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■ synthesis article

The Paris Agreement: resolving the inconsistency between global goals and national contributions

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The adoption of the Paris Agreement in December 2015 moved the world a step closer to avoiding dangerous climate change. The aggregated individual intended nationally determined contributions (INDCs) are not yet sufficient to be consistent with the long-term goals of the agreement of ‘holding the increase in global average temperature to well below 2°C’ and ‘pursuing efforts’ towards 1.5°C. However, the Paris Agreement gives hope that this inconsistency can be resolved. We find that many of the contributions are conservative and in some cases may be overachieved. We also find that the preparation of the INDCs has advanced national climate policy-making, notably in developing countries. Moreover, provisions in the Paris Agreement require countries to regularly review, update and strengthen these actions. In addition, the significant number of non-state actions launched in recent years is not yet adequately captured in the INDCs. Finally, we discuss decarbonization, which has happened faster in some sectors than expected, giving hope that such a transition can also be accomplished in other sectors. Taken together, there is reason to be optimistic that eventually national action to reduce emissions will be more consistent with the agreed global temperature limits.

Policy relevance

The next step for the global response to climate change is not only implementation, but also strengthening, of the Paris Agreement. To this end, national governments must formulate and implement policies to meet their INDC pledges, and at the same time consider how to raise their level of ambition. For many developing countries, implementation and tougher targets will require financial, technological and other forms of support. The findings of this article are highly relevant for both national governments and support organizations in helping them to set their implementation priorities. Its findings also put existing INDCs in the context of the Paris Agreement’s global goals, indicating the extent to which current national commitments need to be strengthened, and possible ways in which this could be done.

Keywords: ambition; climate change; INDCs; mitigation; Paris Agreement; UNFCCC; ambition

1. Introduction

The Paris Agreement, adopted at the twenty-first session of the Conference of the Parties (COP 21) to the United Nations Framework Convention on Climate Change (UNFCCC) in December 2015 (UNFCCC, 2015a), set a major landmark in the history of international climate policy. The Paris

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Agreement not only stipulates the goal of ‘holding the increase in global average temperature to well below 2°C above pre-industrial levels’ and ‘pursuing efforts’ to limit it to 1.5°C (UNFCCC, 2015a, Article 2), but also a corresponding long-term GHG emissions reduction goal of achieving ‘balance between anthropogenic emissions by sources and removals by sinks’ of GHGs in the second half of the twenty-first century (UNFCCC, 2015a, Article 4.1). Almost 190 countries have submitted intended nationally determined contributions (INDCs), which will become an integral part of the agreement. The Paris Agreement also includes many possible steps to raise ambition along the way. A global stocktake has been agreed to regularly monitor the progress towards the long-term goals every five years, starting with a preparatory version in 2018.

The translation of actions to national and global GHG emissions, and then to temperature increase and damages, still involves a number of uncertainties (IPCC, 2014). It becomes clear (and is now also recognized in the Paris Agreement), however, that the cumulative CO₂ emissions largely determine the resulting temperature increase and hence global CO₂ emissions need to reach net zero at one point.

The process for successful implementation of the Paris Agreement has just begun, and what really matters is the action that will take place in the years to come. To date, a wide spectrum of commentaries on the Paris Agreement have been published worldwide,¹ including a number of articles in the scientific literature on the role of research and scientists in limiting global warming to within 1.5°C (Hulme, 2016; Peters, 2016; Rogelj & Knutti, 2016). However, there are few studies that discuss the policy implications and necessary actions for effective implementation of the Paris Agreement by reviewing the progress in climate policy action and the policy-making process observed at both national and multi-lateral levels in recent years, in particular in the lead-up to COP 21.

In order to identify key thematic areas and elements for enhanced action and ambition, it is useful to conduct a short review on: (1) the progress made by the Paris Agreement and its lead-up process in light of the ultimate objective of the UNFCCC;² (2) the scale of the gap between current mitigation actions committed to by national governments and the action levels required to meet the Paris Agreement’s long-term goals; and (3) the mechanisms under the Paris Agreement to ratchet up ambition levels and the challenges that nations will face in doing so.

This article is partly based on a number of recent findings by the authors (in particular sections 3 and 4.2). It focuses exclusively on national and global mitigation goals and actions in relation to the Paris Agreement. The article does not discuss other issues, such as adaptation to climate change, the provision of climate finance or loss and damage (on these issues, see Sharma, 2016 and Lees, 2016).

