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Mission Impossible? Five challenges facing 'Mission Innovation', the global clean energy innovation drive

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Making a difference to policy outcomes locally, nationally and globally

POLICY BRIEF

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Introduction

In December 2015 the landmark Paris Climate Agreement was signed by 195 countries at the 21st Conference of the Parties (COP21)[1]. Covering the period from 2020 it obligates all parties to take action to limit global temperature rise to less than 2°C above pre-industrial levels. Interestingly, in comparison to previous COPs, there was a much stronger focus on the need to accelerate low-carbon innovation in order to avoid catastrophic anthropogenic climate change and wide-spread deliberation about how best this might be achieved. Consequently, to help deliver the Paris Agreement targets, world leaders established *Mission Innovation (MI)*[2]; an agreement between 21 regions to double their clean energy research and development (R&D) investment by 2021 (Fig. 1). This commitment to innovation was matched by the private sector through the *Breakthrough Energy Coalition*[3]*,* a group of 28 high net worth investors including Bill Gates, Richard Branson and Mark Zuckerberg, who have all committed to expand their energy investment portfolio.

Whilst MI is now underway, it is still at a relatively early-stage of development and faces a number of key challenges that must be overcome if it is to be successful in delivering the next generation of clean energy innovations capable of helping us simultaneously address the energy trilemma of climate change, energy security and affordability - whilst also accelerating economic growth. Consequently, this policy briefing outlines the major challenges it faces and discusses how these could be addressed, but first considers the broad aim and structure of MI.

Figure 1: Mission Innovation is launched at the Paris Climate Summit (COP21) (Source: MI)

[1] http://unfccc.int/paris_agreement/items/9485.php
[2] http://mission-innovation.net/
[3] http://www.breakthroughenergycoalition.com/en/index.html

What's the aim of Mission Innovation and who's involved?

The central aim of MI is to double public sector clean energy R&D investment from approximately $15bn per year in 2015 to $30bn per year in 2021 (Fig. 2)[4]. To achieve this aim 21 regions[5] have committed to double their individual energy R&D budgets, and together these account for well over 80% of global public investment in clean energy research, development and demonstration (RD&D). Their common understanding is that whilst important progress has been made in reducing the cost and increasing the deployment of clean energy technologies, the *pace* of innovation remains significantly short of what is needed to avoid catastrophic climate change.

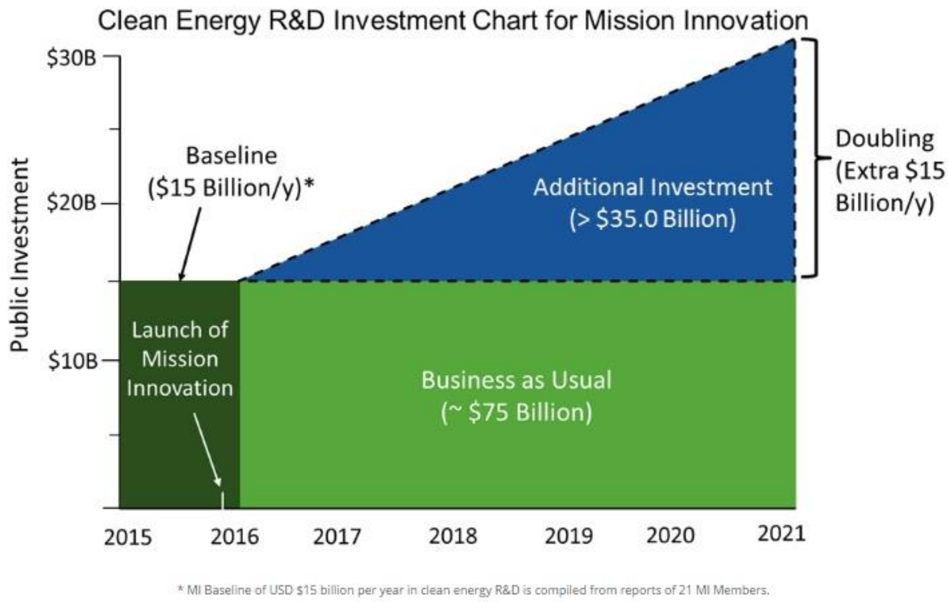

Figure 2: Targeted public energy R&D investment 2016-2021 under Mission Innovation (Source: MI)

How will Mission Innovation work?

