The impact and cost of the 2015 Paris Climate Summit, with special focus on US policies

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The House of Representatives, Committee on Science, Space and Technology

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Summary:

Global warming is real, mostly man-made and a net problem. However, the current Paris COP21 promises will do little to tackle the problem while costing a fortune.

The only peer-reviewed estimate shows that the climate impact of all Paris promises 2016-2030 will reduce temperature in 2100 by 0.08°F (0.05°C). Even if all countries continue their promised reductions for 2031, 2032 … until 2100, it will reduce temperatures by just 0.31°F (0.17°C).

The US Clean Power Plan will reduce global temperatures by maximally 0.023°F (0.013°C) in 2100.

The entire US climate promises will reduce global temperatures by just 0.057°F (0.031°C) by 2100.

Change in temperature °C year 2100	Pessimistic	Optimistic
US INDC	0.008	0.031
US CPP	*0.004*	*0.013*
EU2030 INDC	0.017	0.053
EU 2020	0.007	0.026
China	0.014	0.048
RoW INDC	0.009	0.036
Global	0.048	0.170

Change in temperature °F year 2100	Pessimistic	Optimistic
US INDC	0.014	0.057
US CPP	0.007	*0.023*
EU2030 INDC	0.031	0.096
EU 2020	*0.012*	*0.046*
China	0.025	0.086
RoW INDC	0.016	0.064
Global	0.086	0.306

The cost of Paris is substantial. This submission uses the best available climate-economic model ensembles from the Stanford Energy Modeling Forum, the Asia Modeling Exercise and the EU/EPA CLIMACAP-LAMP project.

It finds the cost for the US climate promises are likely $154-172 billion every year in lost GDP by 2025. This assumes that all US climate policies are enacted in the most efficient way, which is very unlikely. If they are not, the peer-reviewed literature suggests the costs will at likely double.

The costs for the world is at least close to $1 trillion per year in 2030, with likely costs due to policy inefficiency doubling to almost $2 trillion per year:

Billion $ per year	Most effective policy	Most likely policy
USA	154	308
EU	305	610
China	200	400
Mexico	80	160
Rest of World	185	370
Global cost	924	1848

The cost and impact of the 2015 Paris Climate Summit, with special focus on US policies

This paper will estimate the impact of the likely climate impact of the Paris Climate Summit, (the COP21, or hereafter Paris), its costs, and compare this with other model outcomes.

Given the very contentious nature of the climate debate, it is perhaps worthwhile to point out that the current paper embrace man-made global warming and use the standard models from the UN Climate Panel (the IPCC) and others.

Is global warming happening? Yes. Man-made global warming is a reality and will in the long run have overall, negative impact.

How much will the Paris promises reduce global temperature rise?

So far, the only peer-reviewed paper estimating the temperature impact of the likely Paris impact is my paper from November 10 2015 (Lomborg 2015). This paper uses the climate model MAGICC 6.3. This is the latest version of a simple climate model used in all the five IPCC assessment reports from 1990-2014.[1] All the following runs use default values of MAGICC with a climate sensitivity of 3°C. Sensitivity analysis shows that different models and carbon cycling does not substantially change the outcome.

The paper investigates the *change* in temperature in 2100 from implementing promises for Paris, both individual and collective. It does so by running two standard climate scenarios, RCP8.5 and RCP6 with and without the promised reductions. Sensitivity analysis shows that the outcome does not substantially change, and consequently only RCP8.5 is shown here.

There is some discussion as to what the promises of Paris actually constitute. In my article I explicitly limit the promises to "policies that have practical political implications soon and have a verifiable outcome by 2030, but not policies that merely promise actions only or mostly starting after 2030." See the discussion below for why this fits with the definition of what most nations and UNFCCC understand as the Paris promises. It also avoids a slippery slope towards a ridiculous premise: since almost all states have already accepted the 2°C promise, if all promises are included, then by default we will see temperatures rise less than 2°C.

US Clean Power Plan

If we look just at the US Clean Power Plan, it will reduce emissions by 535Mt (million metric tons) CO_2 every year by 2030, compared to the expected emissions from the US power sector, as estimated by the Energy Information Agency (EIA 2015). I investigate two scenarios. In the first, the optimistic scenario, the US will continue the Clean Power Plan forever, which means the US emissions will forever be 535Mt CO_2 lower than the baseline from EIA. In the pessimistic scenario, the US will live up to its Clean Power Plan promises by 2030, but then fall back to its baseline emissions as estimated by EIA.

If we run the MAGICC climate model with the RCP8.5 global emissions with and without the reductions in CO_2 emissions from the US Clean Power Plan, we get the following result:

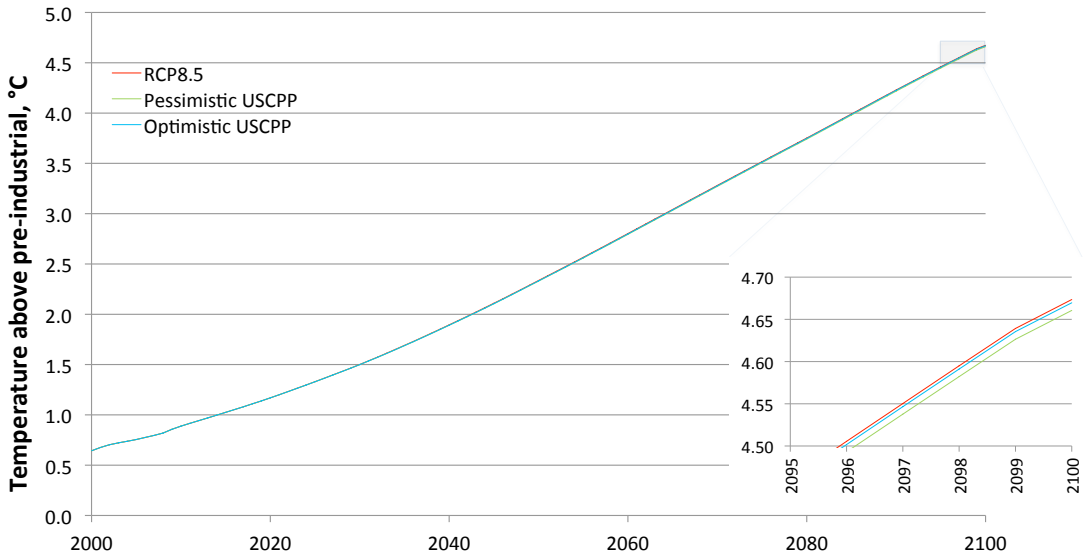

Figure 1 Global temperature anomaly from 2000–2100 with baseline RCP8.5, and optimistic and pessimistic US Clean Power Plan (USCPP) run on MAGICC, enlarged insert at right-hand corner.

