Omission Innovation: The Missing Element in Most Countries’ Response to Climate Change

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Only significantly greater levels of public investment in clean energy research, development, and demonstration (RD&D) will produce the level of innovation necessary to dramatically reduce emissions from unabated fossil fuel consumption.

OVERVIEW

World leaders are converging this week in Poland for COP24, a global meeting on climate change where countries will negotiate rules for implementing the 2015 Paris climate agreement.

The meeting serves to highlight several troubling facts: the transition to clean energy is not occurring fast enough to address climate change, and global carbon emissions are continuing to increase. But in spite of dire warnings from the Intergovernmental Panel on Climate Change (IPCC) and the U.S. Global Change Research Program (US GCRP) that call out the need to reduce emissions to zero well before the end of the century, most countries are omitting an essential element in their response to climate change: innovation.

Innovation in clean technologies is the *sine qua non* to addressing climate change. And only significantly greater levels of public investment in clean energy research, development and demonstration (RD&D) will produce the level of innovation necessary to dramatically reduce emissions from unabated fossil fuel consumption. Reducing carbon pollution to near zero requires a broader set of zero-carbon energy technologies—beyond just wind and solar for electricity generation—that cover all sectors of the economy and are as cheap and reliable as fossil fuels.¹
But countries are woefully under-investing in clean energy RD&D, and there are signs that clean energy innovation is stalling, just when we need it to accelerate. For example, after peaking in 2012, applications for new patents of some clean energy technologies have actually declined globally.\textsuperscript{2}

That’s why 23 nations and the European Union, led by the United States, joined Mission Innovation to “accelerate the pace of clean energy innovation.”\textsuperscript{3} In recognition of the need for greater investment, MI members committed to double clean energy RD&D funding within 5 years from a baseline of $15 billion in 2016 to $30 billion by 2021.\textsuperscript{4}

Sadly, this Mission is not on track. If the member countries stay on their current feeble growth trajectory, MI will reach only 50 percent of its target.\textsuperscript{5} Ironically, even though the Trump administration has officially withdrawn the U.S. doubling pledge, the U.S. Congress has significantly expanded federal energy RD&D over the past two fiscal years.\textsuperscript{6} While the growth rate falls short of the pace needed to hit the MI target, the United States still invests about as much as Japan, the European Commission, France and Germany combined.

Based on ITIF analysis of Mission Innovation, we identify three key findings and propose several recommendations:

- **Key Finding:** Early signs indicate that MI is spurring greater investment in energy R&D, though at the present rate, public RD&D among MI nations will increase by about 50 percent in 5 years, a far cry from doubling.\textsuperscript{7}
  - **Recommendation:** At COP24, MI members should reaffirm their commitment to double investment in energy research and should put their countries back on track to double clean RD&D by 2021.

- **Key Finding:** MI’s Innovation Challenges have been successful at improving international collaboration in energy research, though gaps remain. In particular, some harder-to-decarbonize sectors, including cement, steel, and petrochemicals, and the transportation sector—are not sufficiently represented in the current set of Innovation Challenges.\textsuperscript{8}
  - **Recommendation:** MI should expand the set of Innovation Challenges to cover harder-to-decarbonize sectors.
  - **Recommendation:** MI should set cost and performance targets for clean technologies and should report on cost improvements regularly.

- **Key Finding:** Improved transparency and consistency of reporting—including both innovation input metrics and output metrics—could help MI members improve their RD&D outcomes and accelerate technology transfer and commercialization.
- **Recommendation:** MI should establish consistent reporting guidelines, building off IEA’s framework for energy RD&D, and should also track innovation outputs including new energy patents.

**WITHOUT INNOVATION, GREENHOUSE EMISSIONS WILL INCREASE**

The problem that Mission Innovation was created to address is more urgent than 3 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 Greenhouse Gas Emissions Are Increasing**

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- In preparation for the COP24 talks, the U.N. released its annual “Emissions Gap” report finding that, under current policy and technology scenarios, global emissions are not estimated to peak before 2030.\(^{10}\) These projections account for current Paris climate commitments; however, given that these commitments are not binding, progress is likely to be even slower.

**Growing Energy Demand Is Outpacing the Clean Energy Transition**

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

- Global energy demand grew by 2.1 percent in 2017.
Progress is uneven across different sectors.

