Royal Academy of Engineering

Technology pathways and meaningful innovation

The conversations we need to have on net zero, and how to have them

September 2024

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Technology pathways and meaningful innovation

The Royal Academy of Engineering's programme on Technology Pathways and Meaningful Innovation is focused on listening to public voice about how technology can be developed for a better future.

Its aims are to:

stimulate and contribute to debates and actions to help bring wider society into visioning, designing, deploying and using new technologies

enable meaningful dialogue between a range of stakeholders about emerging technologies and their potential social impacts

generate insights for those creating the pathways for technology change, from fundamental research through to widespread use

promote greater inclusivity in the creation of those pathways, to enable better socio-technical innovation and better outcomes for society

identify meaningful and practical steps towards a just transition to net zero, an inclusive economy and a sustainable society.

Our objectives are to create conversations where they matter, to build impact and to add value to existing public dialogues.

Royal Academy of Engineering – Futures and Dialogue ⬀

The need for conversations

Engineering and technologies can play a critical role in shaping the future we want, but when not carefully stewarded they can deliver outcomes that we don't – we see this through the impact of fossil fuel technologies on the climate and environment.

We need engineering and technology to be societally meaningful. Engineers play a critical role in showing how we can achieve socially beneficial outcomes, and how we might fail to, by providing 'signposts' to show how we to get to the outcomes we want – while also being transparent about limitations and restrictions. Through this, engineers can act as stewards, working with wider society to foster diverse technologies that achieve beneficial outcomes.

Those outcomes must be shaped by wider society, and identifying them needs conversations between publics, policymakers, researchers, innovators, and those that build the infrastructures we rely on.

Having critical conversations about the futures we need to build – especially in relation to net zero – involves actively involving wider publics in the engineering sphere, and having real dialogue about what that is and how we get there.

Through these we can shape the pathways of new technologies and inform the implementation of existing ones in ways that truly and genuinely meet societal needs.

As set out in work developed for the Academy by Careful Industries: "The climate emergency is a 'superwicked problem' that requires active collaboration and strong relationships to develop and diffuse new ways of working. Build on the engineering mindset: take stewardship and systems change within engineering to stewardship and systems change in inter- and multidisciplinary contexts."

Public dialogues: conversations that have happened

Many organisations at all scales are having valuable conversations with publics and communities about how we achieve net zero. We worked with the public dialogue consultancy Involve to map the landscape of those dialogues. The next page shows where there is good evidence from public dialogues and where some of the gaps are. There are a number of highly valuable conversations that have taken place.

– **how can we build on these?**

Summary of findings

Topic	How solutions fit together	Attitudes / behaviours relating to specific solutions	Forthcoming / not available online	Gaps
Net zero	• Climate assemblies (global, UK, regional, local)	n/a	• Climate adaption dialogue • ACCESS programme	• *Pathways* • *Role of AI / digitisation* • *Impact of other changes (smart cities etc)* • *Just transition / underrepresented groups*
Housing/ heating	• Future of Heat / Good home inquiry	• Tech pilots • Different owner types	• Social Housing Decarbonisation Fund and whole house retrofit evaluations	• *Insulation* • *District heating* • *Non-monetary barriers* • *Confidence building* • *Climate adaption?*
Energy	• Climate assemblies touch on this	• Deep dives into new tech (e.g. CCUS, ANT)	• Biomass dialogue • Heat pump ready	• *Storage* • *More ANT work* • *Community ownership models* • *Energy mix strategy*
Transport	• Work focuses on how not what	• Current behaviour and barriers to change	• New materials in roads workshops	• *E-Scooter/bike* • *Mobility hubs* • *Smart charging*
Circular economy	• Favourable views but not clear how it fits	• Recycling • Food (broader than net zero)		• *Most topics e.g. fashion/clothing, white goods*
Business		• Opinion polling at high level		• *What are the issues?* • *Preferred solutions* • *New business models* • *Role of business in employee behaviour change*

🟨 Strong evidence base   🟦 Patchy evidence base   🟥 Limited evidence base

Source: landscape review by Involve, commissioned by the Royal Academy of Engineering

In addition to the above, the academic literature suggests that the key gaps are around ensuring a just transition and a critique that existing work can focus too much on the technical and insufficiently on the social side of the pathway to net zero. There is perhaps more academic work on storage (from the perspective of justice).

Innovate UK has many innovation competitions relating to these topics, but the user-focused products arm of its Net Zero Living programme is still to be announced.

Public dialogues: where are the gaps?

