Wales Centre for Public Policy
Canolfan Polisi Cyhoeddus Cymru

Policy briefing
December 2023

Challenges and opportunities of decarbonising Wales' energy system by 2035

Decarbonising the electricity generation system in Wales will be a necessary step towards reaching net zero. This note summarises the challenges and opportunities electricity decarbonisation will present, within the context of Welsh and UK policy. It forms part of WCPP's work to support the Wales Net Zero 2035 Challenge Group, which was established as part of the Welsh Labour / Plaid Cymru Co-operation agreement to examine potential pathways to net zero by 2035. Specifically, it is a contribution to challenge area 2: *How could Wales meet energy needs by 2035 while phasing out fossil fuels?*

We have interpreted this question as specifically looking at **electricity generation** rather than the whole energy system.

Important areas like the decarbonisation of home heating, industrial electrification and the electrification of transport will be covered by different challenge areas. However, we are mindful of the ways in which electrification elsewhere in the energy system will affect overall demand.

This briefing covers seven key areas of the future electricity system in Wales, and relevant powers and policies at UK and Welsh levels.

This paper was finalised prior to the publication of the UK government's Connections Action Plan and Getting Great Britain building again (DESNZ and Ofgem, 2023; Department for Levelling Up, Housing and Communities, 2023).

Powers and policies

Electricity is an area which is largely reserved to the UK government. The Welsh Government has planning responsibility for developments under 350MW generating capacity and for all onshore wind, as well as the licensing and consenting of onshore oil and gas projects, and promoting energy efficiency outside of regulation and legislation (Welsh Affairs Committee, 2021). The UK government retains overall responsibility for legislation and regulation of the electricity system, as well as the transmission, distribution and supply network (often referred to as 'the grid').

The Crown Estate owns the seabed up to 12 nautical miles out and is therefore responsible for leasing offshore projects. It is developing a leasing round for floating offshore wind in the Celtic Sea.[1]

While Wales only has limited powers over planning and consenting for projects, it is not powerless. Onshore wind is fully devolved, and nearly all other renewable energy projects are within the 350MW capacity planning responsibility of the Welsh Government, for instance.

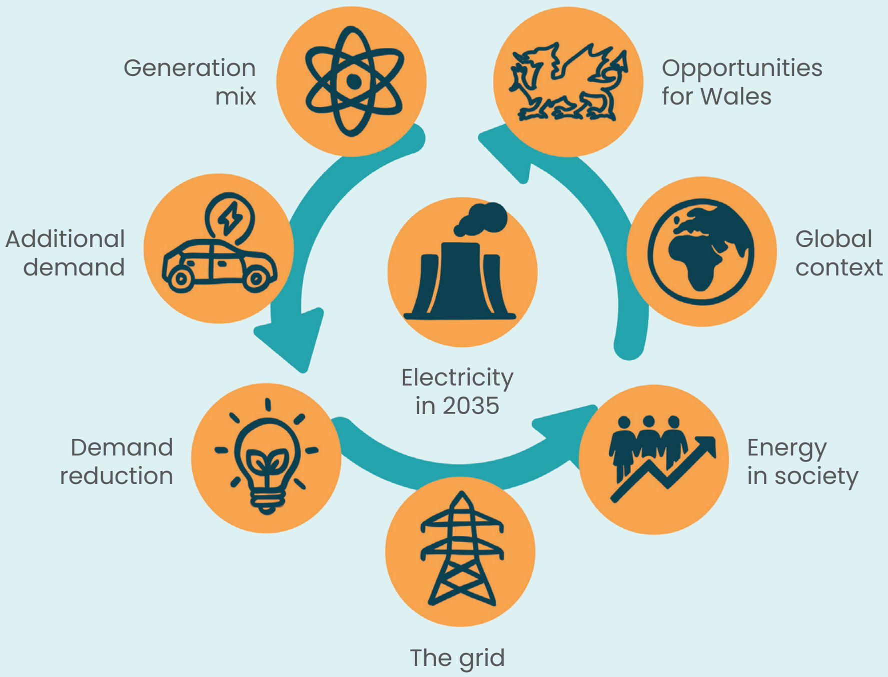
This means that Wales has, as part of its Future Wales development plan, assigned 'pre-assessed' areas where there is a presumption in favour of developing onshore wind (Welsh Government, 2021).

