An analysis of the Trump Administration's economic and policy arguments for withdrawal of the United States from the Paris Agreement on climate change

Bob Ward and Alex Bowen

Policy report

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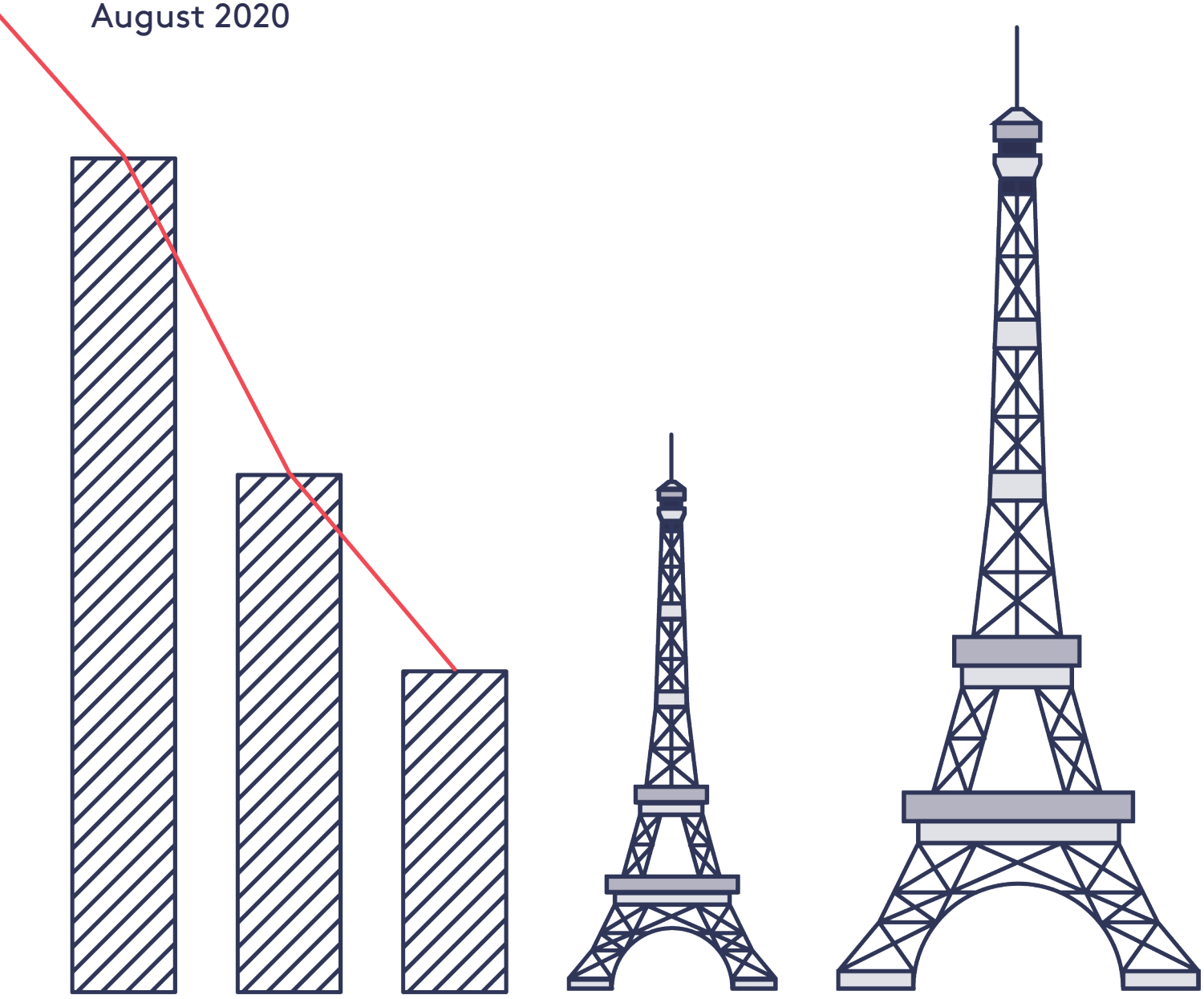

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About the authors

Bob Ward is Director of Policy and Communications at the Grantham Research Institute on Climate Change and the Environment.

Dr Alex Bowen is a Special Advisor at the Grantham Research Institute on Climate Change and the Environment.

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Contents

Executive summary

- The Trump Administration decided to end the participation of the United States in the 2015 Paris Agreement on climate change and started the formal process of withdrawal on 4 November 2019. The country's full withdrawal will become effective from 4 November 2020 unless the Administration relents. It is therefore a matter of urgency to assess whether that withdrawal is warranted so that the decision can be reviewed, either by the current Administration or, failing that, by whichever policymakers are responsible after the November presidential election. This report makes that assessment.
- The Administration has not provided any detailed analysis to support the decision to withdraw. The most substantive attempt at justification was made by President Trump during a speech in the Rose Garden of the White House on 1 June 2017. He relied on a consulting report and a newspaper article that were inaccurate or misleading, and he misrepresented the findings of researchers from the Massachusetts Institute of Technology. In that speech and since, President Trump's account of the Paris Agreement and the participation of the United States and other countries has been contentious.
- Examples of the Trump Administration's actions and inactions that have set back the United States' progress on combatting climate change include: changes made to estimates of the 'social cost of carbon' (SCC), which exaggerate the costs of action and downplay the benefits of regulatory measures to reduce carbon emissions; cancellation of measures to reduce greenhouse gas emissions proposed by the Obama Administration; and a lack of action in response to evidence about the growing risks to American lives and livelihoods from the impacts of climate change.
- The Trump Administration has redefined the SCC in a way that is inconsistent with the established methods of researchers and ignores the damage that emissions by the United States cause to other countries. It also uses an inappropriate discount rate, which places much less value on impacts that occur at the end of the century and beyond. The overall effect of these changes is to significantly downplay the real costs of climate change.
- The Administration abandoned the Clean Power Plan that was introduced by the Obama Administration and replaced it with the Affordable Clean Energy rule, which is expected to have a far weaker effect on emissions from the power sector.
- The Administration has ignored major assessments by experts about the impacts of climate change on the United States, including the *Fourth National Climate Assessment*, mandated by Congress, which warned of growing economic damage.
- Based on our assessment, we conclude that the decision by the Trump Administration to start the withdrawal of the United States from the Paris Agreement is irrational and does not promote the best interests of the American people.
- Even though no other country has followed the example set by the Trump Administration, there is a danger that other countries will be encouraged to lessen their climate actions as well. There should be stronger challenges to the decision, from within and outside the United States, including from the United Kingdom, which is due to co-host the COP26 United Nations climate change summit in November 2021.

1. Introduction

This report investigates whether the evidence supports the reasons given by the Trump Administration to justify its decision to withdraw the United States from the 2015 Paris Agreement on climate change.[1] The Administration has not published any formal analysis to support its decision, so this report examines the substantive public arguments on the issue made by the President and other members of his team, particularly his speech in the Rose Garden of the White House on 1 June 2017 and associated materials (e.g. The White House, 2017c, 2017d, 2017e).

On 4 November 2019, the Government of the United States of America submitted formal notification to the United Nations of its withdrawal from the Paris Agreement, a process that was to be completed in 12 months. In the accompanying press statement, the Secretary of State, Mike Pompeo, said: "As noted in his June 1, 2017, remarks, President Trump made the decision to withdraw from the Paris Agreement because of the unfair economic burden imposed on American workers, businesses, and taxpayers by U.S. pledges made under the Agreement." The statement added that the United States would continue to "work with our global partners to enhance resilience to the impacts of climate change and prepare for and respond to natural disasters", and "research, innovate, and grow our economy while reducing emissions and extending a helping hand to our friends and partners around the globe".

This report first dissects President Trump's speech, examining the sources he quoted from, and then goes on to discuss some important issues to which it did *not* refer, including the net benefits of the previous Administration's proposals for reducing emissions; the use of inappropriate estimates of the 'social cost of carbon'; the mounting evidence on the likely impacts of climate change on the American people; and the possible consequences of a US withdrawal from the Paris Agreement.

[1] See Appendix A for details of relevant Articles in the Paris Agreement.

2. Examination of the cited sources and content of President Trump's speech

President Trump explicitly mentioned two sources for figures mentioned in his speech of 1 June 2017 (The White House, 2017b). One was a report by NERA Economic Consulting, titled *Impacts of Greenhouse Gas Regulations On the Industrial Sector* (Bernstein et al., 2017). The other was a leading article published on the morning of the President's speech in *The Wall Street Journal* print edition under the headline "Paris Climate Discord". Further, the materials published by the White House to coincide with the speech referred to "an MIT [Massachusetts Institute of Technology] study". We examine the contents of these sources and the President's use of them below.

We then consider four particular issues highlighted in the President's speech and accompanying materials from the White House: re-negotiation of the Paris Agreement, the future of the energy industry in the United States, the Paris Agreement's application to China and India, and contributions by the United States to the Green Climate Fund.

The report by NERA Economic Consulting

The report explicitly cited by Trump by NERA Economic Consulting was published in March 2017. It was commissioned by the Center for Policy Research at the American Council for Capital Formation, and co-sponsored by the Institute for 21st Century Energy at the US Chamber of Commerce. The report had already been cited by other Republican politicians, such as Senators Ted Cruz and Rand Paul, in their attacks on action to reduce the risks of climate change to the American people. NERA itself issued a press release on 4 June 2017 after President Trump cited the report, stating: "Use of results from this analysis as estimates of the impact of the Paris Agreement alone mischaracterizes the purpose of NERA's analysis, which was to explore the challenges of achieving reductions from US industrial sectors over a longer term. Selective use of results from a single implementation scenario and a single year compounds the mischaracterization."

In his speech (The White House, 2017b), the President claimed that the report showed "[c]ompliance with the terms of the Paris Accord and the onerous energy restrictions it has placed on the United States could cost America as much as 2.7 million lost jobs by 2025". The President also attributed the following findings to the report:

- "440,000 fewer manufacturing jobs ... including automobile jobs, and the further decimation of vital American industries on which countless communities rely"
- "[B]y 2040, compliance with the commitments put into place by the previous administration would cut production for the following sectors: paper down 12 percent; cement down 23 percent; iron and steel down 38 percent; coal ... down 86 percent; natural gas down 31 percent"
- "The cost to the economy at this time [by 2040] would be close to $3 trillion in lost GDP and 6.5 million industrial jobs, while households would have $7,000 less income and, in many cases, much worse than that." (The White House, 2017b)

However, the NERA report made some extreme assumptions – about the scope for substituting clean technologies for carbon-intensive ones, the way that a cap-and-trade system would work, the benefits of action and the behaviour of other countries – that make these figures implausibly high.

The report is worth examining further. It suggested that "the total potential emissions reductions from existing policies together with planned policies announced by the Obama Administration are insufficient to achieve the NDC [nationally determined contribution] pledge and would fall dramatically short of the 2050 goal".[2] The report stated that "this study aims to estimate the costs and impacts of closing the Paris NDC gap under a number of different scenarios" – in other words, the

[2] See Appendix B for details of the United States' NDC to the Paris Agreement.

costs of going beyond the Obama Administration's specific policy proposals (even though this is not specifically mandated by the Paris Agreement).

In the report's words, its authors used a "top-down general equilibrium macroeconomic model of the U.S. economy and a detailed capacity-planning and dispatch model of the North American electricity system" to estimate costs in three-year increments between 2016 and 2040 to reduce annual emissions of the United States in line with its 'intended nationally determined contribution' (INDC) to the Paris Agreement and with the goal of reducing emissions by 80 per cent by 2050 compared with 2005.

The model simulated the economy of the United States simplified to five regions and 16 industrial sub-sectors, eight of which were manufacturing and another five of which were energy-related. It compared the model results for different scenarios with a 'baseline' scenario that assumed that the 2014 Clean Power Plan was not implemented, as described in the *Annual Energy Outlook 2016,* published by the US Energy Information Administration.

For the core scenario, the report estimated that the GDP of the United States would be 1 per cent (or US$250 billion in 2015 dollars) lower in 2025 than in the base scenario, and 9 per cent (US$2,900 billion) less in 2040, with an "average" level of carbon dioxide (CO_2) sequestration through land use, land-use change and forestry (LULUCF), as a result of achieving the targets set out in the INDC. President Trump cited the results for 2025 and 2040 for this core scenario with average sequestration levels.

Contestable assumptions underlying the report modelling

The limitations of the NERA report as a basis for justifying withdrawal from the Paris Agreement become obvious when the assumptions that were used in the modelling exercise are examined. Many of these assumptions were quite properly explicitly set out in the report. They include:

- Exclusion of all of the economic benefits from policies to reduce greenhouse gas emissions, such as the avoided damages from climate change and so-called co-benefits, including reductions in the harm caused by air pollution.
- The assumption that the United States is the only country that fulfils its INDC – taken as a reduction in annual emissions of 27 per cent by 2025 compared with 2005 – and that all other countries do not undertake their pledged emissions reductions, even though this affects calculations of the global competitiveness of sectors by the model.
- The assumption that existing and planned policies for different sectors of the economy of the United States were implemented within a nationwide cap and trade programme, but with no emissions-quota trading between broad sectors of the economy (defined as Industry, Transportation, Electric Power and Other).
- The assumption that emissions within the industrial sector would be reduced by 38 per cent by 2025 compared with 2005, and by 71 per cent by 2040, and that these reductions would be primarily achieved by high carbon prices, ranging from US$330 per tonne in 2025 to an average of US$540 per tonne between 2034 and 2040.
- The assumption that offsets from LULUCF would be used, assessed as either "average" or "high", but excluding the costs of sequestration.
- Exclusion of the costs of reducing all greenhouse gases except CO_2.
- The assumption that carbon capture and storage technology will not be available in the United States between 2016 and 2040.
- The assumption of no increase in the use of alternatives to fossil fuels in the transportation sector beyond baseline levels, and no growth in electric vehicles.
- The assumption of minimal changes in the future costs of existing technologies, such as wind and solar power, between 2016 and 2040.
- Ignoring the possible development of new technologies that might reduce the costs of decarbonisation.

