The Road to Paris and Beyond

Rodney Boyd & Fergus Green

1. Introduction

In late 2015, representatives of close to 200 national governments and tens of thousands of civil society observers will come to Paris for the 21st Conference of the Parties (COP21) to the United Nations Framework Convention on Climate Change (UNFCCC). It is widely hoped that this will be the conference at which a new international agreement is negotiated, setting out how countries will cooperate to tackle climate change, with a particular focus on the post-2020 period. The conference presents an important opportunity to advance global cooperation toward the urgent task of reducing global emissions of greenhouse gases and adapting to the impacts of climate change.

The purpose of this paper is twofold: (i) to set out certain critical matters of which a shared understanding needs to be built if successful climate cooperation is to occur (Part 3); and (ii) to propose certain key goals, principles, policies and institutions for action and collaboration on climate change, and explain how these can be embedded in the Paris agreement and more generally (Part 4). First, by way of background, we briefly describe the basic model and key features of the climate agreement that is likely to emerge in Paris, and identify some of the obstacles that could inhibit a successful outcome (Part 2).

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2. The road to Paris: directions and obstacles

The conference presents an important opportunity to advance global cooperation toward the urgent task of reducing global emissions of greenhouse gases and adapting to the impacts of climate change.

a) Directions

The Paris COP is the next major event in a long history of such meetings, beginning in the early 1990s. The UN climate process has resulted in: the establishment of the UNFCCC (a framework agreement that mostly sets out broad principles, but with some commitments on emissions reporting); the more detailed, prescriptive, and centralized Kyoto Protocol, whose first commitment period ended in 2012; the less centralized and non-binding Copenhagen Accord/Cancun decisions in 2009/2010, which record climate change targets for individual countries to 2020; and the Durban process, beginning in 2011, which set in train the process of agreeing to a post-2020 framework by the end of 2015.

The French Government, which will host the Paris summit, has indicated that it will seek a "Paris Climate Alliance" as an outcome, based on four aspects:

1. A universal legal agreement, applicable to all countries.
2. National commitments covering control and reduction of emissions.
3. A financial aspect guaranteeing international solidarity with the most vulnerable countries.
4. An "Agenda of Solutions" aimed at implementing accelerators to ensure more ambitious progress beyond binding commitments.

The ongoing negotiations toward the first two aspects of this package can be thought of as a "hybrid" framework that mixes legally binding and non-binding elements, centralised and decentralised elements, based partly on a pragmatic assessment of what has worked better, and what less well, in previous international agreements (Bodansky and Diringer 2014). Specifically, there will likely be a central, universally applicable, legally-binding agreement, and this will be associated with "intended nationally determined contributions" (INDCs) by countries to restrain and reduce emissions, the achievement of which will be non-binding internationally.

Under this hybrid model, while the central agreement would be formally

legally binding, the provisions within it relating to the key issue of greenhouse gas emissions control and reduction would merely be obligations of process/conduct, obliging participating parties to, for example, *submit*, and *record* a nationally-determined emissions reduction commitment—typically a quantified target—and perhaps also to *adopt* and *implement policies and measures* with a view to achieving their quantified commitment.[1] But the substance of those commitments will be "nationally determined," and the agreement is not likely to contain an internationally legally binding obligation on parties to *achieve* their quantified commitment *per se*.[2]

While many think that a superior outcome would be a more centralised regime, entailing legally-binding and enforceable obligations to achieve an internationally-negotiated domestic target, this is not necessarily the case, all things considered (IPCC 2014, ch 13; Green 2014). Participation in international processes and agreements is voluntary on the part of states, and different countries have different motivations and capacities for such participation. In current circumstances, we think a more flexible approach has helped, and will continue to help, increase engagement in the process (encouraging both participation in the agreement and greater ambition in commitments) by some of the most important countries (e.g. the United States, China and India), whereas a more centralised, legalistic, enforcement-oriented agreement would likely have alienated them (Green 2014; Stern 2014a).

