# The role of engineers in achieving a sustainable future

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## Introduction

The challenge to engineers in achieving a sustainable future is clear yet daunting: we must accelerate both adaptation to and mitigation of climate change, while embedding nature-positive practices across engineering. This means not only decarbonising existing systems but also expanding low-carbon solutions in a climate-resilient manner whilst minimising environmental impact. These are not just engineering challenges, but broader societal challenges with engineering, technology, and systems thinking at their core. Let's look at some examples of what that means in practice.

## Decarbonising the electricity system

The Government entered office pledging to accelerate decarbonisation of the electricity system.

A stable, resilient, decarbonised, and flexible electricity system, growing over time to twice, perhaps even three times its current size, is essential for the UK's industrial strategy and sustainability goals. The National Engineering Policy Centre (NEPC), a partnership of engineering organisations led by the Royal Academy of Engineering, looked at how this might be achieved. The report, co-chaired by Sir Patrick (now Lord) Vallance HonFREng and Simon Harrison FREng, sets out the designing architecture of what needs to be done, involving governance, planning, procurement, regulation, and digitisation. This transformation involves all forms of engineering, from electrical, civil, mechanical, chemical and systems engineering, and will require many things to be done in an integrated way.

### Strong central leadership and governance

Transforming the power system is a major infrastructure programme requiring empowered leadership accountable to the Prime Minister. Creating 'Clean Power Mission Control' was a good first step, and including engineers within the 'Clean Power Commission' which is advising the officials in Mission Control was wise. The challenge goes well beyond conventional policy planning, to include engagement with industry and, crucially, systems integration to ensure the many elements of the new system work together effectively and efficiently.

### A flexible, digitally enabled system

The new system must be digital-first and cyber-secure to manage a complex, renewables-based system efficiently. This can deliver consumer benefits and lower costs and make best use of the infrastructure we already have. But experience of other engineering mega-projects attests that digitisation cannot be a bolt on, an afterthought once the physical requirements of the system have been looked after; the system must be designed around it. Countries that are further along with system digitalisation, such as France, are reaping the benefits of doing so.

### Proactive procurement and regulation

The transition to a decarbonised grid is a challenge to the way in which the UK has hitherto done procurement and investment. Before now, a strategy of delaying infrastructure investment until really needed has often been a sensible wish to protect the exchequer and consumers from unnecessary cost. But the situation is markedly different now. The UK simply won't have the infrastructure it needs unless it is happier to make investments ahead of demand, in the knowledge that so called 'stranded assets' aren't likely given the scale of the expansion required. Similarly, a less cautious approach to procurement which gives industry sight of the pipeline ahead is more likely to enable the UK to get to the front of the queue in tight global supply chains, as multiple countries race to redesign their electricity systems. Controlling costs is important, and markets have their place, but it is the lesson of many infrastructure projects that delay quickly leads to escalating expense.

### Planning and consenting

Two major sources of delay are the long lead times for building new transmission infrastructure, and the time it takes to secure a grid connection. Streamlining planning and consenting in a sensitive and intelligent way is an absolute requirement for progress. Communities have a right to be engaged respectfully about a transformation which will impact on the landscape and will require their support. The Electricity Networks Commissioner's Report of August 2023 set out a comprehensive set of recommendations for how these may be addressed together, not seen as opposites, and it is good to see recent developments in that direction from the Strategic Spatial Energy Planning led by NESO to concrete proposals for community benefits.

### Long-term vision

While the 2030 pledge is a significant milestone, full decarbonisation of the economy is the greater prize, and the needs of that more sustainable economy must always be kept in view, to ensure actions taken now in pursuit of accelerated progress do not compromise future objectives.

## Sustainability of AI

AI has a positive role to play in environmental sustainability: supporting better planning to help optimise energy use, improving resource efficiency, and accelerating innovations in sectors like renewable energy, transportation, and agriculture. Smarter, AI-enabled systems and automation can reduce waste, enhance climate resilience, and support efforts to achieve net-zero carbon emissions.

But AI has environmental impacts of its own, and these will increase as AI is more widely used. Large AI models require vast computational power, consuming as much energy as several hundred homes annually, increasing carbon footprints. The data centres AI relies upon account for around 1% of global electricity use, and AI's environmental impact could grow unsustainably without more energy-efficient, renewable-based data centres.

The National Engineering Policy Centre report Foundations for Sustainable AI looks right across the AI lifecycle to see how we can avoid locking ourselves into an unsustainable model of AI.

The report recommends **improving environmental reporting**, requiring engineers and organisations to disclose AI systems' environmental impacts, including energy and water consumption and carbon emissions. It suggests **enhancing lifecycle transparency**, collaborating closely across the AI value chain to improve transparency about environmental impacts throughout the AI lifecycle, from development to deployment.

Establishing **clear standards for data centres** could improve their efficiency and encourage a transition to renewable energy sources, transitions governments can incentivise through supportive policies.

**Adopting data reduction practices** is crucial. Changes such as using smaller datasets or creating shared libraries for existing data can help to reduce the need for massive computational resources for data storage, lowering energy consumption.

Finally, whilst the fiscal environment is tight, government investment can favour green AI technologies to create sustainability frameworks, and thoughtful regulation can enable innovation while limiting AI's negative environmental impacts.