Figure 1 shows (most clearly in the enlargement in the bottom right) that the temperature reduction resulting from the US Clean Power Plan by the end of the century will be 0.007°F (0.004°C) if the policy is gradually abandoned after 2030. If the Clean Power Plan is continued throughout the century, reducing 535Mt CO_2 each year from the baseline, it will reduce global temperatures by 0.023°F (0.013°C) by 2100.

US Paris promises

The US administration has also promised in its Intended Nationally Determined Contribution (INDC) to the UNFCCC (USINDC 2015) that it will reduce its overall greenhouse gas emissions (GHG) 26-28% below the 2005-level by 2025. The US is very clear in its submission that this is a one-point promise in 2025: "The US target is for a single year: 2025."

This reduction promise works out to about 1.27Gt of CO_2 equivalents in 2025. Again, I examine two possible scenarios. One pessimistic scenario where the US will only live up to the letter of its promise, cutting 1.27Gt CO_2e in 2025, but then reverting back to the baseline. The optimistic scenario sees the US living up to its promise not just in 2025 but every year thereafter, reducing 1.27Gt CO_2e from the baseline throughout the 21st century.

If we run the MAGICC climate model with the RCP8.5 global emissions with and without the reductions in CO_2 emissions from the US INDC promises, we get the following result:

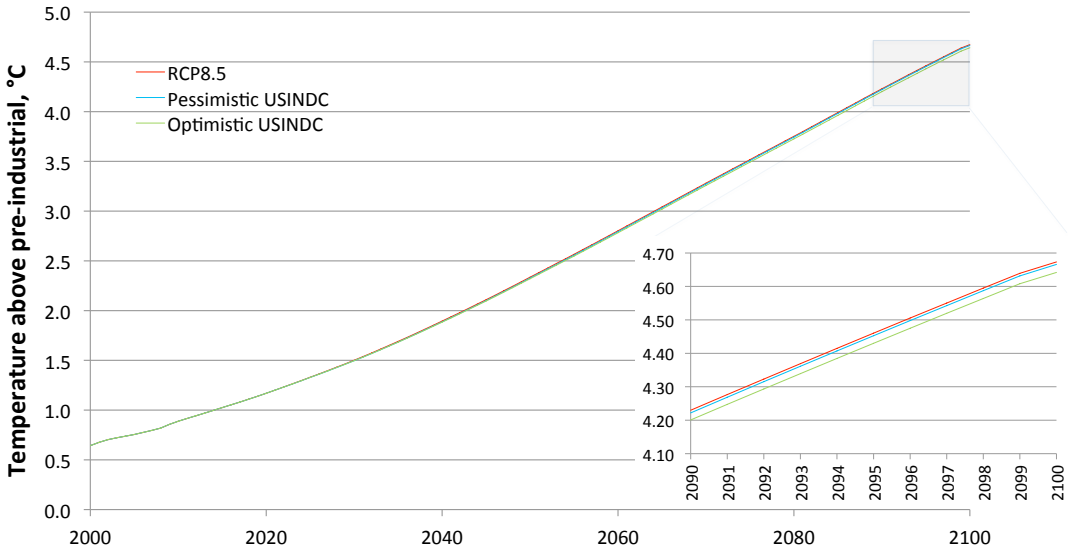

Figure 2 Global temperature anomaly from 2000–2100 with baseline RCP8.5, and optimistic and pessimistic US Paris promise (USINDC), run on MAGICC.

Figure 2 shows (most clearly in the enlargement in the bottom right) that the temperature reduction resulting from the entire US Paris promise by the end of the century will be 0.014°F (0.008°C) if the policy is gradually abandoned after 2025. If the US Paris promise is continued throughout the century, reducing 1.27Gt CO_2 each year from the baseline, it will reduce global temperatures by 0.057°F (0.031°C) by 2100. Since this includes the US Clean Power Plan, the net effect of the extra promise in the US INDC is in the optimistic case 0.034°F (0.057°F-0.023°F, 0.018°C).

Global Paris promises impact

My article similarly estimates the impact of the other major players' contribution to the Paris emission reductions. The EU has done a climate policy for 2020 (the 20-20 policy, promising 20% emission reductions below 1990-level in 2020,

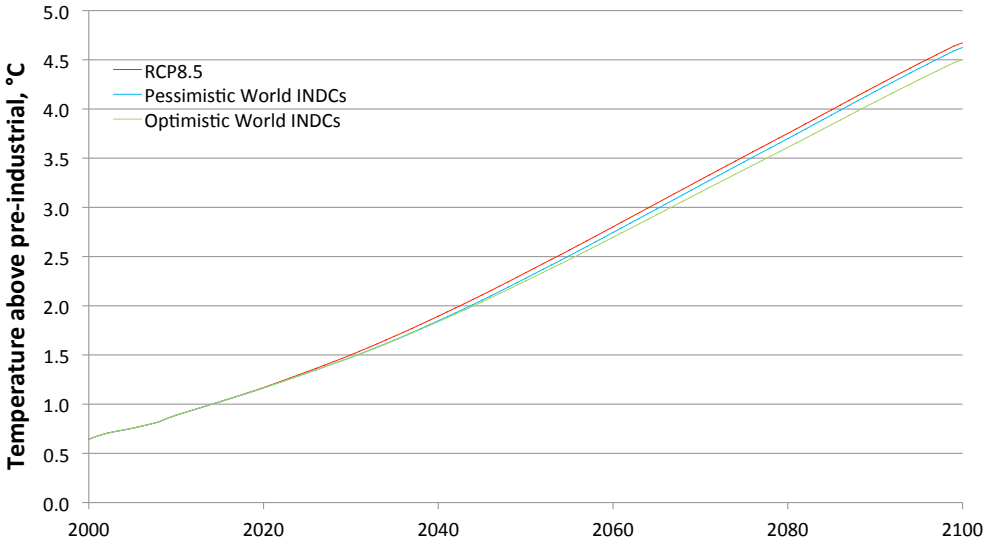

Figure 3 Global temperature anomaly from 2000–2100, from baseline RCP8.5, and optimistic and pessimistic global Paris promises (Global INDCs), run on MAGICC.

leading to 0.93Gt CO_2 annual reduction by 2030) and for its INDC (40% reduction below 1990-level by 2030, resulting in an annual 2.1Gt CO_2 reduction by 2030). China has promised to reduce its CO_2 intensity to 60-65% below 2005, which translates into a 1.95Gt CO_2 annual reduction promise by 2030. The US, China and the EU reductions approach almost 80% of the total promised reductions. Hence I estimate, using (Boyd, Turner, and Ward 2015), that the Rest of the World (RoW) INDCs will reduce emissions by 2030 by 1.48Gt CO_2 annually. In total, the INDCs for Paris will result in an emission reduction of 6.8Gt CO_2 by 2030

In Table 1 one can see the total impact of these policies, both in Celsius and Fahrenheit. The total impact of all INDC climate policies will reduce temperatures in 2100 by 0.086°F (0.048°C) if the Paris promises are gradually abandoned after 2030. If the Paris promises are kept all through the century, reducing emissions 6.8Gt below the baseline every year, the result will be a more optimistic temperature reduction of 0.306°F (0.170°C) by 2100. The global model run can be seen in Figure 3.

