MISSION INNOVATION

Accelerating the Clean Energy Revolution

By

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Representative for Europe

Energy R&D Funds

Mexico

Birmingham

June 15, 2017

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Paris Climate Conference and Agreement – Key Features *

Well Below 2°C	Limit Warming to Well Below Target, and Try to Cap at 1.5°C
Achieve a Balance	Balance Anthropogenic GHG *Sources* and Removal by *Sinks* by Mid-Century
Every 5 years	Countries Will Review and Submit New, More Ambitious Plans Every Five Years
Technology Development	Advance Technology Innovation through Mission Innovation and Breakthrough Energy Coalition
Mobilize Climate Finance	Collectively Mobilize $100B per Year in Public and Private Funding for Developing Economies through 2025
Enhanced Transparency	Enhance Transparency for Reporting GHG Emissions, Subject to Expert Review

* Report on COP-21, "Inside the Paris Climate Deal", *Science*, Warren Cornwall, Dec 2015: Vol. 350, Issue 6267, pp. 1451

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A Unique Moment in Time

- All on One Stage -- Leaders of 20 Countries Representing over 80% of Global Clean Energy R&D Investment Agreed to Support a *Joint Statement* on Innovation
- Each Country Supported a Doubling of Governmental Clean Energy R&D Investment over Next Five Years (www.mission-innovation.net)
- Gov't Investment was Complemented by a Private Sector Initiative led by Bill Gates, the Breakthrough Energy Coalition (www.breakthroughenergycoalition.com)

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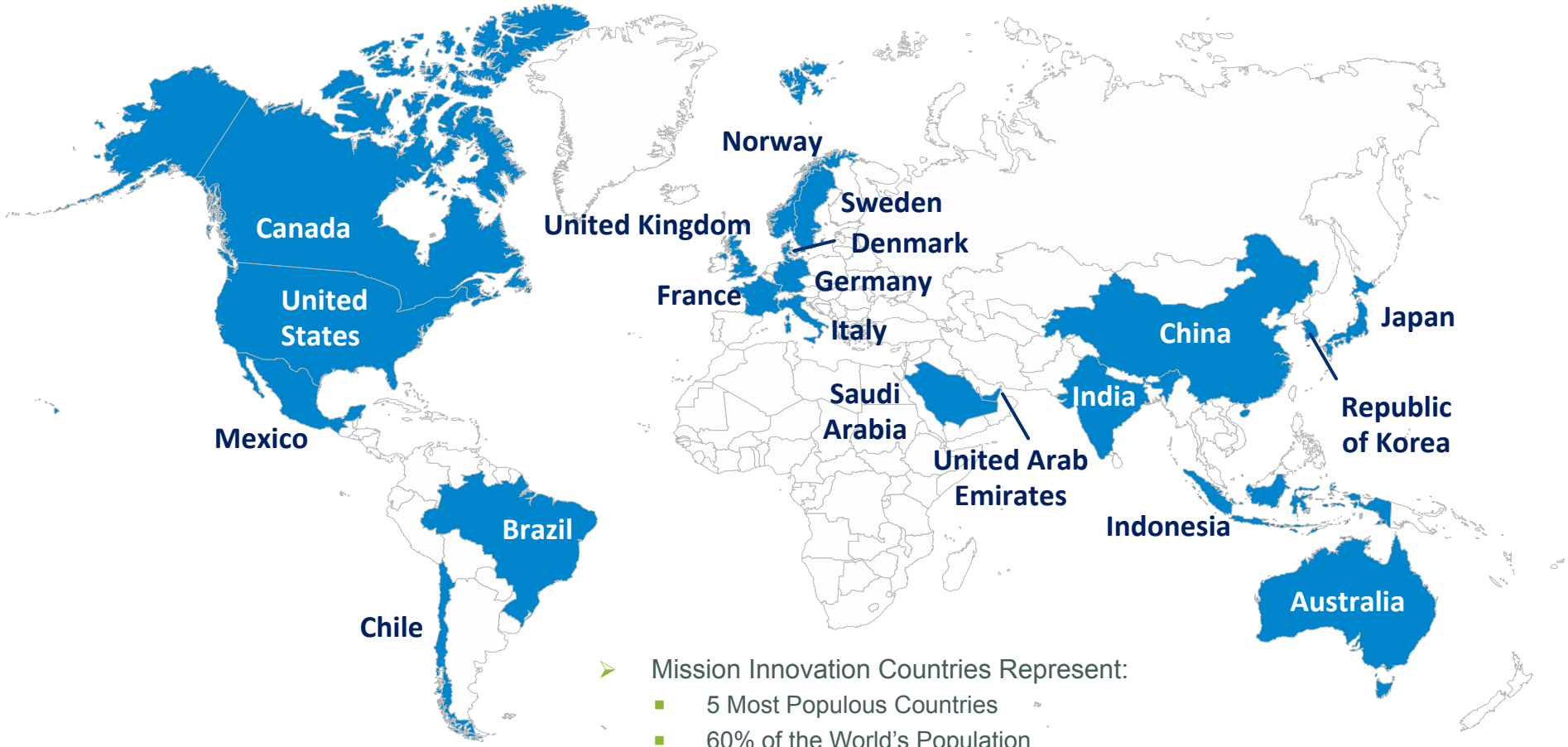
Global Scope



New Members since Launch: Finland, Netherlands and European Commission

- Mission Innovation Countries Represent:
  - 5 Most Populous Countries
  - 60% of the World's Population
  - 67% of the Total Greenhouse Gas Emissions
  - 70% of Global GDP
  - 75% of the CO_2 Emissions from Electricity
  - 80% of Government Investment in Clean Energy R&D