Whilst the structure of the MI is still evolving a general framework for action is now in place[6], which highlights the following:

1. **Clean energy R&D** - Investment must focus on 'clean energy' R&D. MI appears to take a broad view of this includes, incorporating most forms of supply and demand-side energy innovation other than unabated fossil fuel generation (Fig. 3). It therefore includes fossil fuel R&D that supports greater efficiency or lower carbon consumption

[4] http://mission-innovation.net/wp-content/uploads/2016/06/MI-Country-Plans-and-Priorities.pdf
[5] Australia, Brazil, Canada, Chile, China, Denmark, France, Germany, India, Indonesia, Italy, Japan, Mexico, Norway, Republic of Korea, Saudi Arabia, Sweden, the United Arab Emirates, the United Kingdom, the United States, plus the European Commission on behalf of the European Union.
[6] http://mission-innovation.net/wp-content/uploads/2016/06/MI-Enabling-Framework-1-June-2016.pdf

of fossil fuels. The focus on R&D also implies early- to mid-stage technology readiness level (TRL) activity, i.e. not demonstration and pre-commercial deployment.

2. **R&D priority identification** - Each Member is required to independently select its own priorities for clean energy R&D funding (Fig. 3) and the strategy it will employ to deliver on these (i.e. polices, regulation etc.)[7]. In order to select these innovation priorities, members are expected to employ rigorous analysis to identify gaps in their current understanding of these R&D areas and develop a policy roadmap to address these[8].

3. **International collaboration** - Members are encouraged to freely share information between one another in relation to their energy R&D programmes and where mutual interests exist, collaborate on joint research and capacity building[9].

4. **Private sector co-investment** – There is a strong emphasis on members using their increase in public sector R&D investment to leverage additional private sector investment, not least through the *Breakthrough Energy Coalition*.

5. **Not legally binding** – Whilst the Paris Climate Agreement (COP21) constitutes a legally binding global treaty, the MI framework does not and is instead a voluntary arrangement.

	AUSTRALIA	BRAZIL	CANADA	CHILE	CHINA	DENMARK	EUROPEAN UNION	FRANCE	GERMANY	INDIA	INDONESIA	ITALY	JAPAN	KINGDOM OF SAUDI ARABIA	MEXICO	NORWAY	REPUBLIC OF KOREA	SWEDEN	UNITED ARAB EMIRATES	UNITED KINGDOM	UNITED STATES
INDUSTRY & BUILDINGS	●	●	●	●		●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●
VEHICLES & OTHER TRANSPORTATION	●	●	●	●	●	●	●	●	●	●	●		●	●	●	●	●	●	●		●
BIO-BASED FUELS & ENERGY	●	●	●		●	●	●	●	●	●	●	●			●	●	●	●	●	●	●
SOLAR, WIND & OTHER RENEWABLES	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●
NUCLEAR ENERGY	●	●	●		●												●		●	●	●
HYDROGEN & FUEL CELLS	●	●	●			●	●	●	●	●			●	●		●	●			●	●
CLEANER FOSSIL ENERGY		●	●		●	●			●	●	●			●			●				●
CO_2 CAPTURE, UTILIZATION & STORAGE	●	●	●		●	●	●	●	●				●	●	●	●	●		●	●	●
ELECTRICTY GRID	●	●	●	●	●	●	●	●	●	●	●	●	●		●	●	●	●	●	●	●
ENERGY STORAGE	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●		●	●	●
BASIC ENERGY RESEARCH	●		●			●	●	●	●	●	●	●	●	●		●		●	●		●

Indicators are for key areas of R&D investment, but do not imply a comprehensive representation of a country's full R&D portfolio.

