Technology Review for Carbon Neutrality

Perspective

Can we develop better international research collaboration on decarbonization?

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ABSTRACT

International research collaboration on decarbonization is needed if emissions reduction targets are to be achieved at the pace required and with lowest cost to all. While international exchanges on decarbonization still flourish amidst rising geopolitical challenges, whether these exchanges can result in effective collaboration remains unclear. This article reviews the current state and challenges, and proposes potential areas for international research collaboration on decarbonization. While countries are collaborating on research projects such as carbon capture, utilization and storage (CCUS), hydrogen, and materials development, collaboration mainly occurs as loosely coordinated activity between research groups, over relatively short time periods, at relatively modest scale, and still lack the degree of technical leadership and direction needed for effective delivery. These are due to multiple challenges in implementation and coordination, such as operation under different research systems, funding mechanisms and national priorities. This article perceives several opportunities for future international research collaboration on decarbonization, including disruptive technology innovations in different sectors, means for their efficient deployment at pace and scale, and policy planning on carbon budget.

KEYWORDS

Decarbonization; international research collaboration; national research system; disruptive technology innovation; opportunities for collaboration; carbon budget

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Recent studies and observations have shown that global average temperatures have increased by over 1 °C since 1980 and continue to rise at a similar rate[1,2]. It is now widely accepted this is caused by greenhouse gas emissions which were at least 54 billion tonnes of CO_2 equivalent globally in 2022 (estimates range up to 66 billion tonnes)[3], the highest level known to date and resulting from increased energy and resource consumption. Under the United Nations Framework Convention on Climate Change, more than 150 countries have announced quantified greenhouse gas emissions reduction goals. As these are implemented, emissions are expected to stabilize in the near future and then gradually reduce[4]. However, to restrict temperature increase to less than 1.5 °C, a figure estimated to limit impacts to tolerable levels, even faster reductions of around 50% by 2030[5] will be needed.

Achieving such rapid reductions without unacceptable effects on living standards is a major policy and technical challenge for all countries. The International Energy Agency estimates that technologies for half the required future emissions reductions from the energy sector are not currently developed[6] and the situation is similar in other sectors such as industry, construction, international transport, and agriculture. The required transition is of a speed and scale that is unprecedented, but the means to achieve it are not readily available. New or improved technical solutions are needed, that can be deployed at large-scale and at pace, which are now the focus of research and innovation in several countries. But as many needs are similar in several countries, it seems an inefficient use of scarce creativity and resource for each separately to seek and develop new technologies: as an English saying goes, “two heads are better than one”.

Fortunately, while the world continues to address domestic needs and geopolitical challenges, international exchanges on decarbonization still flourish. In October 2024 alone, more than 40 international conferences on new energy technologies were arranged[7]. The range of topics addressed and the level of participants at these events demonstrate the scale of efforts and the interest from the research, policy and commercial organisations. These events show that many public and private bodies are treating decarbonization very seriously, keeping in mind their own needs and challenges, and trying to get the best information and evidence possible to make their own strategies, plans, and priorities and find their own solutions.

But whether these exchanges can result in international research collaboration remains unclear. Multiple factors including different systems, real and perceived barriers, and lack of methodologies have led to missed opportunities in the field. To drive more productive international research discussions and actions on decarbonization, it is important to review the examples, challenges, and potential areas for international research collaboration on decarbonization.

The state of collaboration

A number of international collaborative programmes have operated for several years. The International Energy Agency Technology Collaboration Programmes support dialogue and studies between members on the full range of energy technologies; although given their origins many relate to conventional fossil fuel systems, some now cover new energy systems. In parallel, the International Renewable Energy Agency facilitates exchanges between members on energy transition strategies but does not directly lead development projects. The Clean Energy Ministerial initiative focuses on policy and deployment measures, within which it has a number of multilateral collaborations. In all cases, these are typically exchanges of information or data between national representatives.

Uniquely Mission Innovation, launched at the Paris COP21 in 2015, facilitates multilateral R&D between 23 member countries and the European Union. It coordinates seven “Missions” which in addition to pure energy technologies cover clean shipping, industrial processes and refineries[8]. Participants are research bodies and companies, each undertaking self-funded research on elements of a coordinated programme. Research results are reported to other partners but without any automatic right of access.