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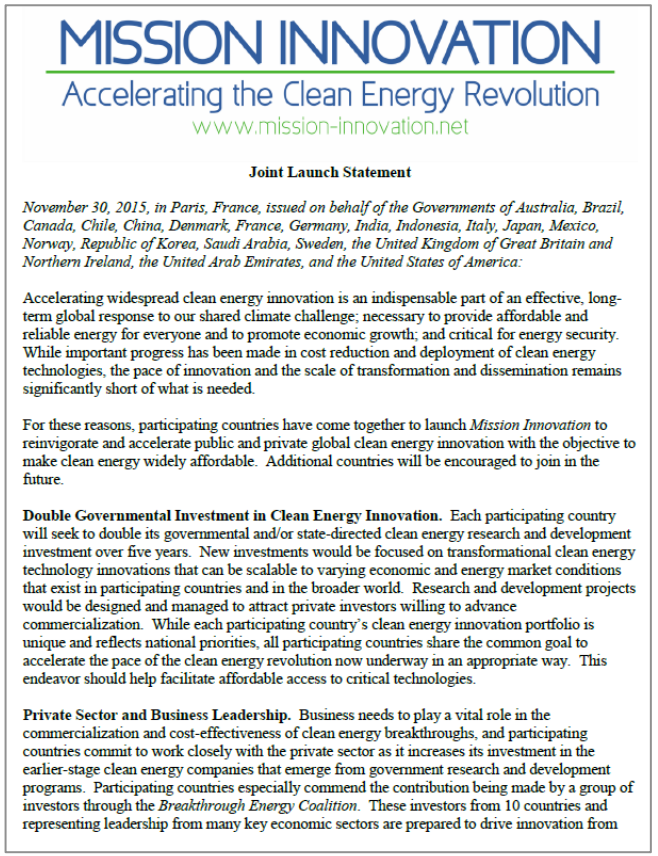
Joint Statement

"Come together to reinvigorate and accelerate public and private global clean energy innovation to make clean energy widely affordable"

- Rationale
- Public Sector Actions
- Private Sector Actions
- Implementation & Cooperation
- Information Sharing



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www.mission-innovation.net

Joint Launch Statement

November 30, 2015, in Paris, France, issued on behalf of the Governments of Australia, Brazil, Canada, Chile, China, Denmark, France, Germany, India, Indonesia, Italy, Japan, Mexico, Norway, Republic of Korea, Saudi Arabia, Sweden, the United Kingdom of Great Britain and Northern Ireland, the United Arab Emirates, and the United States of America:

Accelerating widespread clean energy innovation is an indispensable part of an effective, long-term global response to our shared climate challenge; necessary to provide affordable and reliable energy for everyone and to promote economic growth; and critical for energy security. While important progress has been made in cost reduction and deployment of clean energy technologies, the pace of innovation and the scale of transformation and dissemination remains significantly short of what is needed.

For these reasons, participating countries have come together to launch *Mission Innovation* to reinvigorate and accelerate public and private global clean energy innovation with the objective to make clean energy widely affordable. Additional countries will be encouraged to join in the future.

Double Governmental Investment in Clean Energy Innovation. Each participating country will seek to double its governmental and/or state-directed clean energy research and development investment over five years. New investments would be focused on transformational clean energy technology innovations that can be scalable to varying economic and energy market conditions that exist in participating countries and in the broader world. Research and development projects would be designed and managed to attract private investors willing to advance commercialization. While each participating country's clean energy innovation portfolio is unique and reflects national priorities, all participating countries share the common goal to accelerate the pace of the clean energy revolution now underway in an appropriate way. This endeavor should help facilitate affordable access to critical technologies.

Private Sector and Business Leadership. Business needs to play a vital role in the commercialization and cost-effectiveness of clean energy breakthroughs, and participating countries commit to work closely with the private sector as it increases its investment in the earlier-stage clean energy companies that emerge from government research and development programs. Participating countries especially commend the contribution being made by a group of investors through the *Breakthrough Energy Coalition*. These investors from 10 countries and representing leadership from many key economic sectors are prepared to drive innovation from

www.mission-innovation.net

B. Motivation and Rationale

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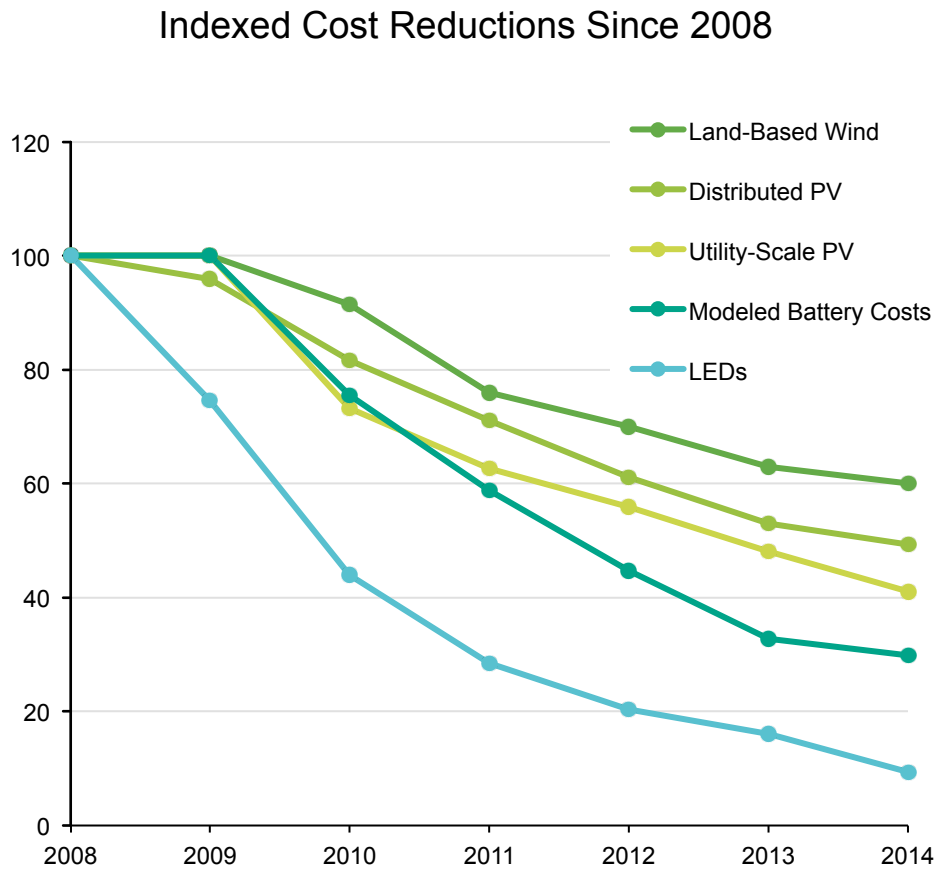
Motivating Factors

- On Climate Change, Time is Running Out:
  - Atmospheric Concentrations of GHGs are Rising, with Inexorable CC Effects
  - Changes in Climate are Manifest, Serious and Increasing
  - Business as Usual Approach is Unacceptable
  - Current Solutions are Ill-Suited or Too Costly for a World-Wide Acceptance
  - The Pace of Innovation is Too Slow
- Widely Affordable Solutions Can Be Found:
  - Costs of Wind, Solar PV, Battery Costs, and LEDs Have Dropped Dramatically
  - More Innovative Ideas Are on the Cusp of Realization, but Need a Boost to Market
  - Private Investment is Poised to Help
  - Global Mobilization of Innovative Talent Will Speed Solutions and Mitigate CC Effects