Figure 3: Mission Innovation's member countries and their priority areas of energy R&D (Source: MI)

[7] http://mission-innovation.net/wp-content/uploads/2016/06/MI-Country-Plans-and-Priorities.pdf
[8] http://mission-innovation.net/wp-content/uploads/2016/06/MI-Sub-Group-on-Innovation-Analysis-and-Roadmapping-Summary-Update-May-2016.pdf
[9] http://mission-innovation.net/wp-content/uploads/2016/06/MI-Sub-Group-on-Information-Sharing-Summary-Update-May-2016.pdf

Five challenges facing Mission Innovation

Having outlined what MI aims to achieve and how is expected to function we now identify five challenges that must be overcome if MI is to work effectively.

Challenge 1: Unprecedented increase in R&D investment during a period of decline

A doubling of clean energy R&D expenditure in 5 years represents an unprecedented challenge. First, the target to double energy R&D comes at a time when energy RD&D[10] investment has fallen by almost a third ($5.5bn) between 2009 and 2013, one of the sharpest declines in support over the past 40 years (Fig. 4). Second, whilst we have seen a doubling of clean energy RD&D funding amongst MI members[11] within 5 years before - between 1976 and 1980 - this period saw a strong emphasis on fossil fuel innovation in reaction to the 1973 oil crisis. Whilst new low-carbon technologies such as nuclear and wind energy emerged following a significant increase in R&D investment during this period, it also saw a tripling of public investment in fossil fuel energy[12]. Both innovation strategies were primarily focused on alleviating global reliance on OPEC oil production by developing alternative energy technologies.

Energy RD&D also doubled more recently, between 1997 and 2009. However, this unfolded over a 12 year period, a substantially longer period than that envisaged by MI. This period also had a similarly strong focus on fossil fuel RD&D to the late 1970s, seeing investment increase by almost a factor of 5 between 1997 and 2009. Whilst some of this fossil fuel R&D investment is likely to have focused on lower carbon or more efficient fossil fuel technologies (e.g. combined cycle gas turbines), R&D of non-fossil fuel technologies is considered a top priority in the future if we are to avoid catastrophic climate change[13].

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[10] IEA data is for RD&D not R&D, therefore including investment in demonstration not included in MI.
[11] We include only the 12 MI members that the IEA provides RD&D data for, namely Australia, Canada, Denmark, France, Germany, Italy, Japan, Korea, Norway, Sweden, UK and United States. Data taken from http://wds.iea.org/WDS/Common/Login/login.aspx
[12] This figure excludes CCS investment whilst Figure 4 includes all fossil fuel investment, both abated and unabated. This falls mainly into 'oil and gas' (e.g. 'enhanced oil and gas production', 'refining, transport, storage of oil and gas', 'non-conventional oil and gas' etc.) and 'coal' (e.g. 'coal production, preparation and transport', 'coal combustion (incl. IGCC)' and 'coal conversion'.
[13] http://www.iea.org/publications/freepublications/publication/EnergyTechnologyPerspectives2016_ExecutiveSummary_EnglishVersion.pdf

