September 2022 - Second Edition

Executive summary

A day in the life of 2035

Our vision of how the decarbonised electricity system of the future will operate through two constrasting, but equally challenging days in 2035.

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Purpose of this document

To meet the UK's climate change commitments and transition to a green economy, the government has set a target to decarbonise the electricity system by 2035.

Achieving this ambition will mean far-reaching change in how our energy system is operated at both a national and local level. It will require sustained technology and infrastructure investment, as well as innovation in business models, markets and processes.

'A day in the life of 2035' explores how the decarbonised electricity system could operate by presenting two snapshot narratives of very different days in 2035, each with their own challenges and opportunities:

- A cold, calm and cloudy **winter day** with high energy demand and low renewable energy generation, leading to high electricity prices and the potential for supply shortages.
- A windy and sunny **summer day** with lower demand and very high levels of renewable generation leading to very low electricity prices and the potential for excess electricity supply.

The narratives are deliberately illustrative and not prescriptive. The final form of the decarbonised electricity system is still evolving. They are intended to provide an insight into the whole-system challenges that must be addressed, including:

- balancing the system
- ensuring system operability
- managing constraints
- maintaining security of supply
- enabling more efficient markets that can minimise costs and make the most of low-cost energy when it is abundant

'A day in the life of 2035' has been produced by Regen and National Grid ESO as part of the Bridging the Gap 2022 programme and draws heavily on the Future Energy Scenarios projections and modelling.

We would like to thank all those at the ESO, Regen and industry experts who contributed their expertise to help create 'A day in the life of 2035'.

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Regen is a not-for-profit centre of energy expertise and market insight whose mission is to transform the energy system for a zero carbon future. We approach the energy transition from a position of knowledge and evidence. By understanding the technical, financial, political and societal enablers needed to make sustainable energy work, we can tackle the barriers preventing progress.

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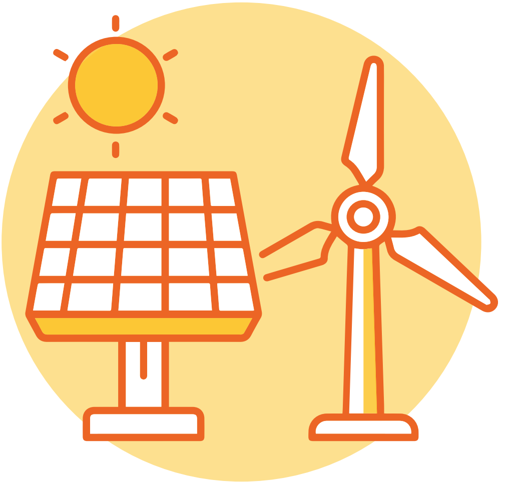
A very different electricity system

To meet the UK's climate change commitments and transition to a green economy, the government has set a target for the power sector to decarbonise by 2035.

How is the electricity system changing?

Renewable generation will see the greatest capacity increase and, alongside nuclear, will provide the overwhelming majority of GB's low carbon energy. At times when demand is low, the wind is blowing and the sun is shining, there may be an over-abundance of very low-cost clean energy.



How we deal with that, making best use of a valuable energy resource by flexing demand, storing or exporting electricity to other markets and converting power to other energy fuels like hydrogen, is the main theme of **the summer day in the life of 2035**.

The overall capacity of the electricity system will increase. Due to the greater demand for electricity, generation, storage and interconnector capacity will be significantly larger than today's system. Moreover, to maintain supply when variable generation output is very low, additional flexible capacity is required.

How the different sources of flexibility, from dispatchable generation, to interconnection, to energy storage, contribute to a reliable electricity supply when renewable output very low, is the main theme of **the winter day in the life of 2035.**

System operability will be a key focus. With far more variable supply due to weather dependency, greater decentralisation of energy resources, and many new system actors, this job of operating and balancing the energy system is becoming more complex. The whole energy system is undergoing a programme of automation, digitalisation and capability building to manage a decarbonised electricity system.

Consumers will remain at the heart of the energy system, but the way they interact with that system will change. Smart meters, appliances and energy management tools will be commonplace for households and businesses. Dynamic tariffs will encourage greater consumption when low cost, low carbon energy is abundant, and the use of less energy when it is more expensive.