In conclusion, the report underscores the shared responsibility of engineers and government in advancing AI in a way that is both innovative and environmentally responsible.

## Critical materials

In making these large-scale shifts, it is vital that we are mindful of the potential environmental and economic implications of how we go about it. The UK's dependency on materials mined elsewhere poses significant risks to its resilience and economic prosperity. Significantly the global transformation of infrastructure to achieve net zero, alongside others needs, will only increase global demand raising the need to limit the environmental and social damage caused by extraction, processing and supply of materials.

As an illustration, a recent report from the National Engineering Policy Centre estimates that the UK is on course to need 268,000 tonnes of lithium metal by 2040 for battery electric vehicles (BEVs), the mining of which would displace 438 million tonnes of earth. Lithium extraction, primarily from South American brines, has severe environmental and social impacts, including ecosystem degradation and harm to indigenous communities.

This is not an argument for avoiding climate change mitigation, the importance of which should not be in doubt. We do, however, need to apply strategic forethought and do what we can to limit the negative impacts of our transition – the NEPC report sets out how (see Box).

Without intervention, the UK risks not achieving Net Zero and being overly exposed to future economic uncertainty. But this is not something we have to accept as inevitable. To return to electric cars, reducing battery sizes by 30% by 2040 could mitigate lithium requirements by 17%, equivalent to 75 million tonnes of rock, while designing lithium out of battery manufacture could help further. The report provides 25 recommendations for policymakers on how to take this approach further, including developing

**Box: National Engineering Policy Centre report recommendations**

### Infrastructure and technology planning

It is crucial to integrate both material requirements and end-of-life considerations into infrastructure planning across energy, transport, and digital systems. This includes considering the material demands of wind turbines, solar panels, batteries, and nuclear power – and planning for the economic recovery and/or safe disposal of those materials when they have served their purpose. There are too many examples of the problems caused by failing to look far enough ahead, from nuclear to plastics (not to mention the opportunities for domestic sources of critical materials provided we design for their recovery now); there is a closing window of opportunity to do differently this time.

### Design and design skills

Smart design changes can minimise or eliminate the need for critical materials, through material substitution, reduction, and can also ensure we design for extended product life, reuse, and recovery. We need to accelerate and pull through exciting research and best design practices and make this a widespread reality.

### Circular economy

Ensuring that materials used can be recovered, reused, or recycled can reduce our 'linear' economy's impact and promote a more sustainable use of resources. For examples, a 6MW offshore wind turbine uses 5,800kg of neodymium magnets, and the UK's existing stock represents a trove of high value materials. Better inventories can help policy makers to know when, where and how much of this neodymium will come available, enabling better re-use. Increasing more decommissioning capacity can improve our ability to recover materials, whilst design changes can make them easier to recover and recycle, as the material's high value is slashed if it is encased in epoxy resin and costly to extract.

an integrated materials strategy, establishing a National Materials Data Hub, and targeting a 15% whole-system energy demand reduction.

## A wider perspective

We tend to tackle large problems by breaking them down into more manageable pieces, and this approach can be very successful, but the transition to a more sustainable UK must go beyond a series of single point solutions in several ways.

**A whole lifecycle perspective.** The cuts to material consumption and the more sustainable AI discussed above both require us to think across the whole lifecycle, and to build consideration of sustainability into every stage.

**A whole system perspective.** Designing more sustainable AI, expanding the grid, and addressing materials demand are issues which overlap in many ways, with many dependencies stretching in multiple directions. A complex engineering project will typically have a chief engineer charged with ensuring with systems integration across the many sub-systems and processes it involves. There is many a government project which could use a chief engineer!

**A whole planet perspective.** The UK has much to do, often in collaboration with other countries, sometimes in competition. Either way, a global perspective is essential.

The Royal Academy of Engineering's partnership with the Lloyd's Register Foundation through its programme Engineering X has regularly highlighted the need for genuinely inclusive global systems. High-income countries' technology and consumer demands often create vulnerabilities in lower and middle-income countries. For example, the demand for goods has driven shipping expansion without addressing end-of-life solutions for ships, leading to significant safety and ecological impacts in Southeast Asia where many ships are decommissioned.

Similarly, the end-of-life phase of offshore wind infrastructure poses complex challenges: by 2035, over 3.5 gigawatts of offshore wind turbines will reach the end of their operational life, equating to roughly 600 turbines by 2030. Without proper planning, these structures could face unsafe and environmentally damaging decommissioning processes, similar to the issues seen in the shipping industry.

Often these impacts surface many miles from where the systems were designed, tucked conveniently out of sight. Policy makers are under huge pressure to move the dial on sustainability, and it can sometimes feel that thinking about end-of-life can wait for another day. It can't. Acting now to develop safe and sustainable end-of-life practices is crucial to avoid unnecessary future harm.

## Engineering the future

Engineers are essential in addressing these challenges. They are systems thinkers who can integrate technology, finance, policy, and logistics. We need more engineers, and a more diverse supply of them, engineers with the technical skills we need, but also the ability and confidence to lead beyond their specific field. The NEPC's Engineers 2030 project has developed a vision and principles for the future engineer and is now exploring how the UK's education and skills systems must change to deliver the engineers we need; the findings will be published later this year. With sufficient engineering expertise we can make significant contributions to local and global sustainability both in this Parliament and beyond.