On the other hand, some of the other centralised institutional elements in existing UN agreements have worked relatively well and could usefully be built upon in a new agreement. For example, there is widespread support among parties for a common framework, agreed rules and some centralised institutions, concerning the accounting, monitoring, reporting and verification (MRV) of countries' emissions. Moreover, many parties support the inclusion in the agreement of a long-term shared goal(s) and centralised processes and mechanisms to prompt higher ambition from parties over time.[3] Such elements would enable a greater degree of coordination and interaction among Parties than under the Copenhagen/Cancun model (Bodansky and Diringer 2014).

...INDCs...must be seen as initial contributions to an ongoing process of raising ambition over time.

b) Obstacles

Yet many obstacles remain on the road to Paris, and on the longer pathway toward an effective and equitable response to climate change. Most prominently, it is very likely that there will remain a significant gap between the aggregate of national commitments pledged toward the Paris agreement and those consistent with plausible 2°C pathways, meaning commitments will need to be ramped up in subsequent years. There are also concerns about how credible the non-binding pledges will be, necessitating an increased focus on the domestic (institutional, legal, policy and political) arrangements affecting the ability of countries to deliver on their commitments and to scale them up over time. And there are concerns over how equitable the agreement in Paris will be, and whether particular developed and developing countries are contributing equitably to the response to climate change.

Equity concerns have been particularly prominent in discussions of climate finance (and, to a lesser extent, non-financial forms of support) within the UNFCCC and could pose a challenge to reaching agreement in Paris. And yet these discussions focus on only a small part of the overall challenge of financing sustainable development over the next two decades—a key issue in tackling the two great challenges of this century, ending poverty and mitigating and adapting to climate change.

Finally, innovation in zero-carbon technologies and processes will be crucial to addressing these challenges, and yet inadequate investment in innovation hampers society's ability to do so.

3. The scale and pace of global action

Bearing in mind the likely shape of the Paris agreement and the obstacles that stand in its way, we now turn to set-

[1] A similar approach is expected with regard to adaptation and financial support (i.e. from developed countries for both mitigation and adaptation in developing countries), i.e. there may be obligations of process with regard to formulating national adaptation plans and financial strategies: see Morgan et al. (2014).

[2] This "nationally-determined" approach was agreed at COP19 in Warsaw and affirmed at COP20 in Lima. One suggestion as to how to achieve the non-binding aspects of the agreement that has attracted considerable interest is to record countries' commitments in a separate, non-binding document, such as a schedule to the main agreement. See, e.g., New Zealand (2014) and United States (2014).

[3] Again, it is envisaged by many that these institutionalised processes could extend not merely to emissions reduction commitments, but also processes for reporting on, and scaling-up over time, adaptation and financial support: see Morgan et al. (2014).

ting out what we see as the key elements of successful international climate cooperation, in Paris and beyond.[4]

a) Understanding the mitigation task

The first key to succeeding in international climate cooperation is to properly grasp the problem and understand what a successful response to it would ultimately require.

In 2014, global emissions were around 51GtCO_2e (Boyd et al. 2015).[5] The IPCC estimates the remaining "carbon emissions budget" consistent with 2°C trajectories as being in the region of 1,000–1,500GtCO_2 emissions. This is roughly equivalent to 40 years of global CO_2 emissions at the present annual level.[6] However, this budget would be exhausted well before that time if the long-term trend of accelerating annual emissions continues. Indeed, global emissions of around 50GtCO_2e into the 2030s could lock in temperature increases of around 3.5°C or more.

By contrast, in order to be on a plausible 2°C pathway, emissions should be:

- Around 35GtCO_2e in 2030[7]
- 20GtCO_2e or below in 2050
- Roughly zero (or "net zero"[8]), and possibly net-negative, before the end of the century[9]

Cutting global emissions from around 50GtCO_2e to 20Gt or below in 2050 is a cut by a factor of 2.5. Suppose also that world output were to grow by a factor of three over the period 2013 to 2050 (given an annual growth rate of around 3%). Under these assumptions, emissions per unit of output would have to be cut by a factor of 2.5 × 3 (i.e., by a factor of around 7 or 8) by 2050.

