Omission Innovation 2.0: Diagnosing the Global Clean Energy Innovation System

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Despite concern over climate change, global carbon emissions continue to rise. Reversing the trend requires clean energy innovation. It is time for Mission Innovation member nations to make good on their commitment to double clean energy RD&D.

KEY TAKEAWAYS

- Under the 2015 Mission Innovation initiative, 24 nations and the EU pledged to double their public investments in clean energy research, development, and demonstration over five years. But they are falling far short of their target.
- MI members increased public investment in clean energy RD&D by $2.6 billion from 2015 to 2018, according to the IEA—far less than the $4.6 billion they self-reported, and well below the $9 billion they would need to meet their goal by 2020.
- Patent applications were already declining across all major clean energy technologies—down 39 percent from 2011 to 2016—indicating that the pace of innovation has been slowing down.
- Carbon prices are too low to accelerate the clean energy transition without more public investment. Taking fossil fuel subsidies into account, the effective carbon price is actually negative (-\$3.44/tCO_2), so clean energy still doesn't face a level playing field.
- Clean energy RD&D and carbon pricing are complementary. To accelerate innovation, Mission Innovation members should make good on their pledge to double investment in RD&D while replacing fossil subsidies with carbon prices.

INTRODUCTION

As world leaders converge in New York for the annual UN Climate Week, perhaps their most important task will be to assess the health of the global clean energy innovation system, aggressively build on its strengths, and address its significant weaknesses.

Unfortunately, neither the current level of technology nor pace of innovation globally is sufficient to address the dual challenges of expanding access to cheap, clean energy while at the same time reducing the greenhouse gas emissions that cause global warming. Emissions continue to rise, having increased at a faster rate in 2018 than at any time since 2011.[1]

The transition to zero-carbon energy at global scale requires innovation on a massive scale. But public investment in clean energy research, development, and demonstration (RD&D) is increasing at only a paltry rate. Patent applications in new clean energy technologies continue to decline. And nations continue to subsidize unabated fossil fuel consumption.

In May of 2015, ITIF called for the establishment of a global initiative in which nations would commit to increase support for clean energy RD&D.[2] The importance of innovation to the clean energy transition was acknowledged by the creation of the Mission Innovation (MI) initiative, which was launched in conjunction with the Paris Agreement in December 2015. Twenty-four nations and the European Union committed to double their public investments in clean energy RD&D, and collaborate in tackling key innovation challenges.

But this Mission needs help. MI members have not come close to meeting their doubling goals. And seven MI countries continue to subsidize fossil fuel energy at levels far higher than the combined clean energy RD&D of all MI nations. Moreover, 170 nations are parties to the Paris Agreement but have not joined MI. It is time for more nations to match rhetoric with action.

This report examines the progress of MI and assesses the health of the global clean energy innovation system across three key indicators: public investment in clean energy RD&D; high-value patent applications in clean energy technologies; and carbon prices and fossil fuel subsidies. It is a companion to the Global Energy Innovation Index, which ranks nations across a range of innovation indicators.[3] Where the Index evaluates national contributions to clean innovation, this report looks at the global system and its ability to meet the climate challenge.

WITHOUT INNOVATION, GREENHOUSE GAS EMISSIONS WILL INCREASE

The problem MI was created to address is more urgent now than it was four years ago. The current suite of clean technologies—even with future anticipated cost reductions—is insufficient to drive the significant levels of emissions reductions necessary to achieve a net-zero-carbon energy system. Without new clean energy technologies and performance improvements, and cost reductions in existing clean technologies, countries will continue to rely on cheap fossil fuels to meet their energy needs.

Global carbon dioxide emissions are continuing to increase. The reason is simple: Growing energy demand is outpacing the clean energy transition.

Global carbon dioxide emissions are continuing to increase. After a three-year pause between 2014 and 2016, energy-related carbon dioxide (CO_2) emissions grew by 1.4 percent in 2017 and 1.7 percent in 2018.[4] And the latest United Nations "Emissions Gap" report finds that, under current policy and technology scenarios, global emissions will not peak before 2030.[5]

The reason for rising emissions is simple: Growing energy demand is outpacing the clean energy transition. As the global population grows, and as nations bring more of their citizens into the middle class—with the accompanying increase in per capita energy consumption—emissions will continue to increase as long as fossil fuels remain cheaper than low-carbon alternatives.