This shows a number of areas relevant to engineering expertise, and the idea of stewardship:

Pathways: we are committed to reaching net zero by 2050 – but what are the pathways for getting there? What are the steps to change in using renewable energy, moving to low carbon transport? Reducing energy for heating our homes?

Systems: what are the interactions between different policy and technology choices, and how do we manage these?

Just transitions: who are the unheard voices, and who is disproportionately affected by the costs of reaching net zero? Can we allocate the benefits equitably?

Community ownership: how can the public be part of the engineering and policy effort, and benefit from renewable power and potentially the income it creates? How can engineering support local initiatives?

Policy delivery: we know we need to deliver on key policies like reducing demand for energy to heat homes. What are the solutions? How do we address the need to insulate? How can systems like district heating play a role?

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Technology trends and opportunities: using what we have and looking at the future

Wired Consulting looked at some of the trends that could shape our path to net zero, relating to:

- **future energy**
- **the built environment**
- **the transport system**
- **sustainable manufacturing**

Any trend is shaped by a complex interplay of social, economic, innovation and research developments. Consideration is needed across all of these areas to ensure that trends emerge that lead to better outcomes for society.

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Technology trends and opportunities: future energy
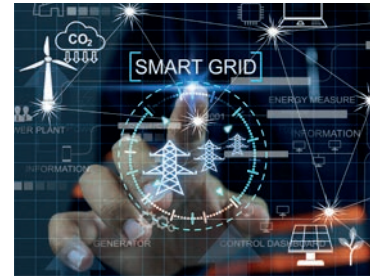
Possible future...	...depends on
Increased efficiency and reduced cost of existing (especially renewable) energy sources.	Working with inadequate and inefficient infrastructures, building storage, and creating robust infrastructure for transmission and distribution.
Improved resilience in system to geopolitical and other shocks.	Reducing reliance on external supply chains vulnerable to outside factors. Supporting more local generation, and engaging with communities on local decision-making.
Long-term promise of mix of hydrogen, fission and fusion technologies.	Democratic decisions on the availability and allocation of scarce resources and critical materials required.

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Technology trends and opportunities: built environment

Possible future...	...depends on
Digital technologies, advances in materials science and new green energy solutions opening up opportunities for redesigning and rebuilding our built environment.	Addressing and engaging inclusively on complex challenges that impede more biodiverse, circular and decarbonised solutions.
	The financial and political support to sustainably manage existing, ageing and inefficient infrastructure for it to be maintained, refurbished, retrofitted.
	Establishing economic incentives.
	Investment to scale promising and effective sustainability technologies.

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Technology trends and opportunities: transport

Possible future...	...depends on
Innovation in digital technologies (AI, IoT, blockchain etc), along with advances in green hydrogen production, batteries, and a shift to electrification, promise to deliver a smart, efficient and integrated transport system.	Updating the existing infrastructure that does not support greener solutions, which is challenged by prohibitive upgrade costs, for example electric vehicle technology is progressing, but the charging infrastructure won't support adoption at scale.
	Financial incentives and new policies that support positive consumer and business behaviour.
	Development and sustainable use of new fuels for larger vehicles, such as aircraft and ships.

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Technology trends and opportunities: sustainable manufacturing

Possible future...	...depends on
A lower carbon, more circular manufacturing sector with efficient supply chains...	Addressing and managing the higher costs of sustainable materials and processes that impact margin and disincentivise adoption, by working with industry and consumers.
...delivered by innovation in bioengineering, materials and e-chemicals...	Policy and regulation creates change in terms of industry and business adoption of greener alternatives.
	The complexities of globalised trade and economic (dis)incentives.
...and the adoption of enabling technologies such as AI, IoT and automation.	Consumer demand for a lower price over sustainable solutions.
	Availability and sustainable, just supply of scarce materials.

Source: adapted from analysis provided by Wired Consulting

The conversations we need to have...

Change is complex, systemic and technology is not deterministic. These are about societal, policy and economic choices and shaping technologies intentionally, to deliver beneficial outcomes.

This requires meaningful conversations across communities and sectors.

...energy

Energy: how do we move to an energy supply system that is decarbonised, decentralised, digitised and democratic?

Decarbonisation needs to happen fast – how do we also make sure that the changes we make are resilient for the **long term**?

How do we build a resilient grid that is safe from **geopolitical** shocks?

What role does **local** decision-making and local energy ownership play?

What are the key factors in reducing energy **demand**?

...travel

How do we **travel** in a net zero world? Transport as a service versus ownership? Slower travel versus mobility on demand? How can all members of society have access to clean, safe and convenient travel?