Change in temperature		
°C year 2100	Pessimistic	Optimistic
US INDC	0.008	0.031
US CPP	*0.004*	*0.013*
EU2030 INDC	0.017	0.053
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RoW INDC	0.016	0.064
Global	0.086	0.306

Table 1 Impact of climate policies in terms of reduction in temperature by 2100 in °C and °F, optimistic and pessimistic, for RCP8.5, using MAGICC, summary of (Lomborg 2015).

Cost of Paris promises

Extraordinarily, there seems to be no official estimates of the costs of the proposed Paris climate policies, either for the US, the EU, China or for the entire world.

I will here use existing data to make a reasonable first estimate of the total cost of Paris.

Europe's climate promises are probably the best documented in peer reviewed literature, but this literature also clearly shows that the studies typically lag political decisions by some years. Thus, we have good estimates for previous decisions but much less exact for the ones the world is thinking of committing to in Paris.

The Stanford Energy Modeling Forum (EMF), the gold standard for the economics of climate and energy, has done several studies of the previous EU climate policy which promised a 20% reduction in CO_2 emissions from 1990-levels by 2020.

It showed two things. First and perhaps not surprisingly, in the rare cases where official cost estimates are made, these are often *much* underestimated. The EU estimated that the total cost of its 2020-policies could be as little as an annual 0.4% GDP loss (€64 billion per year) (Capros et al. 2008, 48). The peer-reviewed cost was 1.3% (€209 billion annually), or more than three times larger (Tol 2012). Similarly, the Mexican government assumed its climate policies would cost $6-33 billion annually by 2050 (Veysey et al. 2015, 12). The peer reviewed literature, supported by the US EPA and the EU, shows that this is "far lower than any of the cost metrics reported by the CLIMACAP-LAMP models." Indeed, they find the cost in 2050 to be between 14 and 79 times higher, at about $475 billion annually (Veysey et al. 2015).

Second, politicians rarely pick the most efficient climate policies that cut CO_2 at lowest cost. This typically doubles the cost. The EU could have reduced its emissions by switching to gas and improving efficiency for a GDP loss of 0.7% (Bohringer, Rutherford, and Tol 2009). However, phenomenally inefficient solar subsidies and biofuels are often more alluring, which is why the actual EU cost almost doubled to 1.3% of GDP. As the researchers say: "The inefficiencies in policy lead to a cost that is 100–125% too high."

In the following, I will tally the costs for the US, EU, Mexico, and China, which makes up about 80% of the total promised reductions.

Cost of Paris for the US

There is no official estimate for the cost of USA's promise to cut 26-28% of its greenhouse gasses by 2025. We can turn to the Stanford Energy Modeling Forum for the US, the so-called EMF 24 (Fawcett et al. 2014). The program has run more than a hundred scenarios estimating all greenhouse gas emissions and the GDP cost. Estimating the lost GDP cost with a regression across all these data points suggests that cutting 26% in 2025 results in a GPD loss of about $154 billion annually, and 28% incurs an annual GDP loss of $172 billion.

The cost of Paris for the EU

The EU promises in its INDC to cut its emissions by 40% below 1990-levels in 2030 (EUINDC 2015). While there are no official estimates of the cost, the latest peer-reviewed Stanford Energy Modeling Forum for the EU, the so-called EMF 28, estimates costs from a number of different reductions (Knopf et al. 2013). The closest policy attempts to reduce emissions by 80% in 2050, which leads to an average reduction in 2030 of 41%. That reduction across the models that estimate GDP loss is equivalent to reducing EU's GDP by 1.6% GDP in 2030 – or €287 billion ($305 billion) in 2010-euros.

The cost of Paris for China

China has promised to reduce its energy intensity to at least 60% below 2005 (China INDC 2015), equivalent to reducing its emissions by at least 1.9 Gt CO_2 each year. In the international research project the Asia Modeling Exercise (Calvin et al. 2012; Calvin, Fawcett, and Kejun 2012), nine energy-economic models estimate what different efficient reduction policies will attain in emission reductions and GDP reductions. Using the AME data, it is likely that China can reduce 1.9Gt CO_2 for about $200 billion in annual GDP loss.

The cost of Paris for Mexico

Another well-documented cost is for Mexico, which has enacted the strongest climate legislation of any developing country. It has conditionally promised to reduce its emissions by 40% below what it would otherwise have emitted by 2030.[2] As mentioned above, the cost estimates of the Mexican government are about 14-79 times lower than the actual cost estimated in a new study supported by the US EPA and the EU. The CLIMACAP-LAMP project has estimated costs throughout Latin America and the peer reviewed analysis for Mexico (Veysey et al. 2015) finds that the Mexican cost in 2030 is about 4.5% of GDP or about $80 billion annually.[3]

The cost of Paris for Rest of World

The total cost of US, EU, China and Mexico adds up to $739 billion (or $757 if the US goes for 28%). Given that the reductions from US, EU, China and Mexico add to about 80%, it is reasonable to assume that the $739 billion constitute 80% of the total cost, making the global cost about $924 billion.

Billion $ per year	Most effective policy	Most likely policy
USA	154	308
EU	305	610
China	200	400
Mexico	80	160
Rest of World	185	370
Global cost	924	1848

Table 2 Cost of Paris promises in GDP loss per year, with effective policy based on best multi-model estimates from EMF24, EMF28, AME and CLIMACAP-LAMP, with comparative estimate for rest of the world. The most likely policy column simply assumes costs to double, as EU and other climate policies have shown likely.

Table 2 show the estimate of $924 billion in annual lost GDP by 2030 if all nations enact the most efficient climate policy (likely an increasing carbon tax which is uniform across sectors and countries). However, previous experience shows that it such an effective climate policy formulation is very unlikely, and this makes the total cost more likely to double (as found e.g. by (Bohringer, Rutherford, and Tol 2009)). Thus, it is likely that the global cost of Paris will reach at least $1 trillion annually by 2030, and the cost with realistically less-efficient policies could very likely get close to $2 trillion annually.

Comparison with other findings

If we look across the entire spectrum of estimations of the Paris deal, there is a great deal of agreement. As is evident in Figure 4, all find that with Paris emissions will be around 53.7-57.6Gt CO_2 equivalent in 2030. My value is within 0.2 Gt of the median.

