

eBook



# Smart Grids and Energy Storage Solutions for the UK: Enabling the Net-Zero Grid by 2035

Actionable strategies for grid modernisation and renewable energy integration

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# Executive Summary

## Overview of the UK's Renewable Energy Targets

The UK is aiming to achieve a net-zero electricity grid by 2035, underpinned by its legally binding 2050 net-zero emissions goal. This ambitious goal demands an accelerated transition to renewable energy sources like wind and solar. However, achieving this milestone will require tackling significant challenges, including aging grid infrastructure, integrating intermittent renewable energy, and scaling up energy storage solutions.

## The Role of Grid Modernisation and Energy Storage

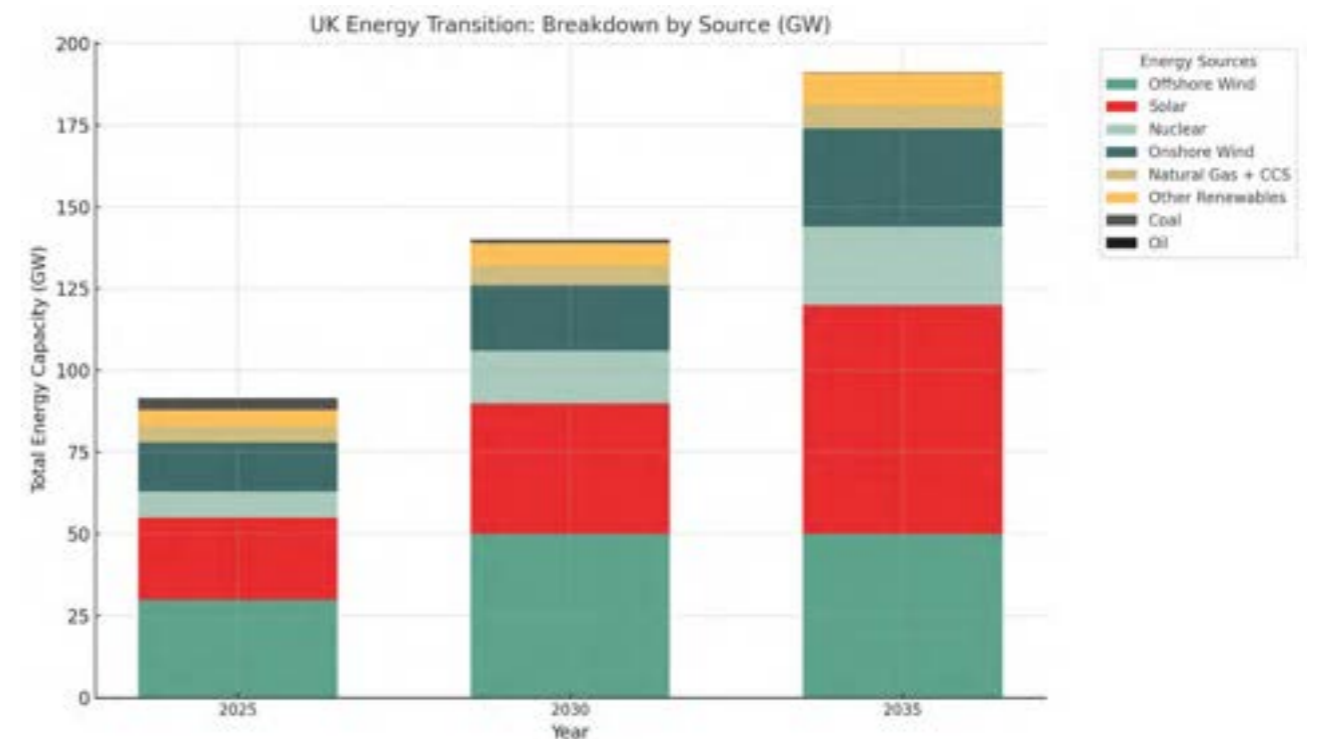
The UK's National Grid infrastructure, much of which dates back to the mid-20th century, faces modernisation needs to integrate new renewable energy capacity and meet the growing demands of electrification. Intermittent renewable energy sources, particularly offshore wind, highlight the necessity for robust energy storage systems. Solutions such as lithium-ion batteries, hydrogen storage, and pumped hydro are important for ensuring grid reliability during peak demand and low renewable generation periods.

Electricity demand in the UK is expected to double by 2050, driven by the electrification

of transport and heat and a growing population. Preparing the grid for this increase is essential for meeting the UK's decarbonisation goals.

## The Role of Energy Storage in a Net-Zero Future

Energy storage is essential for balancing the variability of renewable energy sources in the UK. By storing excess energy during periods of high production and deploying it during high demand or low generation, these systems support grid stability and reliability. Scaling technologies such as lithium-ion batteries, pumped hydro, and flow batteries will be critical as electricity demand increases, driven by electrification in transport and heating.



