How should energy researchers respond to a climate emergency?

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Globally, individuals, organisations and nations have declared a climate emergency, "a situation that poses an immediate risk to health, life, property, or environment".[1] Despite this, there has been no noticeable step change in the way that energy research to help tackle climate change is being organised and conducted. How can and should we be changing what we do to face up to this emergency? How should energy researchers who want to tackle (mitigate) climate change respond to this emergency?

The challenge is clear: to completely decarbonise, in the space of 30 years, a global energy system that is currently reasonably stable, drives 10% of the world's GDP and underpins many important aspects of our lives. Over the last half century, researchers around the world have developed a suite of technologies, policies and scenarios that can help deliver this[2]. But now the focus of our work needs to change from thinking about possibilities, to informing effective action. We need detailed implementation plans, reflecting cultural, political and historic differences. Fulfilling these plans will require transformations touching all aspects of society, including mass up- and re-skilling, and deployment of technologies and business models, with inevitable unintended consequences. To meet the targets everything must change more or less simultaneously, decarbonisation of supply at the same time as demand reduction, industry and transport at the same time as buildings.

In this paper we see energy research as any research around reduction of energy demand or reduction of greenhouse gas emission intensity that will help deliver a net zero carbon world by 2050. In the next decade we would expect research and innovation funding to support the transition to a decarbonised world to expand massively. We are talking about this additional effort rather than general research. For example, we would argue that fusion research is not going to deliver carbon reductions by 2050 and hence is out of scope of this paper. However, this does not mean that normal research should not support fusion research. We are not arguing all research needs to change, just that which is relevant to tackling the climate emergency. We put the focus on research per se, not on individual researchers and their behaviours such as around flying.

Possible responses range from being: **faster** (more urgency, more resource); more **ambitious** (more challenging targets, scenarios, and innovation); more **applied and impactful** (ensuring our research is acted on by policy makers and business); more **coordinated** (eliminating duplication and ensuring findings are additive); more **robust** (results are correct and widely applicable). Ultimately, we might also have to accept that some areas of research are **obsolete** (the time for research to have any impact has passed). These responses can conflict, this paper captures some of the impacts of these responses, what it may mean in practice, and how research support structures may have to rapidly

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[1] *"UK Government Advice on Definition of an Emergency"(PDF). Archived from the original (PDF) on 2007-06-06. Retrieved 2007-05-30.*

[2] *Deep Decarbonization Pathways Project (2015). Pathways to deep decarbonization 2015 report - executive summary, SDSN - IDDRI.*

change to facilitate these. This paper is very much a working paper to encourage discussion amongst researchers and those who support and use research.

Faster

Doing research faster will almost undoubtedly be less cost-efficient than slower options, and the outcomes can be calculated with less certainty. It involves a shift from long term cost-optimal modelling, to a mixture of heuristics plus shorter-term modelling, simulation and emulation with planning and real time evaluation of deployment.

In an emergency, the balance point between the speed and scale of impact and certainty/accuracy of impact must change – long term studies that deliver incremental benefits (e.g. large-scale trials of technologies or policies that take years to verify small impacts) will be less useful. Suites of methods yielding rapid early impact (such as action research or hybrid trials that test the effectiveness of an intervention at the same time as how it should be implemented) - matched with near real-time process and independent outcome monitoring to constantly monitor longer-term impacts are more adaptable to a rapidly changing system. The start-up mantra of 'fail fast – fail early', and agile methods of research management need to become the norm. This will support a shift away from system optimisation – to one on system robustness and early identification of failing approaches. Research institutions need to reward identification of unsuccessful strategies as well as successful ones.

More ambitious

More ambitious targets are being set and timescales shortened, in the UK e.g. from a long-term emissions reduction target by 80% by 2050 to Net Zero by 2050, Finland by 2035, Norway and Uruguay by 2030. Countries, cities, and organisations are almost competing with each other over the most ambitious dates. This is a welcome response to an emergency compared to the last three decades of relative inaction, and this increased ambition has been driven by the results of historic research. However, this creates challenges for research, and for systematic deployment. Our research will therefore need to be more ambitious in terms of the potential to deliver significant carbon reductions in the time-scale required. Portfolios of research will have to be carefully assessed and developed in terms of ambition and risk of not delivering.

More Applied and Impactful

Impact: Now is the time for academics to maximise the impact of their historical research and for institutions to reward such work. This is a challenge for two reasons, academics are not always good at this, nor do they always get incentivised to do this. Yet, most research funders are keen for their funded research to have real world impact, now should be the time for governments to particularly focus on impact funding. If academics should spend the next three years delivering impact by helping plan and delivering the energy system transition, how will their careers be rewarded? At present all the incentives for a young researcher are the traditional ones of publication and proposal winning.