These assumptions are highly contestable. For example, the NERA modelling exercise essentially assumed that no alternatives could further replace fossil fuels as a source of energy. If they could, that would allow sectors to maintain output levels while reducing emissions. Instead, the model forced emissions reductions to be generated primarily by falls in demand and output, driven by very high carbon prices. The falls in output reduced employment.

To estimate potential impacts on the workforce, the study calculated "job-equivalents", defined as "total labor income change divided by the average annual income per job". It stated: "In 2025, the manufacturing sector alone could potentially lose 440,000 job-equivalents relative to the baseline jobs and about 3.1 million in 2040." But it explicitly added the following clarification: "This does not represent a projection of the numbers of workers that may need to change jobs and/or be unemployed, as some or all of the loss in labor income could take the form of lower wages and be spread across workers who remain employed."

The report admitted that the assumption of a nationwide cap and trade system without any trading between industry sectors would create very high carbon prices. It pointed out that if instead trading between all sectors was assumed to be allowed, the carbon price required in the industrial sector would fall from US$330 per tonne of carbon-dioxide-equivalent (tCO_2e) to zero in 2025, and from an average of US$540 to US$150 per tCO_2e between 2034 and 2040. Similarly, in the transportation sector, the carbon price is zero in 2025, with or without trading, but reduces from an average of US$2,030 to US$150 per tCO_2e between 2034 and 2040. These lower carbon prices also mean smaller reductions in employment. For instance, the estimated fall in "job-equivalents" in the manufacturing sector by 2025 shrinks to 12,000, compared with 440,000 in the core scenario.

The elevated carbon prices assumed in the report are far in excess of expert estimates of what will be necessary to implement the Paris Agreement. For instance, a more detailed study by Chen and Hafstead (2016) concluded that a constant carbon tax of $21.22 (in 2013 dollars) across all sectors and beginning in 2017 could meet the 2025 target for the United States INDC with a present-value GDP loss of 0.26 per cent (relative to no carbon tax) from 2017 to 2025 (not including the benefits of avoided climate change impacts and co-benefits, such as a reduction in air pollution). The Report of the High-Level Commission on Carbon Prices, published in May 2017, concluded that the explicit international carbon-price level consistent with staying below the Paris global temperature change ceiling is at least US$40–80 per tCO_2e by 2020 and US$50–100 per tCO_2e by 2030, provided a supportive policy environment is in place.

Conclusion on the NERA report

Our conclusion is that the core scenario described in the NERA report, as cited by President Trump, was based on many extreme assumptions, most of which inflated the costs and economic consequences of reducing emissions while ignoring all benefits. These assumptions render the study largely useless as a guide to public policymakers on the potential economic costs of the United States meeting its INDC as part of a path to its 2050 emissions reduction target. Numerous experts (e.g. Kaufman et al., 2017; Yohe, 2017; Ward and Bowen, 2017) have pointed out clearly that the NERA study was severely misleading, but President Trump and his Administration apparently ignored them all.

The MIT study on the impact of the Paris Agreement on rising global temperature

In his speech on 1 June 2017, President Trump stated: "Even if the Paris Agreement were implemented in full, with total compliance from all nations, it is estimated it would only produce a two-tenths of one degree — think of that; this much — Celsius reduction in global temperature by the year 2100. Tiny, tiny amount" (The White House, 2017b). Although the President did not indicate the source of this estimate, the materials published by the White House to coincide with the speech referred to "an MIT study", and staff directed journalists to a short report by the MIT Joint Program on the Science and Policy of Global Change, *Energy & Climate Outlook: Perspectives from 2015* (Reilly et al., 2015), published in October of that year.

The MIT report does not substantiate the claims by President Trump and his staff. It used a climate model to attempt to calculate how global mean surface temperature might differ in 2100 as a result

of the INDCs that had been published by mid-August 2015 (countries had been expected to make indicative pledges on climate action in the run-up to the Paris session of the Conference of the Parties to the UNFCCC [COP21] at the end of 2015). The report stated: "Assuming the proposed cuts are extended through 2100 but not deepened further, they result in about 0.2°C less warming by the end of the century compared with our estimates, under similar assumptions, for Copenhagen [COP15] – Cancun [COP16]." However, it also noted: "It seems likely that countries that are proposing measures through 2025 or 2030 will not only maintain them beyond that time, but strengthen them further, and that countries currently doing little to control emissions will begin to do something" (Reilly et al., 2015).

Therefore, the MIT study's calculation of the impact of the INDCs, with pledges to limit or reduce annual emissions of greenhouse gases by 2025 or 2030, on temperature assumed no further cuts in emissions for the rest of the century. This would mean global mean temperature would be 3.7°C above its late 19th century average by 2100 instead of 3.9°C higher if the INDCs were not implemented. Contrary to President Trump's claim, it is clear that the MIT report had not calculated the impact of the Paris Agreement, the report having been published two months before the Paris negotiations which led to the adoption of the Agreement and its target of holding global temperatures to well below 2°C above its pre-industrial level.

Following President Trump's misrepresentation of its research, MIT issued a press release that described the material circulated by the White House as "misleading" and pointing out that its study "accounts only for countries' pledges under the Paris Agreement, assuming no further strengthening of the commitments in years after 2030". It added: "The Paris Agreement is a milestone of the ongoing UN Framework Convention on Climate Change, which is committed to ongoing annual meetings to regularly revisit and ratchet up nations' climate goals, making them more ambitious over time."

The *Wall Street Journal* article

President Trump said in his speech on 1 June 2017: "As the *Wall Street Journal* wrote this morning: 'The reality is that withdrawing is in America's economic interest and won't matter much to the climate'" (The White House, 2017b). He was quoting from the opening paragraph of a leading article, published, without a by-line, in the print edition of the newspaper on the day of his speech, under the headline "Paris Climate Discord".

There was much that was false in the article, including:

Claim in WSJ article	*Reality*
President Obama signed the Paris Agreement "in September 2016" [he actually signed it in April 2016] by "ducking the two-thirds majority vote in the Senate required under the Constitution for such national commitments"	Numerous legal scholars, including Bodansky (2016), have explained why President Obama could ratify the Agreement without a vote in the Senate.
"Germany's emissions have increased in the last two years as more coal is burned to compensate for reduced nuclear energy and unreliable solar and wind power"	Although overall greenhouse gas emissions from Germany increased between 2015 and 2016, this was primarily due to an increase in CO_2 emissions from transport. Emissions from the energy supply sector actually decreased (German Environment Agency, 2018) – and fell significantly in each of the three subsequent years (German Environment Agency, 2020).
"China won't even begin reducing emissions until 2030"	According to Friedlingstein et al. (2019), China's annual emissions of CO_2 fell in 2015 and 2016, and, although there were rises in the following two years, emissions were just 2.5 per cent higher in 2018 than 2014.

Claim in WSJ article	*Reality*
Achieving the 2025 emissions target contained in the INDC submitted by the Obama Administration "would require extreme changes in energy use"	According to Aldy et al. (2016), achieving the target in its INDC would reduce the GDP of the United States by only 0.39 per cent by 2025 (relative to what GDP would have been otherwise).
"The Big Con at the heart of Paris is that even its supporters concede that meeting all of its commitments won't prevent more than a 0.17 degree Celsius increase in global temperatures by 2100, far less than the two degrees that is supposedly needed to avert climate doom"	Although the article did not cite a source, it is likely to have been a paper by Bjorn Lomborg (2016), which has been thoroughly discredited because of its extreme assumptions, such as the complete abandonment of climate policies by major countries after they achieved their INDCs (Ward, 2016).
"It's also rich for Europeans to complain about the U.S. abdicating climate leadership after their regulators looked the other way as auto makers, notably Volkswagen, cheated on emissions tests"	The so-called 'dieselgate' scandal related to emissions of nitrogen oxides, which are important for local air pollution but not climate change, and among the companies found to be in violation by the US Environmental Protection Agency was the Italian-American manufacturer Fiat Chrysler.

It is clear that the article in *The Wall Street Journal* was an inaccurate and misleading source of information about the economic impacts of the Paris Agreement.

President Trump's assertions on re-negotiating the Paris Agreement

In his speech on 1 June 2017, President Trump said:

> "I am fighting every day for the great people of this country. Therefore, in order to fulfil my solemn duty to protect America and its citizens, the United States will withdraw from the Paris Climate Accord — [applause] — thank you, thank you — but begin negotiations to re-enter either the Paris Accord or a really entirely new transaction on terms that are fair to the United States, its businesses, its workers, its people, its taxpayers. So we're getting out. But we will start to negotiate, and we will see if we can make a deal that's fair. And if we can, that's great. And if we can't, that's fine."

This demonstrated apparent confusion by the President over the requirements of the Paris Agreement (key elements of which are presented in Appendix A). There is a distinction between signing up to – on the one hand – the collective aspiration in the Paris Agreement to limit global warming to less than 2°C, and to no more than 1.5°C if possible (benefiting the US), and – on the other – committing to particular initial US domestic-policy steps in the near term (incurring costs to the US).

The Paris Agreement itself does not mandate precisely how the burden of mitigation costs should be divided up among countries. Countries agreed in 2011 at the COP17 summit in Durban, South Africa, to work towards a "protocol, another legal instrument or an agreed outcome with legal force" for COP21 in 2015 (Paris). Many commentators have pointed out, both prior to (e.g. Stern, 2016) and since (e.g. Rajamani and Brunnée, 2017) President Trump's speech, that the US Government could have submitted a revised NDC with weaker targets for emissions reductions instead of withdrawing from the Paris Agreement. Although this would have contravened Article 4 of the Agreement, experts have argued that the specific commitments contained in the INDC submitted by the Obama Administration were not legally binding (e.g. Stavins, 2017; Ahmad et al., 2017).

In addition, it seems that President Trump had not approached any other countries about the possibility of re-negotiating the Paris Agreement in advance of his announcement. Nor has any re-negotiation taken place since the President's speech.

Inaccuracies in President Trump's statements on the future of the US energy industry

In his speech on 1 June 2017, President Trump stated:

> "We have among the most abundant energy reserves on the planet, sufficient to lift millions of America's poorest workers out of poverty. Yet, under this agreement, we are effectively putting these reserves under lock and key..." (The White House, 2017b).

This statement was inaccurate and misleading. The Paris Agreement does not specifically require any changes in the energy mix of individual countries – and it does not specify the phase-out of fossil fuels – but it does bind countries to achieve collectively net-zero emissions of greenhouse gases in the second half of this century. It is widely recognised that the consumption of fossil fuels could continue, in theory, if carbon capture and storage (CCS) technology is used to prevent CO_2 being emitted into the atmosphere. The United States is well positioned to exploit CCS (Beck, 2020) because of its experience of developing relevant technologies, such as enhanced oil recovery.

In recent years the United States has increased its domestic production of oil and gas, particularly from unconventional sources, through fracking. But President Trump's statement ignored the fact that its domestic energy reserves also include renewable sources such as wind and solar, which supply a rising proportion of energy. Between 2005 and 2019, the amount of primary energy supplied by coal more than halved and was overtaken by renewables – see Table 1.

Box 1. Timeline for the United States' involvement in the Paris Agreement

23 November 2013: US Government and other Parties agree at COP19 in Warsaw, Poland, to submit 'intended nationally determined contributions' (INDCs) to a new international agreement on climate change by March 2015.

12 November 2014: Joint announcement by President Obama and President Xi about post-2020 action on emissions by the United States and China.

31 March 2015: US Government submits its INDC to the UNFCCC.

12 December 2015: Paris Agreement adopted by Parties to the UNFCCC at COP21 in Paris, France.

22 April 2016: President Obama, among many other world leaders, signs the Paris Agreement in New York.

3 September 2016: US Government ratifies the Paris Agreement.

4 November 2016: Paris Agreement enters into force.

4 November 2016: US Government submits *United States Mid-Century Strategy for Deep Decarbonization* to the UNFCCC.

20 January 2017: Inauguration of Donald Trump as President of the United States of America.

1 June 2017: President Trump announces his intention to withdraw the United States from the Paris Agreement.

4 November 2019: US Government notifies the UN Secretary-General that it is initiating the process of withdrawal from the Paris Agreement.

4 November 2020: Scheduled completion of the withdrawal of the United States from the Paris Agreement.

Table 1. Primary energy consumption by source

Source	Percentage of energy supplied annually		
	2005	2019	2035
Petroleum	40.2	36.7	36.4
Natural gas	22.5	32.0	33.8
Coal	22.8	11.3	8.2
Nuclear electric	8.2	8.4	6.8
Renewables	6.2	11.4	14.8

Sources: US Energy Information Administration (2020a, 2020b)

President Trump also stated during his speech: "At 1 percent growth, renewable sources of energy can meet some of our domestic demand, but at 3 or 4 percent growth, which I expect, we need all forms of available American energy, or our country will be at grave risk of brownouts and blackouts, our businesses will come to a halt in many cases, and the American family will suffer the consequences in the form of lost jobs and a very diminished quality of life."