It is proposing targets around local ownership of renewable energy infrastructure and for the equivalent of 100% of Welsh electricity demand to be generated from renewable sources by 2035 (Welsh Government, 2023). It is also establishing a publicly-owned renewable energy developer, and has set up a company to explore opportunities for deploying small modular reactors in Trawsfynydd (James, 2022; Cwmni Egino, 2023).

The UK government has set overall targets for the energy system, including a target to decarbonise the electricity supply by 2035, subject to security of supply (Department for Business, Energy and Industrial Strategy, 2021).

1 This is separate from the UK government-organised Contracts for Difference allocation process.

Areas for consideration



The diagram above shows the seven areas of the Welsh electricity system we have considered. The remainder of the note looks at some of the key factors to consider for a net zero system by 2035 under each of these headings.

Generation mix

The most consequential question is how Wales generates its electricity and how much it generates. This is at the heart of questions around decarbonisation.

The UK government's 2035 decarbonisation strategy foresees a much larger share for renewables, as well as supporting further nuclear power plants and a (limited) amount of unabated gas (Department for Business, Energy and Industrial Strategy, 2021). Part of this strategy includes development and deployment of new technologies or innovations, including hydrogen; carbon capture and storage; and electricity storage (primarily batteries) (HM Government, 2023).

A renewables-led energy system would certainly need substantial investment in carbon capture and storage and in energy storage technologies, given the intermittency of renewables and the desire to phase out unabated fossil fuel use.

Carbon capture and storage technologies have long been promised but non-experimental implementation has been elusive. The UK government is committed to deployment in the mid-to-late 2020s, focusing initially on industrial clusters (HM Government, 2023). To reduce costs while providing baseline generation capacity, new nuclear is also being explored, but is unlikely to be realised much before 2035.

Small Modular Reactors, as proposed for Trawsfynydd, and new-generation nuclear could be cheaper and deployed more rapidly than larger-scale plants (Cwmni Egino, 2023). However, on current timelines building will not start until the late 2020s (Cwmni Egino, 2023). Nuclear generation is likely to be required in a decarbonised electricity system but will require significant investment, even for (as yet untested) Small Modular Reactors, and timelines will need to be accelerated in order to contribute significantly to a 2035 target.

Energy storage can be through batteries, for short-term storage and balancing demand, or through other means such as hydrogen or pumped hydroelectric storage.

The cost of battery storage has reduced considerably in recent years, but faces competition from use in electric vehicles (EVs) and deployment will be affected by shortages in lithium, needed to produce the most common type of battery (Nilsson and Dempsey, 2023). This is compounded by the need to significantly increase deployment: in order to reach net zero by 2050, analysis from the International Energy Agency (IEA) suggests close to 120 gigawatts (GW) per year of additional battery storage will need to be installed globally between 2023 and 2030, compared to only 11 GW installed in 2022 (IEA, 2023). Longer-term storage tends to be less efficient than batteries, although options like hydrogen storage in salt caverns would provide resilience and enhance energy security (Royal Society, 2023).

Discouraging results from the latest Contract for Difference allocation rounds, in which no offshore wind projects bid for support due to a 'strike price' below what investors felt was viable, suggest that more support may be needed from government to encourage the rollout of larger-scale renewable energy projects, particularly offshore wind (Millman, 2023). However, this will increase costs.

On current trends, and given the challenges above, it is therefore likely that even a decarbonised electricity grid will involve the use of fossil fuels in 2035, such as unabated gas used to balance renewables, or fossil fuels used alongside carbon capture and storage technologies. This fits with IEA analysis suggesting that, even on a Net Zero Emissions scenario, fossil fuels will make up 62% of global primary energy supply in 2030 (IEA, 2022a).[2]

Demand for electricity

Related to the question of generation mix is the important question of how much electricity will be needed in the future, including through the electrification of energy uses such as transport or industrial processes.

It is commonly held that electricity demand will increase significantly with the transition to net zero. The Climate Change Committee's Balanced Pathway estimates that electricity demand will be 50% higher than pre-Covid levels by 2035, and 100% higher by 2050 (Climate Change Committee, 2023).

For the whole of the UK, UK government forecasts estimate demand in a net zero scenario could be between 596 terawatt hours (TWh) and 792 TWh; and generating capacity could be between 335 GW and 459 GW by 2050 (Department for Energy Security and Net Zero, 2023a; 2023b). This compares to a generating capacity of 119 GW in 2022 (Department for Energy Security and Net Zero, 2023b). Separate (and not directly comparable) analysis for Wales indicates demand could increase from 16 TWh to between 27-46 TWh by 2050 and generating capacity could increase from an assumed 8-10 GW in 2025 to 19-23 GW in 2050 (Energy Systems Catapult, 2023).