Deployment: Research has a crucial role to play in supporting effective deployment. This ranges from use of embedded sensors to provide near real-time monitoring and evaluation of programmes, to applying action research which many conventional research funders struggle with. Lacking feedback loops and breakpoints, the linear Technology Readiness Level (TRL) model is not fit for purpose at a time of rapid system change. Deployment is normally considered outside of traditional research, yet there are major impacts research could have preventing unintended consequences. Doing this requires a profound change in our research culture – we need to diversify funding, shorten the timescales for testing and evaluating. It requires a different form of research

infrastructure to that currently in place in many countries. Platforms that can support rapid testing and evaluation of alternate approaches. For example, maximising the value of government funded infrastructure and data - ranging from digital twins of technical systems, to human-in-the-loop and hardware-in-the-loop testing environments.

Methods: Socio-technical research needs to be the norm. Energy is an intermediate economic good that serves no social purpose until converted by people through end use technologies into services. This is a profound shift in the product market focused thinking currently shaping the energy efficiency debate. The next three decades will see the rapid evolution of low carbon technologies, this evolution will need to be focused around rapid mass deployment with minimum emissions in a complex socio-technical system. Methods which can facilitate socio-technical research in a rapidly changing environment and deliver impact quickly will need to be prioritised. Where the infrastructure already exists for traditional empirical research this should be utilised, but if we are to quickly understand what is happening in practice during deployment, and improve real world practice, we will need to support this with other methods such as case-based action research. Many of our models and tools have not been designed for use during rapid deployment with everything simultaneously changing, and great uncertainty. We do not have time to redevelop these, but instead we will need to apply them in parallel with other methods, see Faster above.

More robust and more coordinated

Robustness in this context is "capable of performing without failure under a wide range of conditions" and "(of an object or system) strong and unlikely to break or fail". At the individual research project level this should lead to research that is both rigorous in its capacity to withstand external and multidisciplinary scrutiny, and the findings of which will hold across a wide variety of cases. At the research portfolio level robustness relates to diversification of portfolio risk through supporting research that takes a variety of perspectives from a diverse research community and the collective analysis of the findings of which can be used to challenge majority positions based on common assumptions. This criterion needs careful balancing with the above criterion of 'faster'.

It is crucial that researchers and research institutes are aware of each other's work to avoid unnecessary replication and ensuring additive effects of extending previous work. This is not to say that no work should ever be repeated, in light of the replicability crisis, that should be encouraged in some instances where e.g. evidence is shaky but potentially highly impactful. However, without knowing who is and has been doing what, valuable resources are likely wasted.

What impact does this have on the research system?

The priority of an emergency means you have to reconceptualise priorities, and remove barriers that prevent us achieving our goals**.** Research systems have not been designed to face an emergency but an evolving system. In the UK for example, we have a highly structured research funding system based around TRL levels and subject disciplines. We have procedures and process which slow things. In an emergency, these need to be removed, and this requires strong leadership prepared to take risks and overturn normal practice. We might have to accept that some of our research whilst important and interesting in itself, is not the first priority in responding to the climate crisis. We might also have to accept that we need to do less new research and instead focus on implementation. We may also need to take greater ethical risks in how we use data.

Human research capacity will be a significant constraint, there is no time to train thousands of new researchers, so we will need to focus researcher activities around the critical challenges where research can make a significant difference. This will need the community to agree the most important common objectives apply these with strong leadership and create collaborative not

competitive research procurement. Mission Innovation[3] is a good example of prioritisation, but this is really around technology development and not deployment.

In fact, some will argue that research has no role in an emergency – that all resources should be focused on deployment. It is for the energy research community to engage seriously with this argument and understand if, and where, research adds value.

Summary Actions

This paper is a draft for discussion which suggests profound changes in how we carry out and fund research in an emergency, including the following:

1. We need to see a greater focus on socio-technical research.
2. Funding decisions need to be made more quickly.
3. Less focus needs to be put on traditional metrics of success and instead more on impact.
4. We might have to adopt a funding system similar to the triage system in medicine in how we decide on where funding is first allocated.
5. We need more and better research to support deployment.
6. Support for crucial research needs to be given more promptly; e.g. we do not have time to spend years negotiating access to government data.
7. We researchers need to examine our own research portfolio and ideas critically to see if they are really what is urgently required.

Apology:

We would have normally spent more time researching, reflecting, consulting, redrafting such an article. However, in an emergency we did not have time!

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[3] http://mission-innovation.net/