GLOBAL CCS INSTITUTE

# THE GLOBAL STATUS OF CCS | 2016

## VOLUME 1 INTERNATIONAL CLIMATE DISCUSSIONS AND CCS

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Cover image: Laurence Tubiana, COP 21/CMP 11 Presidency; UNFCCC Executive Secretary Christiana Figueres; UN Secretary-General Ban Ki-moon; COP 21/CMP 11 President Laurent Fabius, Foreign Minister, France; and President François Hollande, France, celebrate the adoption of the Paris Agreement. Photo by IISD/ENB | Kiara Worth (http://www.iisd.ca/climate/cop21/enb/images/12dec/3K1A5493.jpg)

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## VOLUME 1 INTERNATIONAL CLIMATE DISCUSSIONS AND CCS

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## 1 INTERNATIONAL CLIMATE DISCUSSIONS AND CCS



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# ACKNOWLEDGEMENTS


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# VOLUME HIGHLIGHTS

- The Paris Agreement provides a legal framework in which international and national climate and energy polices can establish the economic drivers of climate actions, such as the widespread deployment of carbon capture and storage (CCS).
- The level of global emissions reduction that must be delivered over coming decades positions CCS as a critically important mitigation technology.
- It is not possible to envisage least-cost emissions reduction scenarios, consistent with the Paris Agreement, that do not include the broad deployment of CCS.
- Global modelling efforts, including those by the Intergovernmental Panel on Climate Change (IPCC) and the International Energy Agency (IEA), highlight the importance of CCS in delivering a 2°C climate goal, and even more so within a 'well below' 2°C ambition.
- Complacency in either implementing the Paris Agreement or providing sufficient support for the deployment of CCS will substantially reduce the ability of world economies to limit global emissions to levels consistent with the Paris Agreement's climate goals.
- The emissions reduction targets contained in the submitted Intended Nationally Determined Contributions (INDCs) fall well short of delivering the 'well below' 2°C temperature goal.
- Countries must enhance their mitigation ambitions at every available opportunity, by identifying policies and programs that can support large-scale and localised mitigation opportunities, especially those for CCS.
- In the absence of further mitigation actions, climate models indicate that the 450 parts per million (ppm) atmospheric concentration threshold will likely be exceeded; implying greater reliance in the post-2050 period on the negative emissions generated from bioenergy coupled with CCS (BECCS) to help reclaim the carbon budget.
- Net-negative emissions technologies face considerable hurdles to large-scale deployment.
- A stronger focus must be given to accelerating the uptake of CCS, together with the fullest attention being given to complementary technologies, such as large-scale BECCS.
- While the focus of the Paris Agreement is post 2020, the pre-2020 period is critical for the wide-scale deployment of CCS. Key regulatory and other enablers must be put in place in the next five to seven years if CCS is to maximise its contribution to the 'well below' 2°C temperature goal.
- UNFCCC processes would benefit greatly from hosting a second Technical Expert Process workshop on CCS to help Parties better understand its mitigation potential, especially in light of the expected upcoming findings of the IPCC's Special Report on 1.5°C warming and its Sixth Assessment Report cycle.
- Widespread deployment of CCS will depend on the extent to which governments afford it 'policy parity' – namely, the provision of an equitable level of consideration, recognition and support for CCS alongside other low-carbon energy technologies.
- For CCS, 'policy parity' means the design and implementation of support measures tailored specifically to the technology and its lifecycle stage. Future efforts should focus on identifying a suite of incentive mechanisms that tackle the complexity of risks and serve as economic multipliers to improve the conditions of CCS market uptake.

# FOREWORD BY CAMERON HEPBURN

## Professor of Environmental Economics at the University of Oxford and the London School of Economics

The international agreement on climate change adopted in Paris in December 2015 represents a historic milestone in multilateral climate diplomacy. Two critical components of the Paris Agreement are: (a) limiting the temperature increase to 'well below' 2°C and pursuing 'efforts' to limit such increase to 1.5°C, and (b) achieving a balance between 'sources and removal by sinks' – or net-zero emissions – in the second half of this century. The Paris Agreement sends an unprecedented signal that governments in developed and developing nations understand the scale of the challenge and the necessary speed of the response. Their corresponding commitments suggest greater political willingness to address the challenge and to support the technologies that can scale up to reduce net emissions to zero.

There are reasons for optimism. As is now well-known, impressive technical progress has been made in clean energy technologies such as renewables (especially solar), electric vehicles and energy storage. Progress continues, with ever-deeper reductions in unit capital costs as the market grows and market penetration increases for these solutions. However, these technologies are currently a small proportion of the global energy system and their deployment needs to be massively accelerated if the unanimously agreed goals of the Paris Agreement are to be met.

Even if such a rapid deployment of these technologies is realised, it is very unlikely that this will be sufficient to halt temperature rises to within 2°C, let alone 1.5°C. Our research at the University of Oxford shows that even the emissions from existing power sector assets, if operated to the end of their normal economic life, will exceed the cumulative emissions budget consistent with halting global average temperature rise to 1.5°C. By the end of 2017, the emissions signature from installed power plants implies a greater than 50 per cent probability of exceeding 2°C, unless power plants are either prematurely retired (economically stranded) or carbon capture and storage (CCS) is retrofitted. In short, it is virtually impossible that deploying renewables and nuclear alone can reduce net emissions to zero before the temperature increase reaches 2°C, never mind 1.5°C. Additional effort is required to develop techniques to capture and securely store carbon.

Furthermore, the achievement of net-zero emissions across the entire global economy this century appears economically impossible without negative emissions technologies, such as bio-energy coupled with CCS (BECCS) or other carbon dioxide removal (CDR) technologies. Continued emissions from industrial and agricultural production processes seem very likely for the foreseeable future. To eventually reach a balance between emissions sources and carbon sinks, negative emissions technologies and processes will be important. Renewable energy technologies alone cannot supply the necessary carbon sinks to balance the residual sources and reach net-zero emissions.

Progress on carbon capture technologies is therefore critical to limit cumulative greenhouse gas emissions and to halt global temperature rises to between 1.5°C and 2°C. Negative emissions technologies will be required to deliver net-zero emissions sometime between 2050 and 2100, indicated as essential by the Fifth Assessment Report (AR-5) of the Intergovernmental Panel on Climate Change in order to stabilise the rise in global temperature to 2°C or lower.

Such truths, inconvenient or otherwise, remain truths even if carbon capture technologies are not always afforded a favourable impression by the popular press and some environmental groups. These impressions may stem from understandable opposition to any continued use of fossil energy, but the modern economy has been built upon the foundations of a fossil energy system that will remain vital for our prosperity for decades into the future. Make no mistake, the continued use of fossil fuels will be dependent on the ability of technologies to capture the corresponding greenhouse gas emissions, along with other technologies to greatly reduce damaging local pollutants. Without these advances, fossil fuels can have no place in the economy of a stabilised climate.

In this context, the annual *Global Status of CCS* report provides a very important resource for policymakers and businesses to rapidly get up to speed on the developments and progress of CCS. The core conclusion I take from this report is that, although there are important developments in both theoretical and applied knowledge, with some valuable practical wins, the current rate of progress on CCS is simply too slow.

This conclusion follows from the severity of the risks from climate change, the fact that renewables and nuclear alone are unlikely to reduce emissions fast enough, and the fact that residual process emissions need to be offset for the requirement of net-zero emissions to be achieved. Progress on CCS is much more important than current climate policy suggests it is – a more systematic, substantial and sustained push to stimulate its further development and roll-out, including on carbon pricing, is an appropriate response to the Paris Agreement.