The International Energy Agency's (IEA) most recent energy and emissions report shows just how far clean energy has to go:[6]

- Global energy demand grew by 2.3 percent in 2018, the equivalent of consuming 328 million more tons of oil than in 2017.
- Carbon-free energy from renewables and nuclear power met just 32 percent of this new demand, with fossil fuels supplying the remaining 68 percent. This is an improvement over 2017, when carbon-free energy met 28 percent of new demand, but far from the level needed to reverse or even slow the emissions trajectory.
- Even in the electric power sector, which is generally seen as being easier to decarbonize than other sectors, growth in generation from renewables and nuclear power was only sufficient to meet 54 percent of new demand for electricity.

It is important to note that zero-carbon sources would need to meet 100 percent of new energy demand just to keep emissions constant. In such a scenario, fossil fuel consumption—and consequent emissions—would remain constant even as global energy consumption increased. In order for emissions to decline, zero-carbon energy must be cheap enough to meet 100 percent of new energy demand *and* displace existing fossil energy sources.[7] For example, to meet IEA's Sustainable Development Scenario, which is consistent with limiting global warming to 2 degrees C, zero-carbon electricity would need to meet 150 percent of new electricity demand annually between 2017 and 2040.[8]

Many point to the success of wind and solar power as evidence that clean energy has arrived. While wind and solar provide electricity that is cheaper than conventional fossil fuels in some locations with good wind and solar resources, the challenge of storing renewable energy so that it can be dispatched as needed over daily and seasonal timescales has not yet been fully solved. And further cost reductions are needed to expand the geographic regions where wind and solar are competitive with other sources of electricity.

Additionally, electricity generation is responsible for only 25 percent of global greenhouse gas emissions.[9] In other sectors, such as key transportation and industrial subsectors, zero-carbon options either do not yet exist or are decades away from reaching cost parity with fossil fuels.

COMPONENTS OF THE GLOBAL ENERGY INNOVATION SYSTEM

A healthy innovation system performs three essential functions. It generates new clean energy options; scales up promising options to commercial viability, while weeding others out; and provides a supportive social and regulatory environment for new clean technologies to be adopted.

Public investment in clean energy RD&D is the most important policy lever governments have to generate new clean energy options. While private-sector RD&D is also important, the high costs, long payback periods, and uncertain returns of RD&D limit private-sector investment and bias the private sector toward incremental, rather than transformational, innovation. Governments are uniquely suited to make the high-risk, long-term investments in innovation the private sector is unable to fund.

Patenting activity is a key indicator of the rate of technological innovation, often falling between RD&D and commercialization. Patents provide inventors of new technologies with exclusive rights to make, use, and sell their inventions, and often foster investment in the companies that hold them, thereby accelerating the commercialization of new clean energy options.

Investment in clean technologies is also helped or hindered by the social and regulatory environment into which they emerge. A **carbon price** signals a societal preference for clean energy and enhances the competitiveness of clean energy options. Conversely, **fossil fuel consumption subsidies** slow the adoption of clean energy and deter investment in clean energy companies by lowering the cost of fossil fuels below their market value.

The following sections examine the aggregate performance of MI across these indicators. MI's performance is representative of global performance on these indicators: MI members account for 80 percent of global public investment in clean energy RD&D and more than 90 percent of total high-value patent applications in climate-mitigation technologies.[10]

