An unprecedented push for low-carbon energy innovation

Expert perspectives on R&D opportunities for Mission Innovation

Based on an expert consultation by Near Zero in advance of the Clean Energy Ministerial and Mission Innovation Ministerial, held June 1-2, 2016

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image credit: NASA

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To ensure that low-carbon energy sources continue growing rapidly with the aim of cutting energy-sector greenhouse gas emissions to near-zero, governments around the world have been focused on two major efforts: a “push” from innovation that helps make low-carbon energy cheaper and more versatile, and a “pull” from policies and market design that encourage the commercial scale-up of low-carbon energy.

In November 2015, a diverse set of 20 nations signed Mission Innovation's joint statement that pledged: "Each participating country will seek to double its governmental and/or state-directed clean energy research and development investment over five years."

Mission Innovation's unprecedented cooperative effort can supply a much larger “push” to innovation. This new wave of additional governmental spending (Figure 1) could raise low-carbon energy R&D to an all-time high and provide a stream of sustained innovations.

Similarly unprecedented is the Breakthrough Energy Coalition, a parallel private initiative led by Bill Gates, that secured commitments from

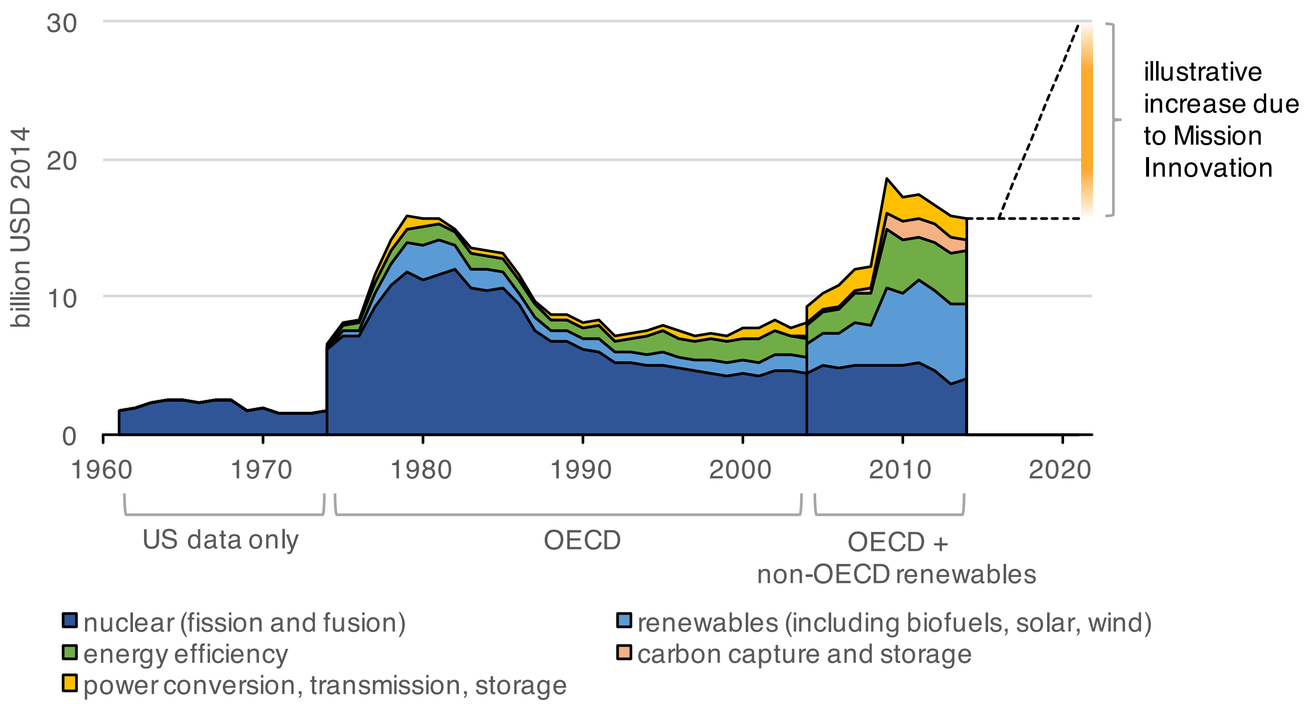

Figure 1. Governmental spending on low-carbon R&D

Conservative estimates for historical R&D spending are shown, due to data limitations. Breaks in data, where new sources are introduced, are indicated by vertical lines in 1974 and 2004. There are varying definitions of clean energy, and different stages of innovation. Shown above is a range of possibilities of what Mission Innovation could entail for R&D spending. Data sources: IEA-OECD, BNEF, PNNL (see supplemental report for full citations and underlying assumptions).

28 significant private capital investors to support innovations coming out of this expanded public research pipeline.