Emissions reductions on this scale imply a transition across society and the economy on a scale that would be appropriately described as an "energy-industrial revolution" (Stern 2015a).

b) Understanding the likely size of the Paris mitigation "gap"

It is very likely that there will be some gap between the INDCs pledged by countries in 2015 for the purpose of the Paris agreement and the emissions reductions needed by 2030 to stay on a plausible 2°C pathway. Recent announcements by a number of major emitters, including China,[10] the US,[11] and the EU,[12] are major steps in the right direction. However Boyd et al. (2015) concluded that based on these three announcements, the total INDCs submitted ahead of COP21 are unlikely to result in aggregate emissions that are consistent with the 2°C goal; a significant gap is likely to remain.

As of November 2, 2015, 128 Parties to the UNFCCC submitted INDCs. These 128 Parties were together responsible for 86.6% of global annual emissions of greenhouse gases (WRI 2015).

Due to the gap between necessary emissions reductions and the emissions implied by INDCs, they must be seen as initial contributions to an ongoing process of raising ambition over time.

c) Understanding the dynamics of transition

i) The benefits and opportunities

The transition to a low-carbon economy is part of a much larger set of processes of structural transformation that will characterize the global economy over the next two decades. These include: continued change in the balance

[4] When we are arguing that something should be in the Paris agreement itself, or could be advanced "on the side" of the Paris conference, we will refer to Paris explicitly.

[5] The EU, US and China account for around 46% of global emissions (23GtCO_2e in 2014). The next major contributions come from Asia (without China) with 16% and Africa and Eastern Europe/Eurasia on 9%.

[6] See IPCC (2013, ch 12). Note that there is a subtle interplay between probabilities of reaching certain trajectories (e.g. a chance of at least 50% or 66%) and accurate measurements of CO_2 emissions levels and its equivalents. Also bear in mind that data limitations restrict us to calculating "CO_2 budgets" as opposed to "CO_2 equivalent budgets." CO_2 is the most important driver of radiative forcing, the gas that is easiest to measure, and is long-lasting in the atmosphere.

[7] The IPCC pathway range is roughly 28-50GtCO_2e in 2030. We prefer to use a 2030 benchmark of about 35-36GtCO_2e: 35Gt is roughly the mid-point between the 10th percentile and median values given by the IPCC in its 2°C pathway range, since this requires less reliance on ambitious assumptions about the potential for negative emissions technologies in the second half of this century. See also UNEP (2014) which analysed model projections that limit global warming to less than 2°C (50-66% chance) but do not assume that net negative carbon dioxide emissions from energy and industry occur during the 21st century. These pathways have a median value of 36GtCO_2e in 2030.

[8] This reflects the reality that there are likely to be some anthropogenic emissions sources in sectors where emissions are difficult to eliminate altogether, and hence a need to offset these with expanded emissions sinks (e.g. from the land sector).

[9] Leaders at the G7 summit in Elmau in Germany in June this year acknowledged that we must reach zero emissions of carbon dioxide in the second half of this century. See Part 4 for more information.

[10] Chinese President Xi Jinping announced in November 2014 China's commitment to peak CO_2 emissions by around 2030, with the intention of peaking as early as possible, and to raise the non-fossil-fuel share of primary energy consumption to around 20% by 2030 (from the current level of ~10%).

[11] President Obama announced a target for the US of reducing their emissions by 26-28% by 2025 compared with the 2005 level.

[12] The leaders of the countries of the European Union decided at the European Council of 23/24 October 2014, to reduce emissions by 40%, 1990-2030 on the basis of domestic action.

of economic activity towards emerging market and developing countries; continued global population growth and urbanization (a projected 9.5 billion people on the planet and 6–7 billion of these in cities by 2050); and technological revolutions in information and communication technologies, materials, and biotechnology. Amid these changes, the world must also tackle ongoing and growing challenges of poverty, inequality, macroeconomic imbalances, ongoing problems in the financial sector, structural adjustment to technical and economic change, and grave pressures on natural resources, local environments and biodiversity.

