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The road to Paris and beyond

Rodney Boyd, Fergus Green and Nicholas Stern

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The Authors

Rodney Boyd and Fergus Green are Policy Analysts and Research Advisors to Professor Stern at the Grantham Research Institute on Climate Change and the Environment at the London School of Economics and Political Science and at the Centre for Climate Change Economics and Policy.

Nicholas Stern is the I.G. Patel Professor of Economics & Government and Chair of the Grantham Research Institute on Climate Change and the Environment at the London School of Economics and Political Science; Chair of the Centre for Climate Change Economics and Policy; and President of the British Academy.

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Executive Summary

Effective international cooperation can enable the world to (i) develop along a pathway that provides a reasonable chance that global average temperatures will not increase by more than 2°C above pre-industrial levels; and (ii) adapt to the climatic changes already locked-in as a result of past and ongoing greenhouse gas emissions. It can also help countries seize the many opportunities and benefits associated with the transition to a low-carbon economy; to achieve an attractive form of inclusive growth that is sustainable. The United Nations climate change conference in Paris at the end of 2015 is an important opportunity to advance toward those objectives.

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: a universal legal agreement, applicable to all countries; national commitments covering control and reduction of emissions; a financial and technology aspect aimed at scaling up finance and technology for climate change mitigation and adaptation while guaranteeing international solidarity with the most vulnerable countries; and an 'Agenda of Solutions' aimed at implementing accelerators to ensure more ambitious progress, above and beyond binding commitments.

The legal agreement that is emerging is a "hybrid" agreement, involving a mix of centralised and decentralised, binding and non-binding elements. The agreement 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. The agreement is also likely to involve centralised, common processes to ensure the transparency of countries' efforts and, it is widely hoped, a review-and-revision process for countries to increase the ambition of their commitments regularly over time (e.g. every five years). Yet, many obstacles remain on the road to Paris, and on the longer pathway toward an effective and equitable response to climate change.

This paper examines: (i) certain critical matters of which a shared understanding needs to be built if successful climate cooperation is to occur; and (ii) the key goals, principles, policies and institutions for action and collaboration on climate change, and how these can be embedded in the Paris agreement and associated efforts.

International agreements are built on shared understanding. It is important that all parties understand certain key characteristics of the problem we face and the opportunities and benefits that lie in possible responses:

- In order to be on a pathway that will plausibly not lead to global warming of more than 2°C, annual global emissions of greenhouse gases need to fall from their current levels of around 51 gigatonnes (Gt) of carbon-dioxide-equivalent (CO_2e) to about 35Gt in 2030, below 20Gt in 2050, and roughly zero (or "net zero"), emissions before the end of

this century — 'net negative' emissions may be required by mid-century if annual emissions are higher than this.

- Analysis of recent commitments from many countries, including the United States, European Union and China, suggests that, if these commitments are implemented, global annual emissions in 2030 will be significantly lower than under a 'business as usual' scenario. Notwithstanding this positive message, a significant gap — potentially of about 20–25Gt — is very likely to remain between the benchmark emissions reductions needed in 2030 (around 35Gt CO_2e) and the aggregate emissions reductions by 2030 implied in the pledges countries submit toward the Paris agreement.
- Countries should recognise the likely size of the gap and work hard to raise the ambition of their pledges as much as possible before the December Paris conference. Assuming there will be a residual gap, post-Paris, pledges should be understood as initial contributions to an ongoing process of raising ambition over time toward the ultimate goal of net zero emissions within the second half of this century. Indeed, the pledges should be understood to be more than mere statements of emissions targets. Many INDCs will, and all should, also articulate the domestic policy and regulatory frameworks that will underpin the achievement of a transition to a zero carbon economy.
- There is a strong case already for fostering cities, energy systems and land-use systems that involve low pollution, low congestion and low waste, and that could deliver a stronger and more attractive economic growth through innovation and resource efficiency. This kind of sound decision-making in countries' own interests will be good for the climate. However, in some cases, there will be a residual need for measures primarily justified by the need to reduce greenhouse gas emissions. Over time, the costs of pursuing the 'sound' path will fall and the benefits will grow, thanks to the dynamics of learning and discovery, the scaling of new innovations, and the effects of new networks, norms and institutions. As such, the incentives countries have to reduce emissions will become even stronger over time. It is thus sensible and realistic to have an international process that acknowledges the dynamic nature of the transition, and facilitates the scaling-up of ambition over time.
- Yet we must also understand that there are barriers to this kind of sound decision-making. Many of these barriers are technical — institutional, regulatory, financial or technological. Others are political and distributional: the costs and benefits of structural change are distributed unevenly, and adverse impacts on particular groups, including groups with vested interests in the status quo, can have political effects that hinder the process of low-carbon transition. Others still are ideational — old norms and values die hard.