Building on R&D in years and decades past, much of it government-funded, low-carbon energy sources such as solar and wind power have already seen huge reductions in costs (Figure 2).

The profound challenge that climate change poses to the world has motivated a resurgence in interest in energy innovation worldwide.

Coordination on R&D across nations, drawing on the diverse perspectives of researchers around the world, can serve as an innovation multiplier and ensure applications for countries with differing resources and development pathways.

As Mission Innovation leads to a scaling up of low-carbon R&D, how to direct those funds may become an issue of increased discussion and debate.

EXPERT PERSPECTIVES

Near Zero, a non-profit research organization, engages groups of experts in online discussions and elicitations in order to explore areas of agreement and disagreement, as well as to help quantify priorities and uncertainties.

Following the November 2015 announcement of Mission Innovation and the Breakthrough Energy Coalition, Near Zero arranged an expert discussion and elicitation on global priorities for increased energy innovation. The results, described below, were published in March 2016 in the report "Global Priorities for Zero-Emission Energy Innovation: An Expert Elicitation and Discussion."

Ahead of the 7th Clean Energy Ministerial and the inaugural Mission Innovation Ministerial, held June 1st and 2nd, 2016, Near Zero gathered perspectives from experts in Mission Innovation countries to explore opportunities for further low-carbon energy R&D. These expert perspectives are presented at the end of this report.

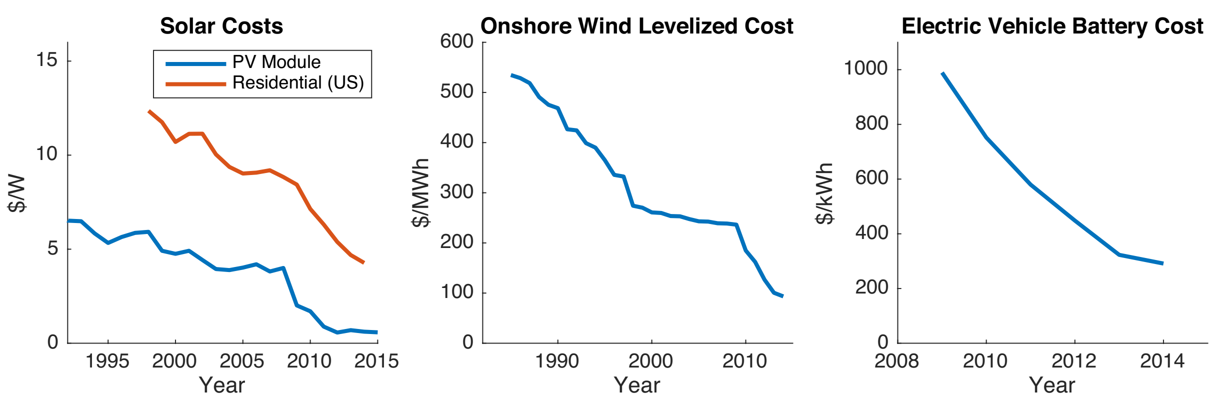

Figure 2. Prices have fallen sharply for various low-carbon energy technologies

Shown here are historical prices for solar photovolatic (PV) power (the power-generating modules alone, and for whole residential systems in the US); for wind power (global levelized cost), and for electric vehicle batteries. (Sources: US DOE, BNEF, LBNL; full citations in supplemental report.)