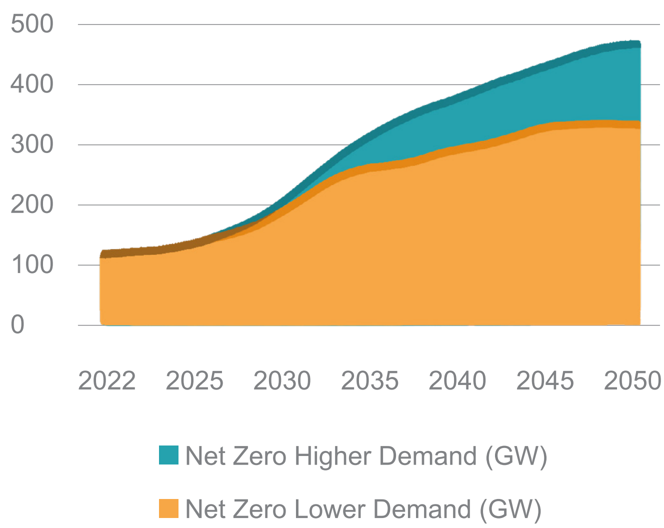
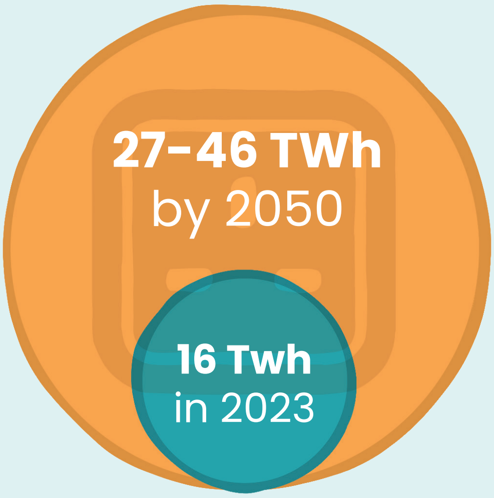
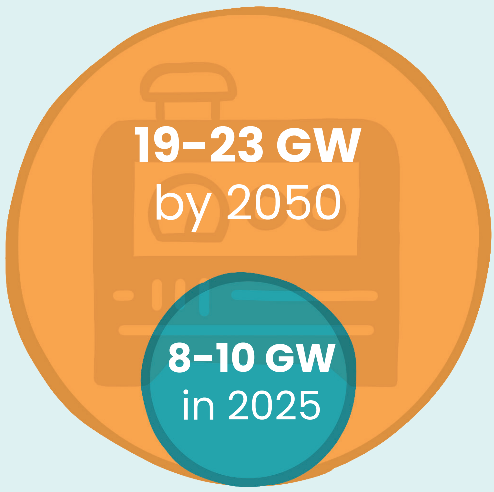


Figure 1: UK generating capacity under higher and lower demand net zero scenarios (Department for Energy Security and Net Zero, 2023b)

2 Primary energy supply includes all energy uses. For electricity generation in contrast, the IEA Net Zero Emissions scenario sees renewable and low-carbon energy sources making up 61% of global generation by 2030 (IEA, 2022).



Estimated electricity demand in Wales



Estimated generating capacity in Wales

Meeting 2035 targets will require more than doubling the best energy build rate achieved in the past 60 years and sustaining it over twelve years

Using 2021 figures, SNC-Lavalin assessed that meeting the equivalent demand figures for 2035 in a way that is consistent with decarbonising the electricity system would require construction of an additional 159 GW – 203 GW of generating capacity by 2035, a build rate of 12.2-15.6 GW per year from 2022 (SNC-Lavalin, 2022). From 1960-2019, the most additional capacity the UK installed in a year was 6 GW in 2012 (Beake and Cole, 2020).

Meeting 2035 targets will therefore require an aggressive rate of increase in generating capacity, more than doubling the best build rate achieved in the past 60 years and sustaining this build rate over the next twelve years.

This level of ambition will also have implications for supply chains and resource use at a time when other countries will be similarly looking to ramp up renewable and low-carbon electricity generation.