It is not clear to which energy measurements President Trump was referring, but the most up-to-date figures from the US Energy Information Administration (EIA) suggest he was incorrect anyway: in the case of annual primary energy consumption in the United States, it has fluctuated only a little over the past 20 years, with the total being only 1.5 per cent higher in 2019 than in 2000, despite GDP rising by around 45 per cent (US EIA, 2020a). The EIA's most recent projections show, for the reference case (i.e. based on current policies), that primary energy consumption is expected to fluctuate within 1 per cent of 2019 levels up to 2035, with renewable energy and natural gas both expanding further while coal and nuclear decrease (US EIA, 2020b). It should be noted that these projections assume current policies only, but nevertheless indicate that energy-related emissions of CO_2 from the United States would decline by 8.4 per cent between 2019 and 2035 (see Box 2 below).

Also, the President stated in his speech:

> "Further, while the current agreement effectively blocks the development of clean coal in America — which it does, and the mines are starting to open up ..., China will be allowed to build hundreds of additional coal plants. So we can't build the plants, but they can, according to this agreement. India will be allowed to double its coal production by 2020. Think of it: India can double their coal production. We're supposed to get rid of ours. Even Europe is allowed to continue construction of coal plants. In short, the agreement doesn't eliminate coal jobs, it just transfers those jobs out of America and the United States, and ships them to foreign countries."

These were inaccurate and misleading claims for many reasons. Here we look at coal in the United States, before examining the cases of China and India in more detail in the next subsection.

The Paris Agreement does not stop the development of coal or any other specific source of power in the United States or any other country. Coal consumption could, in principle, continue while reducing associated emissions of greenhouse gases, if power plants are equipped with CCS technology and emissions of methane are prevented. This would be consistent with cleaning up local air pollutants from coal burning as well.

However, the coal industry in the United States has been in decline for many years, primarily because it is now more expensive than other sources of power, such as natural gas and renewables (US EIA, 2020d). In 2019 the amount of electricity generated annually from coal decreased to its lowest level since 1976 (US EIA, 2020c). Coal-fired power stations have been closing and running for less time, as electricity generation from natural gas and wind, in particular, has steadily increased. As the US EIA notes: "Although coal at U.S. power plants has cost less than natural gas, for coal to be competitive, its delivered cost must be at least 30% lower to make up for the differences in efficiency between a typical coal-fired plant and a typical natural gas-fired plant" (ibid).

Annual production of coal by the United States peaked in 2008 and had fallen by 39.8 per cent by 2019. Over that period, US exports of coal increased by 13.9 per cent and imports dropped by 80.4 per cent, so poor trade performance does not seem to have been at the root of the production fall (US EIA, 2020c). Another recent analysis by the US EIA (2019) showed that employment in coal production peaked in 2011 but then declined until 2016 before roughly levelling off, so that in 2018 it was only 53,583, 42 per cent lower than seven years before.

In its most recent projections, the US EIA states:

> "The electricity generation mix continues to experience a rapid rate of change, with renewables the fastest-growing source of electricity generation through 2050 because of continuing declines in the capital costs for solar and wind that are supported by federal tax credits and higher state-level renewables targets. With slow load growth and increasing electricity production from renewables, U.S. coal-fired and nuclear electricity generation declines; most of

the decline occurs by the mid-2020s. ... The United States continues to be a net exporter of coal (including coal coke) through 2050 ... but coal exports remain at the same level because of competition from other global suppliers that are closer to major world consumers." (US EIA, 2020b)

Thus, the facts show that the real problem for US coal is its lack of competitiveness at home, not erosion of its export markets.

Box 2. Greenhouse gas emissions by the United States

The latest figures on the United States' emissions, published by the Environmental Protection Agency on 13 April 2020, indicate that in 2018 the country emitted 6,676.6 million tonnes of CO_2-equivalent and other greenhouse gases covered by the Kyoto Protocol (not including emissions from land use, land use change and forestry). This was 3.7 per cent higher than emissions in 1990, the baseline year used by the UNFCCC, but 9.7 per less than emissions in 2005, the baseline year used by the United States. The total in 2018 was also 2.3 per cent higher than in 2016, the last full year of the Obama Administration. According to the US Bureau of Economic Analysis, the real GDP of the United States increased 25.0 per cent between 2005 and 2018.

About 75 per cent of the US's greenhouse gas emissions in 2018 resulted from the release of CO_2 during the combustion of fossil fuels. According to the US Energy Information Administration, energy-related emissions of CO_2 were 5,130.5 million tonnes in 2019, which was 14.5 per cent less than in 2005, and 2.8 per cent less than in 2018 (US EIA, 2020a). The EIA's most recent projections indicate that, in its reference case scenario, these emissions would continue to fall until 2031 before rising again, such that by 2050 emissions are 16.8 per cent lower than in 2005 (US EIA, 2020b). The reference scenario assumes that coal-fired plants either invest in heat rate improvement technologies by 2025 or retire, to comply with the Affordable Clean Energy rule (see Section 3 of this report). In this scenario, energy-related emissions of CO_2 by the United States would be 21.1 per cent lower in 2025 than in 2005.

	Annual emissions of energy-related CO_2 by year					
	1990[a]	2005[a]	2019[a]	2025[b]	2030[b]	2050[b]
Million metric tonnes	5,039.9	5,999.2	5,130.5	4,732.6	4,673.9	4,921.9
% of 2005 emissions	84.0	100.0	85.5	78.9	77.9	82.0

Sources: (a) US EIA (2020a); (b) US EIA (2020b)

President Trump's assertions on the Paris Agreement's application to China and India

China

In his speech on 1 June 2017, President Trump claimed that the Paris Agreement did not require China to take any action on climate change until 2030. He stated that, "under the agreement, China will be able to increase these emissions by a staggering number of years — 13", and added: "They can do whatever they want for 13 years. Not us" (The White House, 2017b).

What are China's stated planned climate actions? China ratified the Paris Agreement on 3 September 2016 and submitted an NDC including the following commitments:

- To achieve the peaking of CO_2 emissions around 2030 and make best efforts to peak early.
- To lower CO_2 emissions per unit of GDP by 60 to 65 per cent from the 2005 level.
- To increase the share of non-fossil fuels in primary energy consumption to around 20 per cent.
- To increase the forest stock volume by around 4.5 billion cubic metres on the 2005 level.

Thus, although the INDC submitted by the Obama Administration was more ambitious than China's NDC, because it would have meant an absolute reduction in all greenhouse gas emissions, China is planning significant action up to 2030 to reduce emissions and it was false for President Trump to claim in his speech that China "can do whatever they want".

It should be noted that while China's total CO_2 emissions are the highest in the world, and rising, the latest figures from the Global Carbon Project show that US emissions of CO_2 per capita were more than twice China's in 2018, at 16.6 tonnes compared with 7.0 (Friedlingstein et al., 2019).

India

President Trump said in his speech that "India makes its participation contingent on receiving billions and billions and billions of dollars in foreign aid from developed countries."

India ratified the Paris Agreement on 2 October 2016. Its NDC includes the following commitments on climate change mitigation:

- To reduce the emissions intensity of its GDP by 33 to 35 per cent by 2030 from the 2005 level.
- To achieve about 40 per cent cumulative electric power installed capacity from non-fossil-fuel based energy resources by 2030 with the help of transfer of technology and low-cost international finance including from the Green Climate Fund (see next subsection for more on the Fund).
- To create an additional carbon sink of 2.5 to 3 billion tCO_2e through additional forest and tree cover by 2030.

India's INDC also stated: "The successful implementation of the INDC is contingent upon an ambitious global agreement including additional means of implementation to be provided by developed country parties, technology transfer and capacity building following Article 3.1 and 4.7 of the Convention." These Articles of the UNFCCC commit developed country Parties to provide support to developing countries by providing financial assistance for mitigation and adaptation ('climate finance') and technology transfer. However, the level of that support is not specified, so President Trump was wrong to claim that India's NDC is contingent on receiving "billions and billions and billions" in overseas aid. Estimates vary of what size of transfers would be fair and equitable in the light of developing countries' expected growth, income levels, current dependence on fossil fuels and mitigation opportunities (Bowen et al., 2015).

President Trump's assertions on US contributions to the Green Climate Fund

The Green Climate Fund was "established by 194 governments to limit or reduce greenhouse gas emissions in developing countries, and to help vulnerable societies adapt to the unavoidable impacts of climate change".[3]

During his speech on 1 June 2017, President Trump made a few claims about the Fund, first referring to it as "costing the United States a vast fortune". He went on to say:

> "Beyond the severe energy restrictions inflicted by the Paris Accord, it includes yet another scheme to redistribute wealth out of the United States through the so-called Green Climate Fund — nice name — which calls for developed countries to send $100 billion to developing countries all on top of America's existing and massive foreign aid payments. So we're going to be paying billions and billions and billions of dollars, and we're already way ahead of anybody else. Many of the other countries haven't spent anything, and many of them will never pay one dime.
>
> "The Green Fund would likely obligate the United States to commit potentially tens of billions of dollars of which the United States has already handed over $1 billion — nobody else is even close; most of them haven't even paid anything — including funds raided out of America's budget for the war against terrorism. That's where they came. Believe me, they didn't come from me. They came just before I came into office. Not good. And not good the way they took the money.
>
> "In 2015, the United Nations' departing top climate officials reportedly described the $100 billion per year as 'peanuts,' and stated that 'the $100 billion is the tail that wags the dog.' In 2015, the Green Climate Fund's executive director reportedly stated that estimated funding

[3] See www.greenclimate.fund/

> needed would increase to $450 billion per year after 2020. And nobody even knows where the money is going to. Nobody has been able to say, where is it going to?
>
> "Of course, the world's top polluters have no affirmative obligations under the Green Fund, which we terminated. America is $20 trillion in debt. Cash-strapped cities cannot hire enough police officers or fix vital infrastructure. Millions of our citizens are out of work. And yet, under the Paris Accord, billions of dollars that ought to be invested right here in America will be sent to the very countries that have taken our factories and our jobs away from us. So think of that." (The White House, 2017b)

This lengthy passage of the speech was riddled with inaccurate and misleading claims.

Parties to the UNFCCC agreed at COP16 in Cancún, Mexico, in December 2010 that developed countries should provide US$30 billion in "new and additional resources" in the period 2010 and 2012, and mobilise US$100 billion per year by 2020 from public and private sources to support action on climate change by developing countries. However, the level of financial support from public and private sources in each developed country, including the United States, was unspecified. The Parties also agreed to establish the Green Climate Fund to distribute some of this funding, governed by a Board of 24 members drawn equally from developed and developing countries. At present, the Board includes Mathew Haarsager, who is Deputy Assistant Secretary for International Development Finance and Policy at the United States Department of the Treasury.

In 2014, the Green Climate Fund carried out its 'initial resource mobilisation' and raised US$10.32 billion in pledges from 45 countries, three regions and one city, including nine developing countries. The United States made the biggest pledge, US$3 billion. However, as of 12 May 2020, just US$1 billion had been confirmed from the United States, and only US$8.24 billion overall. Other countries have given more than the US, including Japan (US$1.5 billion), the UK (US$1.2 billion), France (just over US$1 billion) (Green Climate Fund, 2020b). As President Trump pointed out in his speech, the national debt of the United States was about US$20 trillion in 2017. That has since increased, to about US$25 trillion in April 2020. The US$1 billion confirmed pledge by the United States to the Green Climate Fund equates to just 0.004 per cent of the current national debt.

After accounting for variations in exchanges rates, US$7.2 billion has been available for commitment during the period of the initial resource mobilisation. The Fund provides regular reports on how it is distributing its money. Between January 2015 and March 2020, it committed US$5.6 billion to support 129 projects in 108 countries and provided more than 370 capacity-building grants in 138 countries to governments and organisations (Green Climate Fund, 2020a). It has leveraged an additional US$14.1 billion in co-financing from the private sector, governments and other development investment funds.

The 'first replenishment period' for the Fund is being held between 2020 and 2023. As of 12 May 2020, 29 countries and one region (including two developing countries) had pledged US$9.8 billion, and US$3.41 billion had been confirmed (Green Climate Fund, 2020c). The pledges include US$1.85 billion from the UK, US$1.74 billion from France, US$1.69 billion from Germany and US$1.50 billion from Japan. The United States has not, so far, pledged any money to the Green Climate Fund during the Fund's first replenishment period.

The most recent analysis by the Organisation for Economic Co-operation and Development (2019) concluded that the total annual mobilisation of finance by developed countries reached US$71.2 billion in 2017, including US$56.7 billion from public sources. Article 9 of the Paris Agreement indicates that developed countries should provide at least US$100 billion per year after 2020. Hence a ramping-up of climate finance is expected but, again, the level of financial support from public and private sources in each developed country, including the United States, is unspecified.

According to recent figures published by the World Bank, the collective GDP of high-income countries reached US$54.2 trillion in 2018, so the US$100 billion annual commitment to climate finance equates to less than 0.2 per cent of that total. Given that cost-effective opportunities for reducing emissions (relative to projections in the counterfactual absence of climate change) are disproportionately high in developing countries, so that they will have to bear a disproportionately high share of the costs of mitigation, this can be regarded as a small price to pay to clinch a global deal on emissions reductions.