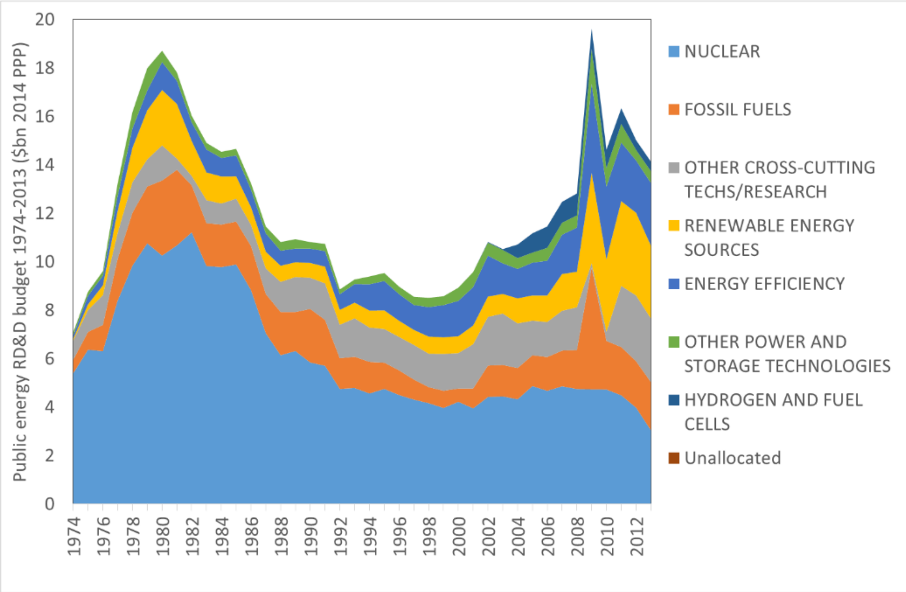

Figure 4: Public energy RD&D budget by technology 1974-2013 (Source: IEA)

In this context, policymakers are venturing into the unknown when we consider that no international clean energy innovation strategy has ever been implemented on this scale before. It is therefore critical that MI members share best-practice policy design to ensure that the additional R&D funds are committed and invested as effectively as possible. This must be sensitive to the wide spectrum of different approaches that can be implemented to support clean energy innovation. For example, some countries adopt a centralised, government led, top-down model, where collaboration is prioritised over competition and government laboratories take the lead (e.g. Fraunhofer in Germany, RISO in Denmark). Other countries may opt for a decentralised, market led, bottom-up model, where competition is prioritised over collaboration, with start-ups and Original Equipment Manufacturers (OEMs) taking the lead. It also relates to the balance of funding for 'supply-push' versus 'demand-pull' innovation support policies, as well as whether the type of investment should differ for supply- versus demand-side energy technologies and large-scale site assembled (e.g. nuclear) versus small-scale modular (e.g. solar PV) technologies.

An honest exchange of the relative strengths and weaknesses of different innovation policy strategies between MI members will be critical to its success. So too will be seeking lessons on best-practice innovation policy from the OECD Directorate for Science, Technology and Innovation[14] and the wider academic innovation policy studies community.

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[14] http://www.oecd.org/sti/

Challenge 2: Balancing members' investment as a proportion of their wealth

The target to double each member's total public investment in clean energy R&D implicitly assumes that all countries are currently contributing the same degree of effort to support energy innovation and that a 'flat rate' doubling of public R&D investment is most equitable. This would see a similar distribution of investment across the MI countries as in 2013 (latest year available), with the US and Japan still contributing approximately 63% of the total public lean energy R&D investment (Fig. 5). However, if we analyse MI members' R&D investment as a proportion of their national wealth we uncover a picture of some countries investing more in energy innovation than others.

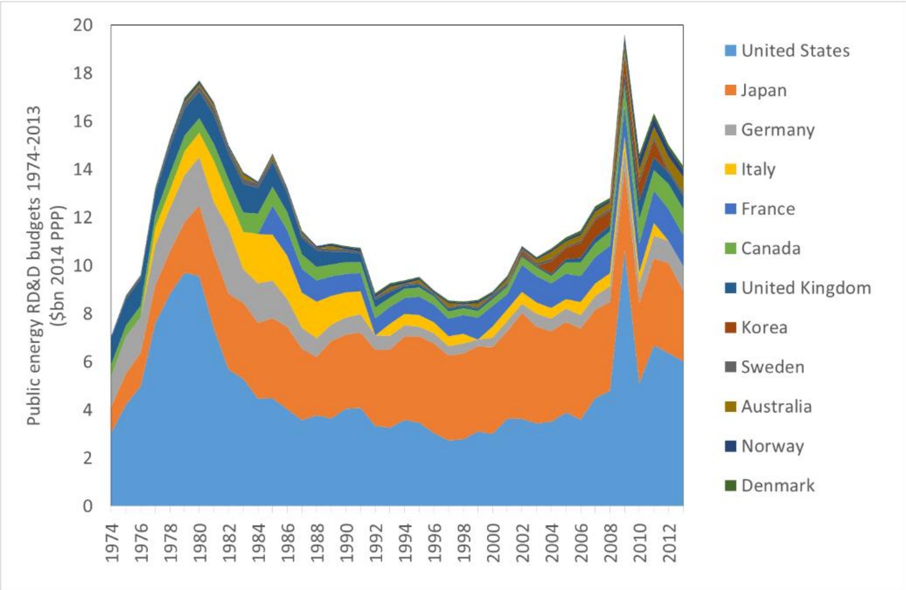

Figure 5 Public energy RD&D budget by country 1974-2013 (Source: IEA)

