Introduction

How much time does the Paris Agreement buy us? After the gavel came down on the Paris Agreement on December 12, 2015, the question that looms in our minds is: How much time does the Paris Agreement buy us? If the world is going to keep global warming below 2 degrees Celsius, from this point forward it can emit no more than a total of 900 billion metric tonnes of CO₂ or CO₂ equivalents from other gases.1 Staying under this emissions threshold requires that the global economy must decarbonize its energy infrastructure well before the close of the century.

Our findings: Paris gets us five years. Around 2030, the U.N. projects CO₂ emissions will decline sharply and permanently.2 We term this event, “the decarbonization miracle.” In this paper we make a few optimistic assumptions, most notably, in the near-term (till 2030) all major emitters will start taking action immediately and will keep to their Paris pledges, or INDCs (Intended Nationally-Determined Contributions). Should they succeed in that effort, we estimate that the agreement adds about 5 years of additional time for research and development to enable us to realize the decarbonization miracle.

What is the agreement ‘worth’ aside from buying us a little time? The Paris Agreement was a starting point for negotiations, even as it was the end point of the Durban Platform, which began in 2011. It was an elaborate dance to bring carbon emitting developing countries to accountability, but in a gentler manner than the precedent set by the Kyoto Protocol. Mainly, it was a way to bring China, the world’s largest emitter by far (almost double of the E.U. and three times that of India) into the family of nations to work towards a common goal. When the Kyoto Protocol was signed, no one thought China would grow and emit as it did for the next 20 years. This underscores the necessity to curb emissions from any country that is emitting too much—whether developed or not. Regardless of GDP, once nations begin to emit a certain level, they should be admitted to a “Carbon Club” where they are expected to place more stringent curbs on emissions and be held accountable to the global community.

Without the Paris pledges, decarbonization would need to start in 2021.

The Paris Agreement was built around nations offering up their INDCs or pledges, in which most set goals for emissions levels going out to 2030. These non-binding promises outlined what nations will try to achieve in the time from now until the “decarbonization miracle” occurs. We begin by modeling a scenario based on what the four major CO₂ emitters, China, the US, the EU and India, had committed to do prior to Paris.

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1 IPCC Climate Change 2014 Synthesis Report Summary for Policy Makers: “Multi-model results show that limiting total human-induced warming to less than 2°C relative to the period 1861–1880 with a probability of >66% would require cumulative CO₂ emissions from all anthropogenic sources since 1870 to remain below about 2900 GtCO₂ (with a range of 2550 to 3150 GtCO₂ depending on non-CO₂ drivers). About 1900 GtCO₂ had already been emitted by 2011.” For 2012-14, annual emissions have been around 30 Gt of CO₂, so about 900 Gt of headroom remain (IPCC Infographic Series, WRI).

2 Synthesis report on the aggregate effect of the intended nationally determined contributions. UNFCCC. October 2015.
Without the Paris Agreement, the E.U. and the U.S. were the only major players that had indicated that they would actually cut emissions: the U.S. pledged to cut back emissions from 2005 levels by 26% to 28% by the year 2025, to culminate in annual CO₂ emissions reduced by 80% in 2050 compared to 2005 levels. The E.U. offered a 2-stage approach, with 80-95% reductions in annual emissions promised by 2050 relative to 1990 levels.

Prior to Paris, China, already the world’s top emitter, had simply promised to stabilize emissions in 2030. In our model, we assumed Chinese CO₂ emissions would proceed in near lockstep with GDP growth, which we put at 3.5% per year, in line with international observer estimates, but well below China’s officially-stated growth targets of 7 percent. India, which had made no commitments prior to Paris was also assumed to have emissions closely tied to GDP growth of 5.2%.

Our model looks at emissions from the “Carbon Club” and compares time frames with and without Paris for surpassing the 900 GT mark. To address the question of what amount of time the Paris Agreement bought us, we put together a simple model that looked at emissions from the big four emitters, which we refer to as the “Carbon Club,” and compared time frames for surpassing the 900 billion tonne mark, with and without Paris. China, the U.S., the E.U., and India account for 55% of global emissions. We lumped the rest of the world (ROW) in a fifth category and made a simplifying assumption that ROW emissions will simply maintain its current levels of being 45% relative to what the big four produce. In the model, as a baseline, we assumed that the U.S. and E.U., which are already on paths of absolute CO₂ emissions reductions, continued on the paths that they had committed to prior to Paris.