3. Pros and cons of the Clean Power Plan

President Trump's concerns about acting on climate change include the cost of the previous Administration's Clean Power Plan as the primary Federal tool to reduce carbon emissions. This section considers the pros and cons of that Plan.

Background to the Plan's development

In November 2009, the White House announced that President Obama intended to attend the 15th session of the Conference of the Parties to the UNFCCC (COP15) due to be held in Copenhagen, Denmark, a month later. The press statement indicated that "the President is prepared to put on the table a U.S. emissions reduction target in the range of 17% below 2005 levels in 2020 and ultimately in line with final U.S. energy and climate legislation" (Office of the Press Secretary, 2009). This target was consistent with one of the targets contained in the American Clean Energy and Security Act (usually called the Waxman-Markey bill after its primary sponsors), which was passed by the US House of Representatives on 26 June 2009. The Bill sought to introduce a federal emissions trading system. However, attempts to pass a similar bill in the US Senate were abandoned in 2010 (Meng, 2017).

In June 2013, The White House published *The President's Climate Action Plan*, which outlined measures that were intended to cut the annual emissions of the United States by at least 17 per cent by 2020 compared with 2005. This plan was accompanied by a Presidential Memorandum (Office of the Press Secretary, 2013) instructing the Environmental Protection Agency (EPA) to develop new emissions standards for both new and existing power plants. These standards were published two years later in the form of the Clean Power Plan. The Plan could be regarded as an imperfect substitute for the more comprehensive Federal cap-and-trade system and its attendant pervasive carbon price that had been proposed but stymied earlier. Nevertheless, the Plan passed cost-benefit tests.

How the Clean Power Plan was designed to reduce emissions

The Clean Power Plan was a key component of the measures through which the Obama Administration proposed achieving its INDC target of a reduction in annual greenhouse gas emissions by 26–28 per cent by 2025 compared with 2005. It was announced by President Obama and the EPA on 3 August 2015, about four months after the INDC had been submitted to the UNFCCC.

The Clean Power Plan sought to create national standards for emissions of CO_2 and local air pollutants from power plants, and proposed a Federal Plan and model rule to assist States in implementing the Clean Power Plan. It was announced alongside finalised Carbon Pollution Standards for new, modified, and reconstructed power plants. The Obama Administration indicated that the Clean Power Plan would reduce emissions of CO_2 from power plants by 32 per cent, or 790 million tonnes, compared with 2005 by the time of its intended full implementation in 2030. The Plan would also reduce annual emissions of sulphur dioxide from power plants to 90 per cent below 2005 levels, and emissions of nitrogen oxides to 72 per cent below.

The Clean Power Plan was based on section 111(d) of the Clean Air Act, through which the EPA could determine the 'best system of emissions reduction' (BSER) that had been demonstrated for a particular pollutant, including CO_2, and a particular group of sources. In the final version of the Clean Power Plan, that BSER consisted of three building blocks (US EPA, 2015a):

- **Building Block 1:** Reducing the carbon intensity of electricity generation by improving the heat rate of existing coal-fired power plants.
- **Building Block 2:** Substituting increased electricity generation from existing natural gas plants for coal-fired power plants – gas-fired power plants emit about half as much CO_2 per unit of electricity generated as coal-fired power plants.
- **Building Block 3:** Substituting increased electricity generation from new renewable energy sources (like wind and solar) for existing coal-fired power plants.

The EPA considered the ranges of emissions cuts that could be implemented by coal, oil and gas plants "at a reasonable cost" through each building block, taking into account how quickly and to what extent the measures could be used to reduce emissions.

The Plan would have required States to develop and implement plans that ensured the power plants achieved interim performance rates for CO_2 emissions (measured in pounds per megawatt-hour) between 2022 and 2029, and final performance rates by 2030. States could also cooperate to achieve performance rates through emissions trading. The Plan would also have established mass-based state-wide CO_2 emission performance goals (measured in short tons) for each state.

Compliance costs of the Plan

The EPA published the *Regulatory Impact Assessment* for the Clean Power Plan Final Rule in August 2015 (US EPA, 2015b). It showed the expected annual incremental compliance cost for the rate-based approach for final emission guidelines to be US$2.5 billion in 2020, US$1.0 billion in 2025 and US$8.4 billion in 2030, including the costs associated with monitoring, reporting, and recordkeeping. The equivalent costs for the mass-based approach were calculated to be US$1.4 billion in 2020, US$3.0 billion in 2025 and US$5.1 billion in 2030.

Environmental, health and economic benefits of the Plan

The EPA's *Regulatory Impact Assessment* also estimated the benefits of the Clean Power Plan, both in terms of avoided climate change impacts and improvements in air quality. When these were taken into account alongside the compliance costs, the net monetised benefits of the rate-based approach were calculated to be US$1.0–2.1 billion in 2020, US$17–27 billion in 2025, and US$26–45 billion in 2030 (assuming a 3 per cent annual discount rate and values of the social cost of carbon determined by the Interagency Working Group on Social Cost of Carbon [2015]). The equivalent net benefits for the mass-based approach were estimated to be US$3.9–6.7 billion in 2020, US$16–26 billion in 2025, and US$26–43 billion in 2030. The assessment found that the Plan would have significant health benefits, such as 3,600 fewer premature deaths each year, and 300,000 fewer missed work and school days annually. The Assessment also explicitly identified additional non-monetised benefits of the Clean Power Plan, including ecosystem benefits associated with reductions in emissions of nitrogen oxides, sulphur dioxide, particulate matter and mercury.

An independent analysis by Schmalensee and Stavins (2019) calculated that the Plan would create net domestic benefits of US$39 billion in 2030, the majority of which would derive from the avoided impacts of local air pollution.

The demise of the Clean Power Plan and substitution with the Affordable Clean Energy rule

States were due to submit final plans by 6 September 2016. However, on 9 February 2016, the United States Supreme Court issued a stay on the implementation of the Clean Power Plan, ruling that it could not proceed until all legal challenges to it by a number of States and industry groups had been heard (Scobie, 2016).

In October 2017, the EPA under the Trump Administration announced that it proposed to repeal the Clean Power Plan, and on 21 August 2018, the Agency announced that it intended to replace the Plan with a new Affordable Clean Energy rule, which was issued in final form on 19 June 2019. The Agency estimated that the new rule would reduce annual emissions of CO_2 from power plants by about 10 million tonnes by 2030, and that this would result in "combined domestic climate benefits and ancillary health co-benefits of $570 million to $1.3 billion at a 3 percent discount rate, and $470 million to $1.1 billion at a 7 percent discount rate" (US EPA, 2019a). This calculation was carried out using the Trump Administration's inaccurate and misleading under-estimate of the social cost of carbon (see next section). The Agency also suggested that, when combined with "industry trends", the reduction in annual emissions could be as much as 35 per cent by 2030.

The projections published by the US Energy Information Administration in September 2016 assumed that the Clean Power Plan would be implemented and that energy-related emissions of CO_2 by the United States would be reduced by 14.7 and 17.3 per cent in 2025 and 2030, respectively, compared

with 2005. Analysis by Climate Action Tracker (2019) concluded that emissions from the power sector were likely to fall by more than the target of 32 per cent by 2030 included in the Clean Power Plan, in part because of the decline in the use of coal. This illustrates that reductions of this order of magnitude need not be costly. Also, had the Clean Power Plan been implemented, the associated fall in emissions would have been greater than expected.

4. The role of the 'social cost of carbon' in the Trump Administration's decision-making

Although President Trump and his Administration have never publicly linked the 'social cost of carbon' to the decision to withdraw from the Paris Agreement, the changes made to the definition and use of this technical term have had a significant impact on the regulatory impact assessment of domestic measures that would have allowed the United States to achieve its NDC. So why is the social cost of carbon important?

Each tonne of CO_2 produced by economic activities and allowed to escape into the atmosphere contributes to climate change and the impacts associated with it. Policymakers need to account for this in their assessments of the costs and benefits of government regulations, because regulations may alter greenhouse gas emissions in the economy. One way of doing this is to put a price on carbon emissions set equal to the 'social cost of carbon' (SCC).

The SCC is measured as the net present value of current and future climate change impacts caused by one additional tonne (metric ton) of CO_2 emitted into the atmosphere today.[4] The SCC depends on what is expected to happen to total cumulative emissions in the future, which cannot be known for sure; it depends in part on how much global action to mitigate climate change is taken.

One way of costing greenhouse gas emissions other than CO_2 is by multiplying any price set for the emission of a tonne of CO_2 by the relevant gas's Global Warming Potential (GWP, a measure of how much heat the gas traps in the atmosphere up to a specific time horizon – often 100 years), relative to CO_2.

This approach is consistent with federal government practice. The Government of the United States has used cost-benefit analysis (CBA) in regulatory assessment since the Reagan administration and President Clinton's Executive Order 12866 (September 1993) requires CBA for any new federal regulation that is "economically significant". Following court action in 2007, the US Government has been obliged to take the impacts of regulations on greenhouse gas emissions into account. In 2010, the Government established its first estimates of the SCC for government-wide use (Interagency Working Group on the Social Cost of Carbon, 2010).

Questions and complexities in setting the social cost of carbon

Calculating a social cost of carbon is not easy and has provoked much discussion in the economics profession (see, inter alia, Ackerman and Stanton, 2012; Anthoff and Tol, 2010; Dietz, 2012; Greenstone et al., 2013; Kotchen, 2018; Nordhaus, 2014; Weitzman, 2013). It is not surprising, therefore, that there has been debate among policymakers about the right way to set the SCC to be used in regulatory analysis. The question is whether the Trump Administration has moved the debate forward.

Issues include:

- How should the value of future impacts be discounted?
- How should uncertainty about the future (including the future path of emissions themselves) be addressed?
- How should impacts without an obvious market valuation be assessed?
- Where market valuations are feasible, how will relative prices change over time?
- Should global impacts or only those within the country in which the regulation is being evaluated be assessed? (In Kotchen's terminology, should a global SCC or a domestic SCC be used?)
- Should income levels, risk aversion, mitigation opportunities and expected economic growth rates affect the assessment of the SCC within a particular country? If so, how are different

[4] Note that the SCC is sometimes instead taken to refer to the impacts of one tonne of the carbon embodied in the CO_2, so confusion can arise in this literature; one tonne of CO_2 contains about 27.3 per cent carbon by mass.

countries' preferences for the global SCC to be reconciled in order to ensure that governments around the world are acting consistently with a common global emissions reduction target?

In one respect, though, costing carbon emissions is an easier economic problem to tackle analytically than many other environmental challenges, where the consequences are heavily dependent on local circumstances. Greenhouse gases mix rapidly with other gases in the atmosphere and most remain in the atmosphere for a long time. As a result, a tonne of CO_2 emitted today will have practically the same impact on climate change whether it originates in New York, London or Hong Kong. Whatever the costs are – the difficult question – they are the same, no matter where the greenhouse gases are emitted.

Some of these complexities of calculating an appropriate SCC have been reflected in the evolution of expert advice to the US Government (e.g. Kopp and Mignone, 2012) and informed the work of the Interagency Working Group on the Social Cost of Carbon (e.g. in its *Technical Update of the Social Cost of Carbon for Regulatory Impact Analysis* in 2013). In 2016, the Group invited guidance from the US Academies of Sciences, Engineering, and Medicine on how best to improve, refine, and update their modelling process. In 2017, the Academies published a comprehensive report identifying research priorities to ensure that SCC estimates remained grounded in the best available science and economics (National Academies of Sciences, Engineering, and Medicine, 2017).

The Trump Administration and the social cost of carbon

As described above, a sensible framework for taking account of climate change in regulatory assessments had emerged by 2017, reflecting a strong degree of scientific consensus but also showing itself capable of reviewing, learning and revising advice to government in line with advances in science and economics. What has happened since, under the Trump Administration?

In the first year of his Presidency, President Trump signed Executive Order 13783 (The White House, 2017a), which, among other actions, disbanded the Interagency Working Group on the Social Cost of Carbon and stated that the estimates generated by the Interagency Working Group were not representative of government policy (Rennert and Kingdon, 2019). This executive order also removed the requirement for individual government agencies to employ a harmonised set of SCC estimates in their regulatory analyses. In addition, the head of the EPA reiterated in 2018 the Trump Administration's position that ancillary benefits ('co-benefits' such as reduced air particulate pollution) are not to be counted in cost-benefit analysis of major rules.

In practice, as Rennert and Kingdon point out, rules proposed by a number of agencies after the issuance of Executive Order 13783 have relied on a set of interim estimates based on the same method and infrastructure used by the Interagency Working Group, but with two major modifications: calculating only damages occurring within the United States, and employing discount rates of 3 per cent and 7 per cent in the analysis of regulations (instead of 2.5 per cent, 3 per cent, and 5 per cent). Both adjustments substantially reduce estimates of the SCC, thus favouring new regulations that bring about smaller emissions reductions than otherwise. Economists have pointed out, for example, how this has weakened proposed regulation for tailpipe emissions from passenger cars and light trucks (the SAFE Vehicle Rule proposed in August 2018), and the Affordable Clean Energy Rule put forward to replace the Obama Administration's Clean Power Program (see previous section and Cropper et al., 2018, and Krupick et al., 2018).

The impact of such changes can be seen in Table 2 below. Using a discount rate of 7 per cent instead of 3 per cent (the old middle assumption for the discount rate) reduces the estimate of the global SCC by a factor of 10. Assessing direct domestic impacts only, not global impacts, reduces the old 'middle' estimate of the SCC by a factor of more than 7.