This article is structured as follows. In Section 2 we review the outcomes of COP 21 in comparison with earlier expectations. Second, we discuss the level of current ambition by comparing the aggregate impact of INDCs with the emission levels required to achieve the long-term goals stipulated in the Paris Agreement (Section 3). Third, we review how the international process in the lead-up to COP 21 contributed to the development of processes and institutions for national climate policy-making (Section 4). Following this, this article discusses how the ratchet mechanism of continually raising ambition towards the 1.5°C or 2°C goal can be implemented in an effective manner, and how non-state mitigation actions can be promoted and implemented to maximize their significant potential impact (Section 5). Finally, in Section 6, we make a number of general recommendations for the successful implementation of the Paris Agreement.

2. The Paris COP: expectations and outcomes

The outcomes of the Paris COP surpassed the expectations of many. This may be partly because the mismatch between the expectations and results of the last major attempt to agree on a global treaty on climate change (Bailey, 2010), in Copenhagen in 2009, may have led to relatively low expectations before the Paris conference.

Research organizations had prepared draft text proposals for a possible Paris Agreement (e.g. Oberthür, La Vina, & Morgan, 2015; Yamin, Haites, & Hühne, 2015), which were surpassed in many areas by the final agreed text. The Paris outcomes were indeed generally welcomed by environmental NGOs and think tanks (Greenpeace, 2015; WRI, 2015). In the authors' view, several newly agreed elements were remarkable.

First, the fact that almost all countries submitted their INDCs before Paris (160 submissions representing 188 countries of the 196 Parties to the UNFCCC) (UNFCCC, 2016b) was an unprecedented engagement that had not been predicted. For example, based on a country survey in March 2015, we estimated that around 80 INDCs would have been submitted before COP21 (NewClimate, 2015). It turned out to be more than double.

Second, the firm inclusion of the clause on 'pursuing efforts to limit the temperature increase to 1.5°C above pre-industrial levels' came as a surprise to many (UNFCCC, 2015a, Article 2). Before the conference, even the 2°C target was under huge pressure (Geden, 2015), being called unrealistic, but the Paris Agreement moved the goal to an even more ambitious level. The agreement on the long-term net zero emission goal was also very uncertain before Paris. It had been framed as a global goal initially by researchers (Haites, Yamin, & Hühne, 2013) and had been supported later by politically prominent actors including the Organisation for Economic Co-operation and Development (OECD) Secretary-General in 2013 (Gurría, 2015) and the G7 leaders (G7, 2015). An expert survey conducted to make a forecast of key outcomes from COP21 showed that more than 75% of respondents predicted that there would be either no goal or only a qualitative target for 2050, and less than a third predicted there would be a quantifiable goal of net zero emissions or net negative emissions, even by 2100 (Kallbekken & Sælen, 2015).

Third, the Paris Agreement includes many possible steps to raise ambition along the way, which is an implicit recognition that the current proposals by countries are not yet sufficient in aggregate. The global stocktake to regularly monitor progress towards the long-term goals is also an important component. Although the details will be determined in future meetings, it is worth noting that the process to raise ambition enshrined in the Paris Agreement is very similar to what was proposed earlier by a group of climate policy experts calling for high ambition (Morgan, Dagnet, Hühne, & Oberthür, 2014) (see Section 5 for details).

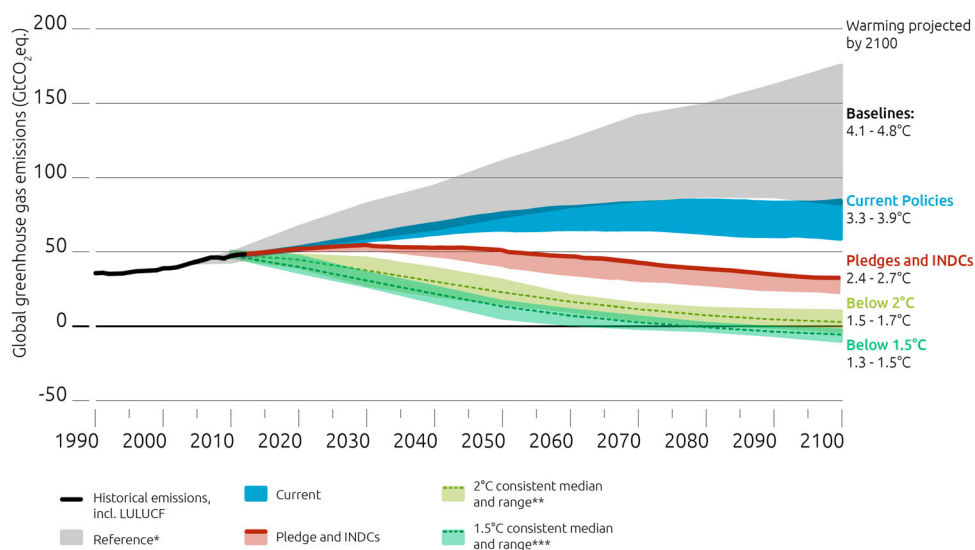
One of the many factors that contributed to the positive outcomes of COP 21 was the increasing number of calls for strengthened climate action from sectors other than academia and environmental NGOs. For example, a number of studies conducted by the New Climate Economy (NCE), the commission of which comprised former heads of government and finance ministers as well as leaders in economics, business and finance, emphasized that lasting economic growth and GHG emissions reductions could be achieved at the same time (NCE, 2014, 2015). Moreover, many business-based and subnational government-based initiatives for enhanced climate action emerged in the lead-up to Paris (discussed in detail in Section 4.4).