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# THE PARIS AGREEMENT REPRESENTS ANOTHER STEP IN THE RIGHT DIRECTION FOR GLOBAL CLIMATE ACTION

## A new paradigm for climate action has been created

As with the 15th Session of the Conference of the Parties (COP) to the United Nations Framework Convention on Climate Change (UNFCCC) in Copenhagen in 2009 (COP 15), the lead up to the 21st Session (COP 21) in Paris was characterised by hope and optimism that a new climate agreement would be adopted. Unlike COP 15, which failed to deliver a new climate treaty, COP 21 saw over 195 Parties adopt the Paris Agreement on 12 December 2015. It also raised the issue of climate change to the highest of political levels with over 150 world leaders attending the conference.[1]

**The Paris Agreement**

The Paris Agreement establishes a long-term, multilateral framework under which countries, or 'Parties to the Paris Agreement', commit to undertake domestic actions to address climate change.

It builds on the arrangements of the Kyoto Protocol and the associated bodies, arrangements, mechanisms and programs already established to help implement the principal objective of the Convention (1992):

> *The ultimate objective of this Convention and any related legal instruments that the Conference of the Parties may adopt is to achieve, in accordance with the relevant provisions of the Convention, stabilization of greenhouse gas concentrations in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate system.*

The national commitments of Parties are currently expressed through 'Intended Nationally Determined Contributions' (INDCs),[2] many of which were submitted to the UNFCCC prior to COP 21 and include national strategies and policies to assist their implementation.[3]

The Paris Agreement requires all signatories to submit a Nationally Determined Contribution (NDC) every five years, and in doing so encourages signatories to not only pursue measures that can achieve their domestic emission reduction targets, but also to continuously progress efforts beyond those previously submitted.[4] The subsequent claims of countries in regards to meeting their NDC commitments will be subject to future international technical expert reviews.

The Paris Agreement defines a number of climate goals. A short-term goal is to reach peak emissions as soon as possible. A longer term goal is to limit average global warming to 'well below' 2 degrees Celsius (2°C) above pre-industrial times, with 'efforts' to limit to 1.5°C. In the second half of this century, it is envisaged that a balance between emissions sources and sinks (sometimes referred to as net-zero emissions) will be needed.[5]

While the Paris Agreement is predominantly focused on the post-2020 period, its supporting implementing decisions strengthen voluntary efforts to enhance climate actions in the pre-2020 period by encouraging developed countries to increase the provision of finance, technology and capacity building to developing countries. COP 21 also saw the appointment of two climate champions. These positions are currently filled by Mmes. Laurence Tubiana (France) and Hakima El Haite (Morocco). They are tasked with facilitating high-level engagement on climate action during this period and providing oversight of the Technical Examination Process (TEP).[6] [7] [8]

1 (United Nations Framework Convention on Climate Change (Uni156), 2015)
2 The INDC will become the first 'Nationally Determined Contribution' (NDC) when a country ratifies the Paris Agreement, unless a new NDC is submitted at the same time of ratification.
3 (United Nations Framework Convention on Climate Change (UNF2), n.d.) INDC website
4 (United Nations Framework Convention on Climate Change (UNF15), 2015); The Convention
5 (United Nations Framework Convention on Climate Change (UNF152), 2015): The Paris Agreement: short term goal Article 4, paragraph 1 (p4), long term goal: Article 2, paragraph 1 (p3), emissions balance goal: Article 4, paragraph 1 (p4)
6 The Technical Examination Process commenced in 2014 under the Ad-hoc Working Group on the Durban Platform for Enhanced Action (ADP), and is now anchored in the Paris Outcome (the Paris Agreement and its associated decisions).
7 (United Nations Framework Convention on Climate Change (UNF), 2015); UNFCCC Newsroom
8 (United Nations Framework Convention on Climate Change (UNF153), 2015); UNFCCC Technical Examination Process homepage

On 22 April 2016, 174 Parties signed the Paris Agreement at a ceremony in New York. The signing ceremony also started a more formal political process in which Parties must decide to ratify the Paris Agreement so that it becomes legally binding under international law.

On 5 October 2016, a sufficient number of Parties to the Convention (at least 55) accounting in total for at least an estimated 55 per cent of total global greenhouse gas emissions, had ratified the Paris Agreement, including China, the US and the European Union.[9] This means that those Parties who have ratified the Agreement will formally convene at COP 22 as the Agreement's ultimate decision making body - that is; the Conference of the Parties serving as the meeting of the Parties to the Paris Agreement (CMA), to start negotiations on its implementation.

A 'facilitative dialogue' will take place in 2018 to assess the implementation of INDCs and to inform Parties of the findings of the IPCC Special Report on the impacts of limiting global warming to 1.5°C above pre-industrial levels and related global greenhouse gas emission pathways (note that COP 21 in Paris formally invited the IPCC to undertake this report, which it accepted to do at its 43rd session in April 2016).

A 'global stocktake' of climate pledges and actions is scheduled for 2023 (and every five years thereafter) to track progress made on achieving climate goals. The stocktake will inevitably focus on technologies with high mitigation potential, such as CCS, to inform Parties as they update their NDCs.

## There are many linkages with other multilateral government arrangements

The effective implementation of the Convention and its related legal instruments are also influenced by a number of other international treaties and multilateral arrangements. While complementing the control of greenhouse gases already covered under the Montreal Protocol on Substances that Deplete the Ozone Layer, any transboundary movement of carbon dioxide ($CO_2$) for the purposes of geological storage in the sub-seabed will likely require the 2006 amendment to the London Protocol to the London Convention on the prevention of Marine Pollution by Dumping of Wastes and Other Matter (1972) to be ratified. This is an outstanding issue within the UNFCCC's Clean Development Mechanism (CDM), and is scheduled for further consideration by the COP at its 22nd Session (COP 22) in Marrakech from 7 to 18 November 2016.

In regards to the Montreal Protocol, an amendment was adopted in October 2016 to phase down the use and production of hydrofluorocarbons (HFCs), which are potent greenhouse gases. It is anticipated that this amendment alone could help avoid an average global temperature rise of up to 0.5°C by the end of 2100.

The Paris Agreement is also intrinsically linked to the United Nations Sustainable Development Goals (SDG); as well as to various international trade and intellectual property treaties. There are also many intergovernmental arrangements that support the implementation of both the Convention, the Kyoto Protocol and the Paris Agreement, such as the Clean Energy Ministerial (CEM), the G7 and G20, and the Carbon Sequestration Leadership Forum (CSLF). All of these multilateral forums are exploring the value of, and support for, CCS in order to help prevent dangerous anthropogenic interference with the climate system.

[9] (United Nations Framework Convention on Climate Change, 2016)

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# AN ENDURING INTERNATIONAL FRAMEWORK TO SUPPORT NATIONAL POLICY DEVELOPMENT

## The Paris Agreement will spur changes in the technology and industrial policy landscapes

The successful implementation of the Paris Agreement can provide for a sustained period of certainty for decision-makers. This is especially true in regard to governments clearly articulating on the international stage the scale of short, medium and longer term national carbon constraints, as well as signalling the types of policy interventions they intend to support to deliver them.

In addition to its enduring multilateral and rules-based framework that will assist nations to decide how these mitigation actions can be given effect, the Paris Agreement relies on a number of mechanisms, goals, frameworks and communication vehicles to further support technology development and transfer (including sharing best practices and knowledge) and encourage the mobilisation of finance at the national level.