Based on this shared understanding we suggest the following goals, principles, policies and institutions to guide international climate cooperation:

- International climate cooperation should be organised around: (i) the long-term objective of achieving net zero emissions within the second half of this century, as detailed in the G7 Communique, which is necessary for holding warming to within 2°C; and (ii) associated medium-term goals including the decarbonisation of electricity by mid-century and, well before mid-century, the phasing out of unabated coal-fired electricity generation. Clear articulation of such goals — in international agreements and statements — can help to set investor expectations about the long-term, zero-carbon direction of global and national economic development;
- Given these goals, and understanding the associated transition as involving many opportunities and benefits quite aside from reduced climate risks, it is appropriate to interpret the principle of equity (contained in the United Nations Framework Convention on Climate Change) of "common but differentiated responsibilities and respective capabilities" (CBDR) in a dynamic, collaborative, and opportunity-focused way. The idea of "Equitable Access to Sustainable Development", which builds on CBDR and was embedded in the agreement at COP16 in Cancun (2010), captures these ideas well.
- Moreover, the Paris agreement should contain, in addition to these goals and principles, dynamic elements that enable ambition to be raised over time, including a regular (e.g. five-yearly) review-and-revision process.
- Countries should also be encouraged and assisted to develop domestic institutions, laws, policies, and political configurations that are conducive to: increasing ambition; seizing opportunities for better growth; and implementing commitments effectively. Two key areas for institutional development are finance (for mitigation and adaptation) and innovation.
- On finance, around US$6 trillion per year will need to be spent globally, and mostly in developing and emerging market countries, on infrastructure over the next 15 years. With the right kind of institutions and policies in place, that finance can flow to resource-efficient, low-pollution, low-congestion, energy-secure, low-carbon and climate-resilient infrastructure. Multilateral development banks, state development banks and "green investment banks" are important institutions that can reduce the cost of capital for such projects. The meeting in Addis Ababa in July this year on financing for sustainable development was an important step on the way to mobilising the financial flows required to meet the Sustainable Development Goals (SDGs) and wider sustainable development needs. The climate finance being mobilised through the UNFCCC/Paris process (aiming towards support from the richer countries for poorer countries of US$100 billion per year by 2020) should be structured in a way that is complementary to the SDG finance (further enhancing the sustainability aspects of the latter) and that is additional to it.

- The case for individual countries to support low-carbon innovation is generally very strong, yet clean innovation is currently badly underfunded and underdone around the world. International coordination on low-carbon innovation should include: a coordinated scale-up of national expenditure on research and development; new public-private regional networks for the development and demonstration of new and locally-adapted technologies and processes; scaled-up public venture capital for innovative clean technology firms; and better global coordination of clean energy deployment support.

The prize of successful international climate cooperation is a much more attractive and dynamic form of economic growth and development that creates a much healthier environment for people everywhere, overcomes poverty, and can be sustained over the long term. An agreement in Paris can play a very important role in signaling to the world that this is the future direction of the global economy, and in accelerating concrete initiatives to achieve it.