GLOBAL PRIORITIES

In Near Zero's earlier expert elicitation on global priorities for energy innovation, 29 experts from academia, non-governmental organizations, and industry were asked to allocate a hypothetical total R&D budget of $30 billion per year across the five categories that the Breakthrough Energy Coalition has said it will invest in.

On average, the participants called for the largest share of funding to go to electricity generation and storage, followed by transportation. Most experts advocated a broad R&D portfolio, allocating a portion of the funds across all categories, which also included energy systems efficiency, agriculture, and industrial use. (See Figure 3 and the associated report for more detail.)

In a discussion about global innovation priorities, expert participants highlighted the range of needs in diverse nations around the world.

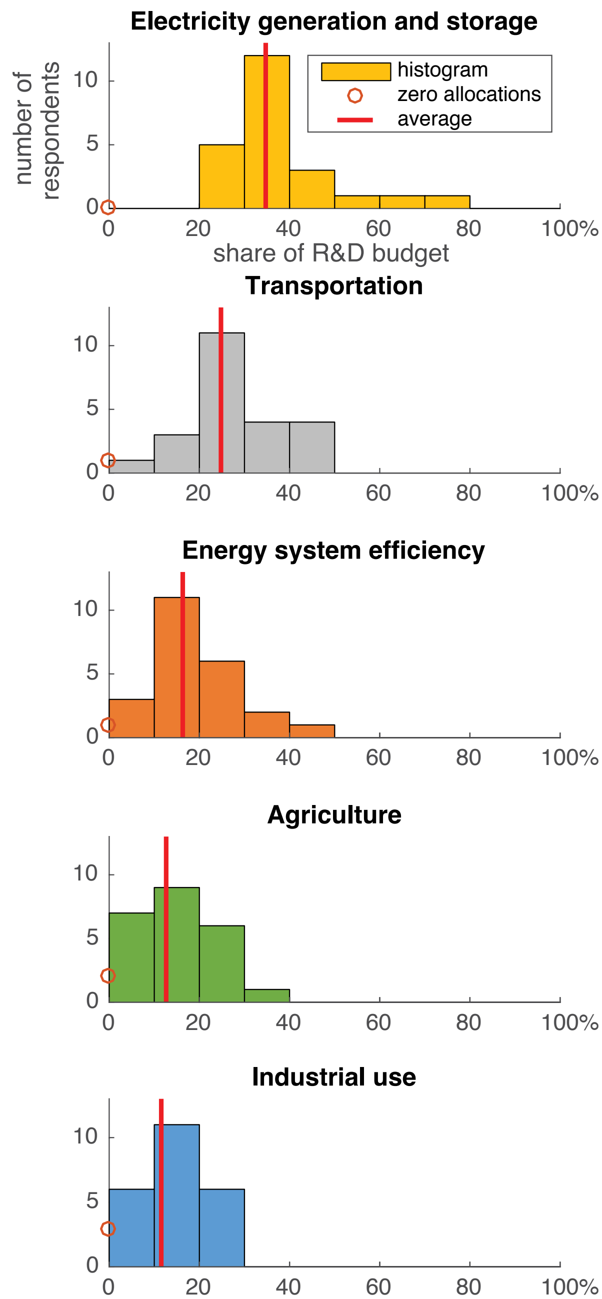

Figure 3. Allocation of a hypothetical $30 billion R&D budget, by category of spending.