Table 2. Effects of different discount rates on estimates of the social cost of carbon (SCC)

Discount rate (%)	Global SCC (US$ per tCO_2e)	Domestic (US) SCC (US$ per tCO_2e)
2.5	75	10
3.0	50	7
5.0	14	2
7.0	5	1

Source: Rennert and Kingdon (2019)

The importance of co-benefits is illustrated by Table 3, where the health co-benefits of cutting emissions (in this case, via the Obama Clean Power Plan Rule) are seen to be large compared with the direct climate change benefits (94 per cent of the domestic benefits of the proposed rule were from health impacts of reducing correlated local air pollutants).

Table 3. Estimated benefits and costs of the proposed Clean Power Plan Rule in 2030

	Climate change impacts		Health impacts (co-benefits) of correlated pollutants plus...	
	Domestic (US$ bn)	Global (US$ bn)	Domestic (US) impacts (US$ bn)	Global climate impacts (US$ bn)
Climate change benefits	3	31	3	31
Health co-benefits			45	45
Total benefits	3	31	48	76
Total compliance costs	9	9	9	9
Net benefits	-6	22	39	67

Source: Schmalensee and Stavins (2019), based on the mid-point estimates of the Regulatory Impact Analysis by the US EPA

There is little justification for any of the changes made by the Trump Administration.

First, focusing on direct domestic US benefits alone when assessing emissions reductions by US firms and households ignores the global nature of the human-induced climate-change problem. As Cropper et al. (2018) point out, "If all countries considered only the domestic effects of their greenhouse gas emissions, about 86 per cent of climate change impacts on US citizens would be ignored" because no one outside the country would be factoring in the impact of their actions on the United States' climate. Kotchen (2018) discusses the game-theoretic issues involved in a continuing process of international negotiation and how these push countries towards choosing a global, not merely domestic, SCC. Even if a narrow US-centric view were to be maintained, the approach would fail to take account of how climate change impacts on other countries could affect the US (through channels such as lower productivity growth in US trading partners and enforced migration in response to climate disasters).

Second, the introduction of a discount rate of 7.5 per cent is inconsistent with the discount rates used in the models used in the past to estimate the net present value of climate change costs and therefore the SCC itself. Although it is consistent with the pre-tax rate of return on private capital recommended by the US Office of Management and Budget for use in evaluating investment returns, that rate is inappropriate in discounting future consumption in models that assess costs and benefits in terms of net effects on consumption over time (on the principle that people ultimately benefit directly from consumption, not investment, which is simply a means to produce goods and services for consumption). Indeed, it has been argued that the evidence supports a rate of at most 2 per cent as

the norm for the consumption rate of discount, given historical trends and expected future conditions – a *lower* discount rate than the lowest used in the Obama era (Council of Economic Advisers, 2017).

Third, ignoring co-benefits makes no sense given that they are systematically related to the specific objective of a regulation such as the reduction of carbon emissions (nor should ancillary 'disbenefits' be ignored, if they exist). As Krupnick (2018) wrote: "...all benefits and costs of a rule should be considered, based both on principles of welfare analysis and on previous case law. Just because the stated purpose of a rule is to reduce CO_2 does not give license to ignore other impacts that occur. As an illustration, environmental rules are not issued to change employment, but are written to protect public health and the environment, making the employment impacts ancillary. Yet any policymaker certainly wants these ancillary impacts on jobs to be considered, including not only employment impacts but also the ancillary health damages that occur from employment loss." And, as Table 3 makes clear, the potential health co-benefits of emissions reductions for the United States are very large. Ideally, regulatory decisions about emissions and particulate pollution would be taken in a coordinated fashion, optimising the setting of policy tools by taking into account the interrelationship of the processes generating each phenomenon. But the second-best solution is not to ignore the interrelationship entirely, as the EPA now appears to do.

Conclusions on the Trump Administration's estimation and use of the social cost of carbon

The Trump Administration has destroyed a sensible procedure for estimating the social cost of carbon and dealing with scientific and economic advances; removed coherent guidance for regulatory assessments of measures affecting carbon emissions; ignored arguments for a global perspective on a global problem, leading to an excessively narrow view of US domestic costs of emissions; encouraged the use of an excessively high discount rate in assessing future benefits of emissions reductions; and promoted the fallacious idea that ancillary benefits of regulations should be ignored.

5. The economic impacts of climate change on the United States

While President Trump and his Administration have frequently cited economic concerns to justify the decision to withdraw from the Paris Agreement, they appear to have completely ignored the direct and indirect economic impacts of climate change on the United States.

Evidence presented in the *Fourth National Climate Assessment*, 2018

Volume II of the *Fourth National Climate Assessment* includes a detailed review of the evidence about the economic impacts of climate change on the United States. It was published on 23 November 2018, but ignored by the Trump Administration, even though it was prepared by some of the best researchers in the United States and mandated by the Global Change Research Act of 1990, which requires that the US Global Change Research Program delivers a comprehensive report to Congress and the President no less than every four years.

The *Assessment* warned:

> "Without substantial and sustained global mitigation and regional adaptation efforts, climate change is expected to cause growing losses to American infrastructure and property and impede the rate of economic growth over this century." (US Global Change Research Program, 2018)

Among the key economic impacts the *Assessment* highlighted were:

- Rising temperatures, sea level rise, and changes in extreme events are expected to "increasingly disrupt and damage critical infrastructure and property, labour productivity, and the vitality of our communities".
- Regional economies and industries that are dependent on natural resources and favourable climate conditions, such as agriculture, tourism, and fisheries, are vulnerable to the growing impacts of climate change.
- Rising temperatures are projected to reduce the efficiency of electricity generation and increase energy demands, resulting in higher electricity costs.
- The impacts of climate change beyond the borders of the United States are expected to increasingly affect its trade and the economy, including import and export prices and American businesses with overseas operations and supply chains.
- Some aspects of the economy of the United States may see slight improvements in the short term in a modestly warmer world, but continued warming that is projected to occur without cuts in global emissions of greenhouses gases is expected to cause substantial net economic damage throughout this century, especially in the absence of increased adaptation efforts.
- With continued growth in emissions, annual losses in some economic sectors are projected to reach hundreds of billions of dollars by the end of this century – more than the current GDP of many US States.

The *Assessment* concluded that:

> "...the evidence of human-caused climate change is overwhelming and continues to strengthen, that the impacts of climate change are intensifying across the country, and that climate-related threats to Americans' physical, social and economic well-being are rising ... These impacts are projected to intensify – but how much they intensify will depend on actions taken to reduce global greenhouse gas emissions and to adapt to the risks from climate change now and in the coming decades."

When President Trump was asked by a journalist about the *Assessment* on 26 November 2018, three days after its publication, he initially said that he had "read some of it, and it's fine" (The White House, 2018). But when challenged about its findings on the potentially devastating economic impacts of climate change on the United States, Mr Trump said "I don't believe it." He did not offer any reasons.

Sources and scenarios used by the *Fourth National Climate Assessment*

The *Assessment*'s estimates of the impacts of future climate change drew on an analysis by the US EPA (2017), which used two scenarios that were developed for the *Fifth Assessment Report* of the Intergovernmental Panel on Climate Change (IPCC). These scenarios were based on two "representative concentration pathways" or RCPs, named RCP4.5 and RCP 8.5, which the *Fourth National Climate Assessment* equated with a "low warming" and "high warming". It should be noted that neither of these pathways is consistent with the goal of the Paris Agreement of holding warming to well below 2°C above pre-industrial average temperatures.

RCP4.5 was estimated by the IPCC (2013), based on the fifth phase of the Coupled Model Intercomparison Project (CMIP5), to result in a global mean surface temperature that would be:

- 2.0°C (1.5–2.6°C with at least 66 per cent probability) higher in 2046–2065, and
- 2.4°C (1.7–3.2°C with at least 66 per cent probability) higher in 2081–2100.

RCP8.5 would result in a global mean surface temperature that is:

- 2.6°C (2.0–3.2°C with at least 66 per cent probability) higher in 2046–2065, and
- 4.3°C (3.2–5.4°C with at least 66 per cent probability) higher in 2081–2100.

Unfortunately, the *Fourth National Climate Assessment* did not use RCP2.6, which *is* consistent with the temperature goal of the Paris Agreement. The most recent assessment of both conditional and unconditional NDCs, if they are fully implemented, is that they offer a 66 per cent chance of limiting warming to 3.0°C by 2100 compared with the pre-industrial average (United Nations Environment Programme, 2019).

The Assessment used statistical downscaling for the United States of the global climate models in the Fifth Phase of the Coupled Model Intercomparison Project (CMIP5) (US EPA, 2017) to assess the probable impacts on several aspects of the economy, some of which are presented in Table 4. The authors of the *Fourth National Climate Assessment* noted that these are likely to be under-estimates as they do not take into account all economic risks, such as rapid destabilisation of the major land-based ice sheets in Greenland or West Antarctica, which would lead to a further acceleration of global sea level rise.

Table 4. Summary of selected economic impacts of climate change on the United States

Impact	Annual cost in 2050 (undiscounted 2015 US$ bn)		Annual cost in 2100 (undiscounted 2015 US$ bn)	
	RCP4.5	RCP8.5	RCP4.5	RCP8.5
Extreme temperature mortality	21.0–48.0	28.0–73.0	37.0–110.0	82.0–200.0
Reduced labour productivity	19.0–56.0	25.0–70.0	52.0–120.0	87.0–220.0
Damage to roads	2.7–16.0	2.8–23.0	3.3–20.0	7.0–37.0
Damage to urban drainage	3.5–4.9	2.1–4.6	2.9–5.9	3.3–7.0
Damage to coastal property	69.0	75.0	92.0	120.0
Inland flooding	4.3	5.1	4.3	8.1
Reduced water quality	1.5	1.9	3.0	4.6

Source: United States Environmental Protection Agency (2017)

Other voices in support of the *Fourth National Climate Assessment* findings and calls for planning

Other organisations have also highlighted the economic impacts of climate change that were identified by the *Fourth National Climate Assessment*. For instance, the US Government Accountability Office, referring to figures from the Office of Management and Budget, pointed out in a report in September 2017 that extreme weather and fire events had cost the federal government over US$350 billion over the preceding decade, and that this sum was likely to grow as a result of climate change. It recommended that "the appropriate entities within the Executive Office of the President (EOP), including the Office of Science and Technology Policy, use information on potential economic effects to help identify significant climate risks and craft appropriate federal responses". There is no evidence that the Trump Administration has acted on this advice. Economic research has tended to revise upwards over time estimates of climate damages, as illustrated by the literature review by Auffhammer (2018).

In June 2019, J. Alfredo Gómez, the Director of Natural Resources and Environment at the Government Accountability Office, told the House of Representatives Budget Committee that federal funding for disaster assistance had been at least US$450 billion since 2005. He noted that there were 14 weather and climate disaster events that had cost more than US$1 billion across the United States in 2018 alone, causing at least US$91 billion in damage altogether. Mr Gómez highlighted that the National Climate Assessment had projected that disaster costs would probably increase as some types of extreme weather events became more frequent and intense due to climate change, and said: "The costs of recent weather disasters have illustrated the need for planning for climate change risks and investing in resilience."

6. The consequences of the United States withdrawing from the Paris Agreement

Impacts on mitigation efforts and international ambition

An analysis by Y-X Zhang et al. (2017) of the Trump Administration's decision to withdraw the United States from the Paris Agreement concluded that it would not affect the development of low-carbon technologies, but "long-term goals and international cooperation on climate change will be affected by budget cuts in American climate change research and the cancelation of donations from the multilateral environmental fund of the U.S." Other researchers have been more pessimistic (e.g. H-B Zhang et al., 2017), suggesting that the United States' withdrawal would increase the costs of other countries' mitigation efforts. Urpelainen and Van de Graaf (2017) argued that withdrawal would not lead to a significant rise in domestic emissions or weaken support by other countries for the Paris Agreement, but could have an adverse effect on the flow of climate finance.

Indeed, three years after President Trump's announcement of the intention to withdraw, no other country has initiated withdrawal from the Paris Agreement. However, there is a danger that other countries will be encouraged to lessen their climate actions as well and it is yet to be seen whether the US disengagement will lead to less ambition on the part of other nations when they draw up their future INDCs.

Impact on US emissions

The most recent assessment by Climate Action Tracker (2019) of domestic policy implementation in the United States concluded that the country's annual emissions of greenhouse gases would be 11–13 per cent below 2005 levels in 2025 and 2030. This would mean its emissions would be 6,322–6,497 million tCO_2e in 2030. If it is assumed that the United States would achieve its targets outlined in its INDC and *Mid-Century Strategy*, its emissions would be 4,954 to 5,069 million tonnes in 2030, or 1,253 to 1,543 million tonnes lower than current projected emissions. An earlier analysis by Climate Interactive (2017) calculated that emissions from the United States would reach 6.7 billion tCO_2e per year by 2025, instead of 5.3 billion tCO_2e implied by the 28 per cent reduction at the most ambitious end of the INDC range. It calculated that if the United States followed a 'business as usual' path for the rest of the century, while other countries continued to pursue policies consistent with their NDCs, global mean surface temperature would be about 3.6°C above the pre-industrial level by 2100 compared with warming of 3.3°C if the United States implemented its Paris pledges.