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).

2. The road to Paris: directions and obstacles

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 and 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 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: a universal legal agreement, applicable to all countries; national commitments covering control and reduction of emissions; a financial aspect guaranteeing international solidarity with the most vulnerable countries; and an ‘Agenda of Solutions’ aimed at implementing accelerators to ensure more ambitious progress, above and 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* (e.g. in an ancillary document) 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 (or goals), and centralised

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[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).

processes and mechanisms to prompt higher ambition from parties over time[3] (which we discuss further below). Such elements would enable a greater degree of coordination and interaction among Parties than under the Copenhagen/Cancun model (Bodansky and Diringer 2014).

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

[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).

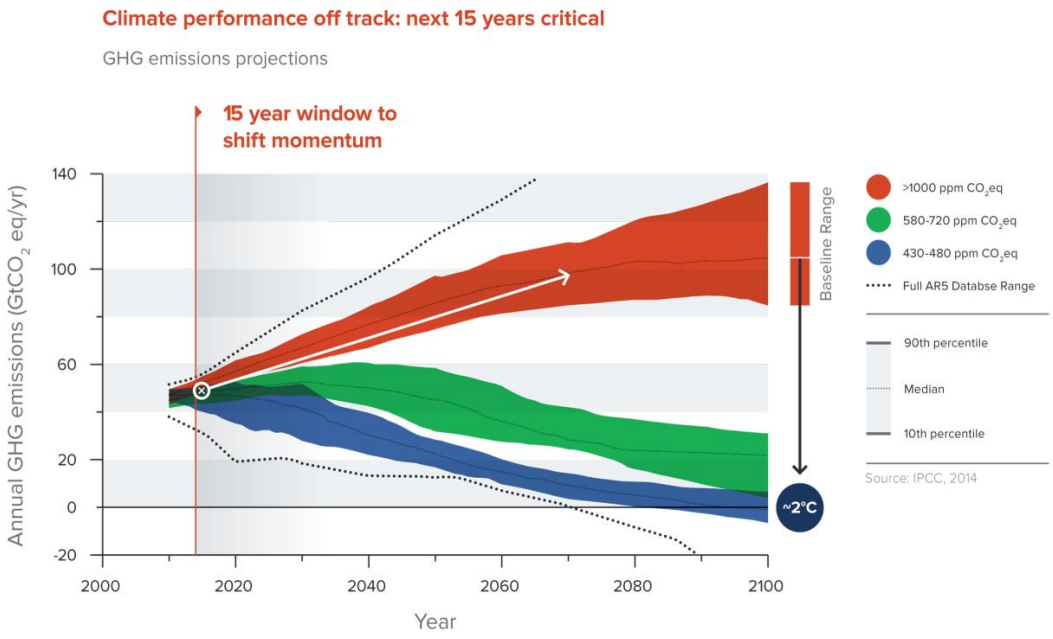
[4] When we are arguing that something should be in the Paris agreement itself, or could be advanced "on the side" of the Paris conference, we will refer to Paris explicitly.

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. 2015a).[5] Figure 1 shows the IPCC's (2014) modelling scenarios of various emissions concentration pathways, with the blue scenario representing pathways consistent with a "likely" (>66%) probability of holding to within 2°C (430–480ppm CO_2e pathway).

Figure 1: Representative emissions pathways for alternative mitigation scenarios



Source: GCEC (2014a) based on IPCC (2014, SPM, Figure SPM.4)

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. To a rough approximation, this is equivalent to forty 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

[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.

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, it can be seen from Figure 1 that, 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 Intended Nationally-Determined Contributions (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.

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[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.