Its implementation will continue to be regularly and strongly informed by the latest climate science, such as the IPCC's Assessment Report cycles and the Party-led global stocktakes, to reveal how national mitigation pledges are tracking to the mitigation outcomes required to achieve climate goals. These formal processes of review will be complemented by an abundance of informal, public and non-government sector led independent assessments as to the sufficiency of national policy responses. This could serve to apply additional pressure on governments to enact appropriate domestic policies that can further assist national emissions reductions.

## Supporting evolutionary rather than revolutionary change

Parties are encouraged to regularly revise their national climate ambitions and actions under the Paris Agreement, within the context of firming scientific knowledge. Between now and 2020, Parties have been requested to develop and communicate in future NDCs their strategies to transition economies towards a low-carbon future.[10] By articulating such strategies over the short term and providing for more predictable policy environments over the longer term, governments can serve to improve business confidence by encouraging investments in the long-lived low-carbon technologies considered so critical to the successful delivery of the Paris Agreement, such as CCS.

The mitigation pledges contained in the current suite of INDCs are insufficient to deliver on the 'well below' 2°C temperature goal.[11] The Paris Agreement was never intended, however, to provide nations with a single opportunity in time to commit to addressing climate change, but rather offers them a number of well-defined opportunities to revise and resubmit enhanced mitigation ambitions over time.

The first opportunity presents itself at the time a country ratifies the Paris Agreement, when it can decide to either re-submit or enhance and revise its INDC as an NDC. There may also be heightened pressure on Parties to enhance and revise their INDCs as a consequence of the facilitative dialogue scheduled for 2018, which is expected to informally indicate what the gap is between national mitigation commitments and the scale of emissions reductions required.

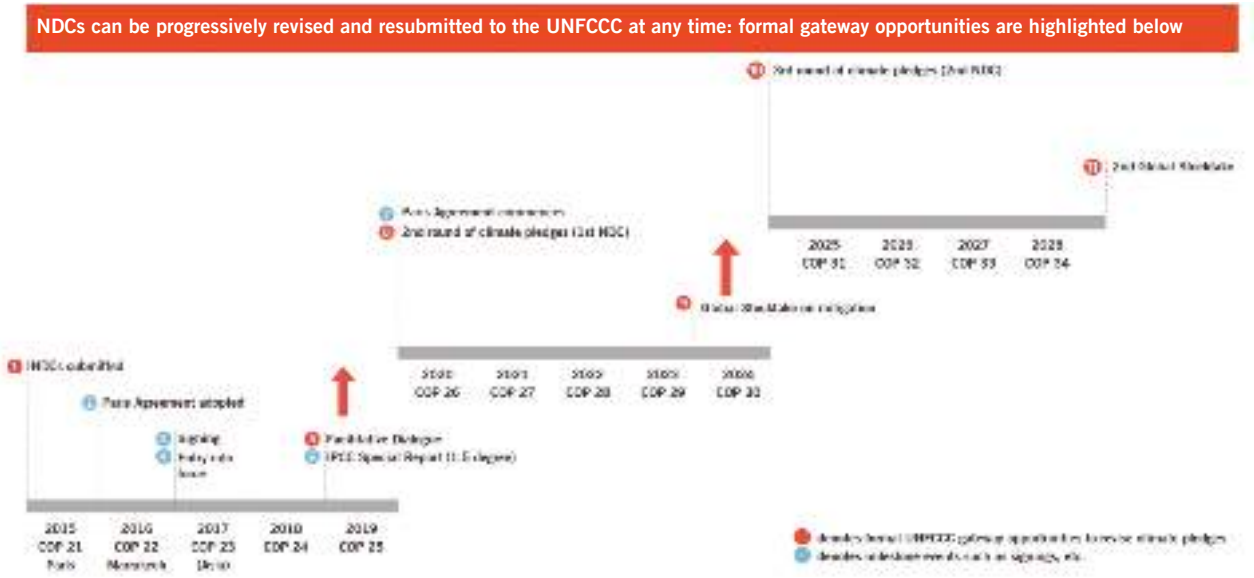
Another opportunity for nations to communicate greater mitigation ambitions will be in 2020 when the Paris Agreement is due to commence, and for which they are encouraged to revise their INDCs or NDCs. The global stocktake in 2023 (and scheduled every five years thereafter) will more formally indicate the emissions gap that exists between collective climate actions and goals. The 2023 stocktake will draw heavily on the findings of the IPCC's Sixth Assessment Report (AR-6), which, on

[10] (United Nations Framework Convention on Climate Change (UNF1), 2015), COP 21 Decisions: paragraph 35 page 6
[11] (Climate Action Tracker (Cli16), 2016): Tracking INDCs, (United Nations Framework Convention on Climate Change secretariat (UNF155), 2015) page 12, (International Energy Agency (IEA15), 2015) page 37

present trends, will likely expose Parties to further international and domestic pressure to enhance their ambitions and policy support for low-carbon developments.

Parties are bound to re-submit their NDCs every five years, with 2025 being the expected date for the second round of NDCs. Parties are also free to revise and resubmit their NDCs at any time as long as there is no backsliding (reversion) in the nature of their commitments.

**Figure 1** **The Paris Agreement: opportunities to enhance mitigation ambitions**




Source: *Global CCS Institute*

## Mitigation actions must remain at the forefront of climate action priorities

Adaptation measures and the development of net-negative emissions technologies are important, but real and scalable emissions reductions are needed now in order to limit the risk of exceeding dangerous levels of atmospheric concentrations of emissions – and to avoid an over-reliance on emerging technologies (which carry considerable uncertainties) to claw back those emissions.[12]

While climate models suggest that clawing back an overshoot in $CO_2$ concentration levels is possible through the generation of net-negative emissions, the IPCC notes that it is highly uncertain whether it will be possible to wind back or prevent the adverse climate impacts caused by an overshoot in the first place.[13,14] International Energy Agency (IEA) modelling indicates that, if all of the emissions reduction pledges contained in submitted INDCs are fulfilled, energy-related $CO_2$ emissions could still be expected to grow by 8 per cent over the period 2014 to 2030, and that this is consistent with an average temperature rise of 2.7 per cent by 2100.[15] This means that there is significantly more work for countries to do if the threat of dangerous climate change is to be averted. For many countries, CCS will be an essential enabler of further emission reductions.

## Implications of delaying mitigation action or too slowly pursuing mitigation outcomes

The World Meteorological Organization reported in early 2016 that the world had already warmed by almost 1.3°C since the pre-industrial era.[16] This is consistent with one of the IPCC's Fifth Assessment Report (AR-5) highlighted conclusions in its *Summary for Policymakers*:

[12] In adopting the climate goal of 'well below' 2°C, Parties implicitly adopted keeping 'well below' an atmospheric concentration of 450 parts per million (ppm) of $CO_2$ equivalence ($CO_2$eq) by 2100.
[13] (Intergovernmental Panel on Climate Change (IPC141), 2014) IPCC WGIII, page 1314
[14] (Intergovernmental Panel on Climate Change (IPC141), 2014) page 1268 "Overshoot pathways"
[15] (International Energy Agency, 2015) pages 3 and 4
[16] (World Meteorological Organization (WMO16), 2016): Press Release Number 8