The European Union “Horizon Europe” programme supports consortium projects performed by researchers and companies from different EU states and 17 “associated” countries. Projects have defined objectives and duration with partners each responsible for specific elements, and an agreement that all can access all outputs under “fair” commercial terms. Costs are shared between the European Union (and the associated countries) and consortium members. The initiative has been successful in developing strong innovation groups and advances in areas such as fuel cells, hydrogen, and renewable energy as well as many other non-energy technology areas.

The challenges of collaboration

One major challenge to international research collaboration on decarbonization is how to bring different science and research systems to work together. Every country has a different innovation and research funding system, which entails different funding structures, approval processes, timeframes, as well as different preferences for research, making a single funded project difficult to set up (Horizon Europe being a notable exception). Often, therefore, a complementary partnership is used. For example, at the UK–China (Guangdong) CCUS Centre, the UK side contributes theoretical thinking and planning, complementing Chinese projects developing demonstration plants[9]. Each partner funds its own contribution. One example where this is not the case is the multilateral international fusion reactor project ITER. Here there is a single development project with a central project team; the seven country partners each provide project staff and specific components or sub-systems specified by the central team and the cash to fund on-site operations[10]. However, its establishment required an international treaty.

Another challenge is how to share fairly the benefits of collaboration. On the use of information, for instance, one country may consider some information sensitive and not wish to share it fully, in which case a collaborative approach is unlikely to be successful.

Potential areas for collaboration

As international collaboration constitutes only a small part of every country’s development, the key is to find win–win topics that interest each party, and then to make practical plans that can be executed. Every nation has a different energy system, and so their solutions may be different and dependent on their own needs, structures, and capabilities.

One instance where this has not been the case is solar photovoltaics (PVs) in China, where intensive development and introduction of large-scale production for local deployment drove performance advances and large price reductions in PV modules. Commercial supply to other countries has enabled significant deployment of solar systems elsewhere usually as components of systems designed and produced within those countries to meet local needs[11].

An important area for potential international collaboration is disruptive innovations. Almost half of technologies needed for decarbonization are still to be developed[6], and totally new ideas are needed for the hard-to-abate sectors. For instance, the energy system today is based mainly on electrons and molecules, but might there be new ways to exploit photons in industrial processes directly, without resorting to the existing electric infrastructure? A few solar-driven processes have already emerged, including reforming for chemical industries[12], but there is still much work to do. Long-term energy storage is an essential enabler of future sustainable energy systems, but more affordable and flexible concepts (unlike hydro storage which needs specific topography) are needed. Hydrogen is a possible solution but remains expensive and of low efficiency, so is unlikely to be the only answer[13]. Alternatives to high-carbon construction materials such as concrete are urgently needed, as are new means of steel production with lower carbon footprint[14].

Policy experience could be yet another area for international research collaboration. Carbon budgeting, for instance, could be one area for international exchanges and collaboration as many countries undertake their own carbon budget planning exercises[15]. As past policy experiences show, decarbonization roadmaps need to make clear which sectors should reduce how much carbon, the scope of change, how fast, and what objective tools are used to measure the results, in order to maintain transparency and make sure that decarbonization benefits the whole population. To deal with uncertainties, regular reviews should be conducted to check whether conditions have changed, whether policies are successful, and what can be improved.

Concluding remarks

International research collaboration on decarbonization is needed if emissions reduction targets are to be achieved at the pace required and with lowest cost to all. While countries are collaborating on research projects such as carbon capture, utilization and storage (CCUS), hydrogen, and materials development, there remain multiple challenges in implementation and coordination. Institutions operate under different research systems, funding mechanisms and national priorities, so most often collaboration occurs as loosely coordinated activity between research groups over relatively short time periods. Initiatives such as Mission Innovation are gradually bringing improved focus and strategy, but remain at relatively modest scale and still lack the degree of technical leadership and direction needed for effective delivery. The Horizon Europe "association" model has been successful in producing strong innovation consortia across and beyond the European Union but is limited in membership. The technical and policy challenges of reducing greenhouse gas emissions are very significant for all countries, and the potential benefits of identifying means for them to work together effectively are large. Opportunities for international research collaboration on decarbonization include disruptive technology innovations in energy systems, industry, construction, transport, and built infrastructure, means for their efficient deployment at pace and scale, and policy planning on carbon budget. If we can improve our current approaches to learn from each other's experiences and utilize resources across borders, the benefits will be evident for all.

Declaration of competing interest

The author has no competing interests to declare that are relevant to the content of this article. The author John N. Loughhead is the Advisory Board Member of this journal.

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