Source: Adapted from DOE, "Revolution…Now: The Future Arrives for Five Clean Energy Technologies – 2015 Update," http://www.energy.gov/eere/downloads/revolution-now-future-arrives-five-clean-energy-technologies-2015-update

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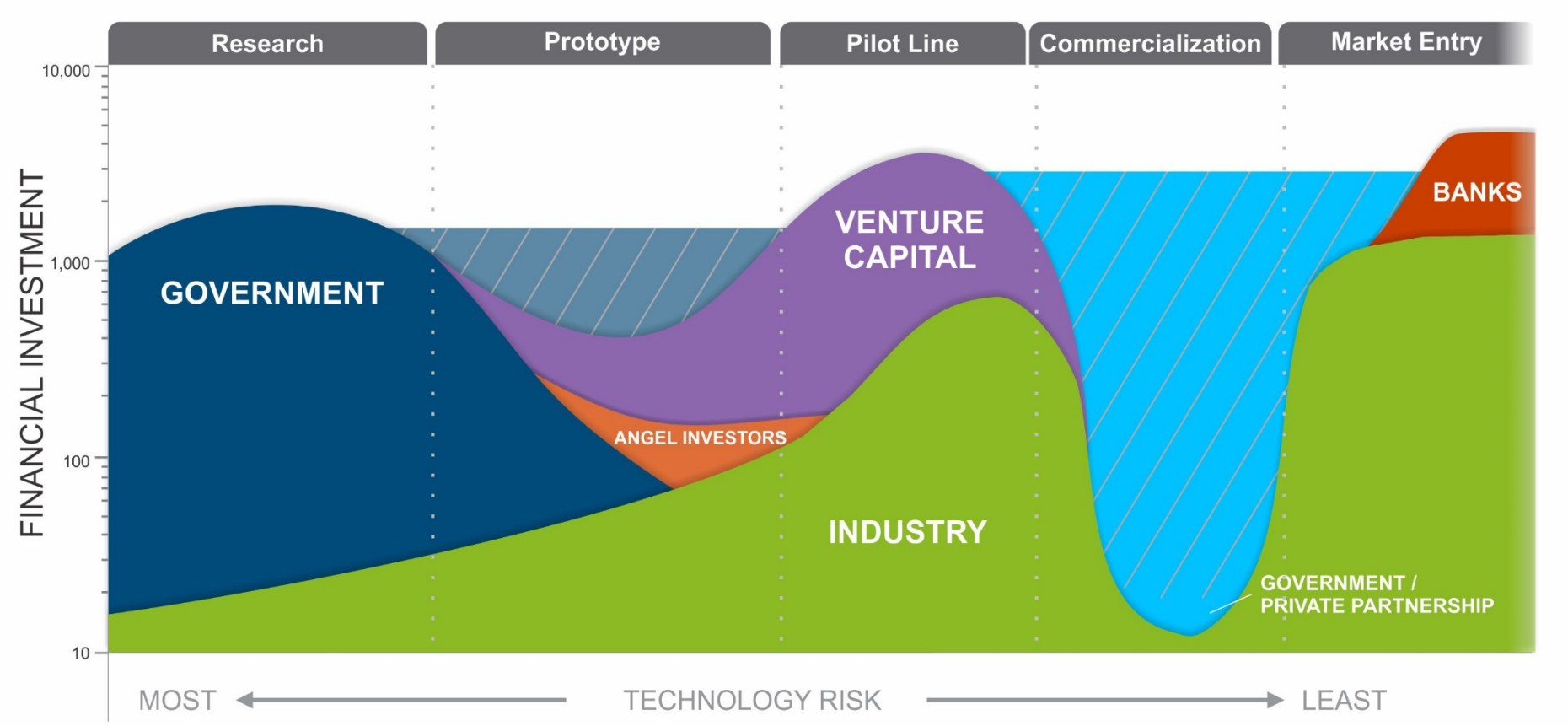
Gaps in the Innovation Cycle



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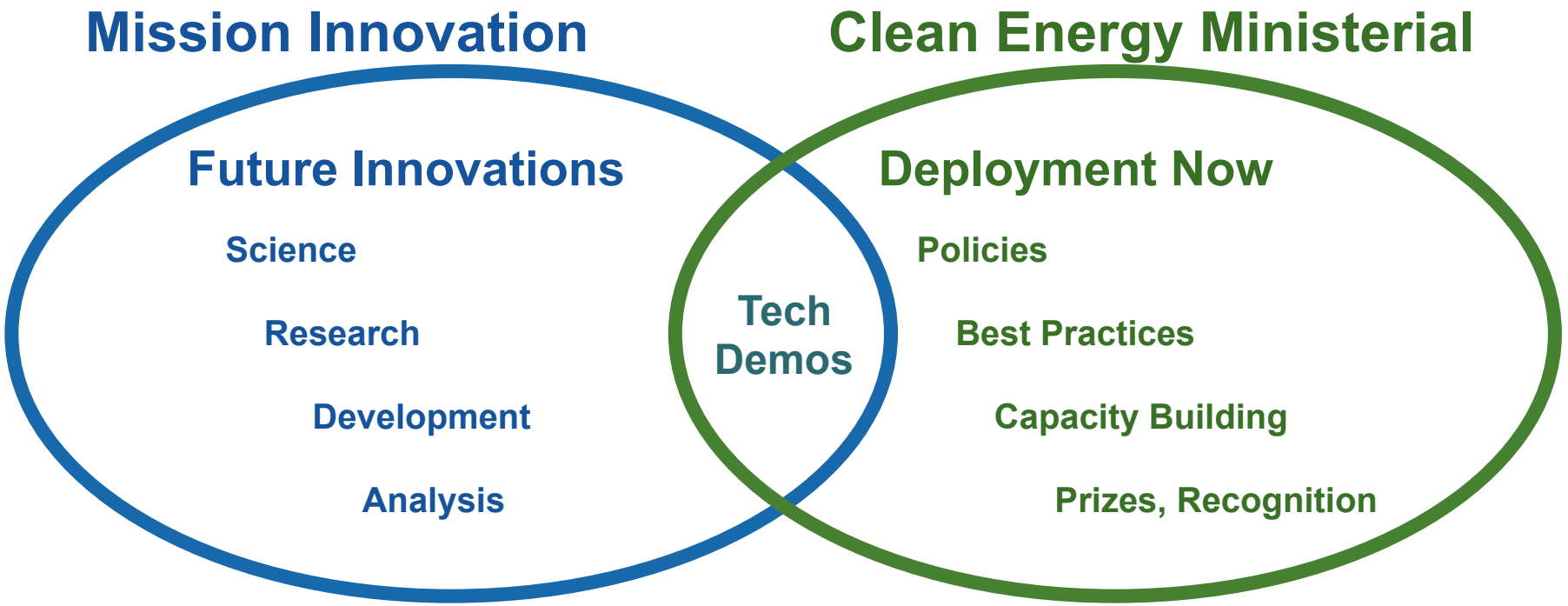
Clean Energy Solutions – For Today and Tomorrow