Technologists are leading the way with electric vehicles and autonomous vehicles, but what role do they play in the wider transport **system**?

Can the roll-out to wholly electric vehicles be an opportunity to rethink models of ownership and access, and be part of a **pathway** to fully decarbonised and healthy travel?

What choices might we make about the size, weight and performance of cars where design choices can balance energy and material efficiency against performance?

...environment

▌ How do we **transition** towards a healthy, safe and sustainable built environment?

▌ What are the options for heating homes and how can we deliver on insulation and building upgrade at scale?

▌ How do we balance building maintenance with building new?

▌ Can social housing be a focus for upgrade?

▌ How do we connect the issue of affordable warm homes with the challenge for younger people to be able to own their homes?

▌ What is the role for digital technologies for better maintaining the built environment, and creating efficiencies in the building process?

And how to have them

▌ In our exploration of these issues, we will aim to put hopes and fears first – ask underrepresented groups, younger people and affected communities some of these questions first and make them central to expert discussions.

▌ Think of publics and engineering as fundamentally connected – engineering is about solutions – the challenges and needs are set by society as the overall 'client' of the engineering profession.

▌ Engineers can provide signposts and the public can deliberate on the best pathways – there are always choices, and no one technology paves the way. Investing in and pursuing technology is always a choice and a decision.

▌ Opening up options rather than narrowing them – enabling a plurality of technology options to flourish creates resilience, choice and enables us to move away from technologies that prove unsafe, or unhelpful or which have unintended consequences.

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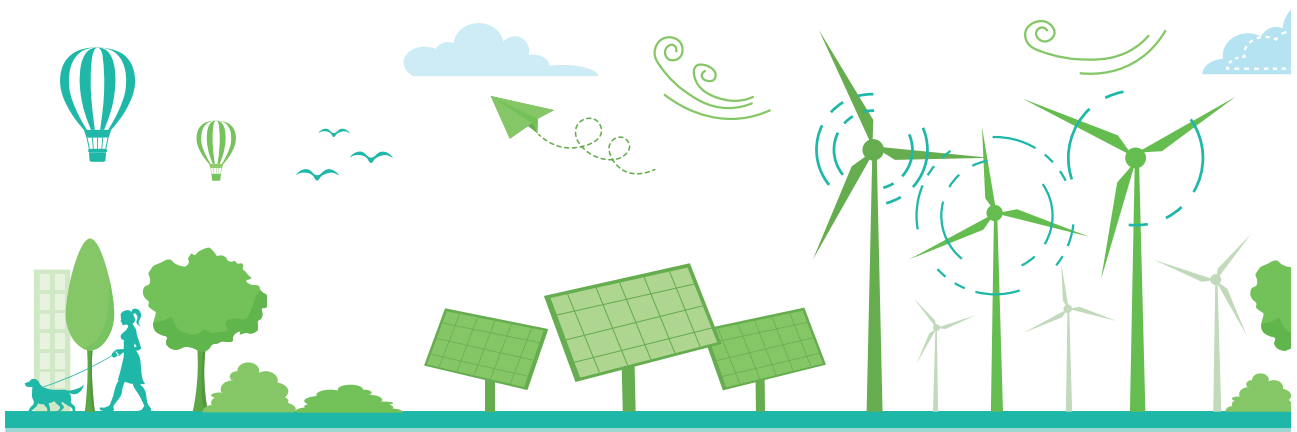
Royal Academy of Engineering

The Royal Academy of Engineering is harnessing the power of engineering to build a sustainable society and an inclusive economy that works for everyone.

In collaboration with our Fellows and partners, we're growing talent and developing skills for the future, driving innovation and building global partnerships, and influencing policy and engaging the public.

Together we're working to tackle the greatest challenges of our age.

What we do

TALENT & DIVERSITY

We're growing talent by training, supporting, mentoring and funding the most talented and creative researchers, innovators and leaders from across the engineering profession.

We're developing skills for the future by identifying the challenges of an ever-changing world and developing the skills and approaches we need to build a resilient and diverse engineering profession.

INNOVATION

We're driving innovation by investing in some of the country's most creative and exciting engineering ideas and businesses.

We're building global partnerships that bring the world's best engineers from industry, entrepreneurship and academia together to collaborate on creative innovations that address the greatest global challenges of our age.

POLICY & ENGAGEMENT

We're influencing policy through the National Engineering Policy Centre – providing independent expert support to policymakers on issues of importance.

We're engaging the public by opening their eyes to the wonders of engineering and inspiring young people to become the next generation of engineers.