Pre-2020 Ambition. The Paris Agreement will not come into force until 2020, leaving open the question of what happens between now and then. One possible answer comes from the Kyoto Protocol process which, in 2009 and 2010, invited countries that were non-signatories to the Kyoto Protocol to submit Nationally Appropriate Mitigation Actions for the pre-2020 period. Whether these are monitored, how they are reported, and what they mean in terms of mitigation are fuzzy at best. Instead, for our model we have chosen to use the most optimistic scenario, that countries will indeed deploy their Paris INDCs, or pledges, in the pre-2020 period.

Our assumptions about growing emissions. We have previously argued that going into Paris, the largest emitters had staked out positions that allowed them to be the dominant emitters forever. While some grumbling about ‘climate justice’ took place at Paris, the dominant positions of the big four have not really been challenged, so in all our

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3 UNFCCC. INDCs as communicated by parties. Web page: http://www4.unfccc.int/submissions/INDC/Submission%20Pages/submissions.aspx


5 The current long-term trend is about a 1% annual reduction in carbon intensity per unit of GDP produced. See for example Worldwatch Institute “Global Energy and Carbon Intensity Continue to Decline” Dec 14, 2014, which reports that CO₂ intensity dropped 36.62% between 1990 and 2013, for an annual rate of reduction of about 1.4%. Our model starts out assuming 1% annual reductions in carbon intensity in India and China.

6 OECD Statistics, and Economist Intelligence Unit

7 See User Guide below and attached spreadsheet.

8 WRI CAIT Climate Data Explorer, Historical Emissions Excluding Land Use Change and Forestry-selected years.


scenarios, we simply assume that the rest of the world adjusts to what the big four do, letting them emit 55% of global greenhouse gases. The rest of the world with more than half of the earth’s population continues to get by on just 45% of the world’s emissions.\(^\text{11}\)

Note that one effect of this assumption is that if the big four make substantial cuts, it is assumed that the rest of the world follows suit; conversely, if the Carbon Club grows emissions substantially, the rest of the world does too. Although this is quite a simplifying assumption, we believe it makes sense because the big four encompass, to some degree, the range of developing to developed economies and the suite of technologies that they use with their energy infrastructure should be broadly available to the rest of the world.

Based on these assumptions, we found that cumulative global emissions would surpass the 900 billion mark shortly after 2030, even if the miracle started in that year. In other words, the “decarbonization miracle” would need to happen before then – specifically, we calculate that absent the Paris Agreement, the world would need to start rapid de-carbonization in 2021 at a rate of 10 percent cuts per year.

**Paris Commitments From China and India Allow Decarbonization to start in 2026**

Two huge new commitments came out of the preparations for Paris: the announcement of dramatic carbon intensity reduction goals by China, and a similar, though less spectacular target offered by India.

China’s revised goal, announced before the Paris talks in 2015 may not have gotten the full attention it deserves. Specifically, China announced that by 2030, it will reduce the carbon intensity of its economy by 60%-65%.\(^\text{12}\) Assuming a smooth annual rate of compounding, this indicates that China will cut the carbon emissions it puts out per unit of GDP by 6.8% per year, every year from now to 2030.

This is a stunningly ambitious goal. In our baseline scenario where China makes trendline improvements in carbon intensity of roughly 1% annually, we project emissions to rise from 10.9 billion tonnes per year in 2012 to 19.2 billion tonnes in 2030 when stabilization is supposed to begin. Assuming China meets its decarbonization goal, the 2030 emissions would be just 7.9 billion tonnes. Indeed, provided Chinese growth averages less than 7.3% annually, this commitment implies that emissions have already peaked.

**Unprecedented cuts are needed to achieve under 2-degree goal.** According to the report “Pathways to Deep Decarbonization in China” published by SDSN-IDDRI in 2015, “during the period of the 11th Five-Year Plan, China achieved its energy-saving targets, with energy consumption per unit of GDP in 2010 dropping 19.1% from 2005, which led to a decrease of CO\(_2\) emissions of more than 1.46 billion tonnes.” This would amount to a 4.2% annual decrease. The extraordinary decrease China is aiming for (6.8% annually) has not been achieved either in China or elsewhere.