INDICATOR 1: PUBLIC INVESTMENT IN CLEAN ENERGY RD&D

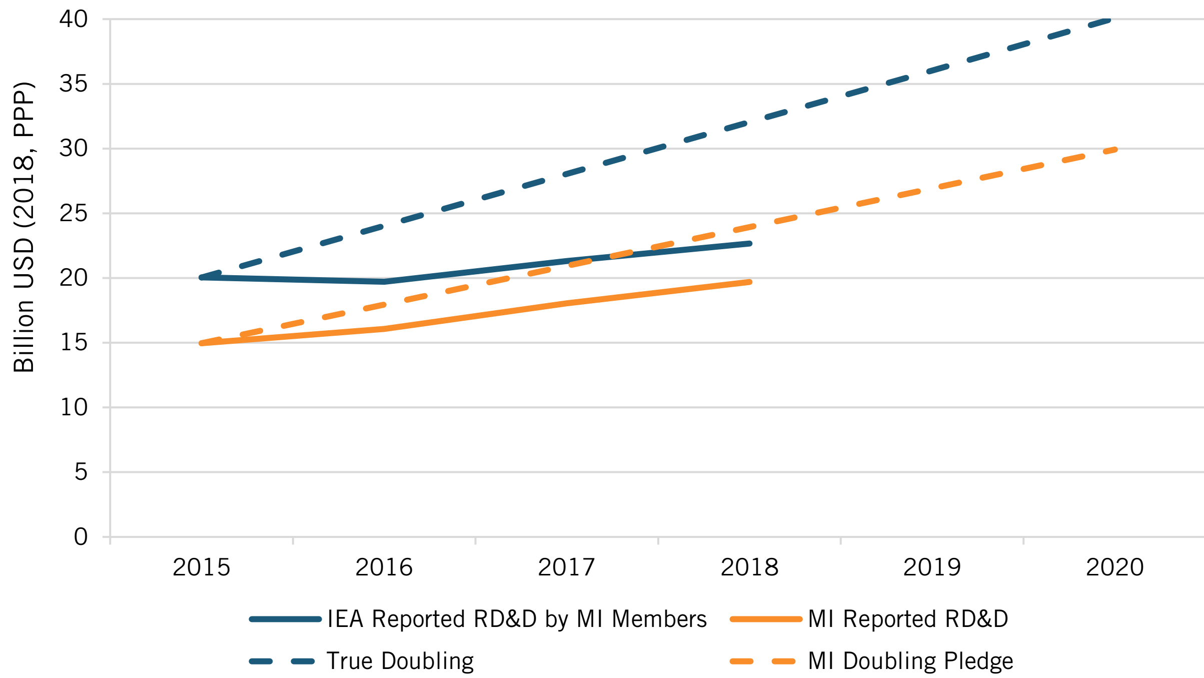
MI was launched in 2015 to reverse declining energy RD&D budgets, which had peaked in 2012.[11] Eight developing nations joined 16 IEA member nations and the EU in committing to double their investment in clean energy RD&D from an aggregate baseline of $15 billion to a target of $30 billion over a 5-year period.

MI has spurred greater government investment in clean energy RD&D… but not as much as has been claimed. From 2015 to 2018, total investment by MI members increased by $2.6 billion, far less than the $4.6 billion in MI reports.

At the fourth annual MI Ministerial gathering earlier this year, the chair announced that MI members were investing a combined $4.6 billion above their baseline pledges, implying that MI members were investing $4.6 billion more in clean energy RD&D than when MI was launched.[12] But the IEA's Energy RD&D database provides an independent check on MI reporting for the 16 nations and the EU that are members of both IEA and MI. Based on IEA data, collective investment by MI members has only increased by $2.6 billion since 2015.[13] Even the $4.6 billion number is only half of the increase needed to put MI on a doubling path (see figure 1).

To double by 2020, MI should increase its RD&D investments by $3 billion annually, or $9 billion as of 2018.

Figure 1: Total public investment in clean energy RD&D from MI members[14]