Changing supply and demand

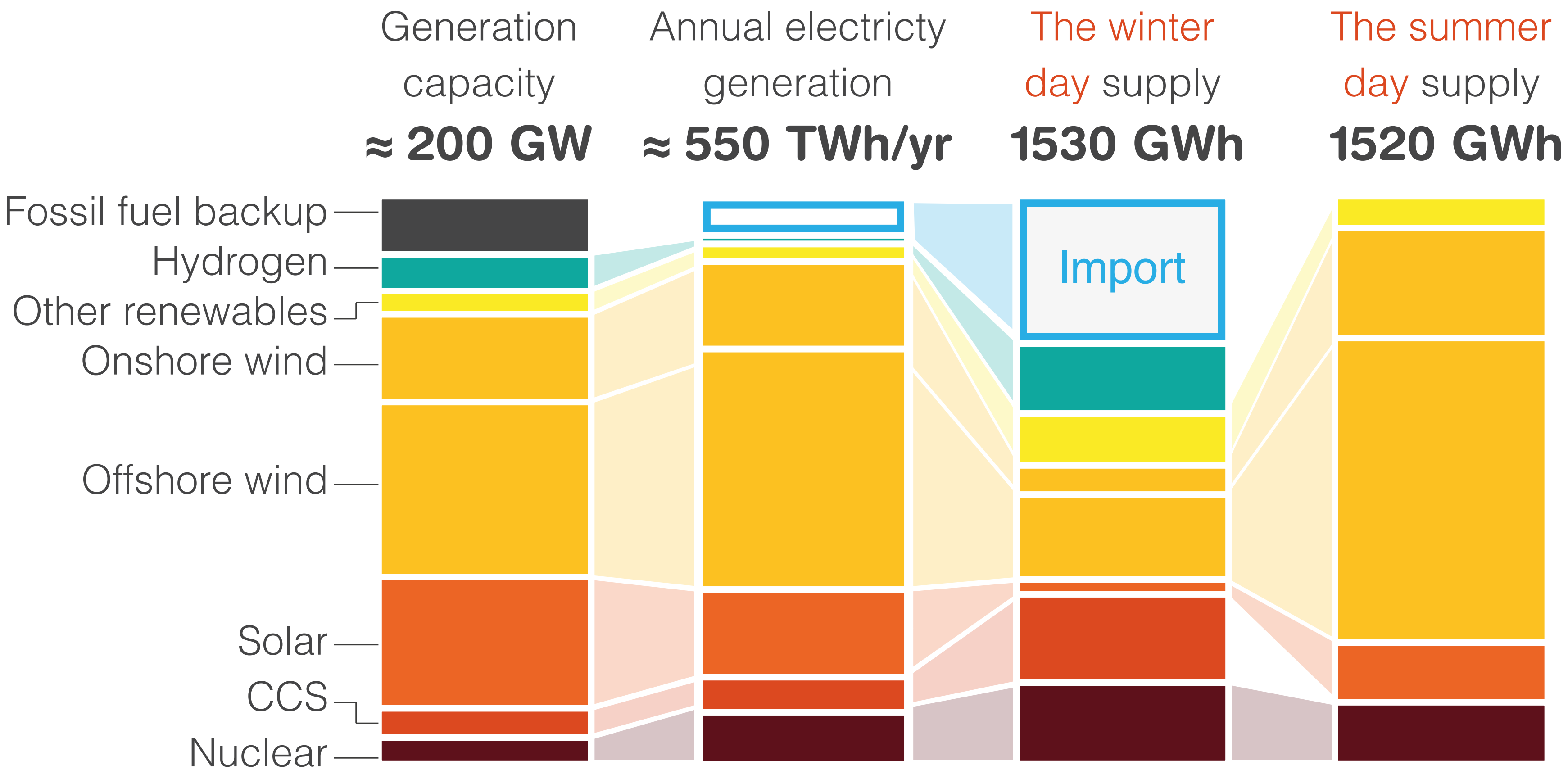
Electricity supply in 2035 Highlights

1 Electricity generation will be almost entirely decarbonised **with renewable energy supplying 75-80% of demand**. To balance the system and increase resilience at least cost, supply will need to be diversified across a range of technologies and locations – e.g. new floating windfarms in the west of the UK.

2 The system will have far more **energy flexibility.**

- **Batteries** will provide short duration, rapid response storage.
- **Long duration storage** (pumped hydro and other technologies) will provide price arbitrage, system balancing and constraint management services.
- **Interconnectors** linking GB to other energy systems will play an important role both for the import and export of energy and by 2035 GB will be a net exporter of electricity.

3 Increasing the capacity of **dispatchable low carbon generation** is a major area of uncertainty and delivery risk. This could come from gas and bioenergy with carbon capture and storage, or from hydrogen fuelled power stations.