- In 2017, zero-carbon electricity (from nuclear power and renewables) accounted for over 52 percent of new electricity generation, with coal and gas accounting for 49 percent of new generation. Electricity generation from oil declined, accounting for -1 percent of new generation.\(^\text{12}\)

- But in the transportation sector, few low-carbon alternatives to oil exist, and electric vehicles made up only 0.3 percent of global vehicle stocks. Global oil demand rose by 1.6 percent, or 1.5 million barrels per day, largely as a result of larger numbers of cars on the road.\(^\text{13}\)

It is important to note that zero-carbon sources would need to meet \textit{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 increases. In order for emissions to decline, zero-carbon energy must be cheap enough to meet 100 percent new energy demand and displace existing fossil energy sources. For example, to meet IEA's Sustainable Development Scenario, zero-carbon electricity from renewables and nuclear power would have to meet 150 percent of new electricity demand annually between 2017 and 2040.\(^\text{14}\)

**Clean Energy Is Not Developing Quickly Enough**

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One metric for examining the rate of innovation is the number of new patent applications for clean energy technologies. Since reaching a peak in 2012, applications for new patents of some clean energy technologies have actually \textit{declined}, when we need them to increase. But even with 2012 patenting levels, clean energy innovation was still proceeding to slowly to address the climate challenge in a realistic time period.
Figure 1 shows patent applications for four clean energy technologies from 2002-2016. Patent applications peaked in 2012 but have since declined. Public investment in clean energy RD&D among members of the International Energy Agency (IEA) is overlaid above the patent filings. Public RD&D increased from under $11 billion in 2003 to a high of $18.5 billion in 2012, with a bump in 2009 due to increased investment in demonstration projects as part of the United States’ American Reinvestment and Recovery Act (ARRA). Public RD&D declined between 2012 and 2016 to about $16 billion, in tandem with the decline in new patent filings.

**SO, WHAT HAS MISSION INNOVATION DONE, AND IS IT WORKING?**

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Mission Innovation was launched to catalyze greater investment in clean energy RD&D. It has also expanded its focus and become a forum for greater international collaboration in public energy research. Since its inception, it has established a Secretariat to coordinate MI activities; held three Mission Innovation Ministerial meetings; established partnerships with Breakthrough Energy Coalition, the World Economic Forum, and the Oil and Gas Climate Initiative to spur greater private investment in emerging clean technologies; and launched eight technology-focused “Innovation Challenges” for high-priority research areas.
Now, three years after the launch of Mission Innovation, it’s time to take stock and check on MI’s progress.

**MI Goal: Doubling Public Investment in Clean Energy Research, Development, and Demonstration**

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Early signs indicate that MI is spurring greater public RD&D investment, though not at the doubling rate initially targeted. Based on member’s own submissions to MI, clean energy funding is not on track to meet the 2021 target, though funding has increased 22 percent between 2016 and 2018. At this rate, MI members will have met only about 60 percent of their target figure by 2021. Additionally, some members low-balled their MI 2016 baseline funding levels, allowing them to report greater spending to MI without actually investing more.

IEA’s database of energy-related RD&D investment among OECD countries going back to 1974 provides a second check on MI reporting, and IEA’s data is well-regarded for its accuracy, transparency, and harmonization across clean energy funding categories. IEA’s data, which only extends through 2017 and includes non-MI countries, finds an increase in public RD&D of 9 percent above 2016 levels. To be on track to double within five years, funding would need to increase at a rate of 15 percent annually.
The United States invests more in clean energy RD&D than any nation, as much as Japan, the European Commission, France, and Germany combined. Even after President Trump announced plans to withdraw the United States from the Paris Climate Agreement and rescind its pledge under Mission Innovation, the U.S. Congress approved a 12 percent increase in energy RD&D in 2018 and a 5 percent increase in 2019. The U.S. commitment to energy RD&D should encourage other MI member countries to accelerate their own investments in energy innovation.

**MI Goal: Fostering International Collaboration Through Innovation Challenges**

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MI’s Innovation Challenges have served as useful focal points for prioritizing energy research and have provided a framework for information sharing and international collaboration. Since its inception, MI has launched eight Innovation Challenges in key technology areas “where increased investment could make a significant impact:”

1. Smart grids
2. Off-grid electricity access
3. Carbon capture, utilization, and storage
4. Biofuels
5. Solar fuels
6. Clean energy materials
7. Heating and cooling of buildings
8. Hydrogen

Each of these Innovation Challenges has one or more lead countries that coordinate activities among other participating countries. Within the Innovation Challenge framework, MI members have begun holding national and international workshops and have developed joint research and development roadmaps that identify priority research directions in each area.