(2015a) 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 20 July 2015, 46 Parties to the UNFCCC, including the 28 Member States of the European Union, had submitted INDCs.[13] These 46 Parties were together responsible for 58% of global annual emissions of greenhouse gases in 2011.[14] Boyd et al. (2015b) estimated the level of emissions in 2030 by constructing a global 'business-as-usual' (BAU) scenario and then modifying the result to account for the emissions implied by the 46 INDCs (no modifications from BAU were made to the trajectories of the countries that have not yet submitted an INDC). They find that the BAU scenario, which results in around 64GtCO_2e by 2030, is reduced by around 5–7 GT when the scenario is modified to account for the 46 submitted INDCs, resulting in total emissions of around 57–59Gt in 2030.[15] While this divergence from BAU is welcome, it suggests that the INDCs submitted so far are not consistent with a 2°C path, being 21–23Gt above the 36GtCO2e 2030 benchmark calculated by UNEP (2014).[16]

There are many uncertainties associated with these calculations. Nevertheless, it is essential that countries recognize the (rough) size of this gap and hence the need for the Paris INDCs to 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 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

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[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.
[13] INDCs that have been submitted to the secretariat of the UNFCCC are published at: http://www4.unfccc.int/submissions/indc/Submission%20Pages/submissions.aspx.
[14] WRI (2014).
[15] See Boyd et al. (2015b) for more information. For a different approach that focuses on the INDCs of the US, EU and China, see Boyd et al. (2015a), and see Green and Stern (2015) for detailed discussion of China's likely trajectory.
[16] This gap is derived from on a snapshot of emissions based on submitted INDCs. As more INDCs are submitted, this snapshot, and the resulting gap, will likely change.

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 (2014a) 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 2014a, 2015; see also Green 2015).

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 2014a; 2015).[17] To the extent this holds, it is more accurate to describe decisions that reduce emissions as *opportunities to be seized*, not as burdens to be allocated or avoided (Averchenkova et al. 2014; GCEC 2014a; Green 2014, 2015; Stern 2014a, 2014b, 2015a).

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 2014a; Stern 2015a). An excellent example of the dynamism

[17] 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).

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 2014b). 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). For many countries, therefore, a strong focus on clean innovation provides a pathway to medium- to long-term growth and prosperity (Perez 2010; 2013; Mazzucato and Perez 2014; Stern 2015a). It is the unleashing of this innovative capacity, through sufficient global action to reduce emissions, that would likely stimulate an energy-industrial revolution or major wave of technological change, and "experience of previous such changes suggest they are associated with 2 or 3 decades, or more, of investment, innovation and growth" (Stern 2014c).

For all of the above reasons, 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.[18] This effect, moreover is likely to be self-reinforcing, leading to "tipping" dynamics that ultimately produce new — low-carbon — 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 (or were treated as if they were) effectively unlimited. These systems are subject to their own inertia and path dependencies that are difficult to dislodge. A useful way to think about the challenges of climate change mitigation in the short term is therefore to focus on removing barriers that, once removed, would accelerate the onset of the desirable tipping dynamics referred to above.

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[18] 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."

Many of these barriers are institutional, regulatory, financial or technological — and these are often significant and intertwined. For example, investments in low-carbon infrastructure tend to be sensitive to the cost of capital because they tend to be more capital-intensive than high-carbon infrastructure, hence the need for policy and institutional reform, discussed below in Parts 4(d)–(e). Moreover, even where low-carbon technologies would be lower-cost than higher-carbon incumbents, policy and regulation may unduly favour the latter, or there may be institutional or capacity constraints that prevent the low-carbon technologies from being deployed (GCEC 2014a). 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); and 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 under-represented 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.

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 (i.e. the minority of cases where the global climate benefits of action become decisive in local decision-making) (Green 2015).

In sum, the above logic — the logic of *ambition*, *opportunity*, *dynamism*, and *collaboration* — should permeate analysis and decision-making on climate change mitigation. It applies equally to decision-making in the UNFCCC as it does to other areas of international climate cooperation. In the following sections, we carry this understanding into discussions of specific suggestions

about how international climate cooperation in Paris and beyond can be structured so as to overcome short-term barriers, and ramp-up countries' ambition over the next decade (and beyond).