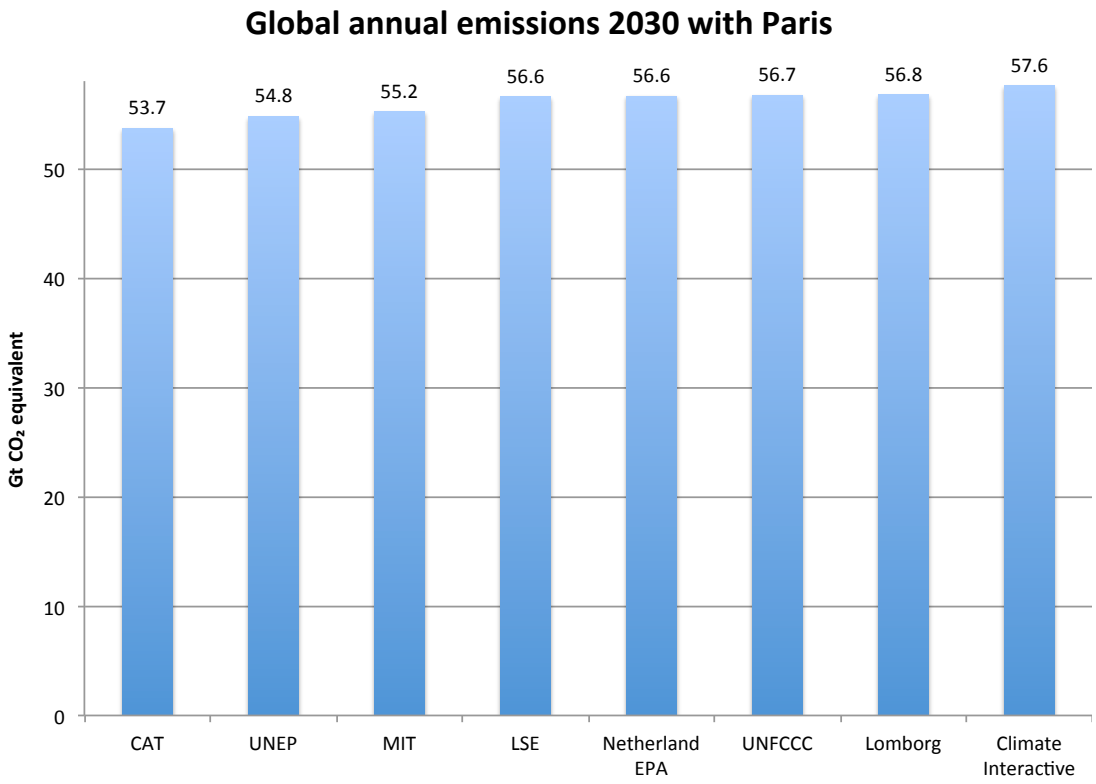

Figure 4 Global annual emissions estimated for 2030 with all INDC Paris promises. CAT is average of Pledges by 2030 (CAT 2015), UNEP is average of unconditional and conditional promises (UNEP 2015), (MIT 2015), LSE average of four different outcomes (Rodney Boyd, Joe Cranston Turner, and Bob Ward 2015), (Netherlands EPA 2015) harmonized, (UNFCCC 2015), (Lomborg 2015) optimistic using mean of EMF27 as baseline (Kriegler et al. 2014), (Climate Interactive 2015).

However, if we look at the baseline – no climate policy through the 21st century – the expected cumulative emissions 2010-2100 in Figure 5 has significant outliers on both sides. MIT is on the low side, likely because it has already included emission reductions from climate policies until 2014.

The AME, Lomborg, EMF27, and UNEP lie just above 7,000 Gt CO_2, whereas CAT and Climate Interactive have much higher baselines, with Climate Interactive more than 2,000 Gt above. The Climate Interactive emissions are actually higher than any model in EMF27.

That means CI can claim that Paris or any other policy will reduce about 2,000+ Gt more emissions than any other analysis, but such a claim is of course entirely spurious. Since the unrealistically high baseline is entirely made-up, these emissions would never have taken place, and hence Paris climate promises can't take credit for eliminating them.

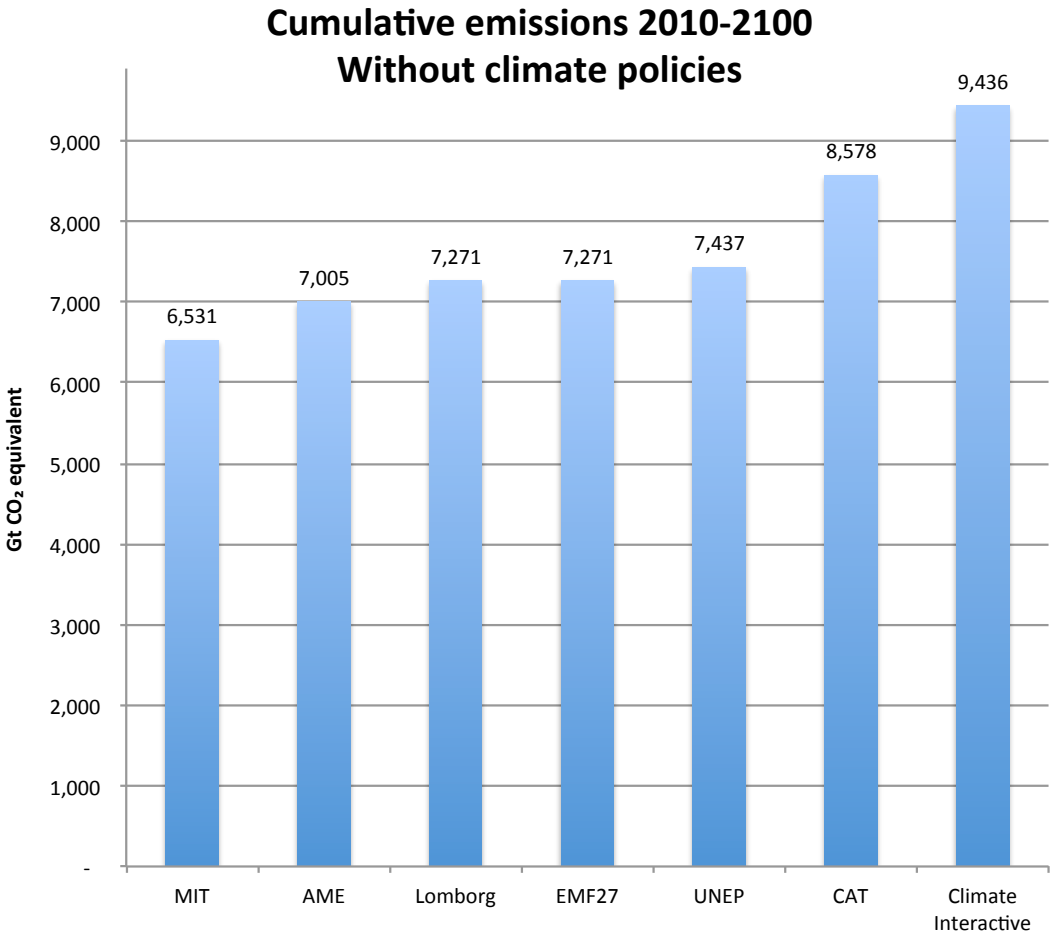

Figure 5 Global cumulative emissions for 2010-2100 without climate policies, estimated with MIT based on changed CO_2 emissions from 2014-15 (MIT 2015, figure 14), Asian Modeling Exercise (Calvin et al. 2012), optimistic (Lomborg 2015) (Kriegler et al. 2014), (UNFCCC 2015) (CAT 2015) (Climate Interactive 2015).