From Near Zero, "Global Priorities for Zero-Emission Energy Innovation: An Expert Elicitation and Discussion," March 2016, at http://www.nearzero.org/reports/global-innovation

ENERGY R&D EXAMPLES

In May 2016, Near Zero conducted a follow-up expert consultation to identify examples of successful R&D projects and other innovative uses of technologies for diverse settings around the world, as well as areas that could use greater R&D attention. Near Zero invited participation from energy and sustainability experts in Mission Innovation countries, drawing on co-authors of major reports such as the Intergovernmental Panel on Climate Change (IPCC)'s reports and the Global Energy Assessment published by the International Institute for Applied Systems Analysis (IIASA).

In this new consultation, Near Zero asked: "What are examples of impactful governmental and/or state-directed R&D efforts in your country of expertise, which can be built on to meet Mission Innovation's goals within your national context?" and "In your country of expertise, what are additional R&D opportunities?"

Forty-five experts participated, and the following pages present a sampling of their responses, with participants' names and affiliations highlighted in blue. An accompanying supplementary report gives the experts' responses at greater length, covering a greater range of technologies, applications, and institutions involved in energy innovation.

Responses reflect the participants' personal views, and not necessarily their organizations or national governments. The responses are not intended to be representative of views of all energy experts in particular countries, nor worldwide.

SOLAR POWER

Solar power was highlighted by many participants as a crucial target for further innovation. Keigo Akimoto of the Research Institute of Innovative Technology for the Earth highlighted Japan's "Energy/Environment Innovation Strategy," issued in April 2016, which argued for solar cell efficiency as a prime target for further innovation. More efficient cells could lower the whole system cost, and allow generation of more power in a given area.

Solar power is an ideal application for desalination and purification of water in Persian Gulf Nations, Waleed Salman of the Dubai Electricity and Water Authority argued, calling for greater innovation to bring down the costs.

Where space is limited, installers have innovated by installing floating solar panels on lakes and reservoirs, sometimes called "floatovoltatics." Several OECD nations have such installations and, as highlighted by Yuyun Ismawati of BaliFokus Foundation, Indonesia is likewise planning a large floating solar farm.

Experts also noted international collaborations as models for sharing discoveries, including the Australia-US Institute for Advanced Photovoltaics and the Solar Energy Research Institute for India and the United States (SERIIUS).

GREENING THE GRID

New ways of building and managing electric grids, in particular to enable use of a high share of renewable power, was one of the topics most often-cited by participants.

Since wind and solar power are intermittent, many participants said that “greening the grid” would likely rely heavily on improvements to energy storage. For example, if India is to meet its targets for greatly increasing wind and solar power and integrate them smoothly into the grid, there is a "need for extensive research" on energy storage, said Anshu Bharadwaj of the Center for Study of Science, Technology and Policy.

"Fundamental R&D on materials, chemistry and electronics" could help improve storage, argued Jeffrey Logan of the U.S. National Renewable Energy Laboratory. This storage could take the form of new types of batteries, said Søren Linderoth of Technical University of Denmark, such as "flow batteries," in which electricity is stored in large tanks of liquid—but using polymers to store electricity, rather than metals as in traditional batteries.

In addition to batteries, there are many other ways of storing electricity, participants highlighted. One possibility is compressed air storage, in which electricity is used to pump air underground, building up to high pressures. Peter Cook of the University of Melbourne pointed to AusDEEP, a proposal in Australia to study Earth’s crust—one application being better understanding of the potential for compressed air storage.

Another type of storage in need of more research, participants said, is using excess electricity to synthesize gases to store the energy chemically. (See the section “Decarbonizing gas” below.)

DECARBONIZING GAS

In some areas, solar and wind power occasionally produce more power than the local grid needs at the moment. This excess electricity could be stored in batteries—but there are other approaches that may prove more economical or provide more flexibility.

Excess renewable electricity could be used to synthesize hydrogen or methane for "power to gas" systems, an area for further R&D, argued Poul Erik Morthorst of Technical University Denmark. These gases would serve as energy carriers that could be stored for later use or sent through pipelines.