The opportunities for tackling climate change alongside these other unfolding changes and challenges are profound. For example, the Global Commission on the Economy and Climate (2014) estimates that between now and 2030, the world will need to spend around US$6 trillion per year over the next 15 years on infrastructure—primarily in cities and energy systems, and primarily in the major emerging economies—for reasons other than to address climate change. The capital costs of this infrastructure, assuming it were to consist of incumbent (high-carbon and high-pollution) technologies and processes—"unsound" investments, in other words—would cost cumulatively around US $89 trillion to 2030. However, if "sound" investment decisions were made—using low-carbon, low-pollution, resource-efficient technologies and processes—the capital cost would be around US$93 trillion, and the additional capital expenditure would be more than offset by savings in operational costs (e.g. renewable energy infrastructure has lower operating costs since fossil fuels do not need to be purchased). Factor in the unpriced co-benefits of following the "sound" investment path—including greater energy security, and lower local pollution, congestion and waste—and it will be more attractive on economic, social and environmental grounds than the unsound path, before the climate mitigation benefits have even been considered (GCEC 2014, 2015; see also Green 2015).

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This general, global conclusion is extremely important. It means that countries will generally have strong local incentives to be ambitious—and increasingly so over time—in their efforts to reduce greenhouse gas emissions, irrespective of what other countries do (GCEC 2014; 2015).[13]

Moreover, these costs and benefits are not static; they are changing all the time in response to factors such as the dynamics of learning and discovery, the scaling of new innovations, and the effects of new networks, norms and institutions. Innovation and scale (and their interdependence) hold especially great potential for further reducing the costs of clean technologies (Aghion et al. 2014; GCEC 2014; Stern 2015a). An excellent example of the dynamism of this kind of structural change is the advances made in solar photovoltaic (PV) energy installations. Extensive innovation and learning in solar PV have driven rapid cost reductions that have far exceeded forecasts. Solar PV module prices declined from around US$2,800 per watt (W) in 1955, to around US $100/W in the 1970s. Since then, the change has been remarkable: installed costs have fallen more than 50% since 2010 to around US$0.60–0.90/W currently (IEA 2014). The cost of energy that can be delivered from these devices is competitive (i.e. without the need for subsidies) in perhaps 79 countries (Stern 2015a).

Concerted innovation in zero/low-carbon technologies is likely also to produce beneficial knowledge spillovers that drive growth in other sectors (see Aghion et al. 2014). Empirical evidence suggests that low/zero-carbon innovation produces significantly more knowledge spillovers than innovation in incumbent, high-carbon technologies, and many of these spillover benefits accrue to the local economy (Dechezleprêtre et al. 2013, 2014).

We can reasonably expect the technology, economics, and politics of mitigation to become more favourable over time, meaning countries will find it increasingly feasible and desirable to increase their ambition.[14] This effect, moreover, is likely to be self-reinforcing, leading to "tipping" dynamics that ultimately produce new, low-carbon

[13] The Global Commission on the Economy and Climate finds that 50–90% of the emissions reductions needed to put the world on a plausible 2°C pathway by 2030 would be net beneficial. This is based on achieving the median value of the IPCC's scenarios for holding to 2°C with a "likely" change, under which global emissions fall to 42Gt per year by 2030, relative to the IPCC's business-as-usual baseline scenario, under which global emissions reach 68Gt by 2030 (see IPCC 2014, SPM, Figure SPM.4; NCE 2015). There will of course remain some actions necessary to reduce emissions that are not, at the time they need to be taken, locally net-beneficial, i.e. actions that do need to be justified primarily by their contribution to global change mitigation. This may be the case for some highly traded, carbon-intensive goods, for example (see Green 2014, 22).

path dependencies in technologies, institutions, political-economy patterns and social norms (Aghion et al. 2014; Green 2015; Heal and Kunreuther 2012).

ii) The barriers

But the process of reaching these desirable tipping points has been slow-going. There are many immediate, local barriers and challenges that often prevent the sound medium- and long-term decisions from being made. Many features of our technical, economic, political and social systems emerged in a high-carbon era where natural resources were treated as if they were effectively unlimited. These systems are subject to their own inertia and path dependencies that are difficult to dislodge.

Many of these barriers are institutional, regulatory, financial or technological —and these are often significant and intertwined. Well-designed and credible institutions, laws and policies are essential preconditions for ensuring that finance and technology are deployed in the most sound way.