India’s more modest 33-35% intensity reduction goal would amount to 2.7% annual decreases, which may be possible, but is not as meaningful because of India’s low overall carbon share.

Finally, we note that the Sino-Indian commitments also adjust the Rest of the World component of our model. Again, we assume

\(^\text{11}\) CIA. World Fact Book. 2015; and Population Reference Bureau. 2015.

\(^\text{12}\) UNFCCC. INDCs as communicated by parties. Web page: http://www4.unfccc.int/submissions/INDC/Submission%20Pages/submissions.aspx
that the rest of the world maintains a 45% share of emissions. Although this may seem slightly inelegant, we believe it makes sense – if China and India have technologies that are reducing carbon intensity, it is probable that such approaches would be distributed worldwide. Therefore, our conclusion was that without Paris, the rest of the world would be emitting 30 billion tonnes per year by 2030. With Paris and the widespread adoption of the whatever general energy path China takes, ROW emissions instead come in at around 16 billion tonnes per year.

If these above pledges (INDCs) are achieved by all four emitters, we calculate that it puts off the date when deep decarbonization must start from 2021 to 2026. So, Paris gains the world 5 years to find and hone the suite of new technologies that will cause the world to abandon all things fossil fuel.

Figure A below describes our scenarios:
- **Paris, 2026**: All Carbon Club pledges, ‘Miracle’ cuts 10% per year starting 2021.
- **Paris, 2030**: All Carbon Club current pledges in Paris (INDCs), ‘Miracle’ cuts 15% per year starting 2030.

**Figure A. What does Paris Buy Us?**

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**Reflections on the decarbonization miracle.** Whatever time Paris buys us, that time must pave the way for the rapid abandonment of fossil fuels. And, when one looks at the charts created by any of the climate optimists, the “miracle” is easily spotted, it is the point where CO₂ emissions peak and begin a deep and permanent decline. In the simple model that accompanies this paper, we assume that the arrival of the miracle results in a 10% annual decarbonization of the global economy from the year of the miracle through the end of
the century. This rate is dramatic: due to the effects of compounding, annual CO₂ emissions get cut by roughly half every seven years – less than the time in office of a two-term US president. We do not offer up what makes the miracle possible, only that it must happen. Anything short of that will result in a substantial overshoot of the 900 billion threshold, and our quest for a less than 2-degree warming.

Figure B: Comparison of global emission levels resulting from the intended nationally determined contributions in 2025 and 2030 with other trajectories

Source: AR5 scenario database, IPCC historical emission database and INDC quantification.
Abbreviations: AR4 = Fourth Assessment Report of the IPCC, AR5 = Fifth Assessment Report of the IPCC, GHG = greenhouse gas, GWP = global warming potential, HST = high short-term target, INDCs = intended nationally determined contributions, IPCC = Intergovernmental Panel on Climate Change.

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13 Synthesis report on the aggregate effect of the intended nationally determined contributions. UNFCCC. October 2015.
Remember too that the 10% annual reduction described in our miracle is an absolute reduction, not an intensity goal. Therefore, new growth must be accommodated even as the cuts are being made. If global growth continues at 2-3% annually, then the carbon intensity cuts need to be more on the order of 12-13% per year.

**Conclusion: Paris buys us a little time (five years) but under current INDCs, the world will overshoot the common goal of keeping warming under 2-degree rise unless emissions are cut 15% per year starting in 2030.** To achieve our warming goal, without the Paris Agreement (i.e., without China's and India's INDCs), the world must cut starting in 2021 at a rate of 10% per year. With the Paris Agreement (i.e., all four emitters' INDCs are included), the world must cut starting in 2026, at 10% per year.

If the world simply plays out its Paris commitments to 2030, then, a bigger miracle would need to take place starting in 2031 (Figure A). By then, we calculate that almost 700 billion of the 900 billion available tonnes of CO₂ emissions will have been put into the atmosphere. (Note that this is a huge improvement over our ‘No Paris’ baseline, where the 900 billion threshold is already surpassed just after 2030.) We then figured out how much more dramatic the miracle would have to be for the world to avoid 2 degree warming. **What we found is that an absolute reduction rate of 15% annually would be required.**

No one realistically believes that such a rapid transformation of the world economy is possible, absent a catastrophic economic collapse.