For example, the United States hosted a workshop on carbon capture, utilization, and storage (CCUS, IC #3) in September 2017 at the newly-opened Petra Nova carbon capture facility in Houston, Texas. That workshop resulted in a joint report from the United States, Saudi Arabia, and the other participating CCUS members that identified 30 priority research directions for reducing costs and improving performance of CCUS technologies. Similarly, a workshop on clean energy materials (IC #6) hosted by Mexico in 2017 led to the development of an R&D roadmap to combine machine learning with automated robotic materials laboratories to accelerate materials discovery for clean energy applications.

RECOMMENDATIONS

The problem that Mission Innovation was created to address is more urgent than 3 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.
1. **Expand the set of Innovation Challenges to encompass a broader number of sectors and technologies.** As MI seeks to double funding for energy innovation, it should also expand the areas of research to include other clean technologies, beyond the current set of innovation challenges, to cover gaps in the current innovation agenda. Many harder-to-decarbonize sectors are not well-represented by the current set of technologies. For example, electrification of light-duty vehicles, in tandem with decarbonization of electricity, could yield substantial emissions reductions. And innovation in batteries, rapid-charging technologies, and integration into electricity systems could enable accelerated electrification of light-duty vehicles. But these technologies are not well-represented under the current set of innovation challenges. Additionally, many large industrial sources of emissions—particularly cement, iron & steel, ammonia, and petrochemicals production—are not adequately addressed and may require their own innovation challenge. Clear Path has recommended new innovation challenges in energy storage, advanced nuclear energy, and industrial processes. Similarly, the Center for International Environment and Resource Policy identified energy efficiency and energy storage as gaps in the MI portfolio. And a recent report from the U.S. National Academies of Sciences, Engineering, and Mathematics identified carbon dioxide removal—also known as negative emissions technologies—as a gap in the U.S. portfolio of climate technologies.

2. **Establish cost and performance goals/metrics for each Innovation Challenge that would allow these technologies to compete with conventional fossil fuels.** Setting concrete goals and performance/cost targets provides a focal point for RD&D programs, and regular reporting on metrics can help governments identify promising lines of research and optimize new spending. For example, the U.S. Department of Energy (DOE) Sunshot goal for utility-scale solar photovoltaic (PV) electricity—$0.03 USD per kilowatt-hour (nation-wide average, unsubsidized) by 2030—provides direction for DOE’s solar energy RD&D program. Similarly, identifying cost/performance targets for each Innovation Challenge could help MI members track progress. For example, the biofuels challenge could set a target of developing advanced biofuels with 80 percent fewer lifecycle emissions than gasoline at a cost of USD $3 per gallon gasoline equivalent.

3. **Improve transparency and consistency of member reporting, and develop an expanded set of metrics for both innovation inputs (e.g., public- and private-sector RD&D by technology) and innovation outputs (e.g., patent applications, cost reductions by technology, emissions reductions).** Annual reporting of innovation input and output metrics can help member countries identify which factors are working to accelerate technology development and support technology transfer and commercialization. The Center for International Environment & Resource Policy has identified a set of metrics that would be useful for tracking clean energy innovation.
Table 1: Complementary innovation metrics that should be collected and reported by Mission Innovation countries.

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<th><strong>Innovation Inputs</strong></th>
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<tr>
<td>Number and type of public activities/projects in RD&amp;D phase, per technology</td>
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<td>Tax incentives for both RD&amp;D and deployment</td>
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<td>Number of specialized research centers/active university labs for RD&amp;D per technology</td>
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<td>Number and type of personnel engaged in government-funded clean energy RD&amp;D innovation projects</td>
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<td>Amount of cost-sharing and leverage created with public-private partnerships</td>
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<td>Clean energy deployment spending by technology</td>
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<td>Private sector spending on clean energy RD&amp;D</td>
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<th><strong>Innovation Outputs</strong></th>
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<tr>
<td>Cost reductions by technology</td>
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<td>Performance improvements by technology (e.g., improved efficiency)</td>
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<td>Annual rates of improvement in individual technologies</td>
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<td>Avoided emissions/emissions reduction potential by technology</td>
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<td>Patents applied for and granted by technology category</td>
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ENDNOTES


12. Ibid.


24. Due to regional differences in resource availability, a single set of cost/performance targets for each Innovation Challenge may not be appropriate, and countries may want to establish local targets. But the MI/IC framework can help members set metrics, and could set global cost reduction targets where applicable.