In relative terms, some countries are committing significantly more energy R&D investment as a share of their GDP than others (Fig. 6). For example, if we take the period since the Kyoto Protocol in 1997, the first legally binding climate change agreement, we find that Japan committed $828 per $m GDP. This was almost three times as much as the US ($306 per $m GDP) and eight times more than the UK ($110 per $m GDP)[15]. This raises important questions about the equity and durability of MI, which is a non-legally binding agreement. Will MI members be prepared to double their energy RD&D budgets when they know that others are committing significantly less as a proportion of their wealth than others? Policymakers need to consider whether those members who are committing the least clean energy R&D investment relative to their wealth should be required to raise their level of support in line with their international peers. Whilst this is likely to be politically challenging, given that it would penalise some countries at

[15] Figure 6 includes all fossil fuel energy R&D investment. This is because MI includes 'cleaner fossil energy' as a priority area, which cannot be isolated within the IEA data because it is not clearly defined by MI.

the expense of others, it would lead to a 'level playing field' whereby each country is contributing the same degree of effort to the global clean energy innovation drive.

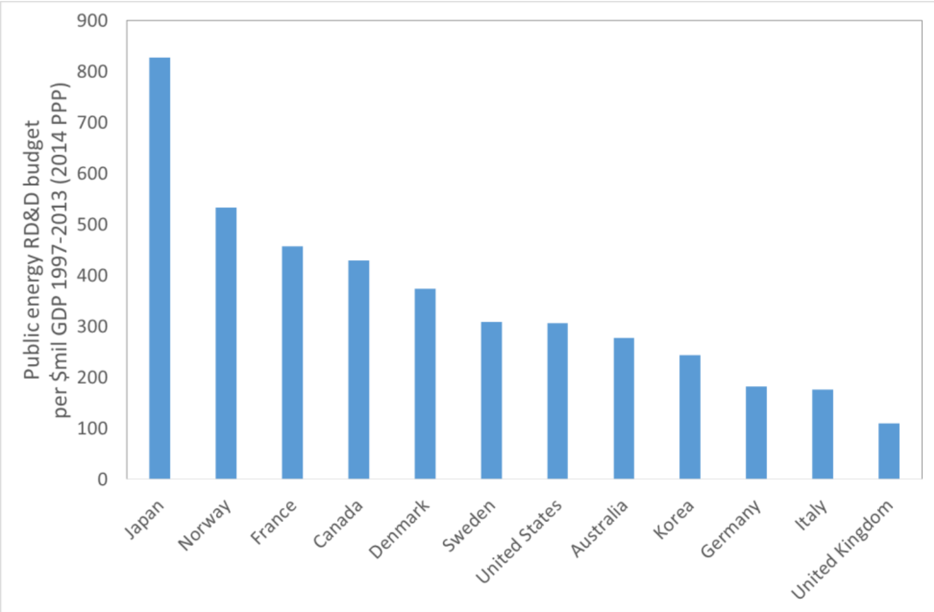

Figure 6: Mission Innovation members' public energy RD&D budgets as a proportion of GDP (Source: IEA)

Challenge 3: Clear understanding of relationship between reward and investment

Following on from ensuring a balanced distribution of investment amongst MI members it follows that there should be a balanced apportioning of the benefits accrued from the innovation. Assuming that members subscribe to the commitment to deliver joint-projects, then it is important that each project member is absolutely clear about what proportion of the benefits they will receive per $ of R&D investment they make and in what form these will be received (e.g. licencing arrangements). Such an arrangement could follow a similar model as that employed by high-profile publicly funded joint ventures like the International Thermonuclear Experimental Reactor (ITER) nuclear fusion project, funded by the EU, India, Japan, China, Russia, South Korea and the US[16]. Even so, multi-partner international R&D projects will undoubtedly be contractually complex as each member is likely to be committing a different level and type of investment. Efforts to develop standard contract templates and a more detailed agreed working framework between MI members would certainly facilitate international collaboration and help deliver clean energy R&D projects more quickly by keeping contractual negotiations to a minimum.