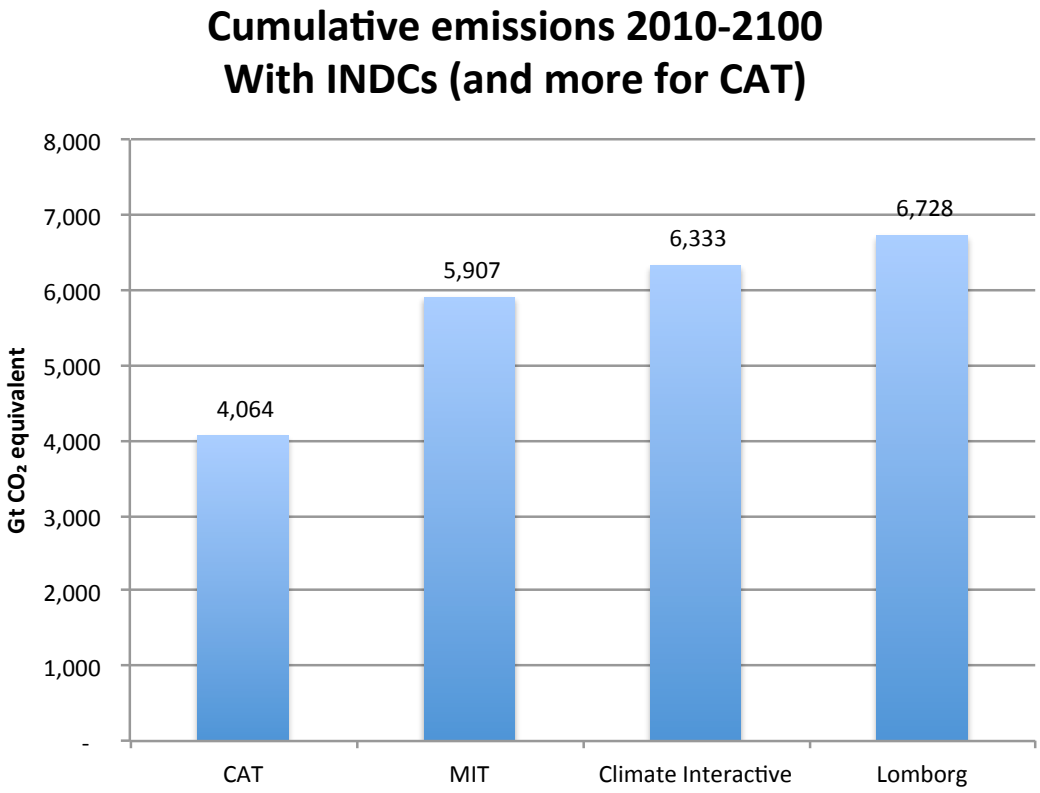

Figure 6 Cumulative emissions 2010-2100 with the Paris INDCs for MIT, Climate Interactive and optimistic Lomborg, and for CAT (including further reductions after 2030), (CAT 2015; MIT 2015; Climate Interactive 2015; Lomborg 2015).

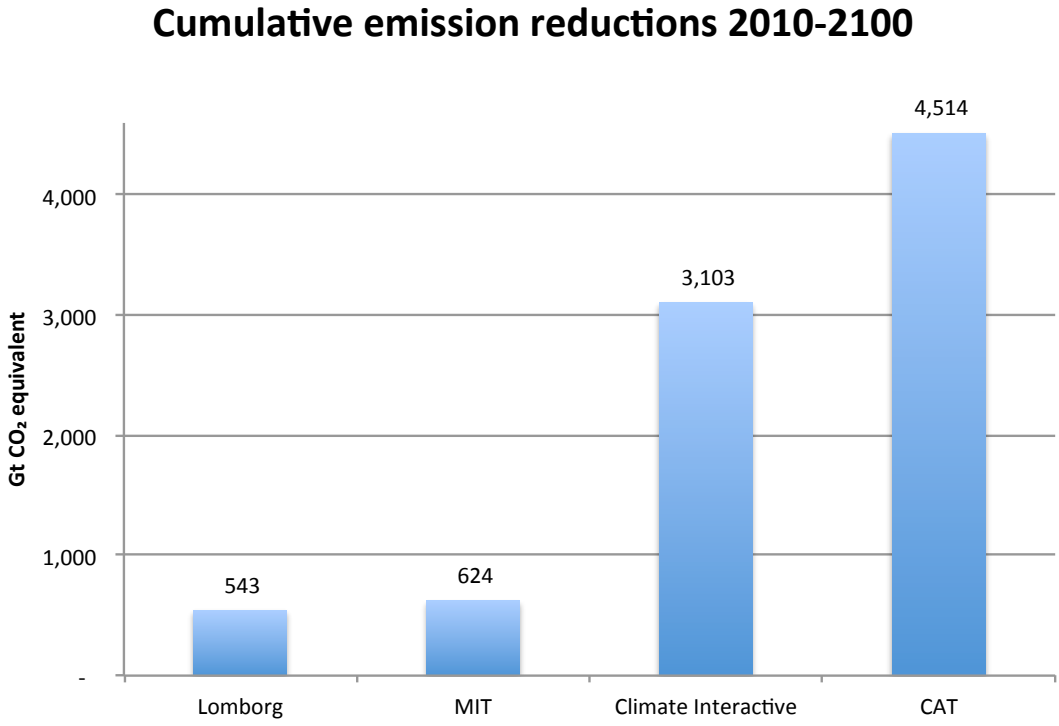

Figure 7 Cumulative emissions reductions 2010-2100 optimistic Lomborg, MIT, Climate Interactive and CAT (CAT 2015; MIT 2015; Climate Interactive 2015; Lomborg 2015).

If we look at the cumulative emissions from the Paris INDCs in Figure 6, it is clear that MIT, Climate Interactive and Lomborg find about the same level across the century, because all three have about the same estimate for 2030 and see the policies in 2030 continued approximately in the same way. CAT finds much higher reductions because it assumes much larger reductions after 2030.