Other barriers are distributional and political. Sound policies and investments will still have costs, even if the costs are exceeded by the benefits. And the way these costs and benefits are distributed matters greatly in political terms: the "losers" from decisions that favour low-carbon outcomes will often be concentrated in particular industries or sectors (e.g. fossil fuel industries and energy-intensive industries). Those sectors tend to be economically and politically powerful and have a vested interest in avoiding potential losses, and can mobilise effectively to block or dilute low-carbon reforms. Moreover, there are often legitimate concerns about the short-run impacts of structural reform on some households, workers and some communities, particularly those least able to manage them. The best response is to ensure that reform processes and policy packages are structured so that they are transparent, inclusive of underrepresented interests, and equitable. In poorer countries especially, this means designing policy reform packages that also help reduce poverty as well as emissions. A further precondition of sound decision-making is thus an attentiveness to configurations of interest and power, and to questions of legitimacy and equity.

In order to get investment flowing in a sustainable way, it is important to have access to the right forms of finance, into the right infrastructure, and at the right time.

iii) Implications for international cooperation

Understanding these dynamics of transition helps to clarify where international cooperation could make a significant difference in accelerating national emissions reductions. Cooperation is needed, among other reasons: to help the finance and technology flow to the best projects, and to improve domestic institutions to that end; to ensure the processes and outcomes of this transition are equitable and legitimate; to generate political momentum for domestic reforms and counterweight the political power of vested interests; to spur innovation and cost reductions in new technologies and processes and their adaptation to local circumstances; and finally to provide direct incentives for mitigation in residual areas where local costs continue to outweigh the local benefits (Green 2015).

4. Goals, principles, policies and institutions for action and collaboration

a) Framing the mitigation task: appropriate long-term and medium-term goals

i) Net Zero emissions in the second half of this century

International climate cooperation should be organised around the long-term objective of achieving net zero emissions within the second half of this century, as detailed in the G7 Communique (G7 2015, 15), which is necessary for holding warming to within 2°C.

ii) Decarbonising electricity by mid-century

Given that in some sectors it will prove more difficult to drive emissions to zero, others will have to go to zero (or negative) well before the end of this century. Countries should therefore think strategically about the sequencing of their plans for phasing out emissions. Taking such a strategic approach enables medium-term goals to be set that

[14] For a developed country expression of this position, see: United States (2014); Stern, T. (2014). Todd Stern, the US Special Envoy on Climate Change, said recently that "because we see both political will and technology development increasing over time, we think the target we could put forward for 2030 five years from now will be measurably higher than a 2030 target we could put forward now. So we don't want to see low ambition locked in for 2030."

are consistent with the long-term net zero emissions goal.

Decarbonizing the electricity sector is the most urgent priority for decarbonizing the global economy (Fankhauser 2012; IDDRI/SDSN 2014).[15] As the UK experience of strategic decarbonisation planning is demonstrating (see, e.g., Committee on Climate Change 2013), it is reasonable to look to developed countries to decarbonize their electricity sectors well before the midpoint of this, and in so doing, fueling the innovation and cost-reductions in key technologies that will enable developing countries to follow closely behind them (Green 2014; Stern 2015a).

We see value in articulating this medium-term goal in the Paris agreement, though it could also be agreed among a smaller grouping of countries.

iii) Phasing out coal

Within efforts to decarbonise electricity, there is a strong case for international cooperation specifically to phase-out unabated coal (GCEC 2014; Collier and Venables 2014). Coal is the single largest contributor to global greenhouse gas emissions from energy.[16] Substituting away from coal would bring many attractive economic, fiscal, public health and environmental benefits to countries, quite aside from benefiting global climate efforts (GCEC 2014).

For these reasons, the Global Commission on the Economy and Climate has argued that high-income countries should commit now to end the building of new unabated coal-fired power generation and accelerate the early retirement of existing unabated capacity, while middle-income countries should aim to limit new construction now and halt new builds by 2025 (GCEC 2014, 301).

Again, we see value in articulating medium-term goals along these lines in the main Paris agreement, though in practice this is unlikely to happen in 2015. Initiative on these issues is more likely to come from a smaller coalition of committed countries, from which further endorsements and participation could grow. In this regard, the fourth aspect of the Paris process, which is focused on generating deeper commitments on specific issues among smaller groups of willing countries—along with sub-national governments, companies and civil society groups—would be the ideal setting in which to articulate, and build cooperative initiatives around, these medium-term goals.