C. Public Sector Actions

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Implementation

Mission: Reinvigorate and Accelerate Global Clean Energy Innovation to Make Clean Energy Widely Affordable

Pledge: Seek to Double Public Investment in Clean Energy R&D Over Five Years

Report Progress: Share Plans, R&D Needs, Priorities and Ongoing Activities

Ongoing Activities:

➢ Information Sharing	Baseline and Annual Updates on Investments
➢ Innovation Analysis and Road-Mapping	Build and Improve Technology Innovation Roadmaps and Other Tools For Optimizing and Leveraging Investments
➢ Joint Research and Capacity Building	Public-Private and Country-to-Country Collaboration
➢ Private Sector Engagement	Collaborate on Data, Analysis, and Technology Expertise, Engagement of Business and Investors.

*Governmental and/or State-Directed Clean Energy Research and Development Investment. For USG, Federal Investment; Does Not Include State and Local Governments

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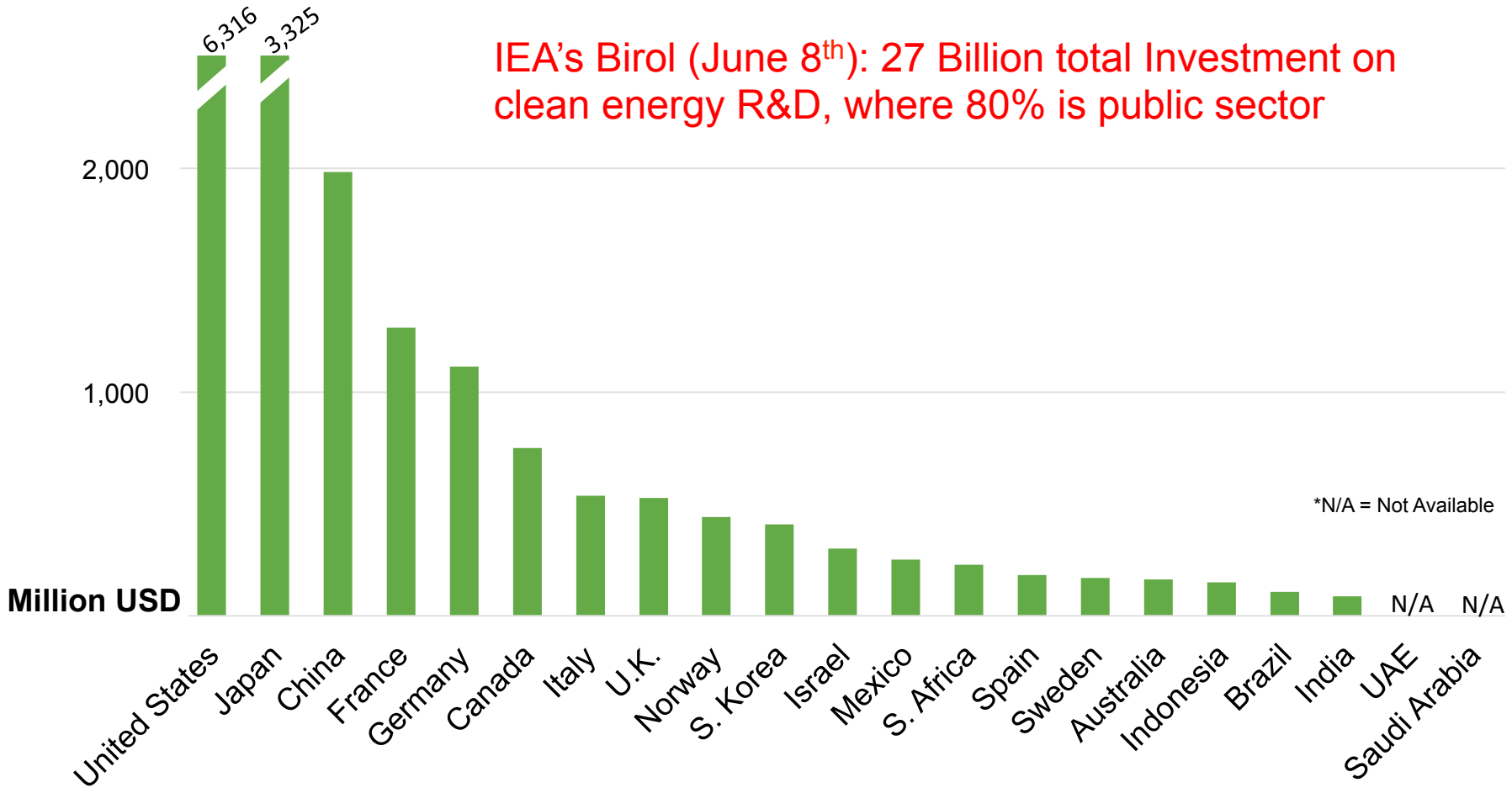
Interim Estimates on 2014 Clean Energy R&D Investments by Country



Source: International Energy Agency for most IEA countries, and Bloomberg New Energy Finance survey data for others. IEA data include all forms of energy R&D and demonstrations, but exclude deployment expenditures and costs for overhead and program direction. Note: the estimate for the United States is USG-based data, but reshaped to be compliant with IEA reporting guidelines.