3. The current level of national mitigation ambition in comparison with the long-term goals of the Paris Agreement

While it is welcomed that the Paris Agreement and its preparation process raised the global long-term goal for climate change mitigation, the current level of national action under the Paris Agreement is still not in line with the agreed global long-term goals.

In this section, we briefly describe the results from the Climate Action Tracker (CAT) project (<http://www.climateactiontracker.org>). We are main contributors to the CAT, which analysed the emissions trajectories under current policies and the potential impact of the INDCs for 30 countries with high emissions (Jeffery et al., 2015). The basis for the analysis was national studies, complemented with estimates of the latest implemented policies. For the quantification of the INDCs we based the estimates on data provided by the countries, scrutinized and complemented by external sources. We aggregated all of the submitted INDCs (at the time of publication), calculated the expected future GHG emission levels and calculated the global temperature increase using the simple carbon cycle climate model MAGICC (Hulme et al., 2000; Meinshausen, Raper, & Wigley, 2011; Meinshausen, Wigley, & Raper, 2011) in a probabilistic mode. More information on the method is provided in the Supplemental Data. The results are presented in Figure 1.

It was found that, without any climate policy, GHG emissions would increase further during the course of the century (the baseline in Figure 1). With currently implemented climate policies in all



* 5%-95% percentile of AR5 WGIII scenarios in concentration category 7, containing 64% of the baseline scenarios assessed by the IPCC

** Greater than 66% chance of staying within 2°C in 2100. Median and 10th to 90th percentile range. Pathway range excludes delayed action scenarios and any that deviate more than 5% from historic emissions in 2010.

*** Greater than or equal to 50% chance of staying below 1.5°C in 2100. Median and 10th to 90th percentile range. Pathway range excludes delayed action scenarios and any that deviate more than 5% from historic emissions in 2010.

Figure 1. Global GHG emissions under different scenarios and the resulting temperature increase by 2100.

Source: (Jeffery et al., 2015).

countries, global GHG emissions would stabilize in the second half of the twenty-first century and lead to a temperature increase of around 3.6°C by 2100 (with a range of 2.2–3.9°C) with an increasing trend thereafter (labelled ‘current policies’ in Figure 1). With full implementation of the INDCs declared by all countries, global emissions could start to decline in the second half of the century and lead to a temperature increase of 2.7°C (with a range of 2.2–3.4°C) by 2100 (increasing thereafter) or lower, if the conditional INDCs are also taken into account (labelled ‘pledges and INDCs’ in Figure 1). However, this path is still far away from what would be necessary to limit temperature increase below 2°C or 1.5°C (the lowest scenarios in Figure 1).

The INDCs, as declared in the lead-up to and during the COP 21, therefore bring us roughly one third of the way in 2030 towards a pathway that would be compatible with keeping the global average temperature increase well below 2°C.

The GHG emissions projections of the CAT are consistent with those from other similar models, including nine studies covered alongside the CAT in the 2015 Emissions Gap Report of the UN Environment Programme (UNEP, 2015), as well as with those from the UNFCCC report on the aggregation of INDCs (UNFCCC, 2015b). With regard to the temperature increase projections, it should be noted that other studies project even higher temperature increases (median estimate), up to 3.7°C (Levin & Fransen, 2015). The finding that INDCs are not yet consistent with the long-term goals of the Paris Agreement is robust even under different interpretations of these long-term goals, which do not specify the timing when, or probability with which, 1.5°C or 2°C should be reached.

Although limiting the global average temperature increase to within 2°C already poses a significant challenge to the international community, the inclusion of an aspirational target of limiting the temperature increase to 1.5°C in the Paris Agreement asks for mitigation ambition to be raised to a whole new level. To illustrate this, Table 1³ presents the remaining CO₂ budgets for keeping the global temperature rise within 1.5°C and 2°C⁴ as estimated from the recent literature (Friedlingstein et al., 2014; IPCC, 2014), along with the implications for the required speed of mitigation.

The CO₂ budgets in Table 1 are used to illustrate the significant differences for the remaining budgets and the consequent mitigation pathways between the 2°C and 1.5°C scenarios, cognizant that there is no single value for a GHG budget that can objectively and clearly be connected to 1.5°C or 2°C targets. The differences in the carbon budget estimates for a >66% chance of limiting the temperature increase below 2°C observed across studies are analysed in detail in Rogelj et al., 2016.