[16] https://www.iter.org/

Challenge 4: International and cross-sectoral co-ordination of R&D investment

International co-ordination of energy R&D funding across different technologies and stages of innovation will be critical to developing the next generation of clean energy technologies. An important question will be how the doubling of investment is distributed across the different priority areas at a global level. This is complicated by that the fact that each MI member has its own individual portfolio of R&D priority areas (Fig. 3) and has been committing R&D investment to different areas of energy research (Fig. 7), together reflecting each member's own interests and capabilities.

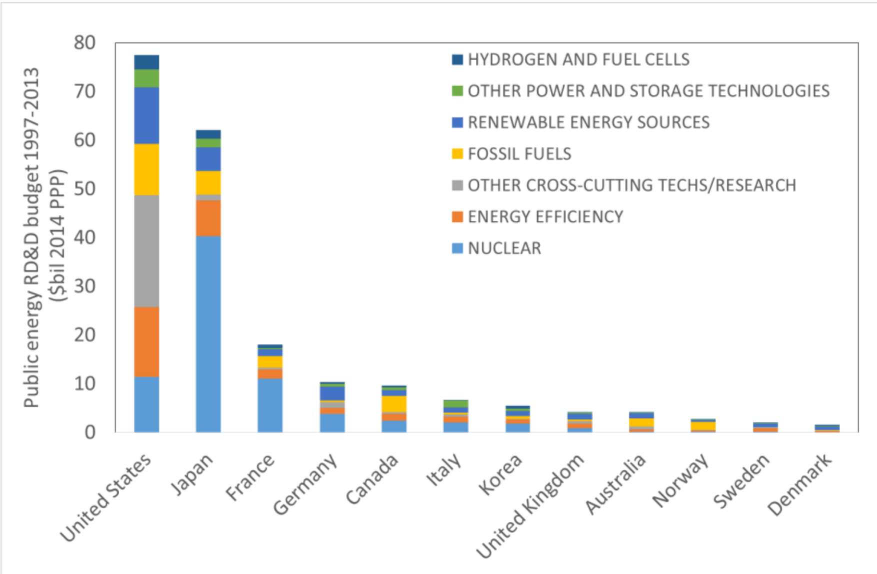

Figure 7: MI members' public energy RD&D budgets 1997-2013 by country (Source: IEA)

Limiting global temperature rise to 2°C above pre-industrial levels demands that no single area of clean energy innovation is neglected and so it is critical that members coordinate their support to ensure this doesn't happen (Fig. 8). To maximize the effectiveness of the increase in energy R&D investment MI members should consider which countries are best-equipped to lead on each R&D area and adopt a 'best-with-best' approach to collaboration. Furthermore, members must also discuss which stage of innovation or technology readiness level (TRL) these should investments focus on, for example basic research vs. pre-commercial demonstration.