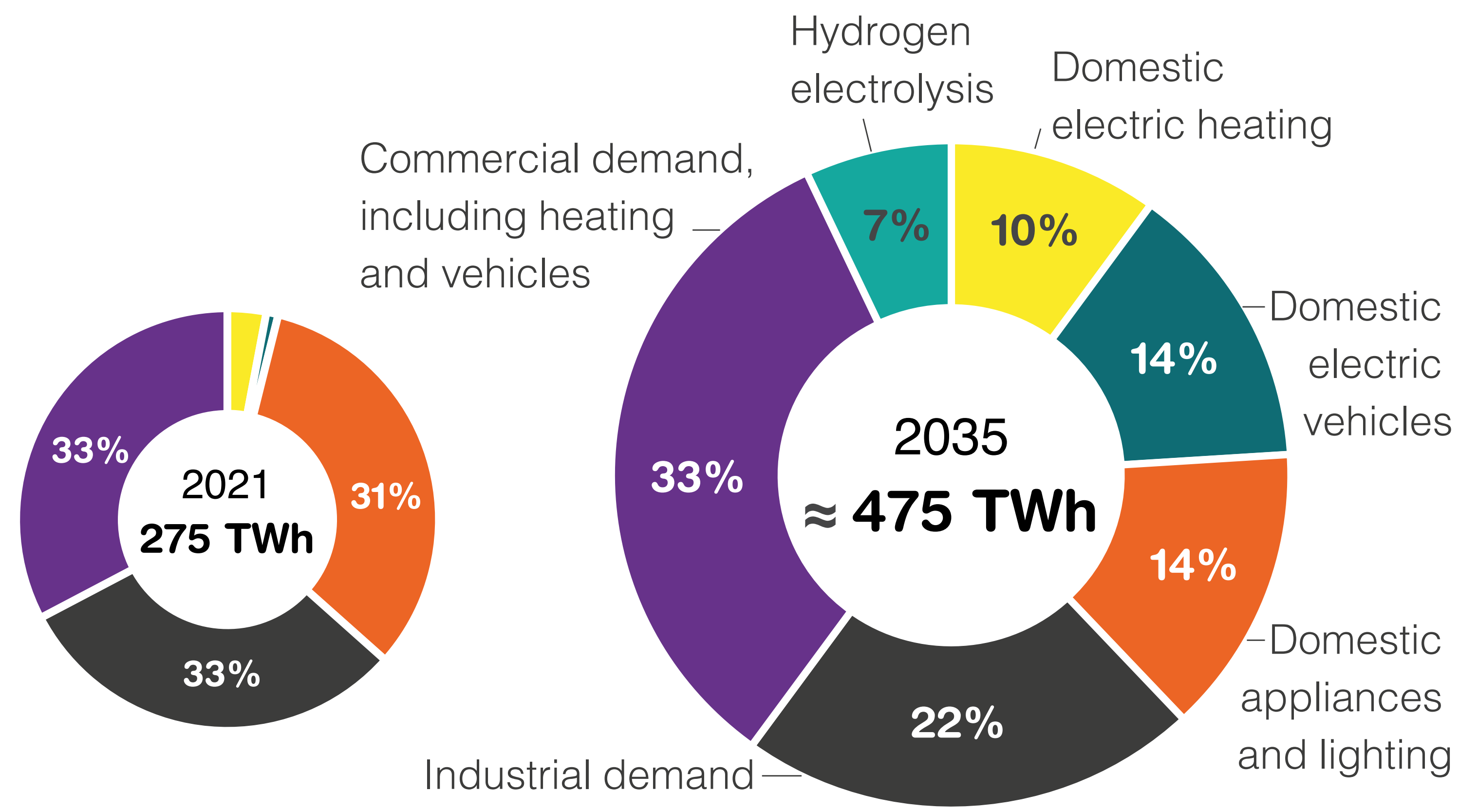
Electricity demand in 2035 Highlights

1 **Electricity demand will increase significantly** and continue to rise into the 2040s. The rate of increase will depend on:

- the electrification of transport and heat;
- use of electricity in industrial processes;
- increasing exports of power to neighbouring markets.

2 The electricity system will be more supply-led, where **demand flexes to meet variable levels of supply from renewable sources**. This flexible response will be incentivised by price signals, encouraging demand to turn down during the periods of high demand during the winter day and to turn up when prices are low.

3 **Hydrogen could play an important system balancing role**; increasing hydrogen production via electrolysis when there is abundant low-cost electricity, then using this to generate power when needed.



The winter day

The winter day sits in a week of high demand with very low wind and solar generation.