*Mitigation scenarios reaching about 450 ppm $CO_2$eq in 2100 typically involve temporary overshoot of atmospheric concentrations, as do many scenarios reaching about 500 ppm to about 550 ppm $CO_2$eq in 2100. Depending on the level of the overshoot, overshoot scenarios typically rely on the availability and widespread deployment of BECCS and afforestation in the second half of the century. The availability and scale of these and other Carbon Dioxide Removal (CDR) technologies and methods are uncertain and CDR technologies and methods are, to varying degrees, associated with challenges and risks.*[17]

Since the release of the IPCC's AR-5 there has been increasing discussion on the role of bio-fuels with CCS (Bio-CCS or BECCS) in meeting climate goals. From a modelling perspective, the vast majority of 430–480 ppm climate scenarios rely on BECCS (as a net-negative emissions technology); without BECCS, there is no flexibility in current scenarios to reach the 1.5°C 'aspiration'. In terms of $CO_2$ capture potential, BECCS compares favourably against other net-negative emissions technologies (such as air capture, enhanced weathering and afforestation).[18]

While BECCS shows significant potential as a technology for the future, it (like all net-negative emission technologies) faces considerable hurdles to large-scale deployment. There is a lack of experience with large-scale BECCS projects and further development in climate policies, accounting frameworks and financial instruments is required. Most importantly, BECCS involves complex sustainability issues, with further research required to address the close links within the 'food-water-energy-climate' chain.[19]

While the evidence suggests that 'fullest attention' should be afforded to BECCS development, much needs to be resolved if projects are to be deployed in the coming decades.

A stronger focus must be given to enhancing the ability of countries to scale-up high-potential mitigation technologies such as CCS, in parallel with other complementary technologies, including commercial-scale BECCS (among others). Their technical and economic scaling-up will be critical in the decades to come. Barriers to deployment need to be addressed now and this will require heightened government and policymaker attention.

## 3 HOW THE PARIS AGREEMENT IS IMPLEMENTED MATTERS A GREAT DEAL

### The Paris Agreement provides a comprehensive and rules-based approach to climate action

The Paris Agreement includes a number of elements that Parties consider critical to addressing climate change, including:

- Mitigation;
- Technology;
- Finance;
- Adaptation;
- Transparency;
- Sustainable development; and
- Capacity building.

[17] (Intergovernmental Panel on Climate Change (IPC14), 2014) page 12
[18] (UK CCS Research Centre, 2016)
[19] (Kemper.J, 2015)

These elements are not mutually exclusive; in fact, the Paris Agreement establishes a number of new arrangements that clearly show how very dependent they all are on the resources that are made available to each. For example, it has been widely recognised through the UNFCCC's Technical Examination Process that mitigation outcomes are largely technology-driven. In turn, technological advances rely heavily on (a) the amount of financing that can be mobilised and made available to help the development and transfer of sustainable and environmentally sound technologies, and (b) the quality of domestic institutional capacities to adapt and deploy them in a locally relevant manner.

This is demonstrated in the Paris Agreement by the establishment of a new vision on the importance of fully realising technology development and transfer to improve resilience to climate change (adaptation) and to reduce emissions (mitigation). A technology framework was also established to ensure a greater accountability by the existing institutions (the Technical Executive Committee (TEC) and the Climate Technology Centre and Network (CTCN) who are charged with stewarding the technology agenda under the UNFCCC's Technology Mechanism.

The technology framework should, for example, ensure that there are sufficient linkages between the Technology Mechanism and other components of the UNFCCC architecture, including the Finance Mechanism and Technical Expert Process, in order to promote and give effect to practical and effective support for a broad suite of mitigation technologies.

## The Paris Agreement needs to serve as a catalyst for all mitigation technologies

The language of the Paris Agreement is technology-neutral, in that it does not state a preference for any particular type of mitigation technology. It is of the utmost importance that the Paris Agreement is implemented in a manner that is not discriminatory and does not disadvantage any particular mitigation technology. The corollary is that the Paris Agreement should also avoid promoting any particular technology, and it can do this by equitably showcasing the mitigation potentials and merits of all technologies.

The legacy implementation efforts of the Convention, the Kyoto Protocol and the UN's clean energy flagship initiative, The Sustainable Energy For All (SE4ALL), indicate that the UN's focus on renewables and energy efficiency tends to outweigh that afforded to other clean energy technologies, including CCS.

This lack of focus on CCS can be demonstrated through a number of explicit examples. The first is the high ratio of Technical Expert Meetings under the Technical Expert Process afforded to renewables and energy efficiency compared to that of CCS. If the number of follow-up workshops is included, then the ratio is about 4:1. A second example is the very limited scope of the objectives that currently and formally underpin the SE4ALL initiative – they include a doubling of the rate of energy efficiency, a doubling of the global share of renewables, and enhanced access to clean energy – but remain silent on the need to reduce fossil fuel-related emissions.

The SE4ALL objectives have been adopted as 'targets' for the delivery of SDG Goal 7 of "affordable and clean energy".[20] Despite the increasingly important mitigation role of both renewables and energy efficiency, in the absence of wide deployment of CCS and other low-carbon technologies over the coming decades, the evidence is very strong that $CO_2$ concentration levels will overshoot the 450 ppm threshold, with a consequent strong reliance on BECCS to achieve net-negative emissions in the second half of the century.

Another example is the six-year examination by Parties on the eligibility of CCS in the CDM, despite the findings of the IPCC in its 2005 Special Report on *Carbon Dioxide Capture and Storage* that the local health, safety and environment risks of CCS are comparable to that of current activities such as natural gas storage.[21] No other mitigation or clean energy technology seems to have been subjected to the same level of scrutiny as CCS has attracted within the UNFCCC's negotiations.

[20] (United Nations (UN) Sustainability Development Goals, 2015)
[21] (Intergovernmental Panel on Climate Change (Int1), 2005) SPM paragraph 22 page 12

In late 2014, the United Nations Economic Commission for Europe (UNECE) publicly issued a statement of recommendations on CCS for the UNFCCC's consideration, noting that CCS should be treated with parity to other no-carbon/low-carbon technologies.[22]

## Technology development and transfer continues its heightened focus within the UNFCCC

An element of the technology agenda that continues to be strongly supported by Parties is the role of Technical Needs Assessments (TNAs) by developing countries. TNAs are government-endorsed documents that aim to identify and determine the mitigation and adaptation technology priorities of countries. The first phase of TNAs was conducted over the period from 2009 to 2013 which supported 36 countries, and the second phase commenced in 2014 supporting 25 additional countries. TNAs are periodically updated; to date, only a handful of developing countries cite CCS in their TNAs.[23]

It is important that future TNAs be undertaken and implemented by bodies that maintain unbiased and informed views of CCS, so as to not preclude it from national considerations. This also applies to organisations with oversight responsibilities of the TNA process, such as the Global Environment Facility (GEF), UN Development Programme (UNDP), UN Environmental Programme (UNEP), Climate Technology Initiative (CTI), UNFCCC secretariat and the UN Industrial Development Organization (UNIDO).

The work programs of these institutions, in addition to the UNFCCC's subsidiary bodies (Subsidiary Body for Scientific and Technological Advice-SBSTA, Subsidiary Body for Implementation – SBI), the TEC and CTCN, and the Green Climate Fund (GCF) are very important for the future of CCS in that they can often influence Party decisions on how multilaterally sourced funding should be considered and ultimately allocated to support technology projects in developing countries. Closer institutional linkages between the Technology Mechanism and the GCF is essential going forward.

