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Carbon Capture and Deep Decarbonization

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Countries across the globe have agreed to limit the global temperature increase from pre-industrial levels to below two degrees Celsius.[1] This requires extensive reductions in global greenhouse gas (GHG) emissions: 40 to 70% lower than 2010 levels by 2050, and near or below zero emissions by 2100. Recognizing this, in June the leaders of the G7 countries announced their commitment to decarbonize the global economy by the end of the century.[2]

Several decarbonization pathways to a two-degrees scenario have been studied by the International Energy Agency, the Intergovernmental Panel on Climate Change and other international organizations. All of these pathways have included a portfolio of solutions in terms of policies, institutions and technologies. The key components of these pathways include:

- **Improvements in efficiency and behavior changes**: These are essential to reduce the use of energy, to reduce the use of carbon-intense energy sources in the near term and to prevent "locking in" carbon-intensive infrastructure investments.
- **Increased energy supply from renewables and nuclear:**[3] Renewable energy technologies are already reaching a stage of technological maturity at which they can significantly expand their share of global power generation. In 2012, renewable energy accounted for just over half of the new electricity generating capacity added globally.[4] It will grow to over 26% of all generation by 2020.[5]
- **Carbon capture and storage (CCS) coupled with fossil fuels or bioenergy**: Fossil fuel energy will likely still be needed for electricity generation and some industrial processes. Extensive modelling work suggests that excluding CCS from the technology options will increase mitigation costs by 138%, and that CCS is a critical cost-effective technology in achieving the two-degree target.[6] Carbon capture can also play an important role in the lifecycle of large-scale energy generated from biomass.
- **Afforestation:** Agriculture, forestry and other land use accounts for about 25% of net GHG emissions.[7] Some of the most cost-effective mitigation measures in land use include afforestation — the establishment of new forests — as well as sustainable forest management and reduced deforestation.

[1] United Nations Framework Convention on Climate Change, "The Cancun Agreements," http://cancun.unfccc.int/cancun-agreements/main-objectives-of-the-agreements/#c33.

[2] Kate Connolly, "G7 leaders agree to phase out fossil fuel use by end of century," *The Guardian*, June 8, 2015. http://www.theguardian.com/world/2015/jun/08/g7-leaders-agree-phase-out-fossil-fuel-use-end-of-century

[3] There are several challenges with nuclear power, particularly public opposition, reactor accidents and spent fuel storage, that need to be addressed, as summarized by the US Environmental Protection Agency: http://www.epa.gov/cleanenergy/energy-and-you/affect/nuclear.html

[4] International Panel on Climate Change, "Summary for Policymakers," *Climate Change 2013: The Physical Science Basis*, Working Group I Report, 20. http://www.ipcc.ch/report/ar5/wg1/

[5] IEA, *Medium-Term Renewable Energy Market Report* (2015). https://www.iea.org/bookshop/708-Medium-Term_Renewable_Energy_Market_Report_2015

[6] International Panel on Climate Change, "Summary for Policymakers," *Climate Change 2014: Mitigation of Climate Change*, Working Group III Report. http://www.ipcc.ch/report/ar5/wg3/

[7] Ibid, 24.

The role of CCS in decarbonization

As noted above, CCS is one of a number of approaches that can help reduce GHG emissions on the scale required to combat dangerous climate change. It is critical that CCS be considered as part of a portfolio of solutions, and that adequate attention is paid to low-impact energy solutions — especially renewable energy and energy efficiency.

The challenge lies in managing the emissions from carbon-intensive legacy energy sources and from processes where emissions are essentially "locked in." CCS can play a valuable role in managing emissions from these assets, especially:

- **Industrial processes:** Oil and gas refining, as well as the production of fertilizers, steel, cement and petrochemicals are all fundamental to our current economy. However, production processes themselves produce significant GHGs (in addition to any secondary GHG emissions due to their intensive electricity consumption). Changes to industrial processes require game-changing technology with long lead time frames, and in many cases an alternative emission reduction is not yet available.
- **Electricity:** Renewables are growing at a fast rate, yet the scale of growth[8] in coal-powered plants in China and India, and the switch to natural gas in the United States,[9] present a serious GHG problem over the lifetime of these assets. Under normal economic conditions, it is likely these assets could operate for another 40 to 50 years. Equipping these assets with CCS may be a cost-effective option for dealing with continued GHG emissions.[10]
- **Bioenergy CCS:** CCS combined with sustainably-sourced biomass (bioenergy-CCS or BECCS) has the unique potential to be a net-negative emissions solution, as the carbon dioxide (CO_2) captured and sequestered is greater than the emissions from producing the biomass, including land use changes. This is therefore one of the few technology options for reducing the current high atmospheric levels of CO_2. At this point, the magnitude of possible reductions through BECCS is uncertain, with estimates ranging from three to more than 10 gigatonnes of CO_2 per year.[11]
- **Emerging economies:** CCS will be critically important in emerging economies, as a number of large developing nations are major carbon emitters, have large fossil fuel reserves and may be locking into economic and energy policies that virtually ensure the continued emission of CO_2 well into the future.