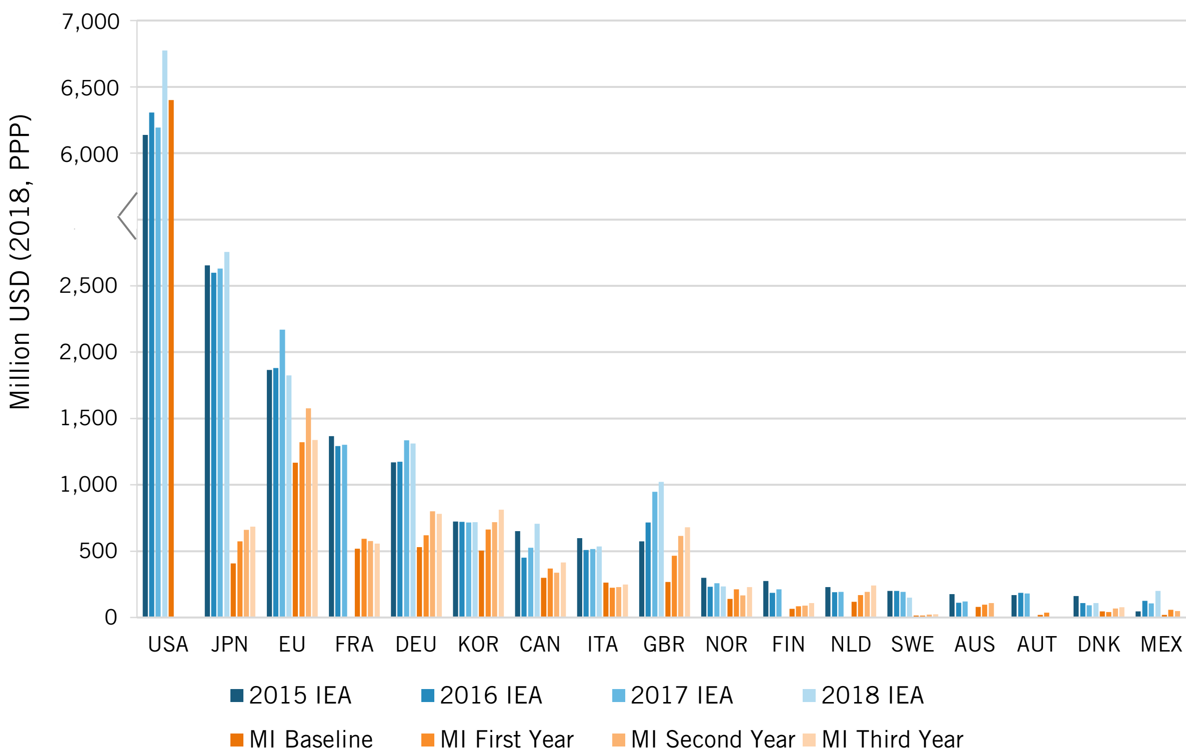
The reason for the discrepancy is MI member baseline pledges represented only a portion of their total energy RD&D investments in the baseline year. This sleight of hand enables such members to take credit for clean energy RD&D they were already supporting before MI, rather than actually increasing their investments to fulfill their pledges.[15] Per IEA data, total investment in clean energy RD&D by MI members started at just over $20 billion in 2015, declined slightly to $19.7 billion in 2016, and then grew to $22.7 billion in 2018.

Figure 2 compares national clean energy RD&D investments tracked by IEA (shades of blue) to the numbers countries voluntarily reported in MI documents (shades of orange) for the years 2015 through 2018. All dollar amounts have been converted from current prices in national currencies to U.S. dollar purchasing power parity (PPP) in constant 2018 prices, using GDP deflators and 2018 PPPs.

For example, Japan's MI pledge was to double funding from a baseline of 45 billion yen ($408 million in 2018) to 90 billion yen. But IEA's data shows Japan invested 280 billion yen, or $2.6 billion, in 2015. Italy, similarly, invested €400 million (about $600 million) in clean energy RD&D in 2015, but set its MI baseline at just €222 million ($330 million). The United States stands out as the only nation that pledged its full clean energy RD&D budget as its baseline MI funding level (see figure 2).[16]

Among IEA member countries, Mexico (341 percent), the United Kingdom (78 percent), Germany (12 percent), and the United States (10 percent) are the only nations that have significantly increased their clean energy RD&D budgets. Nine countries—France, South Korea, Italy, Norway, Finland, Netherlands, Sweden, Australia, and Denmark—and the European Union invest less now than they did in 2015 when MI was launched. More details can be found in the companion Global Energy Innovation Index report.