Sources: [IEA](#), [Gov.UK](#), [McKinsey](#) and [Carbon Brief](#)  
(Energy generation predictions in line with the UK's Net Zero goals in gigawatts)

## Section One

### The Promise of Smart Grids


Smart grid technologies will revolutionise energy management by enabling real-time monitoring, AI-driven decision-making, and enhanced two-way communication between producers and consumers. These advanced systems optimise energy flow, reduce losses, and improve reliability. The [IEA](#) estimates that digitally enabled demand response could reduce the curtailment of variable renewable energy systems by more than 25% by 2030, increasing system efficiency and reducing costs for customers.

### A Roadmap to Grid Modernisation

Achieving the UK's net-zero target requires a multi-faceted approach. Smart grid technologies must be implemented to improve energy flow and reduce inefficiencies. Energy storage systems, such as lithium-ion batteries need to be scaled to manage renewable variability. Decentralised energy systems, including microgrids, can bring clean energy to remote regions while enhancing overall grid resilience. According to [National Grid](#) initiatives such as the Eastern Link and smart meter rollouts are already driving progress toward a more resilient and efficient energy system.

### Transforming the UK's Energy Future

Grid modernisation and energy storage are foundational to the UK's renewable energy goals. Together, these technologies will enable the country to move away from fossil fuels, fully integrate renewables, and ensure that electricity generation meets the growing demand. By adopting these solutions the UK is paving the way for a cleaner, more efficient, and reliable energy system by 2035.



*Grid modernisation and energy storage are the cornerstones of the UK's net-zero energy future*

# Understanding the Current Challenges in the UK's Electricity Grid

## Aging Grid Infrastructure

The UK's electricity grid is facing increasing pressure to modernise. Much of the existing infrastructure, including transmission lines, substations, and transformers, was developed in the mid-20th century to support centralised, fossil fuel-based power generation. This system is now struggling to meet the demands of a decarbonised, distributed, and electrified energy landscape.

The [National Infrastructure Commission](#) has highlighted that aging infrastructure not only increases maintenance costs but also limits the grid's ability to support the growing integration of renewable energy sources like offshore wind and solar. Significant reinvestments are needed to ensure the grid can handle modern energy demands, avoid reliability issues, and mitigate costly outages.

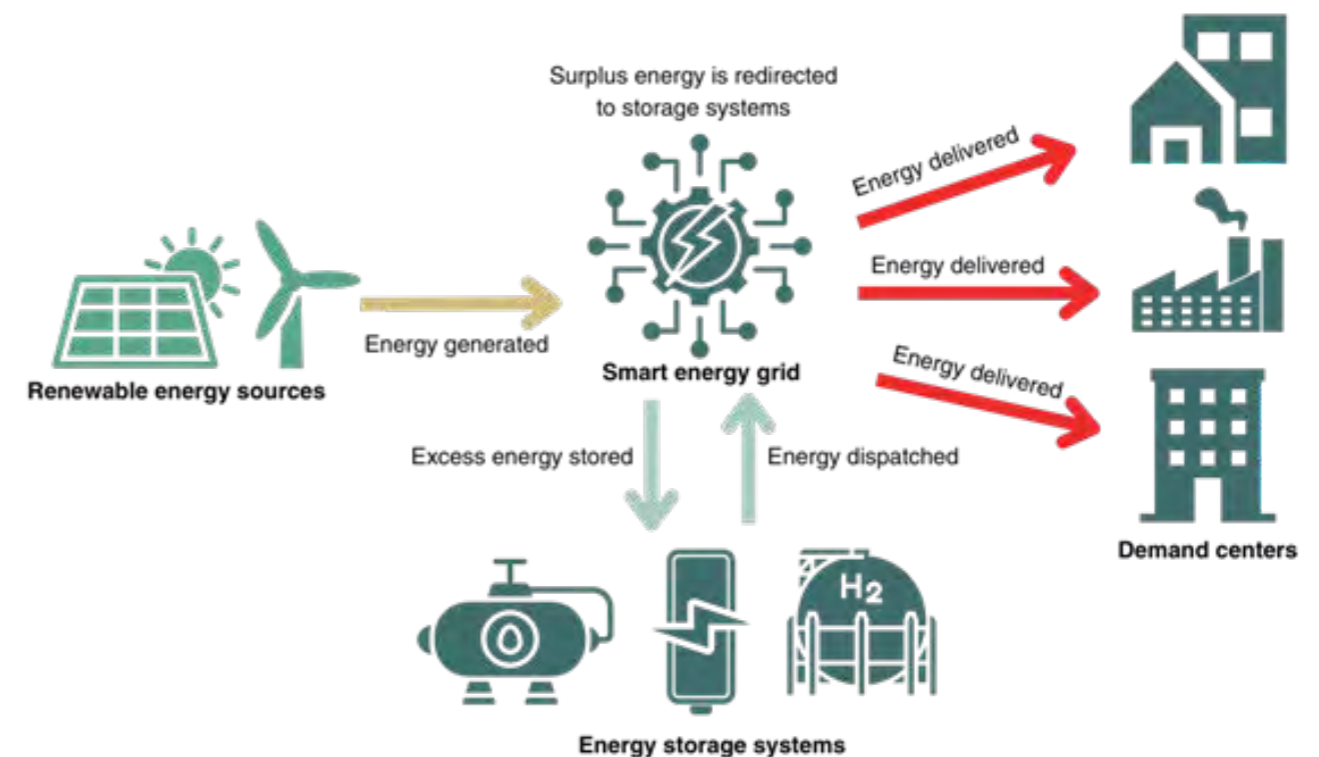
## A History of the UK's Electricity Grid