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

The "2°C goal" agreed by countries in Cancún at COP16 in 2010 is valuable, but its implications are not readily understood by most people.[19] As noted above, the most plausible pathways for achieving the 2°C goal require that global emissions be reduced to roughly zero before the end of this century. It is also a goal that is relatively easy for people everywhere to understand. This is important given that clear goals in international agreements can help to set public and investor expectations about the long-term, low-carbon direction of the global economy.[20]

Accordingly, the notion of phasing out emissions to "net zero" has received considerable support from leading experts,[21] business leaders, civil society and nearly 120 countries.[22] Likewise, we see strong merit in countries agreeing — in the Paris agreement and more generally — to a shared goal to reduce emissions to net zero within the second half of this century Recently, the major G7 economies called for "a common vision" and support of "the upper end of the latest IPCC recommendation of 40 to 70% reductions by 2050 compared to 2010 recognizing that this challenge can only be met by a global response" including that we must decarbonise emissions of carbon dioxide in the second half of this century (G7 2015, 15). It should be understood that developed countries are expected to reduce emissions to zero more quickly than developing countries, and provide appropriate examples and support (equity is discussed further below).

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[19] Indeed, in and of itself it has no clear implications, since different emissions trajectories imply different *probabilities* of holding within 2°C.

[20] More generally: effectively framing the objectives of climate mitigation will increase the likelihood that those goals will affect the expectations and decisions of relevant agents (GCEC 2014a, 280; Morgan et al. 2014, 2; Gauri 2012).

[21] Including OECD Director-General Angel Gurría (2013); UNFCCC Executive Secretary Christiana Figueres (2013); the Global Commission on the Economy and Climate (2014a, 280); Haites et al. (2014); and Morgan et al. (2014).

[22] See PWCLG (2014) and The B Team (2015) (business community), and Track Zero (2015) (civil society and governments).

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 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).[23] 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 century — by perhaps 2030 or 2040 — 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 2014a; Collier and Venables 2014). Coal is the single largest contributor to global greenhouse gas emissions from energy.[24] If the world is to reduce emissions in line with the 2°C goal, only a small fraction of the world's remaining fossil fuel reserves can safely be burned, and the economic case is strongest for phasing out coal first within the 'burnable' margin (Nelson et al. 2014; Collier and Venables 2014; IDDRI/SDSN 2014). Moreover, as the Global Commission on the Economy and Climate surmised, "pollution from burning coal is a contributor to the estimated 3.7 million premature deaths each year from outdoor air pollution, and coal production also causes ill health, injuries and deaths" (GCEC 2014a, 300). And despite the fact that these effects cause economic damages well in excess of the market price of coal in many countries, as the International Monetary Fund has recently demonstrated, coal remains very lightly taxed in many parts of the world (Parry et al. 2014; Coady et al. 2015).

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[23] 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 important role 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.

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

As such, 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 2014a).

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 2014a, 301). Since political and technical barriers are the main reasons for continued investment in coal-fired power generation,[25] international cooperation to declare these medium-term goals could play a valuable normative/signalling role, helping to catalyse local efforts to phase out coal by adding to the existing pressures to so from numerous sources (Green 2014).[26] But goals targeting the demand side — the phase-out of coal-fired generation — will, for well-understood economic reasons, not be sufficient: strong action will also be needed to restrict the supply of coal (Collier and Venables 2014; Sinn 2008, 2012). Accordingly, the recent initiative of President Anote Tong of Kiribati calling for a global moratorium on new coal mines and mine extensions is an important initiative.[27]

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 important medium-term goals.

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.

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[25] When the full costs and benefits are considered, energy efficiency and zero/low-carbon power generation sources are likely to bring greater local net-benefits than building new coal-fired power plants in many parts of the world: see GCEC (2014a, chs 1, 4–6) for discussion.