Questions of equity and justice are intrinsically and instrumentally important...

b) Equity

Questions of equity and justice are intrinsically and instrumentally important in the international climate negotiations. If Paris is to be successful, countries will need to carry into the discussions a shared understanding of what a reasonably equitable approach to climate change would look like, and the empirical matters on which such an approach is predicated.

Insofar as equity relates to mitigation, a great deal of the transition to a low-carbon economy is rightly characterized as a beneficial opportunity for countries to improve their economies and societies in the context of dynamic changes in technologies, prices, institutions and norms, and that the benefits multiply through collaboration. Equity discussions regarding mitigation should be predicated on this shared understanding. It is false and misleading to characterize equity discussions as being entirely, or even mostly, about sharing "burdens" (Averchenkova et al. 2014; Stern 2014a, 2014b).

This framing allows us to interpret the principle, enshrined in the UNFCCC, of "common but differentiated responsibilities and respective capabilities" in a dynamic, collaborative, and opportunity-focused way. A promising way forward is to embrace the twin ideas of:

1. Rich countries embarking on a dynamic and attractive transition to low-carbon and climate-resilient economies in their own societies, involving strong and early emissions cuts, and strong examples.
2. Developing countries undergoing a similar transition, along a sustainable development pathway of their choosing, shaped by their own characteristics and endowments, where that transition is supported by finance, technology and know-how from developed countries and the private sector as a result of the latter's earlier/faster transition.

c) Dynamic elements of the Paris agreement

In the context of the expected "emissions gap," success in Paris will depend

[15] This is for several reasons: first, power generation is a major source of GHG emissions in most countries; second, low-carbon power generation is well understood and feasible, with many options available and costs coming down rapidly; and third, decarbonized electricity has an importantrole to play in reducing emissions in other sectors, especially transport (through battery-powered electric vehicles and rail), residential heating (through, for example, ground source and air source heat pumps), and some parts of industry.

[16] Coal combustion generated 44% of global CO_2 emissions from energy in 2011 (oil 35%; gas 20%; other 1%): IEA (2013).

largely on whether the new agreement contains elements that create pressures to scale-up ambition in the years following the Paris COP. These elements could usefully include:[17]

- Clear long- and medium-term shared goals based on climate science.
- Recognition of the gap between those goals and the commitments pledged under the agreement at that point in time, and provision for a regular, science-based assessment of aggregate emissions embodied in existing commitments and comparison with emissions reduction pathways for 2°C and 1.5°C.
- Acknowledgement that the Paris agreement is intended to be a dynamic instrument, embodying a shared expectation that parties' commitments must rise over time in order to bridge the emissions gap, and therefore that their 2015 INDCs are to be treated as starting points or minimum commitments, to be revised upwards over time.
- Encouragement of parties to adopt domestic institutions, laws and policies that can be expanded over time as conditions for reducing emissions become more favourable, and to explain how these enable the achievement of their INDCs and the progressive raising of ambition.
- Encouragement of parties to submit long-term decarbonisation plans soon after the Paris conference.
- A mechanism for a regular (e.g. five-yearly) major review of commitments at which time all parties are expected to raise the ambition of their commitment.
- Recognition in the agreement of diverse and significant contributions made by agents that are not parties to the agreement (e.g. subnational governments, cities, businesses), and the potential that exists for these agents to raise their ambition over time and in turn facilitate greater ambition by parties.

d) Domestic institutions, policies, and politics

An important catalyst for countries to raise their ambition over time is the presence of domestic institutions, laws, policies, and political configurations that are conducive to ever-greater ambition. In light of the above discussion about the opportunities and net-benefits associated with many low-carbon options, and the short-term barriers that block such sound decision-making, it will be important that countries:

...low-carbon innovation is currently dangerously underfunded and underdone around the world.