The example timelines for reaching net zero CO₂ emissions presented in Table 1 assume that emissions started to decline linearly towards zero after 2014 and that carbon dioxide removal (CDR) or negative-emission technologies⁵ are not used. The remaining CO₂ budget for a 1.5°C goal would be reduced to less than half of that for a 2°C goal. Without the use of CDR technologies, zero emissions would need to be achieved within 20 years to stay within a 1.5°C limit, whereas we will still have about 40 years in case of a 2°C limit. Even for 2°C-compatible pathways, (Fuss et al., 2014) showed that nearly 90% of the pathways that lead to concentration levels of 430–480 ppm CO₂e considered in Working Group III’s contribution to the IPCC’s Fifth Assessment Report (Clarke et al., 2014) required global net negative emissions in the second half of the twenty-first century. Table 1 indicates that, assuming no large-scale deployment of CDR technologies, in particular bioenergy combined with carbon capture and storage (BECCS), in the mid- to long-term future, the 1.5°C limit is only achievable with a complete phase-out of existing fossil fuel-based infrastructure within less than 20 years of now. This would

Table 1 Remaining CO₂ budgets for keeping the temperature within 1.5 °C and 2 °C and the example timelines for reaching net zero CO₂ emissions under the assumptions that the emissions started to decline linearly towards zero after 2014 and CDR technologies as defined by the IPCC (2014) are not used

Indicator	Units	Global average temperature increase above pre-industrial levels		
		2 °C (fraction of simulations that meet the goal: 66%)	1.5 °C (fraction of simulations that meet the goal: 50%)	
Remaining CO ₂ budget ¹	end-2010	GtCO ₂	1000	550
	end-2014	GtCO ₂	840	390
The year net zero CO ₂ emissions is achieved under the assumptions given ²	Year		2056	2034

¹The values for remaining CO₂ budget at the end of 2010 are based on the results for Representative Concentration Pathways from complex models presented in the IPCC AR5 Synthesis Report (IPCC, 2014). The cumulative CO₂ emissions for 2011–2014 were estimated to be 157 GtCO₂ based on Friedlingstein et al. (2014). The remaining budgets at the end of 2014 are rounded to 10 GtCO₂.

²Total CO₂ emissions in 2014 are estimated to be 40.3 GtCO₂ (Friedlingstein et al., 2014).

require shutting down a significant amount of fossil fuel-based installations before the end of their life with significant associated costs.

4. Potential strengthening of INDCs

This section discusses several factors that could lead to a strengthening and/or overachievement of INDCs, so that eventually national action to reduce emissions could be made more consistent with the agreed global long-term goals.

4.1. Conservative nature of INDCs

Some countries have understandably been cautious when submitting their INDCs. This may be partly due to uncertainty over the rules that would be adopted under the Paris Agreement, and in particular the extent to which countries would be legally bound to their contributions. Other countries may have had other reasons to hesitate to make any strong substantive commitments, e.g. concerns over equity, economic implications, possibility of ‘losing face’ by failing to meet targets, lack of experience in setting targets and concerns that the promised support in terms of finance, technology and capacity building would not be forthcoming.

There are indications that several countries considered varying degrees of ambition, but eventually chose not to put forward the most ambitious one. Examples include Vietnam (initial target of 12.5% below business as usual (Department of Meteorology, Hydrology and Climate Change of Vietnam, 2015) in 2030 compared with the final INDC of 8%) and the EU (the impact assessment (EC, 2014) that formed the basis for the decision included several target options, including a reduction of 45% below 1990 in 2030, compared with ‘at least 40%’ in the INDC). These are largely political decisions to minimize the risk of governments failing to achieve what they pledged, and they imply that further

mitigation can be achieved in these countries in a technically and economically reasonable manner. In the case of Japan, its INDC became less ambitious partly due to the assumption of very optimistic future GDP growth rates, which increased the baseline emission levels to be consistent with economic policy (Government of Japan, 2015; Kuramochi, 2015; Kuramochi, Wakiyama, & Kuriyama, 2015).

For some countries, their INDCs do not constitute a great deviation from the GHG emissions projections under currently implemented policies (CAT, 2015), e.g. Argentina (Climate Action Tracker, 2015a) Brazil (Climate Action Tracker, 2015b) China (Climate Action Tracker, 2015c) EU (Climate Action Tracker, 2015d) India (Climate Action Tracker, 2015e) Indonesia (Climate Action Tracker, 2015f) and Japan (Climate Action Tracker, 2015g). This implies that these countries would not have to strengthen their mitigation policies from current levels to meet their INDCs and that they could overachieve their INDCs by implementing additional policies between now and 2025 or 2030. For other countries, like Russia or Ukraine, meeting the INDCs would result in even higher emissions than current trends (Jeffery et al., 2015). They, in particular, could revisit their INDCs.