Electricity prices are high across the week, especially when the demand-supply imbalance is greatest, sending a strong price signal to consumers and energy suppliers. A whole energy system response means that back-up fossil fuel generation is not needed. But, it is extremely challenging to balance the system throughout the day and requires the optimum use of available low carbon generation, interconnectors and flexibility.

- **The system remains ‘in balance’,** despite low levels of renewable energy from wind and solar, without recourse to back-up fossil fuels.
- **Demand flexibility is important.** However, demand shifting over a week carries a risk of creating a demand deficit, which results in higher than normal demand later in the week. This needs to be carefully managed.
- **Low-carbon dispatchable generation is critical.** This is the area of uncertainty for technology development and scale of deployment by 2035.
- **Diversity of renewable energy** technology, and their locations, helps to maintain higher levels of generation over the period.
- **Interconnection is an important source of supply.** The reliance on interconnection carries an inter-market price and supply risk, however it should be noted that the fully capacity of interconnection is not used during **the winter day**.
- **The modelling highlights the importance of longer duration energy storage**; this should be a priority focus for energy policy.

The summer day

During the summer day the energy system must make best use of an overabundance of low marginal cost energy when generation from nuclear and renewable sources is far in excess of demand.

The main challenge is to ensure that the system remains operable with high levels of variable renewables and less dispatchable generation to provide system operability services. Meanwhile the energy market has to deal with the occurrence of very low electricity prices, which could be negative at times. Flexibility is again a key feature of the system including the ability to shift demand to make best use of available energy.

- **Technology innovation** and the development of new markets for ancillary services, means that the system is resilient even on **the summer day**, when supply is dominated by renewables.

- **The system is 'balanced',** however, total energy supply exceeds total demand by around 16% even with an optimal use of demand flexibility, interconnection and storage.

- **Short term wholesale prices are volatile,** during times of excess supply, and could even become negative. This creates a price arbitrage opportunities for storage, interconnectors and for high energy users as well as being an opportunity for power users and investors.

- **Dispatchable low carbon generation, and new nuclear, acts flexibly** and not as firm baseload power. This has implications both for technology development and for their business models.

- **Storage, interconnectors and demand flexibility play key roles.** Hydrogen electrolysis performs a balancing function using-up excess low-cost energy but, in 2035, the hydrogen electrolysis capacity is still growing.

- **A whole system approach is essential.** The power system now interacts directly with many more participants, with transport and heating systems and with industrial processes. The options to convert electricity to other fuels and energy vectors, such as hydrogen, bring further complexity and opportunity.

Conclusions and implications

The twin summer and winter day narratives illustrate that a decarbonised electricity system can be robust and operable on both high and very low renewable generation days.

Many of the key innovations, technologies and ancillary service markets that would be required to operate a fully decarbonised electricity system are already in development. The analysis, however, also highlights some critical aspects of the decarbonised system that would need to be in place, including very high levels of flexibility, low carbon dispatchable generation, storage and interconnectors to neighbouring markets. Without these, we would continue to rely on a fleet of fossil fuel generation and miss out on the UK's decarbonisation targets.

1 A decarbonised electricity system with very high levels of renewable power can operate and be resilient with the right system planning, operation, infrastructure, generation mix and technology innovation.

→ **The system needs a master plan for decarbonised electricity with a clear strategy to deliver it through holistic network design.**

2 There is a pathway to achieve fully decarbonised electricity by 2035, however, within this timeframe the required investment and technology solutions will not be delivered solely by the market.

→ **Financial support mechanisms, policy interventions, and direct investment, will be needed to achieve the 2035 target.**

3 Integration, interconnection and diversity of supply will help maintain system resilience.

→ **The value of flexibility needs to be reflected in energy markets and policy support mechanisms. This includes, the capacity market, balancing mechanism and revenue support schemes.**

4 Dispatchable low carbon generation will be key to provide flexibility to the system, but should not form baseload.

→ **Policy and financial support for carbon capture and storage and hydrogen-fuelled generation should be designed to develop flexible power sources, not fixed baseload.**

5 Demand side flexibility will help ensure a secure and resilient decarbonised electricity system by helping with system balancing and constraint management.

→ **It is vital that consumers are enabled to become participants of the energy system. For this to be successful, consumer engagement, protection and equity need to be addressed.**

6 Coordination and integration of data and processes between the national future system operator (FSO) and distributed system operators (DSO) is vital.

→ **New FSO whole system planning functions and flexibility markets must be aligned and integrated with DSO functions.**

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