Additional demand

While some sources of additional demand may be clear, there are others which might be less immediately obvious. Key additional demand factors are considered in published analyses, so are not covered in depth here (see e.g. Climate Change Committee, 2023), but some factors could include:

- The electrification of heat, which could add approximately 50% onto peak electricity demand by 2050 in the UK (Zhang et al., 2022);
- The electrification of personal transport, which will require additional generating and grid capacity, but also offers opportunity for demand shifting (see below);
- Electrification of certain industrial processes;
- Digitalisation, through increases in the number of data centres and energy-intensive computing functions like generative AI;
- Increase in demand for air conditioning or cooling as summers become hotter and heatwaves more frequent; and
- Demographic changes, such as increases in the number of single-person households, which could increase per capita energy use.

Demand reduction and load shifting

The other side of the coin, and likely to be necessary even with large increases in generating capacity, are interventions which could either reduce electricity demand or spread it over a longer period of time to flatten peak demand. Flattening peaks in demand, known as 'load shifting' would mean that less overall generating capacity would be needed, as demand would be spread out over longer periods of time. Flexibility of demand is seen as necessary for a decarbonised power system (Climate Change Committee, 2023).

Strict demand reduction techniques might involve increasing the energy efficiency of certain processes, such as heating or lighting. The IEA estimates that global energy efficiency improved by 2% in 2022 – but that energy efficiency will need to improve by 4% a year by 2030 in order to meet Net Zero by 2050 (IEA, 2022b). Cost pressures might also reduce energy use, particularly if domestic energy prices remain high, but there are clear moral, economic and public health hazards to high energy prices.

Load shifting is increasing in importance and will continue to do so as the electrification of domestic heat and transport gathers pace. Time-of-use tariffs or other incentives could be used to encourage, for instance, charging vehicles at night when demand is lower, and at times of increased demand stored energy in electric vehicles might discharge to the grid to increase capacity (ESO & Octopus Energy Group, 2023). One paper argues that electric vehicle batteries alone could provide enough storage to meet short-term storage demands on the grid by 2030, if storage requirements are on the lower end of forecasts (Xu et al., 2023). This will require overcoming technical and commercial challenges in order to be successfully implemented.

Reducing demand could become key if the build rate for new power generation does not hit the ambitious rates required, discussed above. Assuming a build rate similar to historic levels, and new technologies not being discovered or deployed rapidly, UK FIRES researchers estimate that the UK would only be able to use 60% of today's energy demand in 2050 without using carbon-emitting generation methods (Allwood et al., 2019). This 'Absolute Zero' scenario would demand a reduction in energy use perhaps far in excess of what will be tolerated by the public, underscoring the need to combine demand reduction or load shifting activities with increases in the build rate of low-carbon energy sources.[3]

3 For instance, Allwood et al. (2019) suggests that, in this scenario, all international shipping and aviation would be in abeyance until towards the end of the century, a scenario that, given the UK's dependence on international trade, would certainly have disastrous effects on the standard and quality of life for UK citizens.

The grid

Expanding the energy transmission and distribution infrastructure ('the grid') is recognised as a key challenge in the rollout of low-carbon energy generation in and beyond Wales. Current grid infrastructure was designed and built for a centralised system of electricity generation and new infrastructure will need to be built and deployed to enable new generation technologies and to handle increased electricity demand.

For new energy generating technologies, Energy Systems Catapult (2023) suggest that 'significant reinforcement' will be needed for transmission networks to handle offshore wind generation. Energy distribution networks will also require reinforcing to cope with additional demand. These will both need to move at pace, to facilitate deployment of new infrastructure (Energy Systems Catapult, 2023). Networks will need to be carefully planned and aligned with forecasted demand as well as planned developments (Energy Systems Catapult, 2023). 'Anticipatory investment', where investment is aligned with prospective developments rather than confirmed projects, would also help to develop the grid (Welsh Affairs Committee, 2022).[4]

Access to the grid will also be needed for community energy projects (Welsh Affairs Committee, 2022). Failing this, 'local grids' could be developed to transmit locally-owned energy generation to nearby communities, although this does not feature as an option in most recent analyses. Beyond new generating technologies, additional energy-intensive uses could put strain on the grid.

For instance, data centres will be required in greater numbers in the future due in part to advances in cloud computing and generative artificial intelligence, and are already placing a significant strain on the UK grid, with parts of West London having to wait until 2035 for new grid connections (Hammond and Morris, 2022).

Ofgem is currently working on overcoming some of these challenges, and forthcoming interventions may make a substantial difference to the electricity system in Wales (Regan, 2023).

4 Changing investment strategies for the grid is explored further in Regan (2023).

Energy in society

Vaclav Smil argues that access to relatively abundant energy is at the heart of global development over the past two centuries, including advances in healthcare, wellbeing and society as well as economic development (Smil, 2022).