[26] These existing pressures include: domestic policy pressures, from Washington to Beijing, in the form of increased direct regulation of coal-fired power plants; social campaigns for fossil fuel divestment, and local activism against new fossil energy projects across the world; and economic pressures from investors increasingly concerned about the risk of stranded assets: see, e.g., Gore and Blood (2014).

[27] See http://www.lse.ac.uk/GranthamInstitute/wp-content/uploads/2015/08/HEs-letter.pdf.

Insofar as equity relates to mitigation, we have argued that 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:

(i) 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; and
(ii) 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.

As Stern (2014a, 2014b) has argued, this is one way in which the idea of "equitable access to sustainable development" (EASD), proposed by India and adopted in the UNFCCC agreement at COP16 in Cancún in December 2010, could be interpreted and revived.

c) Dynamic elements of the Paris agreement

In the context of the expected "emissions gap", success in Paris will depend 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:[28]

- Clear long- and medium-term shared goals, based on climate science, including of the kind discussed above in Part 4(a);
- Recognition of the gap between those goals and the commitments pledged under the agreement at that point in time (see above Part 3(b)), 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,

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

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; and
- 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:

- 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);
- Develop nationally-appropriate institutions for zero-carbon innovation (see below discussion in relation to 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 (including adaptive innovation);
- Design and sequence low-carbon policies and institutions in ways that take account of the politics and political-economy of structural transition. This includes, for example, analysing the winners and losers from planned low-carbon policy reforms and developing packages of reforms that: create mutually-reinforcing incentives in favour of low-carbon activities; ensure distributional outcomes are equitable (e.g.

pro-poor); and enable wide coalitions of support for the reforms to be developed.[29]

The INDCs present an excellent opportunity for countries to explain to the world how they will lay these domestic foundations for moving to a zero-carbon, sustainable economy. Insofar as they do, INDCs should be viewed as going beyond mere statements of intended emissions targets.

e) Finance for sustainable development

i) The financing task

As noted earlier, the Global Commission on the Economy and Climate (2014a) estimates that around US$6 trillion per year will be spent globally on infrastructure over the next 15 years and this can be spent in a sound, low-carbon way (at slightly higher capital cost but with lower operational costs and greater co-benefits), or in an unsound, high-carbon way. Since most of this infrastructure needs to be built in emerging and poorer economies, it is particularly important to consider how the requisite finance can be mobilized, and what role international cooperation (in Paris and beyond) can play.

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 2014a) — 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 (i) the longer we wait to reduce emissions, the harder it is to remove them, and (ii) 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: for example, energy infrastructure can last for perhaps 35 or more years. 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

[29] See, e.g., Ahmad and Stern (1991); GCEC (2014a, ch 5); Lockwood (2013; 2015); and Green (2015).

under-employed. They can be invested in 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 (e.g. as a proportion of rising carbon taxes or carbon permit auctions over time).

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 (i.e. the US$6 trillion per year) 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 (SDGs, which are under preparation for agreement in September 2015 in New York) in the context of the need for very large infrastructure investments over the next 15 years. The climate finance should be *complementary* 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 (see, e.g., UN Secretary-General's High-Level Advisory Group on Climate Change Financing, which reported in 2010). And fourth, it could raise the *scale* of overall ODA resources for climate which is additional to what has been previously committed to development.

Furthermore, the Paris agreement could oblige or encourage parties to work with their national development/infrastructure banks and international financial institutions (as recipients or donors, as appropriate) to shift investments away from high-carbon investments and into low-carbon, climate-resilient investments, and to report on their progress in doing so (Morgan et al. 2014).[30]

f) Innovation

We noted earlier the critical role of innovation in creating new technological and social possibilities, and in bringing down their costs over time. Public and private investments in innovation are the main reason some low/zero-carbon technologies are cheaper than their high-carbon incumbents at current prices.[31] However, innovation in general is hampered by market failures along

[30] Reporting could be under the Convention and based on guidelines to be negotiated, but could be based on ongoing work by the World Bank and International Development Finance Club (IDFC).