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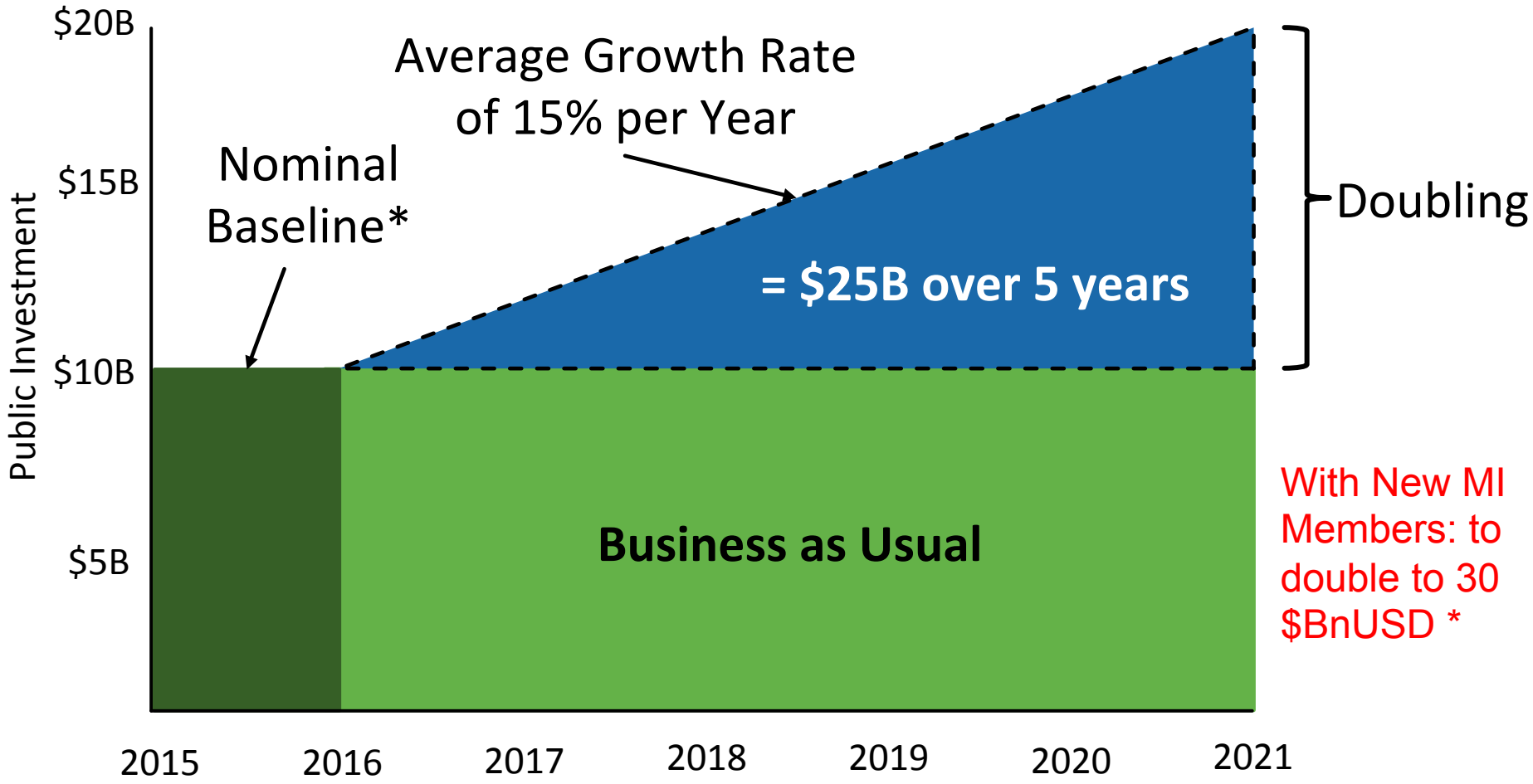
One Possible Global Funding Scenario for all MI Participating Countries



* Nominal baseline of $10 billion is a rough estimate, based on based on IEA Energy RD&D Expenditures and Survey Data from Bloomberg New Energy Finance for 20 MI countries. A better estimate will emerge, once MI countries report later in 2016.

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Investment Focus of the 22-Country MI Doubling Commitment

- Not Just More of the Same
- Mission Innovation Funding Supports:
  - Clean Energy R&D
  - Early Stage Technology Innovation
  - Advancing a New Era of Discovery
- Aimed at:
  - Superior Performance Technologies with Significant Cost Reduction
  - Leveraging MI Countries' Capacities in Areas of Shared Interest
- Breakthrough Energy Coalition will Focus Investment on Projects from MI Countries

F. Example:

U.S. Government

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Meeting the U.S. Pledge: Proposed U.S. FY 2017 Clean Energy R&D Budget

"Mission Innovation and the Breakthrough Energy Coalition constitute powerful complementary efforts to expand research and development for cutting-edge clean energy technologies and support a new generation of scientists, engineers, and entrepreneurs."

- White House Fact Sheet on the Proposed FY17 Budget for Mission Innovation

U.S. Pledged Action	Proposed U.S. Commitment
• Baseline (FY 2016)	$6.4 Billion
• Doubling Target (2021)	$12.8 Billion
• Needed Path to Doubling	15% per Year
• Proposed USG Increase, from FY 2016 to FY 2017	20% in 1st Year
• First-Year President's Budget (FY 2017)	$7.7 Billion (+ $1.3 Billion)
• Across 12 Agencies	DOE + 11 Other Agencies

D. Private Sector Actions

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Private Sector Actions

"We must…add the skills and resources of leading investors with experience in driving innovation from the lab to the marketplace."

"The private sector knows how to build companies, evaluate the potential for success and take the risks that lead to taking innovative ideas and bringing them to the world."

"Governments play an indispensable role in supporting energy research."

"Government research, however, is not enough. "

-Bill Gates

Bill Gates, "Energy Innovation: Why We Need It and How to Get It," http://www.breakthroughenergycoalition.com/assets/resources/Energy-Innovation-by-Bill-Gates-Nov-30-2015.pdf; Breakthrough Energy Coalition, "Introducing the Breakthrough Energy Coalition," http://www.breakthroughenergycoalition.com/en/index.html

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Gates on "Why We Need Breakthroughs in Energy Technology"

- Changes in Climate are Manifest, Serious and Increasing
- Poor Countries are Impacted the Most by Climate Change
- Affordable Clean Energy Helps Fight Poverty
  - Energy Access Reduces Time Spent Carrying Water, Gathering Fuel, etc.
  - High Price of Energy Adds to Cost of Electricity, Transportation, and Other Necessities
  - Lighting Enables Learning and Productive Activity after Dark
- To Stabilize GHG Concentrations, We Need to Move to Net-Zero Emissions
  - Efficiency is Important
  - So-Called "Bridge-Fuels" (Lower Carbon) Can Help in Transition
  - Ultimately, We Must Power All Sectors with CO_2-Neutral Energy Sources
- We Can Make Progress with Today's Tools, But These are Not Enough
  - Challenges: Intermittency, Land Requirements, Reliability, Costs, etc.
- Need to Create an Environment that Mobilizes and Accelerates Innovation