Decisions that we take about energy generation and availability are ultimately decisions about how resources can be used

Energy use does not, therefore, happen in a vacuum, and decisions that we take about energy generation and availability are ultimately decisions about how resources can be used, how factories can operate, how homes can be heated and how vehicles can move. Economies, even those that are increasingly digitalised, rely fundamentally on the production or recycling of stuff, and that takes energy. Therefore, if the energy available to use reduces, then (correcting for advances in energy efficiency) there will also be a reduction in the productive activity we can usefully undertake.

If, therefore, energy generation does reduce then the question is which productive activities we should abandon, and what impact this will have on the broader well-being of people in Wales. Even if energy availability does not reduce, the implications of more expensive energy should be considered, with recent forecasts suggesting that prices could remain above 2022 levels until the late 2030s (Cornwall Insight, 2023). Even if energy prices are not as high as during the 2022 energy crisis, more expensive energy will have implications for health, welfare, economic wellbeing and consumer prices. The prospect of higher energy prices is backed by some research: Royal Society analysis suggests a renewables-based power system with hydrogen storage could cost between £52 and £92 per MWh in 2050, compared to an average of £46 per MWh from 2010-2020 (Royal Society, 2023).

There may additionally be unpredictable psychological implications if energy shifts from being seen as an abundant good to one which is more constrained. Some implications will be positive, such as a greater awareness of energy use: 'since installing PV solar panels, I am much more aware of our electricity and keen to use it well' (Valerio, 2017). Other effects may be more negative, particularly when quality of life is perceived to be affected.

Global context

The capacity of Wales to produce and use energy, and thereby to produce and use resources, has global as well as local implications. For instance, if consumption is to continue at a comparable rate to today (and in some areas, such as the construction of infrastructure, it certainly will), then Wales will either need to produce goods and materials or import them from abroad.

Aside from emissions from the construction of renewable energy infrastructure, there are concerns about the extraction of rare earth minerals and other metals such as lithium and cobalt. Not only is the comparative use of these minerals much higher in renewable energy infrastructure, extracting them is a dirty and intensive process and often involves exploitative labour conditions.

Production is concentrated in a number of countries, such as cobalt in the Democratic Republic of Congo, and refinement and use in others – particularly China, which currently produces 77% of the world's lithium-ion batteries (Bhutada, 2023). Geopolitical shifts could make access to these minerals more difficult if exports are banned or otherwise restricted, or if relationships between China and the West deteriorate further.

More optimistically, a shift towards so-called 'friendshoring' could provide opportunities for Wales which already has advanced manufacturing capabilities in compound semiconductors and which could harness these skills for other high-technology manufacturing.

Opportunities for Wales

Despite the challenges afforded by the energy transition there are a number of opportunities for Wales.

Wales has abundant marine energy potential

Wales has abundant marine energy potential, for instance (Lloyd and Regan, 2021). Taking advantage of this would allow it to be at the forefront of new developments including constructing components for floating offshore wind and demonstrating new generating methods – possibly even tidal lagoons. However, UK government support will be needed if this potential is to be realised by 2035.

If Trawsfynydd is chosen for deployment of small modular reactors, this could also give Wales the skills and expertise in an emerging area, potentially giving Welsh nuclear engineers a global skills profile.

A north-south energy transmission connection could provide opportunities for economic development and facilitate the net zero transition (Energy Systems Catapult, 2023).

Developing skills to make the most of this potential will be important, and Wales has access to existing fossil fuel workforces who could be retrained. The curriculum reform and the establishment of the Commission for Tertiary Education and Research, could also help to promote green jobs and reskilling. These could contribute to other aims as renewable jobs may be more evenly distributed throughout Wales, helping to retain talented younger people.

Finally, although renewables have a large footprint, there are opportunities to demonstrate a positive environmental impact through habitat restoration and biodiversity promotion on renewable sites. Such sites have the potential to become pioneers for 'land sharing' approaches, where nature coexists alongside other land uses to mutual benefit while contributing to Wales's other environmental goals.

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Briefing author

Jack Price
+44 (0)29 2087 5345
jack.price@wcpp.org.uk

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Wales Centre for Public Policy
Cardiff University, Sbarc | Spark,
Maindy Road, Cardiff CF24 4HQ

www.wcpp.org.uk
029 2087 5345
info@wcpp.org.uk
@WCfPP

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