Figure 2: Public investment in clean energy RD&D, as tracked by the International Energy Agency (IEA) (blue bars) and MI (orange bars)[17]



Another reason to doubt MI is its numbers from China, the largest non-IEA nation in MI. According to MI reporting, China increased its investment from a baseline of $3.8 billion in 2015 to $6.3 billion in 2018, a significant increase of $2.6 billion, which accounts for more than half of the total growth in MI investments. But China's self-reported numbers include investments in "cleaner fossil fuels" other than carbon capture, utilization, and storage (CCUS), and are not typically included in international definitions of "low-carbon energy." That $2.6 billion in new energy RD&D breaks down as $1.4 billion in low-carbon energy RD&D—which includes renewables, nuclear, and CCUS—and $1.2 billion in non-CCUS fossil fuel technologies.

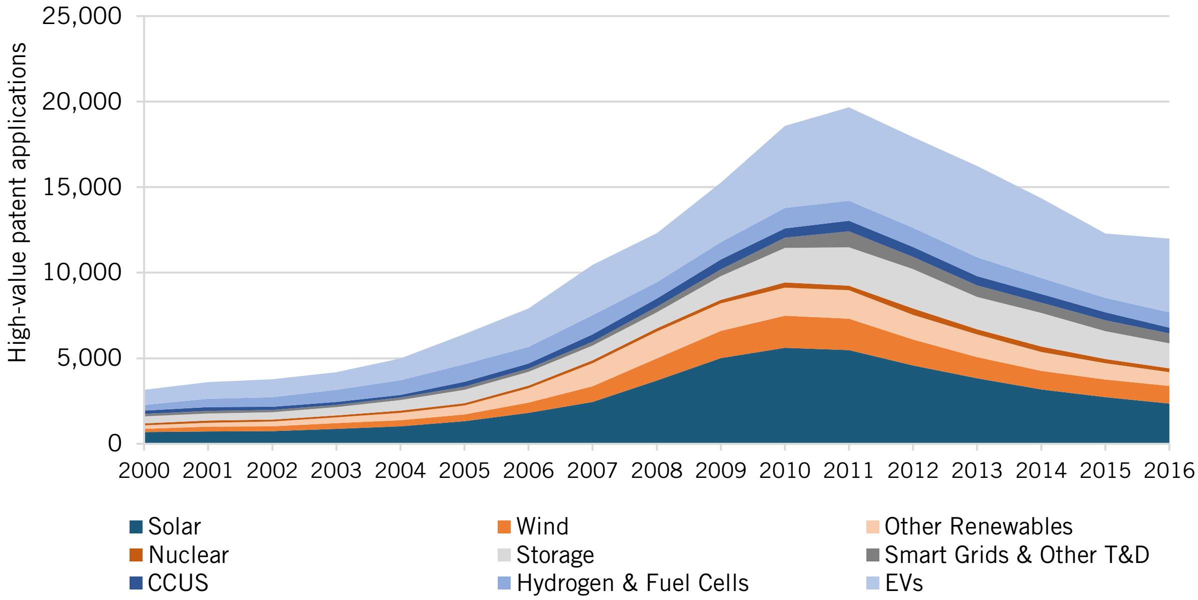
INDICATOR 2: PATENT APPLICATIONS FOR CLEAN ENERGY TECHNOLOGIES

Patenting activity is frequently used as an indicator of technological innovation.[18] In general, an inventor applies for a patent in order to receive exclusive rights to market the patented technology or process. Without such rights, potential investors often forego the opportunity to support new technologies, leaving them without a path to market. Patenting is thus a measure of the global innovation system's ability to turn the options generated by RD&D into products or services of commercial value.

Patenting in clean energy technologies among MI members grew rapidly in the first part of the century, with high-value patent applications increasing sixfold 2000 and 2011.[19] But after peaking in 2011, the number of new patent applications declined by 39 percent between 2011 and 2016.

The decline in patent applications was consistent across all major clean energy technologies (see figure 3).[20] Solar energy (59 percent), wind power (44 percent), and other renewable energy technologies (51 percent) saw the sharpest declines in patent applications, followed by CCUS (44 percent), smart grids (44 percent) and energy storage (36 percent). In the transportation sector, patenting in hydrogen and fuel cells (24 percent) and hybrid and electric vehicles (21 percent) also saw sharp declines from peak patenting activity, though the number of new patent applications for both categories increased from 2015 to 2016.