Economic costs for the United States

Burke (2017) used these results to roughly calculate the implied additional economic costs for the United States of the extra warming, based on the method described in Burke et al. (2015). He found that the annual increase in the GDP of the United States would be reduced from 2 per cent per year to 1.5 per cent per year if global warming reached 3.6°C instead of 3.3°C in 2100. Altogether, about US$8.2 trillion would be lost cumulatively from the GDP of the United States up to 2100, assuming a discount rate of 3 per cent per year. This would be equivalent to annual costs of about US$750 billion, about two orders of magnitude greater than the compliance costs of the Clean Power Plan estimated by the US Environmental Protection Agency (2015b) – the main plank to support the US INDC. Burke et al.'s results are among the larger estimates of climate change costs in the literature, but they indicate the large downside risks to US output from climate change.

As the *Fourth National Climate Assessment* pointed out, the impacts of climate change on the United States will continue to grow until global annual emissions of greenhouse gases are reduced to zero (US Global Change Research Program, 2018). Emissions outside of the United States will be the main cause of future climate change impacts. According to the Global Carbon Project (Friedlingstein et al., 2019), the United States, which is the world's second biggest emitter, was responsible for about 14 per cent of global CO_2 emissions in 2019.

7. Conclusions

President Trump and his Administration did not provide any detailed analysis to justify their initiation of withdrawing the United States from the Paris Agreement. As a candidate for President during the 2016 election campaign, Mr Trump many times indicated that he would end participation in the Agreement. However, he has only made one substantive speech about the issue, on 1 June 2017.

We have examined in detail the reasons outlined in that speech, including the sources President Trump cited. The speech was grossly inaccurate and misleading about the economics and policy of climate change. President Trump misrepresented both the Paris Agreement and the participation in it by the United States, China and other countries. We found that the article in *The Wall Street Journal* and the report by NERA Economic Consulting were inaccurate or misleading. The President's speech, and the material distributed by the White House to accompany it, also misrepresented the findings of researchers at MIT.

Furthermore, when we considered an accurate description of climate change economics and policy, we found that there are strong domestic reasons to support the continued participation of the United States in the Paris Agreement. In particular, we highlight the clear findings of the *Fourth National Climate Assessment*, which concluded that Americans will suffer growing damage to their lives and livelihoods from climate change if net annual global emissions of greenhouse gases are not reduced to zero. For this reason, many US citizens, businesses and sub-national jurisdictions continue to push for greater Federal action and are taking measures themselves to cut emissions.

It is clear that most of the volume of annual greenhouse gases emitted by the United States is in the form of CO_2 from the consumption of fossil fuels for energy use. The combustion of fossil fuels also causes local air pollution, which is associated with illness and death. Estimates of the number of premature deaths from air pollution each year in the United States range from 90,000 to 360,000 (Dedoussi et al., 2020). Therefore, climate change action that also reduces local air pollution creates significant additional economic benefits.

In short, it is clear that the best interests of the United States would be served by playing a leading role in the Paris Agreement, and the decision to withdraw is irrational, in the sense that it does not promote the best interests of the American people, and is based on a distorted presentation of the facts.

As Stavins (2017) wrote shortly after the President's Rose Garden speech: "Truly, Trump's decision to withdraw the nation from the Paris climate agreement was not based on science or sound economics, but on a confused, misguided, and simply dishonest desire to score some short-term political points with his voters."

It is telling that no other country has copied the Trump Administration's decision to withdraw, but it is also surprising that the decision has not been challenged more strongly either within or outside the United States (despite the wide range of citizen initiatives to reduce US emissions in a more piecemeal way).

It would serve the best interests of the American people if the Trump Administration abandoned the process of withdrawal from the Paris Agreement before it is completed on 4 November 2020. The United Kingdom, as the co-host of COP26, the United Nations climate change summit scheduled for November 2021, should robustly challenge the Trump Administration about its decision to withdraw and the inaccurate and misleading reasons it has provided for doing so.

Appendix A. The Paris Agreement

The Paris Agreement was adopted by Parties to the UNFCCC at COP21 on 12 December 2015. As of 31 May 2020, 189 of the 197 Parties to the UNFCCC had ratified the Agreement.

The Paris Agreement is 25 pages in length (in English), and consists of 29 Articles. Of particular salience to the analysis in this report are Articles 2, 4 and 9, which are quoted below:

Article 2

1. This Agreement, in enhancing the implementation of the Convention, including its objective, aims to strengthen the global response to the threat of climate change, in the context of sustainable development and efforts to eradicate poverty, including by:

(a) Holding the increase in the global average temperature to well below 2°C above pre-industrial levels and pursuing efforts to limit the temperature increase to 1.5°C above pre-industrial levels, recognizing that this would significantly reduce the risks and impacts of climate change;

(b) Increasing the ability to adapt to the adverse impacts of climate change and foster climate resilience and low greenhouse gas emissions development, in a manner that does not threaten food production; and

(c) Making finance flows consistent with a pathway towards low greenhouse gas emissions and climate-resilient development.

2. This Agreement will be implemented to reflect equity and the principle of common but differentiated responsibilities and respective capabilities, in the light of different national circumstances.

Article 4

1. In order to achieve the long-term temperature goal set out in Article 2, Parties aim to reach global peaking of greenhouse gas emissions as soon as possible, recognizing that peaking will take longer for developing country Parties, and to undertake rapid reductions thereafter in accordance with best available science, so as to achieve a balance between anthropogenic emissions by sources and removals by sinks of greenhouse gases in the second half of this century, on the basis of equity, and in the context of sustainable development and efforts to eradicate poverty.

2. Each Party shall prepare, communicate and maintain successive nationally determined contributions that it intends to achieve. Parties shall pursue domestic mitigation measures, with the aim of achieving the objectives of such contributions.

3. Each Party's successive nationally determined contribution will represent a progression beyond the Party's then current nationally determined contribution and reflect its highest possible ambition, reflecting its common but differentiated responsibilities and respective capabilities, in the light of different national circumstances.

4. Developed country Parties should continue taking the lead by undertaking economy-wide absolute emission reduction targets. Developing country Parties should continue enhancing their mitigation efforts, and are encouraged to move over time towards economy-wide emission reduction or limitation targets in the light of different national circumstances.

Article 9

1. Developed country Parties shall provide financial resources to assist developing country Parties with respect to both mitigation and adaptation in continuation of their existing obligations under the Convention.

2. Other Parties are encouraged to provide or continue to provide such support voluntarily.

3. As part of a global effort, developed country Parties should continue to take the lead in mobilizing climate finance from a wide variety of sources, instruments and channels, noting the significant role of

public funds, through a variety of actions, including supporting country-driven strategies, and taking into account the needs and priorities of developing country Parties. Such mobilization of climate finance should represent a progression beyond previous efforts.

4. The provision of scaled-up financial resources should aim to achieve a balance between adaptation and mitigation, taking into account country-driven strategies, and the priorities and needs of developing country Parties, especially those that are particularly vulnerable to the adverse effects of climate change and have significant capacity constraints, such as the least developed countries and small island developing States, considering the need for public and grant-based resources for adaptation.

See https://unfccc.int/sites/default/files/english_paris_agreement.pdf for the full text of the Agreement.

Appendix B. The United States' nationally determined contribution (NDC) to the Paris Agreement

At COP17 in Durban, South Africa, on 11 December 2011, the US Government and other Parties to the UNFCCC agreed to set up the Ad Hoc Working Group on the Durban Platform for Enhanced Action, with a deadline to complete its work by 2015 so that countries could "adopt this protocol, another legal instrument or an agreed outcome with legal force at the twenty-first session of the Conference of the Parties and for it to come into effect and be implemented from 2020". Two years later, at COP19 in Warsaw, Poland, each Party was invited to submit by the first quarter of 2015 its "intended nationally determined contribution" (INDC) ahead of the expected new agreement due at COP21 in Paris, France.

In November 2014, President Barack Obama and President Xi Jinping made a joint announcement in Beijing, China about their post-2020 voluntary commitments for reducing emissions (Office of the Press Secretary, 2015). On 31 March 2015, the US Government formally submitted its INDC to the UNFCCC.

The US's INDC included a commitment to reduce the economy-wide emissions of greenhouse gases by the United States by 26–28 per cent by 2025 compared with 2005. This target included all categories of emissions by sources and removals by sinks, and would not require the use of international market mechanisms. It highlighted that this target was "consistent with a straight-line emission reduction pathway from 2020 to deep, economy-wide emission reductions of 80% or more by 2050". It also noted that there was an existing target of cutting annual emissions by 17 per cent by 2020 compared with 1990. According to the latest figures published by the EPA, net annual emissions of greenhouse gases by the United States in 2018 were 5,903.2 million tonnes, 10.2 per cent lower than in 2005 (US EPA, 2020).

The submission explicitly identified a few domestic laws, regulations, and measures that were relevant to the implementation of the INDC. The list included an implicit reference to what would eventually be the Clean Power Plan, which was described as "under the Clean Air Act, the United States Environmental Protection Agency is moving to finalize by summer 2015 regulations to cut carbon pollution from new and existing power plants". However, the Government of the United States has never published any official analysis of the relative costs and benefits of implementing its INDC.

The Second Biennial Report submitted to the UNFCCC by the US Government on 31 December 2015 projected that annual emissions would be 12–16 per cent lower in 2025 compared with 2005 under existing policies and measures (described as the 'Current Measures' scenario), including the Clean Power Plan. The Report also outlined an 'Additional Measures' scenario in which proposed new policies that had not been finalised would "have the potential to bring emissions to 22–27 percent below 2005 levels in 2025".

An analysis by Greenblatt and Wei (2016) concluded that the policies outlined in the INDC would be insufficient to achieve the target reduction in emissions by 2025, and suggested that further measures would be required, such as a phase-out of coal and natural gas for electricity generation, with

accompanying increases in renewables, energy efficiency and possibly nuclear power, and more ambitious policies on transport to promote zero-emissions vehicles and mass transit.

The United States formally accepted the Paris Agreement on 3 September 2016 and its INDC was considered to be its 'nationally determined contribution' (NDC), as required by Article 4, paragraph 9 of the Agreement. It was agreed at COP21 that Parties that had submitted an NDC that contained a timeframe up to 2025 should submit a new NDC by 2020, and at least 9 to 12 months before COP26. Article 4, paragraph 3 of the Paris Agreement states: "Each Party's successive nationally determined contribution will represent a progression beyond the Party's then current nationally determined contribution and reflect its highest possible ambition, reflecting its common but differentiated responsibilities and respective capabilities, in the light of different national circumstances."

President Trump's decision to withdraw the United States from the Paris Agreement means that his Administration has not submitted a new NDC. (Also, the United States is one of only two countries that has yet to submit its latest National Communication [due January 2018] or biennial reports [the third was due in January 2018, and the fourth in January 2020], required under the UNFCCC from all Annex 1 parties.)

Appendix C. The United States Mid-Century Strategy for Deep Decarbonization

Parties also agreed at COP21 to submit "mid-century, long-term low greenhouse gas emission development strategies", in accordance with Article 4, paragraph 19 of the Paris Agreement. The Obama Administration submitted the *United States Mid-Century Strategy for Deep Decarbonization* to the UNFCCC on 16 November 2016.

The document included a brief assessment of the economics of the United States reducing its annual emissions of greenhouse gases by at least 80 per cent by 2050 compared with 2005, declaring that "[t]he United States can achieve rapid emissions reductions while maintaining robust economic growth". It included the following points:

- An analysis by the Council of Economic Advisers in 2014 concluded that a delay in emissions cuts that results in warming of 3°C above pre-industrial temperature, instead of 2°C, could increase economic damages by approximately 0.9 per cent of global GDP, based on an extrapolation of the results of Nordhaus (2013) – 0.9 per cent of the estimated GDP of the United States in 2014 was approximately US$150 billion.
- Warming of 4°C by 2100 could result in damages equivalent to at least 1 to 5 per cent of global GDP.
- Unchecked global warming would disproportionately harm vulnerable Americans, including children and people who are sick, poor or elderly.

It should be noted that the estimate by the Council of Economic Advisers (2014) of the added economic damages associated with warming of 3°C or 4°C instead of 2°C could be a gross underestimate. The model used by Nordhaus (2013) excludes any explicit consideration of the impacts of breaching thresholds in the climate system (Stoerk et al., 2018), such as destabilisation of the major land-based ice sheets on Greenland and West Antarctica, which together hold enough water to raise global sea levels by about 13 metres.

The Strategy did not include a full economic analysis of the costs and benefits of its implementation, but it did estimate that to achieve the 2050 target, annual average investments in electricity generating capacity equivalent to 0.4 to 0.6 per cent of GDP would be required between 2016 and 2050, compared with an average 0.2 per cent of GDP per year from 2000 to 2013. A separate study by Shindell et al. (2016) calculated the benefits derived from the changes required in the power and transportation sectors in order for the United States to pursue a pathway that was consistent with warming of no more than 2°C. It found that the near-term benefits to the United States through avoided climate change and local air pollution would be US$140–1,050 billion a year, which, the authors pointed out, "is likely to exceed implementation costs".

The Strategy highlighted that between 2008 and 2015, annual energy-related emissions of CO_2 from the United States had already decreased by 9 per cent during a period when the country's GDP grew by 10 per cent. It noted three major benefits for the economy of the United States from implementing the Paris Agreement, beyond the avoided damages from climate change:

- Improvements in air quality would mean the workforce is healthier and more productive.
- The development of alternative forms of power for transportation would shield the economy from the volatility of the global oil price.
- The transition to a global low-carbon economy would create opportunities for low-carbon businesses in the United States.