One possibility is to use electrolysis to split water molecules to create hydrogen (an energy carrier) and oxygen. Another possibility is to synthesize methane, the main component of natural gas. This synthesis can use purely chemical means, such as the Sabatier process, in which CO_2 reacts with hydrogen; or it can harness microbes that naturally produce methane. (Electricity from solar or wind can also be used to synthesize liquid fuels, including methanol and diesel.)

Participants highlighted projects studying renewable gas, including Futuregas in Denmark, and Jiahua Pan of the Chinese Academy of Social Sciences highlighted a need for R&D on scaling up biomass gasification, creating methane from waste biomass. These non-fossil gases could be used in power plants, for heating buildings, for industrial uses, or in vehicles as a replacement for petroleum.

David Victor of the University of California, San Diego, called for more R&D on decarbonizing gas, adding that "there's a kind of tournament needed" to find out what technologies would be able to economically scale to achieve this goal.

ENERGY EFFICIENCY

Participants also highlighted many other technologies and approaches that could increase efficiency to provide greater energy services while cutting emissions.

The Repubic of Korea recently made "zero-energy buildings" one of its main project areas for more R&D for a low-carbon future, said Youngah Park of the Korean Institute for Science and Technology Evaluation and Planning. Advances in computing could help manage energy use to achieve energy efficiency, said Taishi Sugiyama of Japan's Central Research Institute of Electric Power Industry, while arguing, however, "that will never come out of [a] climate tech program alone."

There is a need for more research on energy use in buildings, particularly non-residential, said Kathryn Janda of the University of Oxford, since organizations often make "sub-optimal energy efficiency choices." Similarly, Shunsuke Managi of Kyushu University said efficiency could be aided by R&D using behavioral science and "tested in many countries."

LOOKING AHEAD

To support nations around the world—in particular members of the Clean Energy Ministerial and Mission Innovation—in discussions of future energy R&D budgets, more interaction is needed between experts in academia, industry, government, and civil society.

Structured expert elicitation and discussion can help governments identify the best opportunities and most pressing challenges for future energy research.

Supplemental report with data sources, assumptions, and full expert responses:

http://static.nearzero.org/missioninnovation/mission_innovation_supplemental.pdf

List of participants for May 2016 expert consultation

Keigo AKIMOTO, Research Institute of Innovative Technology for the Earth, Japan

Alfredo Bermudez, Universidad Autónoma de Baja California Sur, Mexico

Anshu Bharadwaj, Center for the Study of Science, Technology & Policy, India

Antonina Ivanova Boncheva, Universidad Autónoma de Baja California Sur, Mexico

Ian Bryden, University of the Highlands and Islands, United Kingdom

Helena Chum, National Renewable Energy Laboratory (NREL), United States

Peter Cook, University of Melbourne, Australia

Mark Diesendorf, University of New South Wales (UNSW), Australia

Karin Ericsson, Lund University, Sweden

Gerardo Hiriart Le Bert, Universidad Nacional Autónoma de México (UNAM), Mexico

Yuyun Ismawati, BaliFokus, Indonesia

Kathryn Janda, University of Oxford, United Kingdom

Birte Holst Jørgensen, Technical University of Denmark (DTU), Denmark

Frank Jotzo, Australian National University, Australia

Mikiko KAINUMA, National Institute for Environmental Studies (NIES), Japan

Emilio Lèbre La Rovere, Universidade Federal do Rio de Janeiro (UFRJ), Brazil

Søren Linderoth, Technical University of Denmark (DTU), Denmark

Jeffrey Logan, National Renewable Energy Laboratory (NREL), US

Oswaldo Lucon, University of São Paulo, Brazil

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Sergio Trindade, Independent Consultant, United States

José María Valenzuela, World Wide Fund for Nature (WWF), Mexico

David Victor, University of California, San Diego (UCSD), United States

Rahul Walawalkar, Customized Energy Solutions, India

Jim Watson, University of Sussex, United Kingdom

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