The Paris Agreement also recognises that capacity-building efforts should facilitate technology development, dissemination and deployment.[24] Encouraging technology transfer and development alone will be insufficient to give effect to the necessary structural changes to energy systems required by the low-carbon strategies of many countries, especially in developing countries. Support for the deployment of technologies like CCS must be complemented with competent institutional arrangements that can provide for job creation, skill enhancement, educational opportunities, the development of policy, programme and regulatory frameworks, financing arrangements, and access to affordable energy (among other things).

## Finance remains key to successful technology development and transfer

The GCF is the main UNFCCC fund for investing in low-emissions and climate-resilient developments; it can award substantial sums of funding for clean energy technology projects (among other priorities) with the aim of leveraging additional funds from the private sector. The GCF is but one funding vehicle relevant to the international climate agenda, with governments also contributing significantly to multilateral development banks (MDBs) as well as providing overseas development assistance (ODA).

At COP 15 in 2009, developed country Parties committed to mobilising US$100 billion a year by 2020 from both public and private sources to assist climate action in developing countries. The Paris Agreement reaffirms this funding commitment by developed countries, and continues to strongly

[22] (United Nations Economic Commission for Europe (UNECE), 2014) Press Release
[23] Institute analysis of TNAs: Bangladesh; Kazakhstan; Morocco (planned pilot project proposed using a solar tower to generate energy to capture $CO_2$ and then geologically store); Mongolia; Rwanda (10MW post combustion capture system separation on a Combined Cycle Gas Turbine plant, with geological storage – and are seeking technical assistance from development partners); Republic of Moldova; and Thailand.
[24] (United Nations Framework Convention on Climate Change (UNF152), 2015) Paris Agreement: Page 15 Article 11 paragraph 1

encourage the mobilisation of this scale of climate finance until 2025, with a view to setting a new and more progressive goal prior to 2025.[25]

Some of this funding is being used for the purposes of the GCF, while other amounts are expected to be awarded to projects independent of the GCF. The GCF has raised over US$10 billion to date, and its Board is publicly signalling that it is prepared to take on a larger share of the investment risk than many international and commercial lenders, to help mitigate the risks of such investments and to promote innovative technologies.[26] The GCF's Governing Instrument explicitly includes consideration of funding for CCS projects.[27]

### The Paris Agreement will ensure robust validation of climate obligations and actions

Credible and transparent assessments of national and international climate actions are critical to the success of the Paris Agreement.[28] The Paris Agreement offers a top-down approach to determining country performance (transparency, accounting and reporting arrangements), whilst NDCs provide a vehicle for communicating bottom-up approaches to domestic climate action.

The current transparency framework will track progress towards the achievement of pledges outlined in INDCs/future NDCs, including financial and other support for technology development and transfer. In this regard, countries can formally articulate their ambitions without fear of punitive or legal action for non-compliance. This has helped foster a globally inclusive commitment to addressing climate change, as demonstrated by the many Parties who signed the Paris Agreement in April 2016.

To support the transparency in which the Paris Agreement is implemented, a periodic review, or global stocktake, will be undertaken in 2023 and every five years thereafter.[29] This will incorporate a strong focus on technology transfer and development. These periodic reviews will be conducted in light of the best available science, and the IPCC has agreed to coordinate its AR-6 cycle to inform the 2023 global stocktake. At the 43rd session of the IPCC held in April 2016, it was agreed that AR-6 would explicitly consider 1.5°C to 2°C scenarios, in addition to further considering the key findings arising from the IPCC's Special Report on 1.5°C warming.[30]

## 4 THE PARIS AGREEMENT MUST LEAD TO ENHANCED POLICIES TO INCENTIVISE CCS AT THE NATIONAL LEVEL

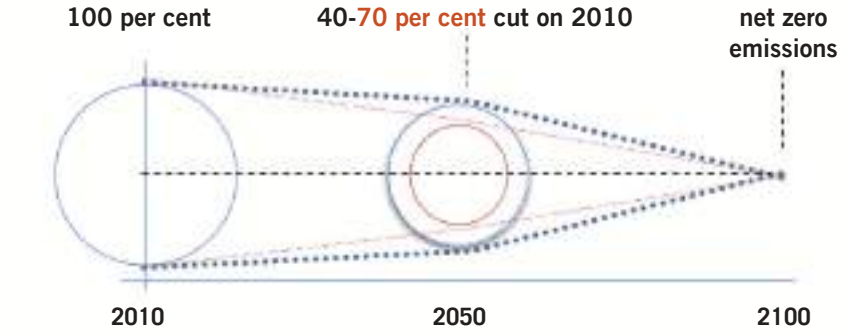
### The policy challenge for governments

Climate change is an emissions stock problem due to the longevity of the associated impacts of the greenhouse gases released to atmosphere. The IPCC considers that once the stock of $CO_2$eq in the atmosphere exceeds 2,900 Gt (gigatonnes) it will likely (66 per cent probability) lead to an average warming of greater than 2°C, which in turn is likely to lead to dangerous levels of anthropogenic global warming.[31]

[25] (United Nations Framework Convention on Climate Change (UNF1), 2015) COP 21 Decisions: Page 8, paragraphs 53 and 54
[26] (Doyle, 2015)
[27] (Green Climate Fund (GCF14), 2011) B.35
[28] (United Nations Framework Convention on Climate Change (UNF152), 2015) Paris Agreement: Page 16 Article 13, Paragraph 1
[29] (United Nations Framework Convention on Climate Change (UNF152), 2015) Paris Agreement: page 19 Article 14 paragraph 2
[30] (Intergovernmental Panel on Climate Change (IPC16), 2016) page 11 paragraph 2
[31] (Intergovernmental Panel on Climate Change (IPC142), 2014) page 10

The IPCC estimates that the present stock of emissions is 1,800 $GtCO_2eq$, leaving a total global carbon budget of 1,100 $GtCO_2eq$ (forever). If this remaining carbon budget is not to be exceeded, the IPCC indicates that global emissions need to be reduced by between 40 per cent and 70 per cent on 2010 levels by 2050, and must reach net-zero emissions by the end of this century. Without substantial deviations in the current annual emissions rate of around 50 $GtCO_2eq$, this budget could be consumed in just over two decades.

**Figure 2** **Scale of emissions reductions needed to reach 2°C goal (66 per cent probability of limiting warming to below 2°C)**




Source: *(Intergovernmental Panel on Climate Change (IPC14), 2014) page 10; Graph: Global CCS Institute*

The IEA's analysis of the INDCs submitted for COP 21 indicates that global energy and process related emissions will increase over the period 2014 to 2030 by 3.7 $GtCO_2eq$.[32] The annual growth rate of global energy emissions slows to around 0.5 per cent per year to 2030, indicating that emissions may not have peaked by this time.[33] The energy-related emissions reduction pledges in the INDCs remain insufficient to avoid dangerous levels of climate change; annual additions to the absolute stock of emissions continue on an upward trajectory over this period (albeit at a much reduced pace than previously). This indicates there is an urgency to deploy technologies like CCS that can avoid fossil fuel-related emissions entering the atmosphere in the first place.

COP 21 decisions supporting the implementation of the Paris Agreement require Parties to substantiate in their NDCs why their climate mitigation actions should be accepted by the international community as being "fair and ambitious" in light of national circumstances; and how they contribute towards achieving the objective of the Convention. Such judgements are expected to be a highly public and contested aspect of the NDC process for years to come. Positively, this should encourage a level of international and domestic scrutiny on the quality of NDCs, and give rise to greater levels of government accountability in communicating national mitigation ambitions and facilitating emissions reduction outcomes.