[31] New technologies typically follow a downward-sloping 'cost curve': as demand for the technologies grows and more units are deployed, costs fall as a result of economies of scale (fixed costs per unit of output fall) and 'learning by doing' (efficiencies and cost reductions are

the innovation chain.[32] *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 emissions[33]).[34] The global case for strong policies and investments in low-carbon innovation is therefore very strong (GCEC 2014a; 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. Public energy R&D in IEA member states was around US$12 billion in 2012 (IEA 2014c, figure 1.22) — less than half what it was in real terms in the late 1970s (GCEC 2014a, ch 7). Were we able to add in non-IEA members, worldwide energy R&D might be of the order of US$20 billion per year. Worldwide, publicly funded research, development and demonstration on renewable energy is only about US$4 billion a year.[35] 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 2014a, ch 7; Aghion et al. 2014).

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discovered along the supply chain through the experience gained from producing the new technology as companies experiment and compete with one another for market share). Policy interventions — such as feed-in-tariffs and renewable energy targets — can provide, and in many cases *have* provided, the demand for available renewable energy technologies that are at the higher end of their cost curves.

[32] 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”.

[33] 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.

[34] 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”.

[35] IEA (2013b, table 5.2 and figure 5.3). For figures on India and China, see Kempener, Anadon, and Condor (2010).

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 (2014a) has argued that the governments of the major economies should at least triple their investment in the R&D of clean energy technologies, with the aim of exceeding 0.1% of GDP per country, and should better coordinate the direction of these investments.[36]
- public-private regional networks focused on the development and demonstration of new and locally-adapted technologies and processes (GCEC 2014a);
- promoting public institutions and funding mechanisms to mobilise public venture capital for green innovators with high growth potential (Mazzucato 2013; Mazzucato and Perez 2014); and
- 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.

5. Conclusion

The Paris climate conference provides an important opportunity to advance global cooperation toward a low-carbon future that greatly mitigates climate risks and helps countries adapt to those risks already locked-in. This paper has highlighted the keys to successful international climate cooperation in Paris and beyond.

The key conclusions and lessons from this paper are as follows:

- If international climate cooperation is to succeed in Paris and beyond, parties need to forge a shared understand of the scale of the emissions

[36] See also Murray (2014); Mazzucato (2013).

reduction task, the likely “emissions gap”, the opportunities, benefits and attractiveness of many potential responses to climate change (e.g. strong and better quality economic growth), and the technical and political barriers that impede those responses from emerging, despite their attractiveness.

- Based on this understanding, there are certain key goals, principles, policies and institutions for action and collaboration that should be embedded in the Paris agreement and developed more widely at the international and domestic level, including —
    - A shared long-term goal to reduce emissions to net zero within the second half of this century, and associated medium term goals concerning the decarbonisation of electricity, the phase-out of unabated coal-fired power generation, and a moratorium on new coal mines and mine extensions;
    - A process for the regular review and upward revision of commitments under the Paris agreement, and other provisions to ensure the agreement reflects the dynamic and attractive nature of the transition to a low-carbon and climate-resilient world, including provisions related to equity;
    - Institutions (especially multilateral and state development banks) to lower the cost of capital for financing clean infrastructure, in the context of the US$6 trillion per year infrastructure finance needs of the global economy over the next 15 years, the financing of Sustainable Development Goals, and the US$100 billion per year climate finance to be mobilised through the UN climate process; and
    - Enhanced state support and well-designed institutions for clean innovation.

The prize of successful international climate cooperation is a much more attractive and dynamic form of economic growth and development that creates a much healthier environment for people everywhere, overcomes poverty, and can be sustained over the long term. An agreement in Paris can play a very important role in signaling to the world that this is the future direction of the global economy, and in accelerating concrete initiatives to achieve it. We can and we must get it right.

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