Figure 3: High-value patent applications for select clean energy technologies made by applicants residing in MI countries[21]

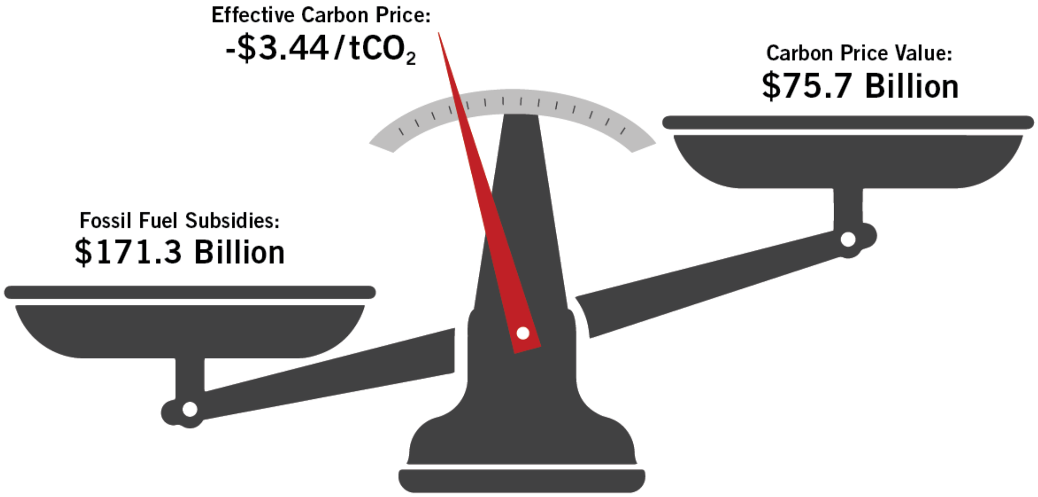


Weak patent applications portend weakness in the commercialization and scale-up of clean energy innovations in the period since 2015.

INDICATOR 3: CARBON PRICES AND FOSSIL FUEL SUBSIDIES

A carbon price incorporates some or all of the costs climate change imposes on society into the cost of fossil fuel energy and other climate-unfriendly products and services. Such a price signals a societal preference for clean energy and provides a market pull that complements RD&D and incentivizes greater private-sector investment. It can be implemented through a carbon tax or emissions trading system, and depends on both the cost of emitting one ton of carbon dioxide ($/t$CO_2$) and the fraction of total emissions covered by the policy.

Figure 4: The total value of carbon pricing policies and fossil fuel subsidies among MI members



The total value of carbon pricing—including the value of emissions trading systems and the revenue raised through carbon taxes—among MI members in 2018 was $75.7 billion. This figure includes national, subnational, and regional carbon policies. Collectively, MI members emitted 27.7 billion metric tons of carbon dioxide in 2018, meaning effective carbon prices from all carbon polices led to a positive average carbon price of about $2.73 per metric ton of CO_2.

For comparison, the World Bank suggests that a carbon price of $40–80/t$CO_2$ is required to be on track to meet the goals of the Paris Agreement.[22]

But fossil fuel subsidies act like carbon prices in reverse, depressing fossil fuel prices and encouraging greater consumption. By lowering the price of fossil fuels below their market value, subsidies reduce incentives for consumers to adopt clean energy, deter investment from financial institutions in clean energy companies, and increase the technical hurdles required for clean energy technologies to compete with the incumbent fossil fuel industry. Fossil fuel subsidies also represent an opportunity cost to clean energy innovation: Nations could use limited funding to invest in clean energy RD&D rather than subsidize consumption of carbon-emitting fossil fuels.