Finally, restructuring and trends change quite quickly in some countries, which may not yet be fully represented in the INDCs. For example, China's economic restructuring may lead to CO₂ emissions from energy growing at a much slower rate than under the old economic model (den Elzen et al., 2016; Green & Stern, 2016).

The Paris Agreement is now adopted with almost universal support. It defines the legal nature of the contributions and clarifies that punitive measures for non-compliance with the proposed contributions are absent. Although there are various reasons that preclude national governments from committing to ambitious mitigation targets as indicated above, the flexible nature of the Paris Agreement could potentially encourage countries to revisit their proposals and possibly strengthen them (see Section 4.3).

It should also be noted that, for a smaller number of countries, the INDCs imply a significant deviation from current trends and require significant additional national policies to achieve this change, such as Australia, Canada and the US (Jeffery et al., 2015). Nevertheless, this alone does not mean that the INDCs are ambitious; the INDCs of these three countries mentioned here are evaluated by the CAT to be 'inadequate' (Climate Action Tracker, 2015g, 2015h, 2015i, 2015j)

4.2. Advancement of national climate policy-making through the preparation for Paris

A second reason for hope is that the preparation of the INDCs for the new international climate agreement under negotiation had advanced national policy-making even before the Paris Agreement was adopted. The international pressure to produce an INDC accelerated national climate policy-making processes significantly.

In October 2015, we carried out a survey among government representatives, national consultants and supporting institutions involved in the national INDC preparation processes, see Figure 2 (Day, Röser, Tewari, Kurdziel, & Höhne, 2015). We obtained information from stakeholders in 52 countries, covering all major regions. The results can only give an indication as they are from a non-representative sample that includes mainly those heavily involved in the preparation process. However, several indications given by these respondents were very clear.

First, the preparation of INDCs kick-started climate planning and strategy development processes and consolidated and built upon existing climate strategy and planning processes, as confirmed by