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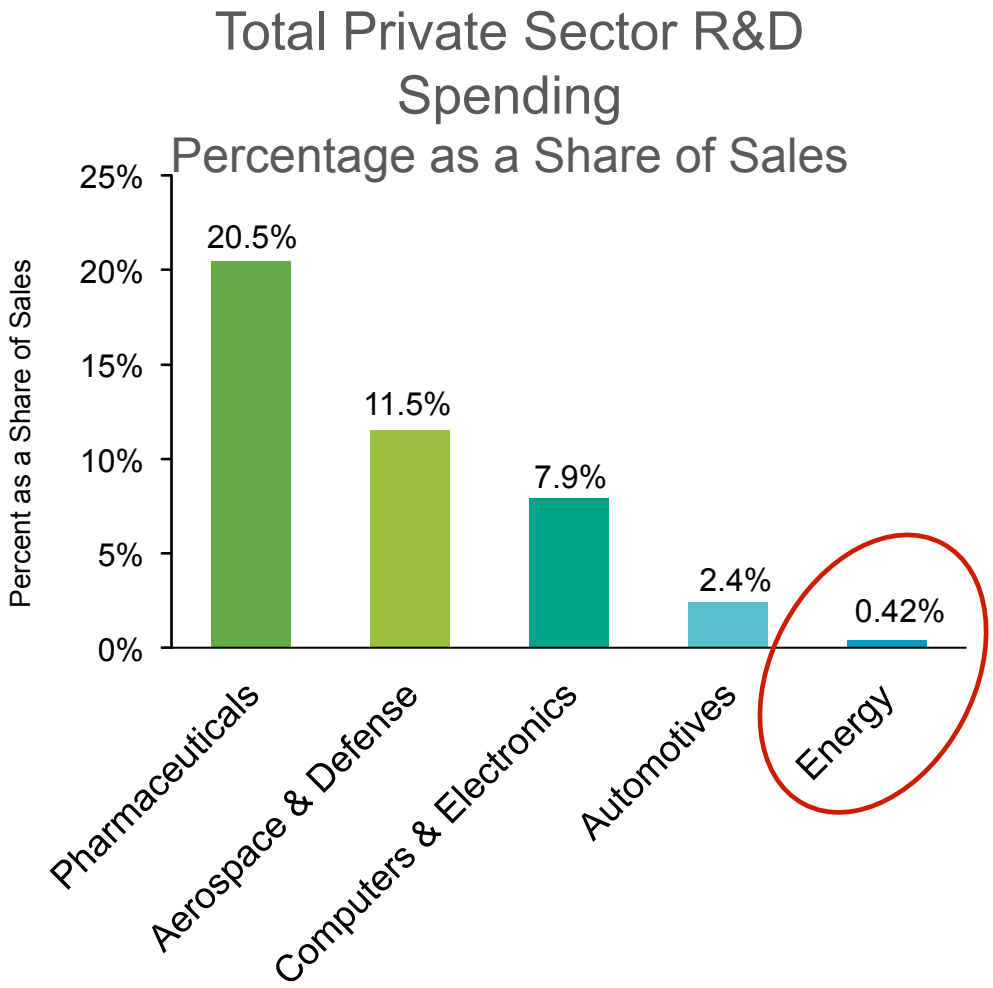
Government and Business Together Can Create the Incentives for Innovation

- Drastically Increase Government Investment in Early-Stage R&D
- Attract Private Capital into a Variety of Potential Solutions
- Act Quickly Given Long Time Frames of Energy Transitions



Source: Bill Gates, "Energy Innovation: Why We Need It and How to Get It," https://www.gatesnotes.com/Energy/Energy-Innovation

Source: American Energy Innovation Council

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Breakthrough Energy Coalition

- **Different Kind** of Investor:
  - Long-term Commitment to New Technologies
  - Utilize Truly Patient, Flexible Risk-Tolerant Capital
- **Different Approach** to Investment:
  - Identify Investable Ideas Early
  - Speed Up Innovation Cycle
  - Focus on Ideas that Go to Scale
  - Adopt Different Types of Deal Structures

<Click on video to load>

Bill Gates, gatesnotes, "A Big Win for Cheap, Clean Energy," https://www.gatesnotes.com/Energy/Investing-in-Energy-Innovation

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Fund Principles

1. Invest Early	Provide Seed, Angel and Series A Investments. Once De-Risked, Traditional Investors may Follow.
2. Invest Broadly	Invest Across a Number of Sectors: ▪ Electricity Generation and Storage ▪ Transportation ▪ Industrial Use ▪ Agriculture ▪ Energy System Efficiency
3. Invest Boldly	Novel Technologies and Dramatic Improvements to Existing Technologies. Credible Path to Rapid Scale-Up without Burdening Essential Systems.
4. Invest Wisely	Tap Leading Experts to Guide Investment Decisions.
5. Invest Together	Invest in Mission Innovation Countries' Innovation Pipelines.

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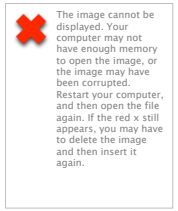
Breakthrough Energy Coalition


Mukesh Ambani


John Arnold


Mark Benioff


Jeff Bezos



Alwaleed bin Ttalal


Richard Branson


Ray Delio


Aliko Dangote


John Doerr


Bill Gates


Reid Hoffman


Chris Hohn

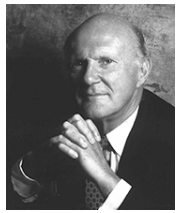

Vinod Khosla


Jack Ma


Patrice Motsepe


Xavier Niel


Hasso Plattner


Julian Robertson


Neil Shen


Simmons & Baxter-Simmons


Masayoshi Son


George Soros


Tom Steyer


Ratan Tata


Meg Whitman


Zhang Xin Pan Shiyi


Mark Zuckerberg, Priscilla Chan

- 27 investors & University of California; collective net worth: $300+ billion
- Commitment to invest in innovation emerging from Mission Innovation pipeline
- Long-term, patient, and risk-tolerant capital

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Coalition's Next Steps

- Create an Innovation Pipeline
- Build and Expand the Coalition
- Make a Case for Greater Early-Stage Investment by Governments
- Define Mechanisms for Coordination and Information-Sharing with Mission Innovation Countries
- Establish a Series of Investment Funds with Scientific Due Diligence Capability
- Goal: Launch Initial Round of Investments by the End of Calendar Year 2017