The scale of CCS deployment needed to decarbonize these industries is massive. The IEA, in its 450 Scenario, predicts capturing 52 Gt CO_2 from 2015 to 2040 in the electricity and industrial sectors. To put this number in perspective, the current capacity of the 13 existing large-scale CCS facilities is 28 Mt CO_2 per year — less than 1% of the IEA's 450 Scenario capture needs.[12]

The IPCC's scenarios, as shown in Figure 1, indicate the large proportion of emission reductions that CCS could contribute in the electricity sector. There are few pathways that can achieve a 450 parts-per-million scenario without CCS, and that those non-CCS pathways will cost 138% more while relying heavily on changes to agriculture and land use for emission reductions.

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[8] In its 2014 Medium-Term Coal Market Report, the IEA predicts global coal demand to grow at an average rate of 2.1% per year, reaching nine billion tonnes per year by 2019.

[9] The U.S. Energy Information Administration projects natural gas-fired generation to increase from 1,118 terawatt-hours in 2013 to 1,382 in 2020 as a result of the Clean Power Plan. EIA, *Analysis of the Impacts of the Clean Power Plan*, (2015), 30. http://www.eia.gov/analysis/requests/powerplants/cleanplan/

[10] IEA, *Energy and Climate Change,* 46.

[11] IPCC, *Climate Change 2014: Mitigation of Climate Change,* 485.

[12] 450 ppm is considered to be, on average, the concentration of CO_2 in the atmosphere that will give the world a fair chance at the two-degree scenario.