This is why we see the total reduction diverge radically in Figure 7. MIT and Lomborg both have realistic cumulative baselines and realistic cumulative emissions with the INDCs. That is why they both find about 500-600Gt cumulative reductions across the 21st century, which both finds translates into about 0.2°C temperature reduction.

Climate interactive sees about 2,500 Gt higher emission reductions but *almost all* of this reduction stems from the vastly inflated baseline. Thus the correct finding of Climate Interactive without the exaggerated baseline would be almost similar findings to (MIT 2015; Lomborg 2015).

CAT finds much higher reductions yet, partly because it has an unrealistically high baseline (about 1,300 Gt too high, Figure 5) *and* assume another 2,000+ Gt reductions after 2030.

It is instructive to see how far away the estimates of Climate Interactive are, since they are often used in the public discourse. In Figure 8, we can see the difference between all EMF24 baseline estimates, with Climate Interactive

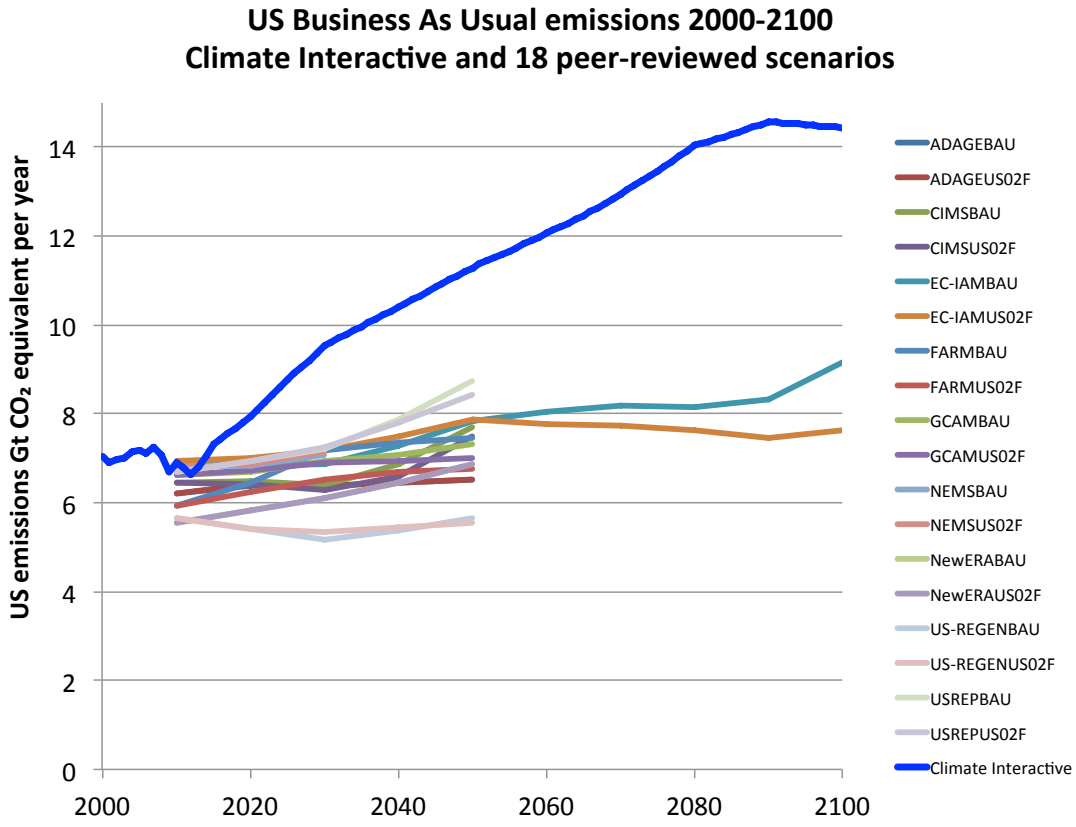

Figure 8 Emissions from all 9 EMF24 baseline scenarios (US01 and US02) 2010-2100 (only on set goes beyond 2050), compared to Climate Interactive's estimate. (Kriegler et al. 2014), (Climate Interactive 2015).

baseline increasingly diverging to the point of being about 80% too high at the end of the century.

Similarly, Figure 9 shows the vast difference between the median baseline of AME and the Climate Interactive estimate for China emissions, which increasingly diverge from the academic literature and towards the end of the century is almost 90% too high.

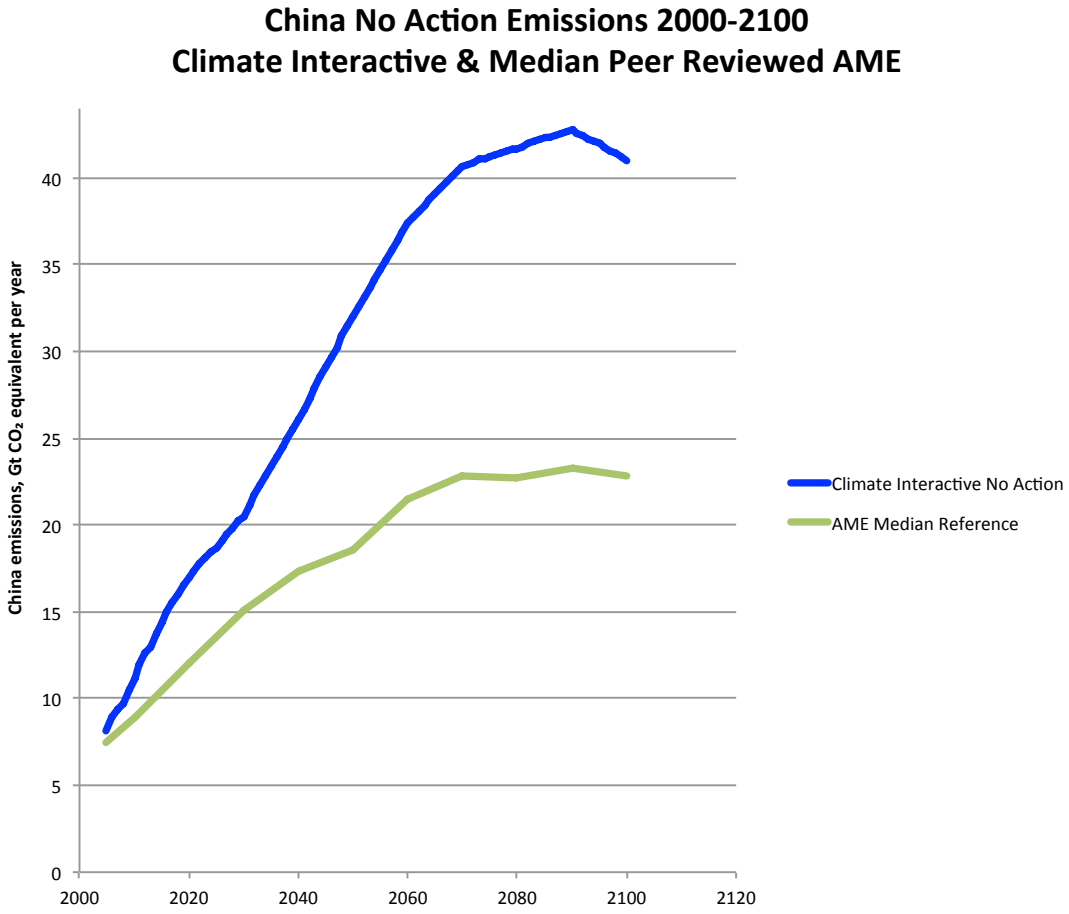

Figure 9 Median of baseline scenarios of 17 individually peer-reviewed reference scenarios in the collectively peer-reviewed Asia Modeling Exercise (Calvin et al. 2012), and Climate Interactive No Action scenario (Climate Interactive 2015).