Seven MI countries—China, India, Indonesia, Mexico, Saudi Arabia, South Korea, and the United Arab Emirates—continue to subsidize fossil fuel consumption. Collectively, these nations spent more than $171 billion on fossil fuel subsidies in 2018, more than double the value of carbon pricing policies among all MI members. What's more, the trend in subsidies is headed in the wrong direction: After declining for four consecutive years from 2012 to 2016, fossil fuel subsidies increased in 2017 and 2018.[23]

The combined effect of carbon pricing policies and fossil fuel subsidies among MI members is a net-negative effective carbon price of $3.44/t$CO_2$, indicating that, on a global scale, clean energy has yet to face a level playing field.[24]

CONCLUSION

The recommendations from last year's ITIF "Omission Innovation" report remain just as relevant today. R&D investments are not increasing on pace, patent applications in clean energy have continued to decline, and fossil fuel subsidies are increasing. To accelerate innovation, MI members should make good on their commitment to double investment in clean energy RD&D, and align their policies, including carbon-pricing policies, to support clean energy.

And the 170 countries that are parties to the Paris Agreement but not members of MI should make innovation a central part of their plan. National commitments to cut greenhouse gas emissions will become empty promises if they are not backed up by an accelerated investment in clean energy RD&D.

Finally, civil society, the media, and other stakeholders should press public officials in these nations to back up their promises to fight climate change with demonstrable and adequate action to spur clean energy innovation.

About The Author

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ENDNOTES

1. Kelly Levin, “New Global CO2 Emissions Numbers Are In. They’re Not Good,” (World Resources Institute, December 5, 2018), https://www.wri.org/blog/2018/12/new-global-co2-emissions-numbers-are-they-re-not-good.
2. Robert Atkinson, “Time for a climate agreement on innovation, not targets,” The Hill (May 11, 2015), accessed September 11, 2019, https://thehill.com/blogs/pundits-blog/energy-environment/241579-time-for-a-climate-agreement-on-innovation-not-carbon.
3. Colin Cunliff and David Hart, “The Global Energy Innovation Index: National Contributions to the Global Clean Energy Innovation System” (Information Technology and Innovation Foundation, August 2019), https://itif.org/publications/2019/08/26/global-energy-innovation-index-national-contributions-global-clean-energy.
4. International Energy Agency (IEA), “Global Energy & CO2 Status Report 2017” (IEA, March 2018), https://webstore.iea.org/global-energy-co2-status-report-2017; IEA, “Global Energy & CO2 Status Report 2018” (IEA, March 2019), https://webstore.iea.org/global-energy-co2-status-report-2018.
5. United Nations Environment Programme, “Emissions Gap Report 2018: Executive Summary” (UN Environment Programme, November 2018), https://wedocs.unep.org/bitstream/handle/20.500.11822/26879/EGR2018_ESEN.pdf.
6. IEA, “Global Energy & CO2 Status Report 2018.”
7. This simple scenario ignores potential contributions from energy efficiency, which could play a large role in meeting sustainability goals. But the outlook for efficiency is also bleak. To meet IEA’s Sustainable Development Scenario, the energy intensity of the global economy would have to decline by an average 3.4 percent per year, but energy intensity has only declined by an average annual 2.1 percent between 2010 and 2018. And the rate of energy intensity improvements has actually declined since 2015. IEA, “Global Energy & CO2 Status Report 2018.”
8. IEA, “Global Energy & CO2 Status Report 2017,” 9.
9. Bill Gates, “Climate change and the 75% problem” (GatesNotes; October 17, 2018), accessed September 9, 2019, https://www.gatesnotes.com/Energy/My-plan-for-fighting-climate-change.
10. IEA, “Mission Innovation, a global partnership that seeks to accelerate clean energy innovation,” accessed September 9, 2019, https://www.iea.org/newsroom/news/2016/july/mission-innovation-a-global-partnership-that-seeks-to-accelerate-clean-energy-innovation.html; Cunliff and Hart, “Global Energy Innovation Index.”
11. Simon Bennett, “Commentary: Declining energy research budgets are a cause for concern” (IEA, October 16, 2017), accessed September 9, 2019, https://www.iea.org/newsroom/news/2017/october/commentary-declining-energy-research-budgets-are-a-cause-for-concern.html.
12. Mission Innovation, “Summary from the Chair of th Fourth Mission Innovation Ministerial (MI-4),” http://mission-innovation.net/wp-content/uploads/2019/05/MI-4-Chair-Summary.pdf
13. Some MI members use 2015 as a baseline year, while others use 2016, or an average over several years. Thus, some countries aimed to double their budgets by 2020 or 2021.
14. Countries vary in their budgeting and reporting cycles, and information for some countries may lag by one or more years. For Australia, Austria, Finland, France, Indonesia, the Netherlands, Saudi Arabia, and United Arab Emirates, we estimated 2018 funding by using 2017 or the most recent year. All dollar amounts are in have been converted from current prices in national currencies to US dollar purchasing power parity (PPP) in constant 2018 prices, using GDP deflators and 2018 PPPs. International Energy Agency (IEA), “Energy Technology RD&D Budget Database,” accessed September 9, 2019, https://wds.iea.org/wds/default.aspx; Mission Innovation Secretariat, “Mission