- Develop new, or utilise existing, state development / green investment banks to lower the cost of capital for low-carbon infrastructure (discussed further below in relation to finance) and institutions for zero-carbon innovation.
- Undertake nationally-appropriate reforms to improve the domestic investment climate and so lower the cost of capital for low-carbon projects and facilitate technological innovation.
- Design and sequence low-carbon policies and institutions that take account of the politics and political-economy of structural transition.

e) Finance for sustainable development

i) The financing task

Financial support for sustainable development in poorer countries (which are generally the most vulnerable to climate change) can promote better growth by creating healthier, more liveable and efficient cities; cleaner, more reliable and secure energy systems; and well managed and rehabilitated land, forests, and natural resources (GCEC 2014)—all of which is at the core of sustainable development and poverty reduction (Stern 2015a). Better, cleaner economic growth and sustainable development can reduce the risks of climate change by cutting GHG emissions through efforts to lower traffic congestion for instance, or to improve local air pollution and to be less wasteful. But it should also be complemented and reinforced through climate finance to support additional adaptation and mitigation.

In order to get investment flowing in a sustainable way, it is important to have access to the right forms of finance, into the right infrastructure, and at the right time. Delay is dangerous in the sense that the longer we wait to reduce emissions, the harder it is to remove them, and the more expensive it will be, which could crowd out valuable options. At the same time, infrastructure is long-lived, and so investment decisions made now will cast long shadows. Getting investment decisions wrong by investing in the wrong (high-carbon) infrastructure could jeopardise meaningful action.

Fortunately, there is no shortage of sustainable investment opportunities, and now is exactly the time to invest for low-carbon growth. In many developed countries, the private sector is sitting on record levels of savings and liquidity, and long-term real interest rates are low. Many resources are unemployed or under-employed. They can be invested in

[17] For further discussion of these kinds of elements, see Bodansky and Diringer (2014); GCEC (2014, ch 8); Green (2014); Stern (2014a).

activities and infrastructure that have strong economic and social rates of return and a long-term future.

The needed investments will be increasingly reliant on trustworthy domestic institutions and stable, long-term policy frameworks. Domestic institutions and policies in recipient countries are important to facilitate smoother access to private capital and overseas public financial assistance, and to increase the flow of public financial assistance over time in donor countries.

In these discussions, one critical element related to perceived riskiness of infrastructure investment is the cost of capital; that is, from an investor point of view, the cost of providing financing to an infrastructure project. For newer and more innovative types of green infrastructure projects more generally, the cost of capital is particularly sensitive to and dependent on government policy, which can introduce risk into decisions. The cost of capital of more innovative/sustainable projects tend to be higher because there is a greater perception of policy risk, and investors may have less experience in financing such projects.

Public development banks, both national and international, have historically played an important role in mobilizing infrastructure development. In the transition to a low-carbon economy to date they have been critical (Mazzucato 2013), and they are likely to continue to be so. The presence of a national or multinational development bank can lower the cost of capital in an investment by reducing the perceived policy and governmental risks, for instance, as governments are less likely to change policy if a public entity has committed to a major project with a long time horizon. They can also provide financial products, convene parties, and provide specialist knowledge and other capabilities. And they have a wide range of experience with innovative risk-sharing instruments and dealing with complex infrastructure sectors, particularly in the energy, transport and industrial sectors —sectors that will receive a great deal of attention in the next 20–30 years. As a benchmark of the role of development banks, the UK Green Investment Bank is unique in that it will only target infrastructure to "green" and profitable projects; lending on commercial terms but bringing with it lower risks and crowding in private capital.

ii) Financing sustainable development: the role of Paris (December) in relation to Addis (July)

In Copenhagen (COP15) in 2009, and later embodied in decisions made in Cancun (COP16), developed countries agreed to collectively mobilise US$100 billion per year by 2020, from both public and private sources, for the purpose of financing climate change mitigation and adaptation in developing countries. The financial flows that will result from this initiative are significant, but are dwarfed by the funds required to put the world on a path to a sustainable, low-carbon and resilient economy.

A critical question is how the financial aspects of the agreement in Paris can complement and add to agreements shaped in Addis Ababa in July concerning the financing of sustainable development goals in the context of the need for very large infrastructure investments over the next 15 years. The climate finance should be complementary and additional to the finance for SDGs in a way that further enhances the sustainability aspects of the latter, and additional in the senses outlined below.

With regard to complementarity, there is clear and strong recognition in the draft SDGs of the importance of sustainability. Indeed the word "sustainable" appears in 11 of the 17 draft goals. In addition, the word "resilient" is used in connection with infrastructure and cities. Further, goal 13 (without the word sustainable) says explicitly "take urgent action to combat climate change and its impacts." Thus Paris climate finance should be defined in the context of a very clear emphasis on climate and sustainability in the SDGs.