The extent to which countries can control the emissions from their existing and future fossil assets in the post-2020 period will to a large degree determine whether a 2°C carbon budget can be preserved. Managing emissions from the power and industrial sectors, which generate about two-thirds of global energy-related $CO_2$ emissions, will be critical.[34]

## The Paris Agreement gives cause for government intervention to manage national emissions

The climate goals contained within the Paris Agreement should prove to be key mobilisers of national support for CCS and, depending on how the treaty is implemented, will largely determine the amount of support made available to encourage CCS projects in both developed and developing countries. The Paris Agreement itself is only 11 pages and 29 Articles long; but at least 10 Articles are of direct relevance to technology development and transfer, and so too for CCS.

[32] (International Energy Agency (IEA15), 2015) page 23
[33] (International Energy Agency (IEA15), 2015) page 12 (energy emissions grow 8 per cent over 2014 to 2030 = 0.48 per cent per annum)
[34] (Intergovernmental Panel on Climate Change (IPC07), 2007); (International Energy Agency (IEA151), 2015)

The core climate goal in Article 2, which adopts holding the increase in the global average temperature levels to 'well below' 2°C, defines in a legal sense what the Parties consider to be a dangerous threshold of climate change. A consequence of this is that CCS is securely positioned as a very important mitigation technology, given that the IPCC (and other global climate models) has shown that mitigation will only be cost-effectively delivered with an accelerated and scaled up deployment of CCS.[35]

The Paris Agreement strongly affirms both funding and technology as being key to its implementation. Specific reference is given in the Paris Agreement to the importance of the enhancement of sinks and reservoirs, and while this clearly includes forestry activities, the IPCC defines 'reservoirs' in the context of CCS as referring to a geological $CO_2$ storage location.[36] The Paris Agreement also establishes an intrinsic link between climate change action and sustainable development, and brings into relevance the UN's SDGs; especially SDG #7 which is "affordable and clean energy".

The Paris Agreement places importance on the co-benefits of mitigation. In this context, CCS can be a very cost-effective mitigation technology for non-$CO_2$ pollutants, including particulate matter (PM) and other air pollutants generated from fossil-based power generation and industrial sources. The application of CCS as a mitigation technology is often mistakenly presented as a trade-off between high $CO_2$ mitigation and sound socio-economic and environmental outcomes. Because high levels of $CO_2$ purity are required for storage purposes, CCS can deliver very favourable outcomes when used to control key atmospheric emissions such as nitrogen oxides (NOx), sulphur oxides (SOx), ammonia, PMs, mercury, hydrogen fluoride and hydrochloric acid, in parallel with mitigating $CO_2$.

**Air quality – an important co-benefit of CCS**

Depending on the type of $CO_2$ capture and conversion technologies applied, in addition to other installed pollution control measures for regulatory and/or operational requirements, there can be a significant reduction in conventional atmospheric pollutants. A 90 per cent reduction in sulphur oxide emissions can be achieved (through integrated Flue Gas Desulfurization), a reduction of over 70 per cent in nitrogen oxides emissions (from selective catalytic reduction), highly effective in removal of fly ash from electricity generation (electrostatic precipitators and fabric filters) which can be recycled for use in the construction industry; heavy metals (mercury) and particulate matter can also be effectively managed.

## Global climate agreement is to be given effect through national policies and regulations

The binding nature of the Paris Agreement on Parties to submit NDCs calls for ambitious mitigation and adaptation efforts to be articulated within. There is clearly a heavy reliance on technology development and transfer to implement the NDCs, especially given the requirement for successive NDC submissions to present a progression beyond the mitigation ambitions previously submitted (no backsliding of commitment and action).

Based on the adopted principle of 'common but differentiated responsibilities', the Paris Agreement states that developed countries are expected to take the lead by undertaking economy-wide emission reductions, while developing countries are encouraged to continue to enhance their mitigation efforts. Both of these expectations are capable of inspiring positive operational environments conducive to enabling CCS.

[35] (Intergovernmental Panel on Climate Change (IPC14), 2014) SPM Table SPM.2 page 15
[36] (Intergovernmental Panel on Climate Change (Int1), 2005) page 410 "Reservoir" is defined as "A subsurface body of rock with sufficient porosity and permeability to store and transmit fluids".

While the longer term commercial deployment and transfer of large-scale mitigation technologies like CCS can be supported through arrangements that place a financial value on emissions reductions, it is clear that, in the interim, additional and complementary policy settings are required to support their development and demonstration in the pre-2020 period.

## The UNFCCC recognises arrangements that place a value on emissions reduction and least-cost technology options as important considerations for national policymaking

A technology-neutral approach is important to creating incentives, regardless of whether they take the form of carbon pricing arrangements or other policy options, to support least-cost deployment of low-carbon technologies. The principle of 'policy parity' should also apply to the eligibility of all environmentally sound mitigation technologies under UNFCCC arrangements, mechanisms and programs, which should be implemented without favour or bias for any particular technology. This is particularly important for mitigation technologies that clearly have no substitutes, like CCS in major industrial applications (such as iron and steel production, among others) where renewable technologies cannot be applied to decarbonise those processes.

Parties resisted pressures from some stakeholders at COP 21 to establish a list of mitigation technology types, mostly related to fossil energy, to be excluded from being eligible to receive future UNFCCC support under the Paris Agreement. There was little to no consensus by Parties on either the need for, or merit of, limiting the availability of environmentally dependable mitigation technologies, as reflected in the decision text.[37]

**Carbon markets (Article 6 of the Paris Agreement)**

The Paris Agreement allows Parties to voluntarily use market and non-market approaches for the purpose of meeting pledges contained in their NDCs. This includes the establishment of a new market-based mechanism intended to support sustainable development outcomes. Whether the inclusion of this provision was aimed at complementing and/or superseding the CDM is yet to be fully understood. If designed and implemented well, these market-based arrangements can help to cost-effectively encourage and enable clean energy investments and sustainable development outcomes, and to efficiently allocate scarce funds to highly promising and prospective clean energy technologies, such as CCS.

In order to ensure CCS is not disadvantaged against other low-carbon technologies, it will be important that 'policy parity' exists across the portfolio of clean energy technologies to be deployed. Therefore, it is essential that any future recognition of emission-reduction units, referred to in the Paris Agreement as 'internationally transferred mitigation outcomes' (ITMOs), accept CCS mitigation as an eligible emissions offsetting and/or $CO_2$eq avoidance activity. This is critical for the delivery of the climate goals in terms of scale of mitigation and net-negative emissions outcomes required, as well as the facilitation of least-cost abatement in any and all carbon markets.

## Inaugural submission of national mitigation efforts indicate an insufficient but plausible way forward

The Paris Agreement introduces a new age of global urgency to undertake mitigation action, but the challenges are far more complex and urgent than is reflected in the current suite of INDCs.

While mitigation action in the pre-2020 period is critical, and this is largely addressed within the UNFCCC under the Kyoto Protocol and the Technical Examination Process, this period is arguably

[37] (United Nations Framework Convention on Climate Change (UNF1), 2015) COP 21 Decisions, page 10 paragraph 67(c)

more important for establishing the technological capacity of the post-2020 period to constrain emissions to within the global carbon budget consistent with 'well below' 2°C. Much more needs to be done in the next five years to progress those actions that must be in place (e.g. regulatory and infrastructure requirements) so that mitigation technologies such as CCS are ready to speedily deliver the necessary scale of abatement in the post-2020 period.