Innovation Country Highlights 2019" (MI Secretariat, May 2019), http://mission-innovation.net/wp-content/uploads/2019/05/MI-Country-Highlights-2019.pdf.

15. Zdenka Myslikova, Kelly Sims Gallagher, and Fang Zhang, "Mission Innovation 2.0: Recommendations for the Second Mission Innovation Ministerial in Beijing, China" (Tufts University and the Center for Internatioal Environment & Resource Policy, May 2017), https://sites.tufts.edu/cierp/files/2017/09/CPL_MissionInnovation014_052317v2low.pdf.

16. The United States used fiscal year 2016 as its baseline year, and set an initial goal of doubling clean energy RD&D by 2021. Under the Trump administration, the United States has remained a member of Mission Innovation but is no longer reporting clean energy RD&D expenditures to MI. See Executive Office of the President, "Domestic Implementation Framework for Mission Innovation" (November 2016), https://obamawhitehouse.archives.gov/sites/default/files/omb/reports/final_domestic_mission_innovation_framework_111616_700pm.pdf.

17. IEA RD&D Statistics Database, and MI Country Highlights.

18. Patent applications are typically published 18 months after they are received, but can take anywhere from 3 to 10 years to be granted. Because the first filing of a patent application is closest to the invention date, the Organization for Economic Cooperation and Development (OECD) recommends using the priority application date to measure inventive activity. For more, see the OECD Patent Statistics Manual (OECD, 2009), https://www.oecd-ilibrary.org/science-and-technology/oecd-patent-statistics-manual_9789264056442-en; For a discussion on the limitations of using patent data to measure innovation, see David Popp, "Using the Triadic Patent Family Database to Study Environmental Innovation" (OECD, 2005), https://www.oecd.org/env/consumption-innovation/38283097.pdf.

19. The quality and value of patents vary: Some inventions are extremely valuable, while others have little commercial value. And some countries, such as China, have incentives for researchers to patent that may inflate the number of patent applications without increasing the commercialization of new technologies. This report focuses on "high-value" patent applications—additional filings of the same patent application in two or more countries—to control for the quality of the application. Because of the additional costs of filing for patent protection in multiple countries, only the most valuable applications are filed in multiple countries.

20. Lorena Rivera Leon et al, "Measuring innovation in energy technologies: green patents as captured by WIPO's IPC green inventory," Economic Research Working Paper No. 44 (World Intellectual Property Organization, September 2018).

21. OECD, "Environment database: technology development," accessed September 4, 2019, https://stats.oecd.org.

22. World Bank Group, *State and Trends of Carbon Pricing 2019* (Washington, D.C.: World Bank 2019), 10, https://openknowledge.worldbank.org/handle/10986/31755.

23. Wataru Matsumura, "Commentary: Hard-earned reforms to fossil fuel subsidies are coming under threat," IEA (October 29, 2018), https://www.iea.org/newsroom/news/2018/october/hard-earned-reforms-to-fossil-fuel-subsidies-are-coming-under-threat.html; IEA, "World Energy Outlook," https://www.iea.org/weo/energysubsidies/. Note that these are aggregate numbers for Mission Innovation members. Total fossil fuel subsidies, across MI and non-MI members, was more than $400 billion 2018.

24. Extending the calculation to the entire world gives an effective carbon price of negative-$10.49/t$CO_2$. Global energy CO_2 emissions in 2018 were 33.1 billion metric tons, while the total value of all carbon-pricing policies is $79.6 billion. And global fossil fuel subsidies have reached $426.7 billion.