With regard to additionality, the UN/Paris climate finance could be additional to the SDG finance in the following four ways (Stern 2015b). First, it could generate specific projects and programmes that would not have otherwise materialized. Second, it could generate projects and programmes in areas of activity that wouldn't have otherwise been strongly covered in SDGs (possibly including adaptation and forests). Third, it could mobilise new sources of finances that would not otherwise have been forthcoming or available such as a slice of carbon taxation revenue. And fourth, it could raise the scale of overall ODA resources for climate which is additional to what has been previously committed to development.

f) Innovation

Innovation in general is hampered by market failures along the innovation chain.[18] Low-carbon innovation is further undermined by its particularly high capital requirements (especially for low-carbon energy generation) and by the mispricing of many existing goods and services central to climate change (especially the under-pricing of GHG

[18] These include: positive externalities; public goods aspects of knowledge/technology; imperfections in capital markets and risk-sharing; network infrastructure; and coordination problems. The problems associated with underinvestment can become more acute as technologies proceed into development, demonstration and early scale commercial deployment, just as the need for capital increases—the so-called "valley of death."

emissions[19]).[20] The global case for strong policies and investments in low-carbon innovation is therefore very strong (GCEC 2014; Stern 2015a). Strong policies and investments in innovation are also likely to facilitate increasingly higher ambition from countries of the kind that is needed to close the mitigation gap.

Yet low-carbon innovation is currently dangerously underfunded and underdone around the world. In particular, there is a major shortfall in the research and development and demonstration of clean energy technologies in both the public and private sector. This is not an area where the data allow us to be precise, but the general conclusion is clear: given the challenges we face, on climate change, energy insecurity, energy poverty, and air pollution, investments in energy R&D (and demonstration)—especially for renewable energy—are far too low (Stern 2015a).

The case for individual countries to support low-carbon innovation (e.g. through subsidies or direct government financing) is also likely to be strong, given the potential for high local knowledge spillovers, as discussed earlier. Nonetheless, there is a good case for greater international coordination on low-carbon innovation, since some of the public benefits from innovation do spill over into other countries, and since greater coordination could increase efficiencies through specialisation, scale and network effects (IEA 2012; GCEC 2014, ch 7; Aghion et al. 2014).

In light of these realities, international cooperation on low-carbon innovation could valuably include the following (Green 2014):

- Scaled-up public R&D funding, in the form of increased national funding coordinated internationally and, where appropriate, collaborative international partnerships—recognising that the latter can be complex (Anadon et al. 2011, ch 5; de Coninck et al. 2008). The Global Commission on the Economy and Climate (2014) has argued that the governments of the major economies should at least triple their investment in the R&D of clean energy technologies.
- Public-private regional networks focused on the development and demonstration of new and locally-adapted technologies and processes (GCEC 2014).
- Promoting public institutions and funding mechanisms to mobilise public venture capital for green innovators with high growth potential (Mazzucato 2013; Mazzucato and Perez 2014).
- Expanded and better coordinated deployment support policies, such as feed-in tariffs and renewable energy obligations (IEA 2012).

Importantly, these institutions should reflect the diverse needs and capabilities of different types of countries. High-income countries should focus more on frontier innovation, and other countries more on adaptive innovation and diffusion of new technologies and processes (Aghion et al. 2014).

The specific initiatives concerning innovation outlined above would be more suitably pursued outside the UN climate process, including by smaller groupings of states and non-state actors. However, the Paris conference could provide a political opportunity to advance and announce such initiatives, i.e. "on the side" of the formal process in Paris. As much as is possible, the Paris agreement could valuably acknowledge the factual context, principles and specific commitments concerning innovation discussed here.

[19] In addition to the under-pricing of GHG emissions, these include the mispricing of: natural capital and ecosystem services; energy (in)security; worker health and safety issues associated with fossil fuels; public health impacts of fossil fuels (especially air and water pollution); amenity impacts of fossil fuels; and natural resource scarcity and rents.

[20] The OECD and IEA have thus described low-carbon technology R&D as "twice a public good" (Philibert 2004); they could have gone further than "twice."

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