The IEA estimates that, to achieve a 450 ppm scenario, CCS will need to capture and store some 52 $GtCO_2eq$ between 2015 and 2040; with 60 per cent of this to be delivered in the power sector and 40 per cent in the industrial sector.[38] This scale of CCS mitigation will require global investment to grow from the few billion dollars already invested, to an average of between US$70 billion per year in the 2020s and US$110 billion per year in the 2030s.[39]

The inaugural INDC submission process reveals that only 10 of the 162 documents cite a strategic interest in CCS; these include China, Canada, Norway, Saudi Arabia and the UAE. These countries collectively account for about 30 per cent of global emissions. There are many other countries, potentially representing a further third of global emissions, that may be considered to have an 'inherent interest' in CCS but have chosen (perhaps to maintain technology neutrality) not to represent it in their INDCs.

## More needs to be done to acknowledge and support large-scale clean energy technologies like CCS

Looking forward, the Paris Agreement sets an expectation that Parties need to be able to demonstrate in their NDCs credible emissions reduction pathways. By acknowledging the importance of CCS in future NDCs, as well as in other communication vehicles like TNAs and Nationally Appropriate Mitigation Actions (NAMAs), Parties with an 'inherent interest' in CCS will more easily be recognised by the international community as taking seriously their mitigation obligations, as well as signalling opportunities for further international collaboration and financing on CCS technology development and projects.

## The deployment of renewables cannot decarbonise the energy sector in time

The world will continue to invest trillions of dollars in energy over the coming decade.[40] Without comprehensive and long-term policy support, business as usual investments will likely encourage an energy infrastructure that could lock in significant carbon emissions that are incompatible with the goals of the Paris Agreement. Appropriately designed and well implemented policies can encourage investments in clean energy and industrial solutions such as CCS.

The share of renewables in the power sector will continue to rise, with new capacity expected to mostly meet the growth in electricity demand; and so may do very little in the decades to come to displace the fossil fuel emissions entrenched in the energy system. It is also worth noting that only a small portion of the 'name plate' capacity of renewables can actually be relied upon to generate baseload power in the absence of power storage solutions.[41]

Adding to the mitigation challenge, especially in the power sector, is the fact that there is currently more than 1,800 GW of installed coal-fired power generation capacity globally.[42] China accounts for around half of these installations, with 900 GW of installed capacity; there is a further 200 GW

[38] (International Energy Agency (IEA15), 2015) page 105 Note that the IEA's estimate for CCS abatement is greater than the total annual global anthropogenic greenhouse gas emissions in 2010, which were estimated to be 49 (±4.5) $GtCO_2eq$
[39] (International Energy Agency (IEA15), 2015) page 116
[40] (Intergovernmental Panel on Climate Change (IPC142), 2014) page 110
[41] A capacity factor is the maximum rated output of a generator under specific conditions designated by the manufacturer, commonly expressed in megawatts (MW) and is usually indicated on a nameplate physically attached to the generator. See https://www.eia.gov/electricity/monthly/epm_table_grapher.cfm?t=epmt_6_07_b for US based renewable energy generation.
[42] (International Energy Agency (IEA15), 2015)

under construction and more than 400 GW in various stages of planning.[43] According to the IEA, some 1,000 GW of coal plants currently operating or under construction could still be operational in 2050.[44] If this coal fleet were to remain unabated to 2050, it could alone consume about 123 $GtCO_2$ of the remaining 1,100 $GtCO_2eq$ carbon budget.[45]

The IEA also identified significant opportunities to retrofit about 310 GW of China's existing coal fired power capacity with CCS, which could substantially reduce the emission intensity of its coal fleet.[46] Such actions can assist China in meeting its INDC ambition to lower emissions per unit of GDP by 60 to 65 per cent from 2005 levels by 2030.

The type of investment that takes place in new coal capacity in the coming decades will also have a profound impact on the global carbon budget, making CCS an even more important consideration for the international climate community and governments alike.[47]

## The global mitigation response cannot simply 'wish away' the emissions from fossil energy use

The IPCC's AR-5 states that the consumption of coal will continue to expand, and, without CCS, will remain the most emission-intensive of all fossil fuels.[48] It is unlikely that much of the existing global fleet of coal plants, especially those privately owned, will be voluntarily stranded in the absence of government policy and/or regulations as long as they are considered by their owners to be economically productive and/or continue to provide value-add to a fossil resource base.

It is estimated that combustion of remaining fossil fuel resources would release nearly 11,000 $GtCO_2eq$, with the combustion emissions of remaining reserves alone totalling nearly 2,900 $GtCO_2eq$.[49] Even if there were some sort of consensus from a climate perspective on the desirability of not consuming these resources, and there currently is not, it seems almost impossible to envisage any single nation or indeed decision-maker being in a position to be able to appropriately decide which of these resources and/or reserves should remain unused, let alone be able to give effect to such a decision.[50]

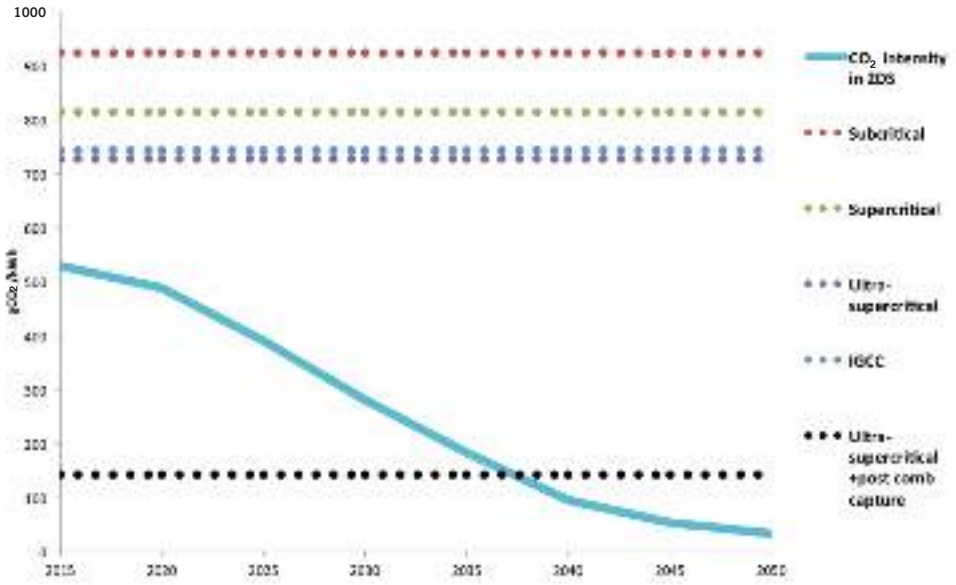
It is critical therefore that, rather than arguing for premature cessation of operation of coal plant assets that are still highly productive, consideration be given to encouraging the retrofit of such plants with CCS (to avoid point source emissions today) and encouraging already approved fossil fuel investment to consider being at least 'CCS ready'.[51] While it is plausible that investment decisions in new fossil-based (power) assets may be revisited and possibly withdrawn as a result of ever increasing carbon constraints, such decisions are unlikely to impact investments already made in plant under construction or approved, and so may be too late to safeguard the global carbon budget.

The global mitigation challenge is so challenging that simply encouraging fuel switching to unabated natural gas and/or adoption of best available coal technology will also prove insufficient in delivering the scale of emissions reductions needed, and could well lock in future emissions.

IEA analysis shows that, within a 2°C scenario, even a medium-term use of coal for power generation cannot rely on unabated technologies without CCS.