So, why the optimism around Paris? Perhaps because it leaves the door open to nations upping their commitments between now and the agreement’s sunset in 2030. According to the agreement, there will be a global stocktake in 2023 and then every five years. The agreement’s architects hope that international pressure will cause countries’ pledges to “ratchet up”. Over time, the hope is that ever-more aggressive reductions will allow the world to meet the common goal of staying under a 2-degree Celsius rise.

Perhaps that is possible. But what exactly is it that will cause sharp reductions in emissions, whenever that might happen? At the Paris meeting itself, Columbia University economist Scott Barrett raised the uncomfortable question of what suddenly changes things at that point where emissions magically drop in 2030? It seems clear that what must happen is a stupendous change in the global energy infrastructure. Something must arrive that undercuts fossil fuel use so dramatically that perfectly operational fossil fuel infrastructure will be abandoned in the eager transition to the decarbonized alternatives. Or, something with far lower carbon emissions will be developed that will still use the old infrastructure.

Whatever that miracle, the message from Paris is clear: we gained about five years. Yet, Paris is the work of our global collectivity, an agreement that includes all nations for the first time, and one where all the big emitters are held accountable.
User Guide to Attached Spreadsheet to Model the Scenarios Discussed in the Text, and to User-Created Scenarios

1) The spreadsheet opens on the tab labeled “Model” and with the following numbers already inputted:
   a. **Box 1: key variable assumptions** for the model are as follows (all blue background cells can be varied by the user):
      i. **China**: China’s reduction in carbon intensity from now to 2030. This is initially set at 15% (cell D8), which translates to 1% annual decrease for China, and this is roughly consistent with the overall global trend of a 1% annual decrease in carbon intensity.
      ii. **India**: India’s reduction in carbon intensity from now to 2030. Like China, our default is 15% (cell D12), which is consistent with the 1% global annual decrease in carbon intensity.
      iii. **Start year of the decarbonization miracle** (cell D18): This is the year when the greenhouse gas annual emissions curves suddenly turn sharply negative. Typically UN documents put this around 2030 (see for example, Figure B in the text above.) We therefore use 2030 as the default start year.
      iv. **Annual Reduction Pace of the miracle**: The annual pace of decarbonization once the miracle arrives. We somewhat arbitrarily picked 10% as our default miracle rate (cell D19). We note that the most aggressive goal of any of those put forward by any single Paris participant is that of the E.U., which has committed to 8.8% annual reductions from 2030 to 2050. A 10% annual reduction pace is, therefore, a very optimistic scenario.
   b. **Box 2: key output** for the model (cell D23) gives the total CO$_2$ output from now to the end of the century based on the above assumptions. Again, the goal of keeping global temperature rise below 2 degrees centigrade requires that this number come in below 900. With the default settings, the result is 1406 billion tonnes, well above the target threshold. **In short, without the Paris agreement, the earth is on track to warm well more than 2 degrees.**
   c. **Box 3: additional secondary assumptions** follow. Some of these, though quite important, are not a focus of our paper. Still, adjusting some of them may be of interest to some readers. Specifically,
      i. **China’s underlying GDP growth rate 2015-2030** (cell D28). We use a fairly modest 3.5%, which comes from international observers, but is well below China’s central planners’ targets, which remain in the 6-7% range. Note that a cell is available (cell D29), for the years 2020-2030, which allows for a two-stage growth model – e.g. plugging in 6.5% for the next five years and then slowing down to 3.5% for the decade leading up to 2030. Slower economic growth in China, of course, makes hitting carbon goals easier. However, when the UNFCCC came into existence, no one thought China would grow at an unprecedented rate for the next twenty or more years. In any case, even if China’s growth slows down, it is very plausible that other developing economies will grow rapidly.
      ii. **China Annual CO$_2$ reduction rate 2030-2050**. (cell D30) Here too, our default assumption is optimistic – the Chinese have only committed to stabilize their
emissions starting in 2030. Note that this cell only affects the model's output if the decarbonization miracle happens after 2030. If the miracle happens in 2030 or before, China is swept up in that event and the miracle trumps China's long range plans.