The Strategy outlined three principles for the policies to implement in order to "create and preserve economic opportunities for all Americans":

- Implement market-based policies that reward outcomes: these focus emissions reduction efforts on the most cost-effective opportunities and provide incentives for all businesses to contribute.
- Act as quickly as possible: early and ambitious action reduces the risks of later disruptions caused by locked-in high-carbon investments. A study by the Council of Economic Advisers (2014) concluded that "the cost of hitting a specific climate target increases, on average, by approximately 40 percent for each decade of delay", based on a review and analysis of estimates published in the academic literature by that time.
- Support Americans who could be adversely affected by the low-carbon transition: although most American workers and businesses would have the opportunity to make a successful transition, additional support – such as the Power Plus Plan introduced by President Obama for workers in the coal industry – would be needed for households on low incomes or dependent on employment in high-carbon sectors.

A study by Galik et al. (2016) calculated that the lack of domestic action during Donald Trump's Presidency may not prevent the United States from achieving the targets set out in the Strategy. It concluded: "Assuming that emissions remain constant under President Trump and that reductions resume afterwards to meet the Obama Administration mid-century targets in 2050, this near-term pause in reductions yields a difference in total emissions equivalent to 0.3–0.6 years of additional global greenhouse gas emissions, depending on the number of terms served by a Trump Administration."

References

Ackerman F, Stanton E (2012) Climate risks and carbon prices: Revising the social cost of carbon. *Economics: The Open-Access, Open-Assessment E-Journal*, 6(2012-10): 1-25. http://www.economics-ejournal.org/economics/journalarticles/2012-10.

Ahmad F M, Huang J, Perciasepe B (2017) The Paris Agreement Presents a Flexible Approach for US Climate Policy. *Carbon & Climate Law Review*, 11 (4): 283 – 291. https://doi.org/10.21552/cclr/2017/4/4

Aldy J E, Pizer W A, Akimoto K (2016) Comparing emissions mitigation efforts across countries. *Climate Policy*. http://dx.doi.org/10.1080/14693062.2015.1119098

Anthoff D, Tol R (2010) On international equity weights and national decision making on climate change. *Journal of Environmental Economics and Management*, 60(1): 14-20. https://www.sciencedirect.com/science/article/pii/S0095069610000422

Auffhammer M (2018) Quantifying economic damages from climate change. *Journal of Economic Perspectives*, 32(4): 33-52.

Beck L (2020) Carbon capture and storage in the USA: the role of US innovation leadership in climate-technology commercialization. *Clean Energy*, 4(1): 2–11.

Bernstein P, Montgomery W D, Ramkrishnan B, Tuladhar S D (2017) *Impacts of Greenhouse Gas Regulations On the Industrial Sector*. March. Washington DC: NERA Economic Consulting. https://www.nera.com/content/dam/nera/publications/2017/170316-NERA-ACCF-Full-Report.pdf

Bodansky D (2016) The Legal Character of the Paris Agreement. *Review of European Community & International Environmental Law*, 25(2): 142-150. https://onlinelibrary.wiley.com/doi/epdf/10.1111/reel.12154

Bowen A, Campiglio E, Herreras Martinez S (2015) An 'equal effort' approach to assessing the North–South climate finance gap, *Climate Policy*. http://dx.doi.org/10.1080/14693062.2015.1094728

Burke M (2017) The cost of Paris withdrawal. Global Food, Environment and Economic Dynamics (G-FEED) blog. http://www.g-feed.com/2017/06/the-cost-of-paris-withdrawal.html

Burke M, Hsiang S M, Miguel E (2015) Global non-linear effect of temperature on economic production. *Nature*, 527: 235–239. https://www.nature.com/articles/nature15725

Chen Y, Hafstead M A C (2016) Using a Carbon Tax to Meet US International Climate Pledges. Discussion Paper, November. Washington DC: Resources for the Future. https://media.rff.org/archive/files/document/file/RFF-DP-16-48.pdf

Climate Action Tracker (2019) Country Summary: USA. 2 December. https://climateactiontracker.org/countries/usa/

Climate Interactive (2017) *Analysis: U.S. Role in the Paris Agreement*. 27 April. Cambridge, Massachusetts: Climate Interactive. https://www.climateinteractive.org/analysis/us-role-in-paris/

Council of Economic Advisers (2017) *Discounting for public policy: Theory and recent evidence on the merits of updating the discount rate*. Issue Brief, January. https://obamawhitehouse.archives.gov/sites/default/files/page/files/201701_cea_discounting_issue_brief.pdf

Cropper M, Kopp R, Newell R, Pizer W, Rennert K, Wichman C (2018) *Comments to NHTSA and US EPA on methodological considerations for updated social cost of carbon dioxide estimates*. 29 October. Washington DC: Resources for the Future. https://www.rff.org/publications/testimony-and-public-comments/comments-to-nhtsa-and-us-epa-on-methodological-considerations-for-updated-social-cost-of-carbon-dioxide-estimates/

Dedoussi I C, Eastham S D, Monier E, Barrett S R H (2020) Premature mortality related to United States cross-state air pollution. *Nature*, 578: 261–265. https://www.nature.com/articles/s41586-020-1983-8

Dietz S (2012) The treatment of risk and uncertainty in the US social cost of carbon for regulatory impact analysis. *Economics: The Open-Access, Open- Assessment E-Journal*, 6(2012-18): 1-12. http://www.economics-ejournal.org/economics/journalarticles/2012-18

Executive Office of the President of the United States (2013) *The President's Climate Action Plan*. June. Washington DC: The White House. https://obamawhitehouse.archives.gov/sites/default/files/image/president27sclimateactionplan.pdf

Executive Office of the President of the United States and the Council of Economic Advisers (2014) *The Cost of Delaying Action to Stem Climate Change*. July. Washington DC: The White House. https://obamawhitehouse.archives.gov/sites/default/files/docs/the_cost_of_delaying_action_to_stem_climate_change.pdf

Friedlingstein et al. (2019) Global Carbon Budget 2019. *Earth System Science Data*, 11: 1783-1838. https://doi.org/10.5194/essd-11-1783-2019

Galik C S, DeCarolis J F, Fell H (2016) Evaluating the US Mid-Century Strategy for Deep Decarbonization amidst early century uncertainty. *Climate Policy*, 17(8): 1046-1056. https://www.tandfonline.com/doi/abs/10.1080/14693062.2017.1340257

German Environment Agency (UBA) (2018) Greenhouse gas emissions rose again in 2016. Press release, 23 January. https://www.umweltbundesamt.de/en/press/pressinformation/greenhouse-gas-emissions-rose-again-in-2016

German Environment Agency (UBA) (2020) 2019 greenhouse gas emissions in Germany declined by 6.3 percent. Press release, 16 March. https://www.umweltbundesamt.de/en/press/pressinformation/2019-greenhouse-gas-emissions-in-germany-declined

Gómez J A (2019) *Climate Change: Opportunities to Reduce Federal Fiscal Exposure*. Testimony Before the Committee on the Budget, House of Representatives, 11 June. Washington DC: United States Government Accountability Office. https://www.gao.gov/assets/700/699605.pdf

Government of China (2015) *Enhanced actions on climate change: China's intended nationally determined contributions*. Submission to the UNFCCC. Bonn, Germany: UNFCCC. https://www4.unfccc.int/sites/ndcstaging/PublishedDocuments/China%20First/China's%20First%20NDC%20Submission.pdf

Government of India (2015) *India's intended nationally determined contribution: Working towards climate justice*. Submission to the UNFCCC. Bonn, Germany: UNFCCC. https://www4.unfccc.int/sites/ndcstaging/PublishedDocuments/India%20First/INDIA%20INDC%20TO%20UNFCCC.pdf

Government of the United States (2015a) *Intended nationally determined contribution*. Submission to the UNFCCC. Bonn, Germany: UNFCCC. https://www4.unfccc.int/sites/ndcstaging/PublishedDocuments/United%20States%20of%20America%20First/U.S.A.%20First%20NDC%20Submission.pdf

Government of the United States (2015b) *Second Biennial Report of the United States of America Under the United Nations Framework Convention on Climate Change*. Submission to the UNFCCC. Bonn, Germany: UNFCCC. https://unfccc.int/sites/default/files/resource/2016_second_biennial_report_of_the_united_states_.pdf

Government of the United States (2016) *United States Mid-Century Strategy for Deep Decarbonization*. November. Washington DC: The White House. https://unfccc.int/files/focus/long-term_strategies/application/pdf/mid_century_strategy_report-final_red.pdf

Green Climate Fund (2020a) *Report on the progress of the Green Climate Fund during its initial resource mobilization period (January 2015 through March 2020)*. April 2020. https://www.greenclimate.fund/sites/default/files/document/irm-brief.pdf

Green Climate Fund (2020b) *Status of Pledges and Contributions (Initial Resource Mobilization)*. 12 May. https://www.greenclimate.fund/sites/default/files/document/status-pledges-irm.pdf

Green Climate Fund (2020c) *Status of Pledges and Contributions (First Replenishment: GCF-1)*. 12 May. https://www.greenclimate.fund/sites/default/files/document/status-pledges-gcf1_0.pdf

Greenblatt J B, Wei M (2016) Assessment of the climate commitments and additional mitigation policies of the United States. *Nature Climate Change*, 6: 1090–1093. https://www.nature.com/articles/nclimate3125

Greenstone M, Kopits E, Wolverton A (2013) Developing a social cost of carbon for US regulatory analysis: A methodology and interpretation. *Review of Environmental Economics and Policy*, 7(1): 23-46. https://academic.oup.com/reep/article/7/1/23/1577964

High-Level Commission on Carbon Prices (2017) *Report of the High-Level Commission on Carbon Prices*. 29 May. Washington, DC: World Bank. https://www.carbonpricingleadership.org/report-of-the-highlevel-commission-on-carbon-prices

Interagency Working Group on Social Cost of Carbon (2010) *Technical Support Document: Social Cost of Carbon for Regulatory Impact Analysis Under Executive Order 12866*. February. Washington DC: Government of the United States. https://19january2017snapshot.epa.gov/sites/production/files/2016-12/documents/scc_tsd_2010.pdf

Interagency Working Group on Social Cost of Carbon (2015) *Technical Support Document: Technical Update of the Social Cost of Carbon for Regulatory Impact Analysis Under Executive Order 12866*. July 2015 revised version. Washington DC: Government of the United States. https://obamawhitehouse.archives.gov/sites/default/files/omb/inforeg/scc-tsd-final-july-2015.pdf

Interagency Working Group on Social Cost of Greenhouse Gases (2016) *Technical Support Document: Technical Update of the Social Cost of Carbon for Regulatory Impact Analysis Under Executive Order 12866*. August. Washington DC: Government of the United States. https://19january2017snapshot.epa.gov/sites/production/files/2016-12/documents/sc_co2_tsd_august_2016.pdf

Intergovernmental Panel on Climate Change (2013) *Climate Change 2013: The Physical Science Basis. Contribution of Working Group I to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change* [Stocker T F, Qin D, Plattner G-K, Tignor M, Allen S K et al. (eds.)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA. https://www.ipcc.ch/report/ar5/wg1/

Kaufman N, Gasper R, Igusky K (2017) U.S. Chamber of Commerce's Energy Institute Misleads on Climate Action Costs: 3 Things to Know. 26 April. Washington DC: Word Resources Institute. https://www.wri.org/blog/2017/04/us-chamber-commerces-energy-institute-misleads-climate-action-costs-3-things-know

Kopp R, Mignone B (2012) The U.S. Government's Social Cost of Carbon Estimates after Their First Two Years: Pathways for Improvement. *Economics: The Open-Access, Open-Assessment E-Journal*, 6(2012-15): 1-41. http://www.economics-ejournal.org/economics/journalarticles/2012-15

Kotchen M J (2018) Which social cost of carbon? A theoretical perspective. *Journal of the Association of Environmental and Resource Economists* 5(3): 673-694.

Krupnick A (2018) Comments on the estimation of health co-benefits in EPA's Affordable Clean Energy Rule. In: *Comments to US EPA on the Proposed Affordable Clean Energy Rule* [Krupnick A, Cropper M, Kopp R, Newell R, Pizer W A, et al.]. 31 October. Washington DC: Resources for the Future. https://media.rff.org/documents/RFF_Comments_10-31-18_EPA_6.pdf

Krupnick A, Cropper M, Kopp R, Newell R, Pizer W A et al. (2018) *Comments to US EPA on the Proposed Affordable Clean Energy Rule*. 31 October. Washington DC: Resources for the Future. https://media.rff.org/documents/RFF_Comments_10-31-18_EPA_6.pdf

Lomborg B (2016) Impact of Current Climate Proposals. *Global Policy*, 7(1): 109-118. https://onlinelibrary.wiley.com/doi/full/10.1111/1758-5899.12295

Meng K C (2017) Using a Free Permit Rule to Forecast the Marginal Abatement Cost of Proposed Climate Policy. *American Economic Review*, 107(3): 748–784. https://pubs.aeaweb.org/doi/pdfplus/10.1257/aer.20150781

MIT News Office (2017) MIT issues statement regarding research on Paris Agreement. Press statement, 1 June. http://news.mit.edu/2017/mit-issues-statement-research-paris-agreement-0602

National Academies of Sciences, Engineering, and Medicine (2017) *Valuing climate damages: Updating estimation of the social cost of carbon dioxide*. Washington DC: The National Academies Press. https://www.nap.edu/catalog/24651/valuing-climate-damages-updating-estimation-of-the-social-cost-of

NERA Economic Consulting (2017) NERA Economic Consulting's Study of US Emissions Reduction Policies: Statement of Facts. Press release, 4 June. Washington DC. https://www.nera.com/news-events/press-releases/2017/nera-economic-consultings-study-of-us-emissions-reduction-polici.html

Nordhaus W D (2013) *The Climate Casino: Risk, Uncertainty, and Economics for a Warming World*. New Haven: Yale University Press.