Which promises should be included in a Paris COP21 analysis?

Some critics claim that in analyzing Paris, we should look not just at the promises made for 2016-2030, but also promises much further out, like the Chinese promise to reduce emissions after 2030, the US promise to reduce its emissions to 80% below 2005 in 2050 and the EU promise to cut emissions 80-95% below 1990-levels in 2050.

Such an interpretation is implausible and for three interlocking arguments, as I also point out in my article

First: It is difficult to defend the inclusion of targets with a very low likelihood of implementation.

In my article, I only include policies that have practical political implications soon and have a verifiable outcome by 2030.

It is undeniable that political targets further away are less likely to be implemented. Recent history clearly indicates that climate promises even 10-15 years ahead will be routinely flouted.

When China commits to reduce its carbon intensity of GDP by 60% to 65% below 2005 levels by 2030, we can analyze the progression towards that goal very clearly over the next 15 years and clearly determine if it is met by 2030 – so this is included in my analysis.

However, the promise to "achieve the peaking of carbon dioxide emissions around 2030 and making best efforts to peak early" (often curiously misquoted, as for instance in "peak CO_2 emissions by 2030 at the latest"[4]) is something that will only have an effect *after* around 2030, and it is something that will first be verifiable around 2035 or later.

This is especially true given that Chinese energy statistics are notoriously opaque. Just in the last few weeks it became clear that China burned perhaps 17% more coal per year in recent years than was previously understood.[5]

China's 'peaking' promise is very unlikely to be achieved based on economic reality alone. The cost can be identified from the Asia Modeling Exercise which indicates that the lowest GDP loss would be about $400bn or about 1.7% of GDP, and likely twice that. It strains credibility to expect China to commit such economic self-harm.

(It is worth noting in passing that China also promises in its INDC to be "democratic" in 2050 (China INDC 2015). The one-party state's vow should probably be treated rather similarly to the suggestion that it will rein in economic growth so dramatically).

Second: my approach is methodologically clear. The alternative is unable to avoid a slippery slope that would include every target, vow, promise, or vague political undertaking.

In my analysis, I was consistent in ruling out longer-term promises that were further off and economically implausible.

I also left out the US promise of "deep, economy-wide emission reductions of 80% or more by 2050." Data from the Stanford Energy Modeling Forum for the US (Fawcett et al. 2014) shows an average GDP loss at more than $1 trillion annually, if done efficiently. If not, which seems to be the only constant in climate policy, the cost will likely double to almost $2.5 trillion or 7.5% of US GDP in 2050.

And I left out the EU promise "to reduce its emissions by 80-95% by 2050 compared to 1990." Data from the Stanford Energy Modeling Forum (Knopf et al. 2013) shows the average GDP loss at almost €3 trillion annually, if done efficiently. If not, the cost will likely double to almost €6 trillion or 25% of EU GDP in 2050.

If we were to include the Chinese 'peaking' promise, why not also include the US promise to cut 80% by 2050 and the EU promise to cut 80-95% by 2050, both of which are mentioned in their INDCs?

Including these promises would make a mockery of any real analysis of what the Paris treaty can achieve.

Indeed, since almost every nation has signed up to reduce temperature rises to 2°C[6], and about 80-90 nations including the EU and the US 'endorse' this target in their INDCs, where should we draw the line?

Third: the commitment period of 2016-2030 is by far the most common understanding of what Paris constitutes.

This is true whether we pay attention to the United Nations or at the official material from nations themselves:

- The UNFCCC itself describes the central results as emission reductions achieved in 2025 and 2030, not further. It specifically labels possible emission reductions after 2030 as actions taken by nations "beyond the time frames stated in their INDCs (e.g. beyond 2025 and 2030)" (UNFCCC 2015)
- The US clearly states that its understanding of its INDC is for 2025 and not further: "The U.S. target is for a single year: 2025." (USINDC 2015)
- The EU sets its targets for 2030 and not any further.
- In its own INDC, China clearly writes what it expects from the Paris agreement, namely to "formulate and implement programs and measures to reduce or limit greenhouse gas emissions for the period 2020-2030." (China INDC 2015) So even China itself is unequivocal that the Paris deal is not about promises after 2030, but up until 2030.

What does climate policy history tell us?

It is also worth remembering what previous promises have routinely been flouted, which lends less credibility to new promises, especially far-off promises. Consider an analysis conducted in 1997 on the likely effect of the Kyoto Protocol. Should it have included not just the specific commitments made in Kyoto, but every far-reaching promise made around that time? Likely not, because we should have assumed that not only would this treaty be implemented, but that stronger and ever-increasing cuts would consistently be made as a result of

policy (and not economic downturns) for decades. History shows that we would have been utterly wrong to do so.

Moreover, should such an analysis of Kyoto have included President Bill Clinton's 1993 announcement[7] that the US would reduce its emissions by 2000? That promise was never fulfilled. According to the Washington Post, the US administration's excuse was that the "goal is no longer possible because the economy has grown more rapidly than expected."[8] The commitment failed even though it was for just seven years later, was to be implemented right away, and under the same president who made it.

Every industrialized nation actually promised in 1992 to return their emissions in 2000 to 1990-levels[9] – and almost every single OECD country missed that target.

Even the commitments made in the Kyoto Protocol itself ended up meaning nothing. The treaty was abandoned by the USA, and eventually by Russia, Japan and Canada.

We would clearly not have known this if we were conducting analysis in 1997 – but the examples show that it is folly to assume that we can realistically believe targets much further ahead to be right.

Literature

Bohringer, Christoph, Thomas F. Rutherford, and Richard S. J. Tol. 2009. "THE EU 20/20/2020 Targets: An Overview of the EMF22 Assessment." *Energy Economics*, International, U.S. and E.U. Climate Change Control Scenarios: Results from EMF 22, 31, Supplement 2 (December): S268–73. doi:10.1016/j.eneco.2009.10.010.