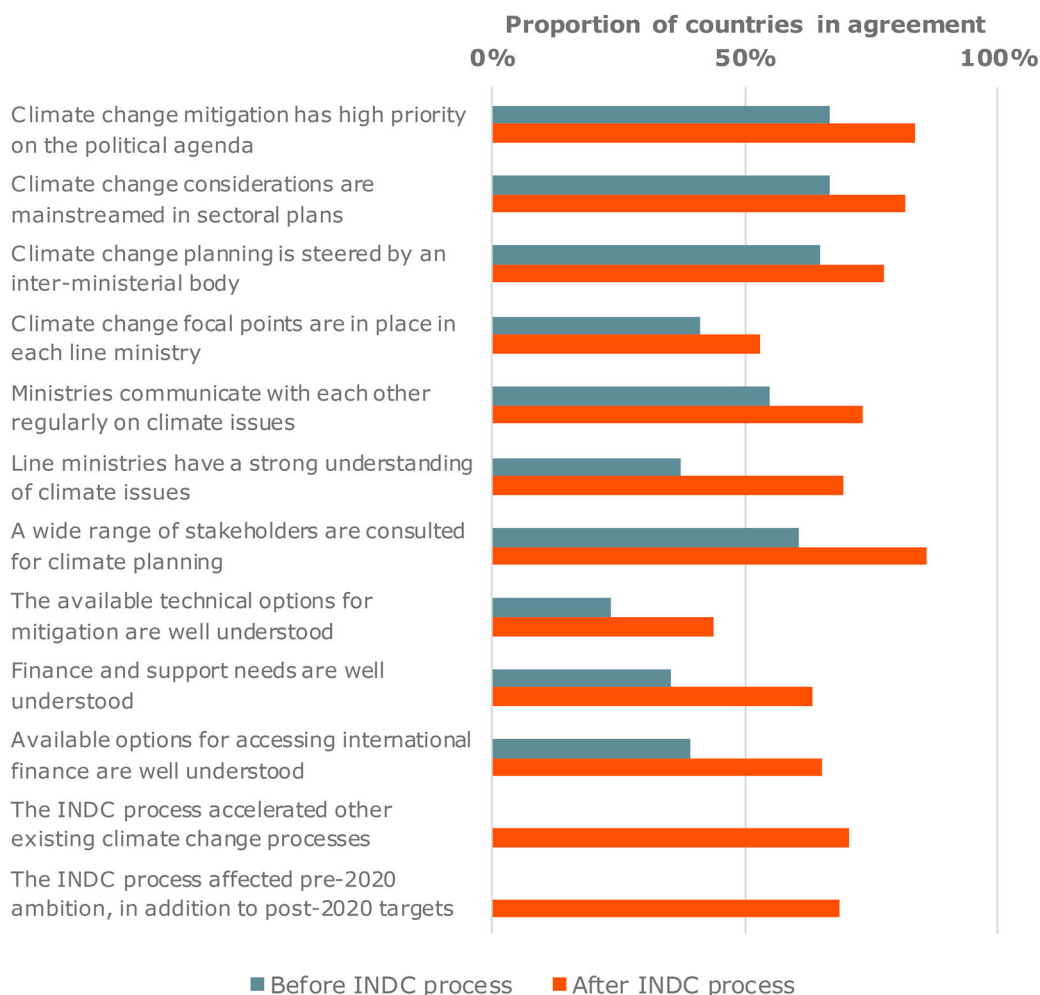


Figure 2. Opinions on the benefits from the process of preparing the INDCs from a survey of stakeholders from 52 countries.

Source: (Day et al., 2015).

over 70% of the respondents from developing countries. The concentrated international focus brought on by the INDC process catalysed new or renewed momentum at the country level for the development of new policies and legislation and new action plans for implementation that reach down to the sectoral level.

Second, the INDC process significantly advanced national political agendas. Climate change mitigation is now a high political priority for the vast majority of consulted developing countries (approximately 84%, compared with 67% before), which may represent a new critical mass for enhanced international cooperation and negotiation. Institutional structures were developed or strengthened,

with new interministerial committees, climate change focal points in line ministries and enhanced communication between ministries. The number of countries stating that climate change is understood well by all ministries nearly doubled through this process. Countries with a broad participation in climate change policy-making have increased (from 60% to 80%).

Third, the pre-2020 ambition was indirectly enhanced by the INDC process in over two thirds of the developing country respondents. In some countries, this benefit came through reinforcing and providing renewed impetus for previously developed strategies and commitments, whilst in others the increased awareness and capacity across governmental and non-governmental stakeholders led to more regular consideration of climate change mitigation at the sector planning level.

Fourth, progress is still needed for elaboration of the technical options and finance plans. The catalysing impact of the INDC process has been limited in some areas. In particular, countries report that the limited timeframe available for INDC development was not conducive to the development of detailed implementation plans for the specific technical measures proposed.

With regard to finance plans, a thorough assessment of the finance and support needs also remain critical issues. As described in Section 4.1, one of the reasons for countries setting conservative INDCs is the concern that promised support in finance, technology and capacity building will not be forthcoming. It was found that at least 78% of the INDCs submitted by the closure of COP 21 included conditions, and that financial support was the key condition for over 80% of these (Day, Kurdziel, & Roeser, 2016).

4.3. Provisions to strengthen ambition under the Paris Agreement

The Paris Agreement puts in place several elements to gradually increase national ambition, indirectly acknowledging that the level of ambition of individual action is not yet sufficient to meet the long-term goals. The new agreement includes virtually all of the elements that had been proposed earlier by some researchers (Morgan et al., 2014) to facilitate an increase in ambition, without being prescriptive to countries:

- A country can adjust its contribution to enhance the ambition level at any time (UNFCCC, 2015a, Article 4.11). This can start already when submitting an updated contribution with the instrument of ratification of the agreement (UNFCCC, 2015a, Decision paragraph 22).
- Governments will need to update their actions every five years and each successive update has to be at least as strong as the current one (UNFCCC, 2015a, Article 4.3). The new or renewed contributions for 2030 have to be submitted 9–12 months in advance of the COP in 2020 (UNFCCC, 2015a, Decision paragraph 23/24).
- Each country's actions will be reviewed and individual suggestions for improvement for each country will be provided during that review.⁶

Tracking the progress of individual and collective contributions is another important achievement of the Paris meeting. With regards to the global stocktake, a facilitative dialogue on stocktaking will occur in 2018 and the first full global stocktake will take place in 2023 (UNFCCC, 2015a, Decision paragraph 20 and Article 14). This exercise will occur every five years thereafter. To assist countries in the implementation of their actions, a facilitative implementation committee of experts has been

agreed (UNFCCC, 2015a, Article 15). The exact modalities of the review remain to be determined in the years to come (Röser, Fekete, Höhne, & Kuramochi, 2015).

The Paris Agreement also increased the need for long-term management of cumulative GHG emissions at a national level to ensure consistency with long-term goals. Simply setting a 2050 target, for instance, is no longer sufficient, and regular carbon management will be needed – as implemented, for example, in the UK under the Climate Change Act (UK Government, 2008). The assessment of the remaining carbon budgets at a national level consistent with the 1.5°C or 2°C limit, and the corresponding emission pathways towards net zero emissions – as carried out in Fekete, Hagemann, & Höhne, 2013; Kuramochi, Asuka, Fekete, Tamura, & Höhne, 2015, among others – may become increasingly important for national climate policy-making in the coming years.