E. Implementation

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MI Sub-Groups

- 3 Thematic, Ad Hoc Sub-Groups: *
  1. Information Sharing
  2. Innovation Analysis, Joint Research and Capacity Building
  3. Private Sector Engagement
- Sub-Groups "Staffed" by Int'l Volunteers from MI Countries
- Sub-Group Products to Flow into MI Framework Document

* Organized around themes of Joint Statement by MI Country Leaders

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Schedule

Mission Innovation Countries Flesh-out Key Elements of the Initiative's Implementation, Including Pledges	May 2016
Energy Ministers of MI Countries Meet in San Francisco, in Conjunction with Clean Energy Ministerial, Publicly State MI Baselines, Doubling Plans and Other Initiatives	1-2 June 2016
MI Countries Explore Joint R&D Opportunities, Announced 7 Innovation Challenges in COP22	Fall 2016
MI announced the collaboration with World Economic Forum at Second MI Ministerial in Beijing, China	June 2017

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BIE – MI- WEF

Mission Innovation and World Economic Forum to collaborate for Business and Investor Engagement across MI topics and on selected MI Innovation Challenges.

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BIE – MI- WEF

- MI-WEF collaboration:

- **Engagement of private sector members** from the Forum's Communities with MI, including through specific, commonly identified "Innovation Challenges";
- **Collaboration on a joint high-level platform** for strategic public-private dialogue to accelerate clean energy innovation action and crowd-in investment through leveraging a series of events that will serve to advance specific innovation challenges and address cross-cutting clean energy innovation issues; Joint-MI-WEF event in Mexico City Sept 12-13, 2017.
- **Collaboration on knowledge research and technological development on clean energy innovation and information sharing**

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Mission Innovation Challenges

- **What are the MI Innovation Challenges?**
- Innovation Challenges are global calls to action aimed at catalyzing global research efforts in areas that could provide significant benefits in reducing greenhouse gas emissions, increasing energy security, and creating new opportunities for clean economic growth. Seven Innovation Challenges **were launched at COP22** in November, 2016.
- The Innovation Challenges cover the entire spectrum of RD&D**; from early stage research needs assessments to technology demonstration projects. They were developed through a collaborative process between MI members**. Engagement in an Innovation Challenge is entirely voluntary and is built around a coalition of interested MI members. With sufficient interest from MI members, new Innovation Challenges could be launched in the future.

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MI 7 Innovation Challenges

- **The 7 Innovation Challenges are as follows**:
- **1. Smart Grids Innovation Challenge** – to enable future grids that are powered by affordable, reliable, decentralised renewable electricity systems;
- **2. Off-Grid Access to Electricity Innovation Challenge** – to develop systems that enable off-grid households and communities to access affordable and reliable renewable electricity;
- **3. Carbon Capture Innovation Challenge** – to enable near-zero CO2 emissions from power plants and carbon intensive industries;
- **4. Sustainable Biofuels Innovation Challenge** – to develop ways to produce, at scale, widely affordable, advanced biofuels for transportation and industrial applications;
- **5. Converting Sunlight Innovation Challenge** – to discover affordable ways to convert sunlight into storable solar fuels;
- **6. Clean Energy Materials Innovation Challenge** – to accelerate the exploration, discovery, and use of new high-performance, low-cost clean energy materials; and
- **7. Affordable Heating and Cooling of Buildings Innovation Challenge** – to make low-carbon heating and cooling affordable for everyone.

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MI 7 Innovation Challenges

- **Collective Objectives**:
- Work under the Innovation Challenges is guided by 4 collective objectives:
- Building an improved and shared understanding of what is needed to address the Challenge, and how to define measurable targets and track progress towards them;
- Identifying key gaps and opportunities not sufficiently addressed by current activities;
- Promoting opportunities for researchers, innovators and investors in order to build support and excitement around the Challenges and boost engagement; and
- Strengthening and expanding collaboration between key partners, including governments, researchers, innovators, and private sector stakeholders.

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Clean Energy Materials Challenge

Issue:

- Materials discovery is a key element of the innovation cycle of energy conversion, transmission, and storage technologies, as well as energy use.
- Development of next-generation energy technologies faces the challenge of finding and integrating new materials at a faster rate. However, even with current state-of-the-art technologies, the innovation process to discover new materials and bring these to market can take 10 to 20 years and is very expensive.
- Accelerating and improving this process through international collaborative research and development (R&D) could result in major breakthroughs for the energy sector and beyond.

Organisation:

- The Clean Energy Materials Innovation Challenge is led by Mexico, and co-led by the United States.
- Other participating countries include: Canada, Denmark, the European Commission, France, Germany, India, Italy, the United Arab Emirates, Finland, Norway, Republic of Korea, Saudi Arabia, Sweden, the Netherlands, and the United Kingdom.

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Clean Energy Materials Challenge

Objective:

- The Clean Energy Materials Innovation Challenge aims to accelerate by 10x the innovation process for new, high-performance, low-cost clean energy materials.

The IC has the following goals:

- Build an improved, shared understanding of the state of technologies for the automation of materials discovery, as well as identify the knowledge gaps, opportunities and the recommendations from the leading scientists around the world;
- Promote collaboration opportunities to researchers, innovators, and potential investors;
- Develop new collaboration projects between key partners (government-to-government, researcher-to-researcher, public-private, etc.) in order to integrating and automating the components of materials discovery; and
- Inspire the decision makers and leaders around the world and showcase the possibilities and benefits that can be generated from bringing together the top minds in science and industry and from working together on finding solutions to the biggest global materials challenges.

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Clean Energy Materials Challenge

Approach:

- Work conducted under this Challenge will be directed towards developing a fully integrated, end-to-end platform that will accelerate materials discovery along the whole process from low to high technology readiness levels (TRLs). The focus will be on R&D breakthrough technologies with a long-term approach towards 2030 and beyond that will lead to a single breakthrough as a platform, as opposed to deployment and/or policy issues with a shorter time horizon than MI.

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Clean Energy Materials Challenge

What does it include:

- This Innovation Challenge will combine advanced theoretical and applied physical chemistry/materials science with next-generation computing, artificial intelligence (machine learning), and robotics tools, with the aim of creating a comprehensive and fully integrated, end-to-end materials innovation platform.
- Experts and partners in this initiative will automate and/or improve each step of the innovation chain of new materials, such as the discovery, synthesis, data and performance assessment, and process design and scale-up.
- The proposed unified platform will benefit all stages of the materials innovation process (model, simulate, predict, synthesize, characterize, and test the properties and performance) of new clean energy materials and will leverage international advances from individual activities.