Boyd, Rodney, Joe Cranston Turner, and Bob Ward. 2015. "Tracking Intended Nationally Determined Contributions: What Are the Implications for Greenhouse Gas Emissions in 2030? | Grantham Research Institute on Climate Change and the Environment." In . LSE. http://www.lse.ac.uk/GranthamInstitute/publication/tracking-intended-nationally-determined-contributions-what-are-the-implications-for-greenhouse-gas-emissions-in-2030/.

Calvin, Katherine, Leon Clarke, Volker Krey, Geoffrey Blanford, Kejun Jiang, Mikiko Kainuma, Elmar Kriegler, Gunnar Luderer, and P. R. Shukla. 2012. "The Role of Asia in Mitigating Climate Change: Results from the Asia Modeling Exercise." *Energy Economics*, The Asia Modeling Exercise: Exploring the Role of Asia in Mitigating Climate Change, 34, Supplement 3 (December): S251–60. doi:10.1016/j.eneco.2012.09.003.

Calvin, Katherine, Allen Fawcett, and Jiang Kejun. 2012. "Comparing Model Results to National Climate Policy Goals: Results from the Asia Modeling Exercise." *Energy Economics* 34 (December): S306–15. doi:10.1016/j.eneco.2012.03.008.

Capros, P., L. Mantzos, V. Papandreou, and N. Tasios. 2008. "Model-Based Analysis of the 2008 EU Policy Package on Climate Change and Renewables." http://ec.europa.eu/clima/policies/strategies/2020/docs/analysis_en.pdf.

CAT. 2015. "Climate Action Tracker Data." http://climateactiontracker.org/assets/Global/october_2015/CAT_public_data_emissions_pathways_1Oct15.xls.

China INDC. 2015. "China INDC Submission." http://www4.unfccc.int/submissions/INDC/Published%20Documents/China/1/China's%20INDC%20-%20on%2030%20June%202015.pdf.

Climate Interactive. 2015. "Data for INDC and Baseline." https://d168d9ca7ixfvo.cloudfront.net/wp-content/uploads/2013/12/Climate-Scoreboard-Output-27Oct2015-to-share.xlsx.

EIA. 2015. *Data for Annual Energy Outlook 2015*. http://www.eia.gov/forecasts/aeo/tables_ref.cfm.

EUINDC. 2015. "European Union INDC Submission." http://www4.unfccc.int/submissions/INDC/Published%20Documents/Latvia/1/LV-03-06-EU%20INDC.pdf.

Fawcett, Allen A., Leon C. Clarke, Sebastian Rausch, and John P. Weyant. 2014. "Overview of EMF 24 Policy Scenarios." *The Energy Journal* 35 (01). doi:10.5547/01956574.35.SI1.3.

Knopf, Brigitte, Yen-Heng Henry Chen, Enrica De Cian, Hannah Förster, Amit Kanudia, Ioanna Karkatsouli, Ilkka Keppo, Tiina Koljonen, Katja Schumacher, and Detlef P. Van Vuuren. 2013. "Beyond 2020 — Strategies and Costs for Transforming the European Energy System." *Climate Change Economics* 04 (supp01): 1340001. doi:10.1142/S2010007813400010.

Kriegler, Elmar, John P. Weyant, Geoffrey J. Blanford, Volker Krey, Leon Clarke, Jae Edmonds, Allen Fawcett, et al. 2014. "The Role of Technology for Achieving Climate Policy Objectives: Overview of the EMF 27 Study on Global Technology and Climate Policy Strategies." *Climatic Change* 123 (3-4): 353–67. doi:10.1007/s10584-013-0953-7.

Lomborg, Bjorn. 2015. "Impact of Current Climate Proposals." *Global Policy*, November, n/a – n/a. doi:10.1111/1758-5899.12295.

MIT. 2015. "Energy and Climate Outlook 2015." http://globalchange.mit.edu/research/publications/other/special/2015Outlook.

Netherlands EPA. 2015. "PBL Climate Pledge INDC Tool." http://infographics.pbl.nl/indc/.

Rodney Boyd, Joe Cranston Turner, and Bob Ward. 2015. "Intended Nationally Determined Contributions: What Are the Implications for Greenhouse Gas Emissions in 2030?" Accessed November 25. http://www.lse.ac.uk/GranthamInstitute/publication/intended-

nationally-determined-contributions-what-are-the-implications-for-greenhouse-gas-emissions-in-2030/.
Tol, Richard S. J. 2012. "A Cost–benefit Analysis of the EU 20/20/2020 Package." *Energy Policy*, Special Section: Fuel Poverty Comes of Age: Commemorating 21 Years of Research and Policy, 49 (October): 288–95. doi:10.1016/j.enpol.2012.06.018.
UNEP. 2015. *Emissions Gap Report 2015*. http://uneplive.unep.org/media/docs/theme/13/EGR_2015_ES_English_Embargoed.pdf.
UNFCCC. 2015. "Synthesis Report on the Aggregate Effect of the Intended Nationally Determined Contributions." http://unfccc.int/resource/docs/2015/cop21/eng/07.pdf.
USINDC. 2015. "United States INDC Submission." http://www4.unfccc.int/submissions/INDC/Published%20Documents/United%20States%20of%20America/1/U.S.%20Cover%20Note%20INDC%20and%20Accompanying%20Information.pdf.
Veysey, Jason, Claudia Octaviano, Katherine Calvin, Sara Herreras Martinez, Alban Kitous, James McFarland, and Bob van der Zwaan. 2015. "Pathways to Mexico's Climate Change Mitigation Targets: A Multi-Model Analysis." *Energy Economics*. Accessed November 25. doi:10.1016/j.eneco.2015.04.011.

[1] https://www.ipcc.ch/publications_and_data/ar4/wg1/en/ch8s8-8-2.html, http://unfccc.int/adaptation/nairobi_work_programme/knowledge_resources_and_publications/items/5430.php, http://ipcc.ch/pdf/assessment-report/ar5/wg3/ipcc_wg3_ar5_summary-for-policymakers.pdf
[2] http://climateactiontracker.org/countries/mexico.html
[3] http://www.sciencedirect.com/science/article/pii/S0140988315001346
[4] http://climateactiontracker.org/countries/china.html
[5] http://www.nytimes.com/2015/11/04/world/asia/china-burns-much-more-coal-than-reported-complicating-climate-talks.html?_r=0
[6] http://unfccc.int/meetings/cancun_nov_2010/meeting/6266.php
[7] http://www.presidency.ucsb.edu/ws/?pid=46460
[8] http://www.washingtonpost.com/wp-srv/inatl/longterm/climate/stories/clim102397.htm
[9] http://unfccc.int/resource/docs/a/18p2a01c01.pdf