[43] (International Energy Agency (Intl16), 2016)
[44] (International Energy Agency (IEA151), 2015) page 41
[45] GCCSI calculation: 35 year period between 2015 to 2050 multiplied by 3.5 $GtCO_2eq$ per annum equals 122.5 $GtCO_2eq$
[46] (International Energy Agency (Intl16), 2016) page 5
[47] (Stern, 2006) page vi
[48] (Intergovernmental Panel on Climate Change (IPC141), 2014) page 119
[49] (McGlade & Ekins, 2015) page 188
[50] (Socolow, February 2016)
[51] A large-scale industrial facility or power source of $CO_2$ which could and is intended to be retrofitted with CCS technology when the necessary regulatory and economic drivers are in place.

**Figure 3** **Coal: 'High efficient-low GHG emissions'? Only with CCS!**




Source: *IEA*[52]

The IPCC notes that gas-fired power will need CCS given that its unabated lifecycle can, in the worst case, be close to the emissions from current coal technology.[53] The IEA suggests that a significant share of unabated coal-fired (and gas-fired) power plants, whether old or new, will need to have CCS retrofits at some time in the future or be retired.[54]

5

# POLICY PARITY FOR CCS IS IMPERATIVE IF CLIMATE GOALS ARE TO BE MET

## The Paris Agreement could be the last chance to meaningfully mitigate the global risks of climate change

The Paris Agreement will need to promote aggressive climate mitigation action in the post-2020 period by encouraging nations to increasingly limit their greenhouse gas emissions as pledged in current and future NDCs.

Many projections indicate that fossil energy use will remain both necessary and economic for decades to come in balancing growing energy demands, enabling the use of indigenous fossil resources, and by doing so ensuring energy security. Its continued use however will only be granted a social licence if it is considered to be environmentally sound. CCS is considered highly credentialed in this regard, as demonstrated by its acceptance in the CDM, the GCF and its explicit reference in the Kyoto Protocol.

The UNFCCC's facilitative dialogue in 2018, that will assess the implementation of the INDCs, will be informed by the findings of the IPCC's Special Report on 1.5°C warming. This Special Report, whose development is already underway, is expected to reaffirm and heighten the IPCC's AR-5 conclusions on the importance of CCS to achieving the climate goals adopted in the Paris Agreement.

[52] (Benoit, 2016)
[53] (Intergovernmental Panel on Climate Change (IPC141), 2014) Figure 7.6 page 539
[54] (International Energy Agency (IEA151), 2015) page 126

## CCS and the successful implementation of the Paris Agreement

The future success of the Paris Agreement to halt global temperature rises will, like its predecessors of the Convention and the Kyoto Protocol, continue to rely on the deployment of a broad portfolio of mitigation technologies that can collectively deliver sufficient and affordable emissions reductions. This in turn will rely on the extent to which the Paris Agreement can:

- Maintain inclusiveness: the extent to which it can continue to encourage timely and scalable mitigation outcomes amongst all nations, and by all actors, and across all sectors of the global economy; and
- Reduce uncertainty: its capacity to promote the development and implementation of appropriate national policies that can help mobilise a sufficient scale of investment, both public and private, in high-mitigation potential technologies in a non-discriminatory manner.

The IPCC's AR-5 indicates that CCS remains one of the single largest and most cost-effective mitigation options currently available for the industrial sector. Overall, without CCS, the cost of achieving 450 ppm $CO_2$eq concentrations by 2100 could be 138 per cent more costly (compared to scenarios that include CCS).[55] The extent to which fossil-dependent countries facilitate CCS-supportive policies may also be considered an indicator of the extent to which such governments are embracing least-cost, least-risk solutions to climate change.

## All governments acknowledge more must be done to reduce emissions over the short to medium term

Organisations such as the IEA and the IPCC have observed that more can and must be done to support the wide-scale deployment of CCS in the post-2020 period, as well as its pre-commercial demonstration (in certain applications) in the pre-2020 period.[56]

Widespread deployment of CCS will depend on the extent to which governments afford it 'policy parity' – namely, the provision of an equitable level of consideration, recognition and support for CCS alongside other low-carbon technologies. For CCS, this means the design and implementation of support measures appropriate to the technology and its lifecycle stage. Future effort should be addressed to identifying a suite of incentive mechanisms that tackle the complexity of risks and act as economic multipliers to improve the conditions of CCS market uptake.

The case study of renewable energy is instructive. Worldwide, around US$2.5 trillion has been invested in clean energy technologies in the last ten years, of which US$1.8 trillion has been spent on wind and solar technologies.[57] In comparison, large-scale CCS investments during the same timeframe amount to around US$20 billion, or less than one per cent of the investment in clean energy technologies.[58] In the past decade, governments have provided significant policy support to renewable generation sources through mandated energy targets[59] and other forms of subsidies, including feed-in tariffs for households. A success of these policies has been the rapid expansion of the photovoltaic (PV) industries in countries such as Germany and China, with significant reductions in the cost of PV production.

CCS mitigation is already institutionally recognised within the UNFCCC as an environmentally sound and sustainable development–friendly technology. Ensuring it can deploy at a rate that will see it reach its mitigation potential will help empower Parties dependent on fossil fuel-based economies to meet their current emissions reduction pledges, as well as help enhance future mitigation ambitions in an economically and socially responsible manner.

[55] (Intergovernmental Panel on Climate Change (IPC14), 2014) Table SPM.2 page 15
[56] (International Energy Agency (IEA151), 2015) page 11
[57] (Bloomberg New Energy Finance, 2016)
[58] (International Energy Agency, 2015) page 32
[59] For instance, a binding target of 20 per cent renewables in final energy consumption by the year 2020 in the European Union, to be achieved through the attainment of individual national targets.

## The UNFCCC must also step up to deliver more positive technology outcomes through the Paris Agreement

The UNFCCC has done little to date to either heighten the critical mitigation role of CCS amongst the international community or mobilise substantive financial resources to support its deployment at the project level.

The Paris Agreement must provide, at a minimum, an enduring platform in which Parties can consider the economic and mitigation potential of industrial-scale mitigation technologies like CCS. This will allow CCS to be invested in as a mainstream mitigation technology, on a par with the treatment currently afforded to technologies such as solar, wind and energy efficiency.

## Delaying mitigation action will serve only to increase the associated control and damage costs

A major finding of the Stern Review on *The Economics of Climate Change* is that "the costs of stabilising the climate are significant but manageable; and delay would be dangerous and much more costly".[60]

In the decade since the release of the *IPCC Special Report on Carbon Dioxide Capture and Storage* in 2005, CCS has been recognised as a major climate change mitigation option and included in all major global emissions reduction scenarios. There is no realistic medium-term least-cost carbon-constrained scenario where CCS does not play a critical mitigation role to:

- Help rapidly decarbonise the power and industrial sectors to meet the UNFCCC's climate goals;
- Remedy any future emissions overshoot of the 450 ppm concentration through the generation of negative emissions (such as BECCS); and
- Reduce the expected costs and adverse environmental impacts associated with delayed mitigation.

While there have been important CCS project advances since that time, the vital role attached to CCS in global models in the transition to a low-carbon economy has not translated broadly enough into policy support at national levels. The longer the wide-scale deployment of CCS is delayed, the greater will be the costs of mitigating climate change.

A key driver in accelerating CCS deployment is to strengthen the foundations for widespread deployment by providing an equitable level of consideration, recognition and support for CCS alongside other low-carbon technologies ('policy parity').

[60] (Stern, 2006) page vii

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