, 2015. Why Finance can Save the Planet, Project Syndicate commentary. http://www.project-syndicate.org/commentary/why-finance-can-save-the-planet-by-jean-pisani-ferry-2015-09

Jerry Taylor, 2015. The Conservative Case for a Carbon Tax. Niskanen Centre Working Paper. http://niskanencenter.org/wp-content/uploads/2015/03/The-Conservative-Case-for-a-Carbon-Tax1.pdf

Jesse D. Jenkins, 2014. Political economy constraints on carbon pricing policies: What are the implications for economic efficiency, environmental efficacy, and climate policy design? Energy Policy. Volume 69, June 2014, pp 467-477.

Ker Than, 2015. Estimated social costs of carbon not accurate, Stanford scientists say.

Kotchen, M., K. Boyle, and A. Leiserowitz, 2011. Willingness to pay and policy-instrument choice for climate change policy in the United States. NBER Working Paper. http://www.nber.org/papers/w17539

Kristin Eberhard (@KristinEberhard) on November 17, 2014 at 6:30 am **SightLine Daily**. http://daily.sightline.org/2014/11/17/all-the-worlds-carbon-pricing-systems-in-one-animated-map/

Michael Grubb, with Jean-Charles Hourcade and Karsten Neuhoff, 2014. Planetary Economics: Energy, climate change and the three domains of sustainable development. Routledge.

Mark Carney, 2015. Breaking the tragedy of the horizon - climate change and financial stability. Speech to Lloyds, London. http://www.bankofengland.co.uk/publications/Pages/speeches/2015/844.aspx

Robert P. Murphy Patrick J. Michaels Paul C. Knappenberger, 2015. The Case Against a Carbon Tax, Cato Institute, Working Paper No. 33. http://object.cato.org/sites/cato.org/files/pubs/pdf/cato-working-paper-33.pdf

Stephen M. Gardiner, 2006. A Perfect Moral Storm: Climate Change, Intergenerational Ethics and the Problem of Moral Corruption. Environmental Values, Vol. 15, No. 3, Perspectives on Environmental Values: The Princeton Workshop (August 2006), pp. 397-413

The Economist, 2012. Theatre of the Absurd. http://www.economist.com/news/21567342-after-three-failures-years-un-climate-summit-has-only-modest-aims-theatre-absurd

Tove Ryding, 2012. Climate Protection between hope an despair: 20 years of UNFCCC, Greenpeace International. http://www.greenpeace.org/international/Global/international/publications/RioPlus20/20-Years-of-UNFCCC.pdf

World Bank, 2014. State and Trends of Carbon Pricing, Washington DC.