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Clean Energy Materials Challenge

Benefits:

- This initiative will benefit a wide range of energy sectors and applications. Specific application areas for new materials include, for example, advanced batteries, high efficiency solar cells and fuel cells, low energy semiconductors and solid state lighting, thermal storage, coatings for various applications, and catalysts for the conversion and capture of CO2.
- Many of the technologies for the implementation of this Innovation Challenge have been developed and are used in separate domains. Machine learning, for example, is heavily employed in the information technology (IT) sector and has recently been applied to materials discovery, while advanced computational tools are common in the pharmaceutical industry and other sectors.
- The novelty and challenge of this initiative is the integration of the advances for separate parts of the materials innovation process into a single framework, or platform, to result in materials that can be successfully used in clean energy applications.

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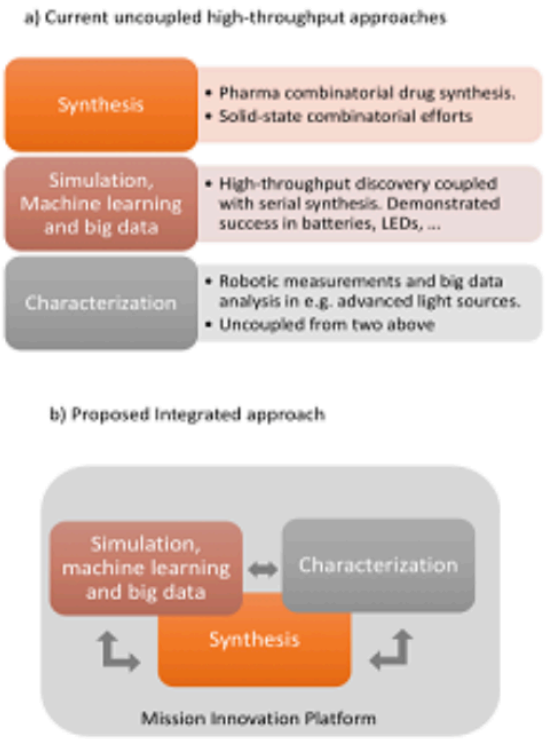
Clean Energy Materials Challenge



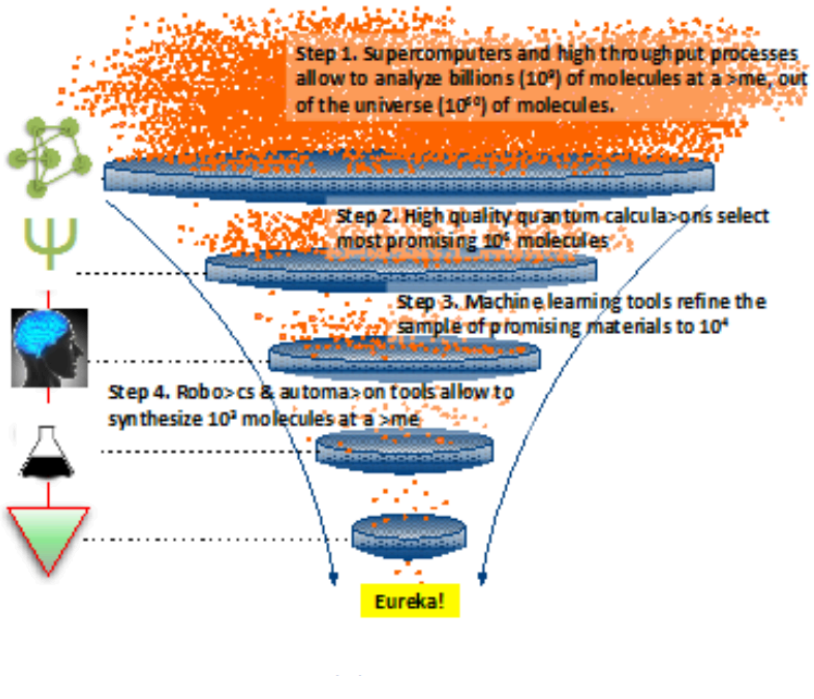


Figure 1 (left): The current uncoupled approach to materials discovery (a) could be integrated to accelerate materials discovery (b). Figure 2 (right): A disruptive technology for discovering high performance, low-cost energy materials. The integrated approach, or platform, for materials innovation could help model billions of molecules, simulate millions, predict hundreds of thousands, and synthesize and test thousands of molecules to accelerate the discovery, design, and use of new materials for high-impact energy technologies.

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MI IC #6 Advanced Clean Energy Materials

Objective	Work Programme Highlights
Accelerate the exploration, discovery and use of new high-performance, low-cost clean energy materials.	1. Plan to host a 3-day Energy Materials Innovation (EMI) Expert Workshop that will take place in Mexico City on September 11-14, 2017 to convene more than 50 preeminent scientists and experts in advanced theoretical and applied physical chemistry/materials sciences, advanced computing, machine learning, and robotics. These experts will identify critical R&D priorities and gaps in clean energy materials innovation processes and explore opportunities for deeper collaboration. Representatives from business interests are also invited to attend the workshop as observers and to provide insights from the private sector perspective regarding materials discovery innovation opportunities.

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MI IC #6 Advanced Clean Energy Materials

Objective	Work Programme Highlights
Accelerate the exploration, discovery and use of new high-performance, low-cost clean energy materials.	2. Plan to publish a workshop report describing the state-of-the-art of technologies and methods relevant for materials discovery and identifying the gaps, opportunities and recommendations to accelerate materials discovery. This report will intend to serve as a resource for academia, private sector, government and any stakeholders interested in R&D efforts to accelerate materials discovery and technologies in this field.

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MI IC #6 Advanced Clean Energy Materials

Objective	Work Programme Highlights
Accelerate the exploration, discovery and use of new high-performance, low-cost clean energy materials.	3. MI members and other stakeholders may consider launching Requests for Proposals, grants, research programmes, and collaboration projects to address the gaps and opportunities identified by the leading scientists participating in this Challenge and the EMI Expert Workshop. 4. In the longer term, plan to develop a fully integrated platform in the form of laboratories that incorporate automated synthesis and characterization facilities, together with the modelling and theoretical work, which will lead to more and faster materials' discoveries.

Thank you

Nelson Mojarro

Representative in Europe

Energy R&D Funds (Mexico)

UK based

Mission Innovation BIE Co-lead

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