The detailed rules of the ambition cycle of the Paris Agreement, and its implementation, will determine if it can effectively raise ambition. The limited carbon budgets for 2°C, and in particular for 1.5°C, suggest that existing contributions for 2020, 2025 and 2030 have to be strengthened; if these goals are to be reached, it will be too late to only submit strengthened contributions for new and later years. Ambition must already be increased up to 2020. This will only work if the Paris Agreement is ratified quickly alongside the prompt development of the rules for the global stocktake and the review procedures.

4.4. Non-state action

Another of the positive elements of the Paris conference was the unprecedented number of actions and announcements of so called non-state actors or non-Party actors such as cities, regions, companies and sectors. Non-state actions cover a wide range of activities; some of these are international, which are often referred to as international cooperative initiatives (ICIs), while others are domestic. The COP decision adopting the Paris Agreement (UNFCCC, 2015a, Decision paragraphs 118–120 and 134–137) acknowledges the importance of non-state actors and encourages them to undertake enhanced mitigation actions. As of July 2016, more than 11,500 non-state actions and initiatives had been registered under the UNFCCC portal (UNFCCC, 2016a). It is expected that more international non-state actions will be declared and implemented following the Paris Agreement.

Although there are only a few studies available in the literature, they indicate that the combined potential impact of mitigation initiatives by non-state actors could make a significant contribution to achieving the 2°C or 1.5°C goal. The 2015 UNEP Emissions Gap Report reviewed and compared four recent studies on ICIs, all of which were prepared well before the extensive tabling of INDCs in the run-up to Paris. It concluded that the potential global impact of existing ICIs could already be as large as 0.75–2.2 GtCO₂e by 2020, after taking into account overlaps among initiatives as well as any overlap with the national pledges (UNEP, 2015). The first available grey literature that includes the announcements of Paris and extends the analysis to 2030 (Graichen et al., 2016) estimates that, if the 19 initiatives analysed reach their stated goals, they together would potentially deliver 6–11 GtCO₂e of additional emission reductions compared with the INDC emission pathway in 2030. Peer reviewed literature, however, is not yet available.

National governments are probably not yet capturing the entirety of the mitigation commitments made by their subnational governments and businesses in their INDCs. A case study on Germany, for example, suggests that a selected set of quantifiable commitments that have already been made by

non-state actors would reduce emissions by an amount equivalent to 0.8–1.7% of 1990 emissions, in addition to the implemented national policies, by 2020 (Höhne, Sterl, & Fekete, 2015). At the global level, some targets of ICIs, e.g. the Climate and Clean Air Coalition (CCAC) on the reduction of non-CO₂ GHGs, are more ambitious than national-level policies planned under the INDCs (Graichen et al., 2016).

It should be noted, however, that the mitigation impact of non-state actions requires that the non-state actors live up to their commitments (Graichen et al., 2016; UNEP, 2015). Non-state actions are, by definition, voluntary and may not have a robust system to measure, report and verify (MRV) their mitigation impacts. Enhanced transparency would therefore be key to identifying real progress in mitigation delivered by non-state actions (IVM, 2015).

4.5. Technological breakthroughs

Finally, it is encouraging that some sectors are experiencing a faster low-carbon transformation than expected. The recognition of the significant co-benefits of such a transformation (NCE, 2014) may have supported this trend.

For example, the development of some renewable energy technologies (such as solar photovoltaics and onshore wind) has consistently been faster than projected (Cronin et al., 2015; Mai et al., 2013; Metayer, Breyer, & Fell, 2015), although still short of achieving scenarios consistent with the 2°C goal (IEA, 2015). The policy interventions of a small group of countries, including Denmark and Germany, has supported the fast uptake of renewables and stimulated mass production and further support policies, particularly in China. The associated cost reductions have made electricity generation from wind and solar economically competitive in many regions of the world.

Most recently the use of electric cars has seen an unprecedented boost. Again, a small set of countries and regions, in this case China, Norway and California, has supported the deployment of the technology to such an extent that the cost reductions have had global repercussions. In Norway, which currently has the highest rate of electric cars per capita globally, 20% of newly registered cars are electric (ICCT Europe, 2014). Sales have doubled annually between 2012 and 2015 (Aasness & Odeck, 2015).

At the same time, there are countervailing trends, such as the discovery of new fossil fuel resources, increased transport demand and faster-than-expected economic development in some regions. Moreover, as described in Section 3, staying within the 1.5°C limit will in the long term require the massive deployment of BECCS and other CDR technologies. However, CDR technologies are still underdeveloped, emerging more slowly than expected,⁷ and are associated with large challenges, risks and uncertainties, which are described in detail in the WGIII Contribution to IPCC AR5 (Bruckner et al., 2014; Clarke et al., 2014). It is warned that insufficient near-term mitigation efforts would result in a heavy reliance on CDR technologies such as BECCS, and put future decision makers under greater pressure (Clarke et al., 2014). Policy makers around the world would be required to carefully develop a long-term strategy towards the very large-scale deployment of CDR technologies.