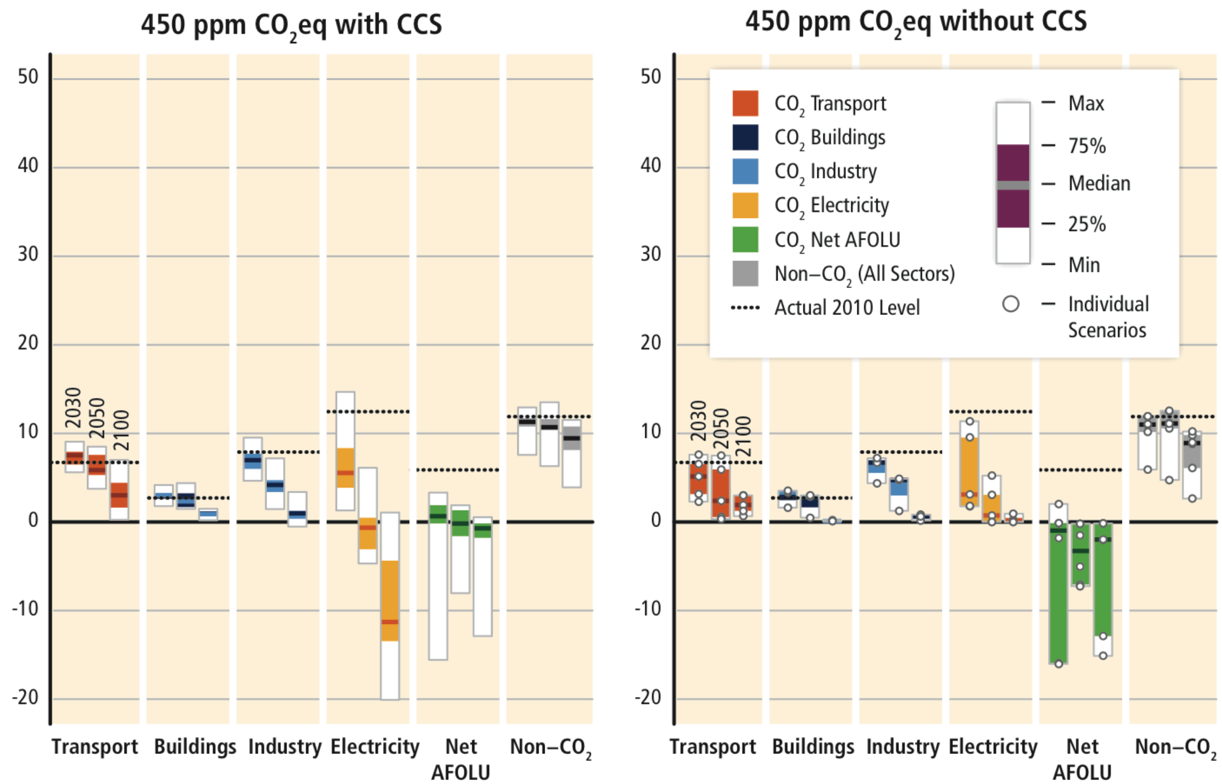

Figure 1. IPCC 450 ppm scenarios, showing direct emissions of CO_2e per year (Gt) in different sectors for the years 2030, 2050 and 2100

Source: IPCC[13]

The current state of CCS

The components of CCS technology have long been in use in different industries. But as a complete carbon capture and storage process, constructed on the back end of a combustion process, the technology is in the early stages of commercial rollout.[14]

With respect to the underground management of the stored CO_2, recent commercial-scale projects, research programs and other initiatives are building the level of understanding of the integrity of CO_2 wells, managing pressurized CO_2 within a geologic formation, as well as the risks and potential health and environmental impacts from CO_2 that migrates out of the primary injection zone.[15]

Public perceptions around CCS have included concerns over risk of leakage and a sense that CCS is being used to justify additional fossil fuel extraction, as well as a belief that CCS is difficult, expensive and unpopular. Building a clear case that CCS benefits the public — and not only its proponents — could create stronger support and understanding of CCS among policy makers, politicians and citizens.[16]

[13] IPCC, "Summary for Policymakers," *Climate Change 2014: Mitigation of Climate Change,* 18.

[14] Global CCS Institute, "Large Scale CCS Projects". http://www.globalccsinstitute.com/projects/large-scale-ccs-projects

[15] IPCC, "Summary for Policy Makers," *Climate Change 2014: Mitigation of Climate Change,* 21.

[16] Bart W. Terwel et al., "Going Beyond the properties of CO_2 capture and storage (CCS) technology: How trust in stakeholders affects public acceptance of CCS," *International Journal of Greenhouse Gas Control 5* (2011), 187-188

How to support CCS

Carbon pricing: CCS would be economically viable if the price on carbon was set high enough to account for the additional investment and operational costs of CCS compared to unabated facilities. A 2012 Climate Change and Emissions Management Corporation report estimated the cost of abatement using CCS at $75 to $200 per tonne.[17]

Direct and indirect investment by government: As early carbon prices will likely be too low to directly incent CCS, governments will need to continue to provide public support in the early stages of the development of CCS technology through direct and indirect investment. This includes capital grants, investment tax credits, credit guarantees and insurance.

Regulations for short-term and long-term responsibilities for storage: Our understanding of storage technology continues to increase as more projects come online. Clear regulations are needed to set out the responsibilities and liability for storage in the short and long terms. Clearly defining responsibilities for managing the stored CO_2 is also critical to gain further public support.

Performance targets: As an alternative to effective carbon pricing, emission reduction targets could also be legislated on a sector-by-sector basis. For example, in 2008 the Canadian government proposed a mandatory requirement for all oilsands projects and coal-fired power plants built in 2012 or later to use CCS or other equivalent technologies to drastically cut their carbon footprint.[18]

CCS considerations

While CCS should be part of decarbonization, a few considerations must be borne in mind when building policies for CCS:

- GHG emissions are not the only problem with fossil fuels. With fossil fuel use, we are tacitly accepting a trade-off between concentrated, portable energy and the significant impacts of extraction on the local environment (biodiversity, land, water and air).
- Financial support for the full portfolio of solutions needs to be balanced. It must create space to incent new technologies, overcome barriers to entry and drive down the costs of commercialization.
- It is widely recognized that the threat of climate change necessitates a more fundamental societal, economic and political shift in how we manage our resources and energy systems. Relying primarily on technological solutions such as CCS could prevent our society from addressing this more fundamental shift. We need to consider how sustainable development connects to the responsibility for future generations, and how to support innovation for new energy systems.

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[17] Climate Change and Emissions Management Corporation, *A Greenhouse Gas Reduction Roadmap for Oil Sands,* prepared by Suncor Energy and Jacobs Consultancy (2012), 4-20.

[18] Government of Canada, *Turning the Corner: Taking Action to Fight Climate Change* (2008), 3. http://publications.gc.ca/collections/collection_2009/ec/En88-2-2008E.pdf