Nordhaus W (2014) Estimates of the social cost of carbon: Concepts and results from the DICE-2013R model and alternative approaches. *Journal of the Association of Environmental and Resource Economists*, 1(1/2): 273-312. https://www.journals.uchicago.edu/doi/abs/10.1086/676035

Office of the Press Secretary (2009) *Support for President's Copenhagen Announcement Receives Immediate Support*. 25 November. Washington DC: The White House. https://obamawhitehouse.archives.gov/the-press-office/support-president-s-copenhagen-announcement-receives-immediate-support

Office of the Press Secretary (2013) *Presidential Memorandum -- Power Sector Carbon Pollution Standards*. 25 June. Washington DC: The White House. https://obamawhitehouse.archives.gov/the-press-office/2013/06/25/presidential-memorandum-power-sector-carbon-pollution-standards

Office of the Press Secretary (2014) *U.S.-China Joint Announcement on Climate Change*. 12 November. Washington DC: The White House. https://obamawhitehouse.archives.gov/the-press-office/2014/11/11/us-china-joint-announcement-climate-change

Organisation for Economic Co-operation and Development (2019) *Climate Finance Provided and Mobilised by Developed Countries in 2013-17*. Paris: OECD. https://www.oecd-ilibrary.org/deliver/39faf4a7-en.pdf?itemId=%2Fcontent%2Fpublication%2F39faf4a7-en&mimeType=pdf

Rajamani I, Brunnée J (2017) The Legality of Downgrading Nationally Determined Contributions under the Paris Agreement: Lessons from the US Disengagement. *Journal of Environmental Law*, 29 (3): 537–551. https://doi.org/10.1093/jel/eqx024

Reilly J, Paltsev S, Monier E, Chen H, Sokolov A, et al. (2015) *Energy & Climate Outlook: Perspectives from 2015*. 20 October. Cambridge, Massachusetts. https://globalchange.mit.edu/publications/signature/2015-energy-and-climate-outlook

Rennert K, Kingdon C (2019) *Social cost of carbon 101: A review of the social cost of carbon, from a basic definition to the history of its use in policy analysis*. 1 August. Washington DC: Resources for the Future. https://www.rff.org/publications/explainers/social-cost-carbon-101/

Scobie C (2016) Supreme Court Stays EPA's Clean Power Plan. Practice Points, Website of the American Bar Association. https://www.americanbar.org/groups/litigation/committees/environmental-energy/practice/2016/021716-energy-supreme-court-stays-epas-clean-power-plan/

Schmalensee R, Stavins R N (2019) Policy Evolution under the Clean Air Act. *Journal of Economic Perspectives*, 33(4): 27-50. https://www.aeaweb.org/articles?id=10.1257/jep.33.4.27

Shindell D, Lee Y, Faluvegi G (2016) Climate and health impacts of US emissions reductions consistent with 2 °C. *Nature Climate Change*, 6:503–507. https://www.nature.com/articles/nclimate2935

Stavins R N (2017) Why Trump Pulled the U.S. Out of the Paris Accord And What the Consequences Will Be. 5 June, website of *Foreign Affairs*. https://www.foreignaffairs.com/articles/2017-06-05/why-trump-pulled-us-out-paris-accord

Stern T (2017) President Trump, stay in the Paris Agreement. You'll regret it if you don't. 8 May, *The Washington Post*. https://www.washingtonpost.com/opinions/president-trump-stay-in-the-paris-agreement-youll-regret-it-if-you-dont/2017/05/08/c2cc9f78-337d-11e7-b412-62beef8121f7_story.html

Stoerk T, Wagner G, Ward R E T (2018) Policy Brief—Recommendations for Improving the Treatment of Risk and Uncertainty in Economic Estimates of Climate Impacts in the Sixth Intergovernmental Panel on Climate Change Assessment Report. *Review of Environmental Economics and Policy*, 12(2): 371–376. https://doi.org/10.1093/reep/rey005

United Nations (1992) *United Nations Framework Convention on Climate Change*. New York: United Nations. https://unfccc.int/resource/docs/convkp/conveng.pdf

United Nations Environment Programme (2019) *Emissions Gap Report 2019*. Nairobi, Kenya: United Nations Environment Programme. https://www.unenvironment.org/resources/emissions-gap-report-2019

United Nations Framework Convention on Climate Change (UNFCCC) (2011) *Report of the Conference of the Parties on its sixteenth session, held in Cancun from 29 November to 10 December 2010 Addendum Part Two: Action taken by the Conference of the Parties at its sixteenth session*. 15 March. Bonn: UNFCCC. https://unfccc.int/resource/docs/2010/cop16/eng/07a01.pdf

United Nations Framework Convention on Climate Change (UNFCCC) (2012) *Report of the Conference of the Parties on its seventeenth session, held in Durban from 28 November to 11 December 2011. Addendum Part Two: Action taken by the Conference of the Parties at its seventeenth session*. 15 March. Bonn: UNFCCC. https://unfccc.int/resource/docs/2011/cop17/eng/09a01.pdf

United Nations Framework Convention on Climate Change (UNFCCC) (2014) *Report of the Conference of the Parties on its nineteenth session, held in Warsaw from 11 to 23 November 2013. Addendum Part two: Action*

taken by the Conference of the Parties at its nineteenth session. 31 January. Bonn: UNFCCC. https://unfccc.int/resource/docs/2013/cop19/eng/10a01.pdf

United Nations Framework Convention on Climate Change (UNFCCC) (2015) *Paris Agreement*. Bonn: UNFCCC. https://unfccc.int/files/essential_background/convention/application/pdf/english_paris_agreement.pdf

United Nations Framework Convention on Climate Change (UNFCCC) (2016) *Report of the Conference of the Parties on its twenty-first session, held in Paris from 30 November to 13 December 2015. Addendum Part two: Action taken by the Conference of the Parties at its twenty-first session*. 29 January. Bonn: UNFCCC. https://unfccc.int/resource/docs/2015/cop21/eng/10a01.pdf

United States Energy Information Administration (US EIA) (2016) *Annual Energy Outlook 2016 with projections to 2040*. 15 September. Washington DC. https://www.eia.gov/outlooks/archive/aeo16/

United States Energy Information Administration (US EIA) (2019) *U.S. coal production employment has fallen 42% since 2011*. 11 December. Washington DC. https://www.eia.gov/todayinenergy/detail.php?id=42275

United States Energy Information Administration (US EIA) (2020a) *Monthly Energy Review*. May 2020. Washington DC. https://www.eia.gov/totalenergy/data/monthly/pdf/mer.pdf

United States Energy Information Administration (US EIA) (2020b) *Annual Energy Outlook 2020 with projections to 2050*. 29 January, Washington DC. https://www.eia.gov/outlooks/aeo/pdf/aeo2020.pdf

United States Energy Information Administration (US EIA) (2020c) *U.S. coal-fired electricity generation in 2019 falls to 42-year low*. 11 May, Washington DC. https://www.eia.gov/todayinenergy/detail.php?id=43675

United States Energy Information Administration (US EIA) (2020d) *U.S. renewable energy consumption surpasses coal for the first time in over 130 years*. 28 May, Washington DC. https://www.eia.gov/todayinenergy/detail.php?id=43895

United States Environmental Protection Agency (US EPA) (2015a) *The Clean Power Plan*. Fact Sheet, August. Washington DC: United States Environmental Protection Agency. https://archive.epa.gov/epa/sites/production/files/2015-08/documents/fs-cpp-overview.pdf

United States Environmental Protection Agency (US EPA) (2015b) *Regulatory Impact Analysis for the Clean Power Plan Final Rule*. 23 October update. Washington DC: United States Environmental Protection Agency. https://www3.epa.gov/ttnecas1/docs/ria/utilities_ria_final-clean-power-plan-existing-units_2015-08.pdf

United States Environmental Protection Agency (US EPA) (2017) *Multi-Model Framework for Quantitative Sectoral Impacts Analysis: A Technical Report for the Fourth National Climate Assessment*. EPA 430-R-17-001, May. Washington DC: United States Environmental Protection Agency. https://cfpub.epa.gov/si/si_public_record_Report.cfm?Lab=OAP&dirEntryId=335095

United States Environmental Protection Agency (US EPA) (2019a) *Regulatory Impact Analysis for the Repeal of the Clean Power Plan, and the Emission Guidelines for Greenhouse Gas Emissions from Existing Electric Utility Generating Units*. EPA-452/R-19-003, June. Washington DC: United States Environmental Protection Agency. https://www.epa.gov/sites/production/files/2019-06/documents/utilities_ria_final_cpp_repeal_and_ace_2019-06.pdf

United States Environmental Protection Agency (US EPA) (2019b) *Final ACE Rule – CO_2 Emissions Trends*. Fact Sheet, June. Washington DC: United States Environmental Protection Agency. https://www.epa.gov/sites/production/files/2019-06/documents/ace_co2_trends_6.18.19_final.pdf

United States Environmental Protection Agency (US EPA) (2020) *Inventory of U.S. Greenhouse Gas Emissions and Sinks 1990-2018*. 13 April. Washington DC. https://www.epa.gov/sites/production/files/2020-04/documents/us-ghg-inventory-2020-main-text.pdf

United States Global Change Research Program (2018) *Impacts, Risks, and Adaptation in the United States: Fourth National Climate Assessment, Volume II* [Reidmiller D R, Avery C W, Easterling D R, Kunkel K E, Lewis K L M, et al. (eds)]. Washington DC: United States Global Change Research Program. https://nca2018.globalchange.gov/downloads/NCA4_2018_FullReport.pdf

United States Government Accountability Office (2017) *Climate Change: Information on Potential Economic Effects Could Help Guide Federal Efforts to Reduce Fiscal Exposure*. Report to Congressional Requesters, September. Washington DC: United States Government Accountability Office. https://www.gao.gov/assets/690/687466.pdf

Urpelainen J, Van de Graaf T (2017) United States non-cooperation and the Paris agreement. *Climate Policy*, 18(7): 839-851. https://www.tandfonline.com/doi/abs/10.1080/14693062.2017.1406843

Wall Street Journal (2017) Paris Climate Discord. 1 June. https://www.wsj.com/articles/paris-climate-discord-1496272448

Ward R E T (2016) Comment on 'Impact of Current Climate Proposals'. *Global Policy*, 7(1): 125-126. https://onlinelibrary.wiley.com/doi/10.1111/1758-5899.12316

Ward R E T, Bowen A (2017) *President Trump getting inaccurate and misleading advice about Paris Agreement on climate change*. Web commentary, 1 June. London: Grantham Research Institute on Climate Change and the Environment, London School of Economics and Political Science. http://www.lse.ac.uk/GranthamInstitute/news/president-trump-getting-inaccurate-and-misleading-advice-about-paris-agreement-on-climate-change/

Weitzman M (2013) Tail-hedge discounting and the social cost of carbon. *Journal of Economic Literature*, 51(3): 873-882. https://www.aeaweb.org/articles?id=10.1257/jel.51.3.873

White House, The (2017a) Presidential Executive Order on Promoting Energy Independence and Economic Growth. 28 March. https://www.whitehouse.gov/presidential-actions/presidential-executive-order-promoting-energy-independence-economic-growth/

White House, The (2017b) Statement by President Trump on the Paris Climate Accord. 1 June. Washington DC. https://www.whitehouse.gov/briefings-statements/statement-president-trump-paris-climate-accord/

White House, The (2017c) President Trump Announces U.S. Withdrawal From the Paris Climate Accord. 3 Minute Read, 1 June. Washington DC. https://www.whitehouse.gov/articles/president-trump-announces-u-s-withdrawal-paris-climate-accord/

White House, The (2017d) Paris Accord – Talkers. *Politico*, 1 June. https://www.politico.com/f/?id=0000015c-64e7-d6b9-a17c-f6e75dcc0000

White House, The (2017e) *President Trump Puts American Jobs First*. Fact Sheet, 1 June. Washington DC. https://www.whitehouse.gov/briefings-statements/president-trump-puts-american-jobs-first/

White House, The (2018) Remarks by President Trump Before Marine One Departure. 26 November. Washington DC. https://www.whitehouse.gov/briefings-statements/remarks-president-trump-marine-one-departure-26/

Yohe G (2017) *Rand Paul argument for withdrawing from Paris climate agreement based on flawed information, Prof. Gary Yohe explains*. 23 May. Climate Feedback website. https://climatefeedback.org/rand-paul-argument-withdrawing-paris-climate-agreement-based-flawed-information-prof-gary-yohe-explains/

Zhang H-B, Dai H-C, Lai H-X, Wang W-T (2017) U.S. withdrawal from the Paris Agreement: Reasons, impacts, and China's response. *Advances in Climate Change Research*, 8(4): 220-225. https://www.sciencedirect.com/science/article/pii/S1674927817301028

Zhang Y-X, Chao Q-C, Zheng Q-H, Huang L (2017) The withdrawal of the U.S. from the Paris Agreement and its impact on global climate change governance. *Advances in Climate Change Research*, 8(4): 213-219. http://www.sciencedirect.com/science/article/pii/S1674927817300849