Nevertheless, the positive developments observed in recent years provide evidence that a low-carbon transition that is faster than expected is possible, and that such change can be influenced by the determined actions of a rather small number of countries. The massive scaling up of such activities will be necessary to achieve the long-term goals of the Paris Agreement, acknowledging that some will inevitably fail.

5. Conclusions

In this article we reviewed the status of mitigation actions after the Paris Agreement and confirm that the pledged national action is not compatible with the agreed long-term goals of the Paris Agreement. But we also identified a number of elements that point to avenues for raising global ambition to the level consistent with the Paris goals. We conclude that to this end three major steps are needed.

First, the INDCs need to be rapidly and fully implemented; in most cases they need to be, and can be, overachieved. The momentum created in Paris must be captured by building on the positive experiences with INDC planning, and continuing with the same processes to turn them towards effective implementation. These processes need to include efforts to scale up action immediately. If mitigation action does not scale up significantly before the preparatory global stocktake in 2018, or even up to 2020, it will be very difficult to make up for the time lost.

Second, the leading non-state actors need to be supported, and their efforts need to be captured in national ambition. After the unprecedented involvement of non-state actors in Paris, an increasing number of such actors are likely to set mitigation goals and implement mitigation actions that go beyond the ambition level of their respective national governments. These actions should be supported both financially and institutionally so that they actually deliver substantial emissions reductions that can be monitored and verified.

Finally, the faster-than-expected transformations in some sectors can be used as a model by new 'transformative coalitions': groups of countries and other stakeholders of sufficient critical mass that have the intention to flip global markets by deploying new technologies at a large scale. They would support market uptake, and with that technology development on a sufficient scale to transform not only their domestic markets, but also the global market. Potential areas include zero-energy buildings, efficient electrical appliances, electricity storage, zero-emissions aviation and zero-emissions cement or steel.

Taken together, there is reason to be optimistic that national action to reduce GHG emissions will eventually be more consistent with the agreed global temperature limits of the Paris Agreement. The window of opportunity for reaching 2°C, let alone 1.5°C, without massive deployment of CDR technologies, is closing rapidly. A reinforcing upward spiral of national government policy, non-state actions and transformative coalitions will be essential if dangerous climate change is to be avoided.

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Supplemental data

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Notes

1. A non-exhaustive list of commentaries can be found in a blog post of the Global Environmental Policy Program of the School of International Service, American University: <http://teachingclimatelaw.org/compendium-of-commentary-on-the-paris-agreementcop21> (accessed 9 March, 2016).
2. The ultimate objective of the UNFCCC is to stabilize GHG concentrations in the atmosphere 'at a level that would prevent dangerous anthropogenic interference with the climate system' (UNFCCC, 1992, Article 2).
3. Inspired by <http://www.carbonbrief.org/six-years-worth-of-current-emissions-would-blow-the-carbon-budget-for-1-5-degrees>
4. For the 1.5°C, threshold values at which 50% of the simulations from the research projects reviewed in Collins et al. (2013) met the 1.5°C limit. Similarly for 2°C, threshold values at which 66% of the simulations from the research projects reviewed in Collins et al. (2013) met the 2°C limit. There is no data available for >66% for 1.5°C due to the limited number of scenarios. Nevertheless, the combination of >66% for 2°C and >50% for 1.5°C used here adequately represents the goal of the Paris Agreement.
5. CDR methods

refer to a set of techniques that aim to remove CO₂ directly from the atmosphere by either (1) increasing natural sinks for carbon or (2) using chemical engineering to remove the CO₂, with the intent of reducing the atmospheric CO₂ concentration (IPCC, 2013, p. 1449).

CDR methods include large-scale afforestation, BECCS and direct air capture and sequestration (Rogelj & Knutti, 2016).

6. Article 13.12. The relevant text reads

The review shall also identify areas of improvement for the Party, and include a review of the consistency of the information with the modalities, procedures and guidelines referred to in paragraph 13 of this Article, taking into account the flexibility accorded to the Party under paragraph 2 of this Article.

It is ambiguous if the 'areas for improvement' relate only to reporting or to improving policy implementation (UNFCCC, 2015a).

7. As of 2012, there are only two small-scale examples of commercial precursors to BECCS that capture CO₂ emissions from ethanol production facilities for enhanced oil recovery in close-proximity facilities (Bruckner et al., 2014, based on DiPietro, Balash, & Wallace, 2012).

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