iii. **India underlying growth rate 2015-2030** is a simpler one-stage model and again we plug in conservative international observer numbers to start with (cell D33)

iv. **India annual CO2 reduction rate 2030-2050** mirrors what we did with China. Given how far India lags China in per capita GDP and development, the assumption that India will be ready to begin emissions reductions in 2030 (absent the miracle) seems a bit optimistic.

v. **U.S. pledges** (cells D37-39): the U.S. has pledged to slowly but steadily make increasingly aggressive emissions cuts. The model assumes the U.S. proceeds on this path until such time as the decarbonization miracle occurs.

vi. **E.U. pledges** (cells D42-47): like the U.S., the more distant cuts are the most aggressive and, when we combine the E.U.’s rather modest pre-Paris commitments with their strong 2050 goal, we get the most aggressive commitment period of any major player, the 8.8% annual reductions needed from 2030 to 2050.

d. **Box 4: Detailed Output—Cumulative Emissions:** The final box gives the detailed output. Each year is modeled out. The most important assumption built into this section is that the big 4 emitters – China, the U.S., the E.U. and India will maintain their current 55% share of global emissions. If assumptions for these countries change and they cut emissions more dramatically, the model is set up such that the rest of the world also cuts. Conversely, if the big 4 emit more, the rest of the world is assumed to follow suit and continue to get by on 45% of the global “carbon pie.”

2) **Modeling Questions:** Users can pose the following questions, and plug in different values to obtain answers.

**Question 1: Absent the Paris agreement, when would the decarbonization miracle need to occur if warming is to be held below 2 degrees Celsius?**

i. Plug different years into cell D18 until cell D23 (total global emissions) drops below 900.

ii. The user will find that 2021 is the most distant target year for the decarbonization miracle if the temperature threshold is not to be breached.

**Question 2: With Paris, what is the outlook?**

iii. Plug the two major new commitments (China’s and India’s, brought forth as INDCs because of the Paris Agreement, previously not covered by the Kyoto Protocol) into the spreadsheet –

1. 65% in cell D8
2. 34% in cell D12
3. Return cell D 18 to 2030

iv. Note that even with the Paris commitments, the world remains on course to warm more than 2 degrees, because the 900 goal is breached (the spreadsheet yields 1013). So, Paris is a starting point, but more needs to be done if the goal is to be achieved.
**Question 3:** With Paris, when would the decarbonization miracle need to occur if warming is to be held below 2 degrees Celsius?

v. Leaving D8 and D12 at 65% and 34% respectively, plug new values into D18 until emissions come in under the 900 billion mark.

vi. 2026 is the new most distant year for the miracle. Note that this is 5 years after what Question 1 yielded (2021).

**Question 4:** With Paris and decarbonization beginning in earnest in 2030, how profound must the miracle be?

vii. Return D18 to 2030.

viii. Plug new values into cell D19 until cumulative emissions are brought below 900 billion tonnes (this happens at roughly 15%).

ix. Given that the most aggressive reduction in CO₂ emissions that any nation is willing to commit to at the moment is the EU’s 8.8% annual reductions projected in the 2030-50 time horizon, we view 15% as highly unlikely. The decarbonization miracle, therefore, will need to be profound, almost double that of the most aggressive goal (that of the E.U.’s).

We believe these exercises give you a sense of how the spreadsheet works and likely future outcomes. Should readers wish to model other possible scenarios (e.g. more rapid China growth, or a less rapid decarbonization miracle), the appropriate cells can be altered. Finally, we fully acknowledge that most spreadsheets contain bugs and math errors, so, if you spot something that looks off, we hope you will contact us so we can make appropriate revisions.

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**Disclaimer:** This is a working paper, incorporating informal feedback from peers, but is not peer-reviewed in the traditional sense of the word. Please use information from this paper with this caveat in mind.

The authors, Anukriti Hittle and Alexander Hittle are instructors at Washington University in St Louis, in the International Affairs Program and the Economics Department, respectively. Anukriti Hittle is a Visiting Scholar at the East-West Center for 2015-2016. Any comments may be directed to Anukriti_Hittle@wustl.edu. The views of the authors are not necessarily the views of the institutions with which they are affiliated.