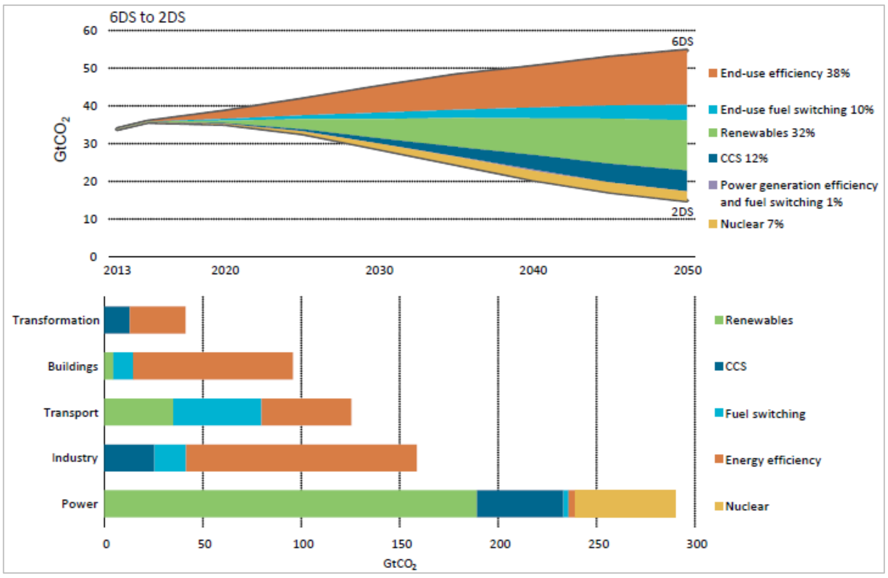

Figure 8: Contribution of technology area and sector to global cumulative CO2 reductions (Source: IEA ETP 2016)

Cross-sectoral coordination will also be critical for similar reasons, i.e. to ensure that no single priority area or stage of innovation benefits at the expense of others. Mechanisms such as the MI's Business & Investor Engagement Sub-Group[17] will be critical to consolidate the partnership between MI and the *Breakthrough Energy Coalition,* and ensure that key actors from both sectors are clear which technologies and stage of innovation they are expected to support. However, the private sector typically favours free market principles and is likely to resist a highly coordinated strategy that constrains their freedoms.

Clear, objective and honest discussions between government and industry representatives about how MI members should best coordinate investment across the different clean energy priority areas will be critical to MI's success. Proposals from MI's various Sub-Group to develop work programmes that inform future activities present an excellent start to achieving a coordinated approach. However, it is essential these discussions are informed not just through discussions within MI's sub-groups but by wider debate across other relevant fora, not least the Clean Energy Ministerial[18], IEA Technology Collaboration Programmes (TCPs)[19] and European Energy Research Alliance (EERA)[20].

[17] http://mission-innovation.net/wp-content/uploads/2016/06/MI-Sub-Group-on-Business-and-Investor-Engagement-Summary-Update-May-2016.pdf
[18] http://www.cleanenergyministerial.org/
[19] https://www.iea.org/tcp/
[20] http://www.eera-set.eu/

Challenge 5: Understanding the emissions reduction potential of Mission Innovation

It is currently unclear what level of carbon emissions reduction MI hopes to achieve. To ensure global temperature rise is limited to less than 2°C above pre-industrial level it is important that MI members analyse what level of decarbonisation could realistically be delivered by a doubling of R&D investment across its portfolio of clean energy priority areas and how this tallies with existing 2°C scenarios (e.g. Fig. 8). The International Energy Agency (IEA) is excellently placed to deliver any additional systems-level modelling of how and when these MI R&D investments could deliver carbon emissions reductions. Even so, this presents an excellent opportunity for university researchers across the world to explore in-depth.

Conclusions

In conclusion, *Mission Innovation* represents a much-needed and timely initiative, one focused on ushering in the next generation of clean energy technologies capable of helping the world avoid catastrophic climate change. However, the initiative is still at an early stage and it faces a number of important challenges that policy makers need to address if it is to be a success.

First, a doubling of clean energy R&D investment within 5 years during a period of declining R&D public investment represents an unprecedented challenge. Its success will rely on MI members sharing best-practice in energy innovation policy to ensure not only that this increase is achieved but that investment is delivered effectively, leading to high-quality innovation outputs.

Second, the political credibility and durability of a non-legally binding scheme is questionable when it demands all countries to double their total clean energy R&D investment despite some already committing significantly more investment as a proportion of their wealth than others (i.e. $ R&D per GDP).

Third, a clear enabling framework must make clear the scale and type of benefit each MI member will receive as proportion of their investment from multi-partner international R&D collaboration.

Fourth, a combination of international and cross-sectoral coordination of R&D investment is critical to ensuring a balanced distribution of investment across different clean energy priorities and stages of innovation.

Fifth, MI members need to carefully consider the carbon emissions reduction potential of their increased energy R&D investment in each priority area and how together these activities will contribute to a 2^{o}C future.

Taking these recommendations into account will undoubtedly help transform the ground-breaking Mission Innovation from Mission Impossible to Mission Accomplished.

<u>About the author</u>:

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