The UK's electricity grid has undergone significant transformations since its inception. In 1926, the Electricity (Supply) Act established the framework for a standardised and interconnected energy system, leading to the creation of the National Grid. This development facilitated rapid industrial growth and widespread electrification across the nation.

During the 1920s and 1930s, the focus was on developing coal-fired power stations and constructing the initial infrastructure of the National Grid. The mid-20th century saw the grid's expansion to incorporate nuclear power, addressing the increasing

energy demands of the post-war industrial boom. Later, in the late 20th century, the liberalisation of the energy market introduced private sector participation and competition, reshaping the industry's landscape.

In the 21st century, the grid faces new challenges as the UK transitions from centralised, fossil fuel-based power generation to decentralised, renewable energy systems. While the historical design of the grid enabled widespread access to electricity, its centralised architecture is no longer suitable for the demands of a net-zero economy. Modernising the grid to support renewable energy sources and enhance flexibility has become imperative to meet the UK's current and future energy needs.



How Renewable Energy Grids Balance Supply and Demand



## The Integration Challenge for Renewable Energy

The UK is among the global leaders in renewable energy adoption, with offshore [wind capacity now exceeding 14 GW](#) and further expansion planned. Unlike traditional power generation, these sources are weather-dependent and intermittent, which means their output can vary significantly. For instance, wind energy production can vary significantly depending on weather conditions, requiring technologies to store and distribute energy effectively.

Electricity consumption is projected to increase by 44% by 2050, driven by factors such as population growth, the electrification of transportation, and industrial shifts toward clean energy. Without adequate energy storage or dynamic demand response systems, renewable energy surpluses may go to waste during high production periods,

while reliability could suffer during periods of low generation.

## The Energy Storage Gap

Energy storage systems are vital for addressing these challenges, especially as renewables take on a larger role in the UK's energy mix. Storage technologies such as lithium-ion batteries, pumped hydro, and emerging innovations enable excess renewable energy to be saved during periods of high generation and deployed during peak demand or low output periods.

Globally, the need for energy storage is clear. The International Energy Agency reports that storage capacity must increase sixfold by 2030 to effectively integrate renewables and support global energy systems.

Projects like the [Minety Battery Storage](#)

facility in Wiltshire, with a capacity of 150 MW, illustrate how large-scale battery storage can reduce curtailment of renewable energy and enhance grid stability.

## Regional Disparities in Grid Modernisation

The UK's geography and decentralised energy policies contribute to regional differences in grid modernisation efforts.

- **Scotland:** Abundant wind resources, but the existing grid infrastructure cannot fully transmit this renewable energy to demand centres in England and Wales without major upgrades like the Eastern Link.
- **Wales and the Midlands:** Grid constraints in rural areas limit the integration of renewables and new energy projects.

- **Urban Areas:** High electricity demand in cities like London requires grid reinforcements and efficient energy management systems.

Tailored strategies that address these disparities are important to ensure that all regions contribute to and benefit from the transition to a net-zero grid.

## Building a Resilient Grid

The UK's grid modernisation journey is foundational to achieving its net-zero goals. By addressing aging infrastructure, scaling energy storage, and bridging regional disparities, the country can create a resilient and reliable energy system capable of supporting its renewable ambitions. Modernisation is not just an upgrade; it is a necessary transformation for the UK's energy future.

# Smart Grid Technology in Focus

## What is a Smart Grid?

A smart grid is a modernised electricity network that uses advanced digital technology to monitor, manage, and optimise energy flow in real-time. Unlike traditional grids, smart grids enable two-way communication between energy producers and consumers, allowing for greater flexibility, efficiency, and reliability. Key features include real-time monitoring, AI-driven energy flow management, and demand response systems that adapt to shifting energy needs.

## The Benefits of Smart Grids

Smart grids provide numerous benefits, particularly for renewable energy integration. By using IoT devices and sensors, they optimise energy flow, reducing waste and preventing power outages. Real-time data enables grid operators to balance energy supply and demand effectively, mitigating the variability of renewable sources like

wind and solar. The IEA estimates that digitally enabled demand response could reduce the curtailment of variable renewable energy systems by more than [25% by 2030](#), increasing system efficiency and reducing costs for customers. Additionally, a study published in Springer indicates that integrating artificial intelligence (AI) and Internet of Things (IoT) technologies into smart grids can lead to [a 20% increase in energy efficiency compared to traditional grids](#).

## Case Study: National Grid's Demand Flexibility Service

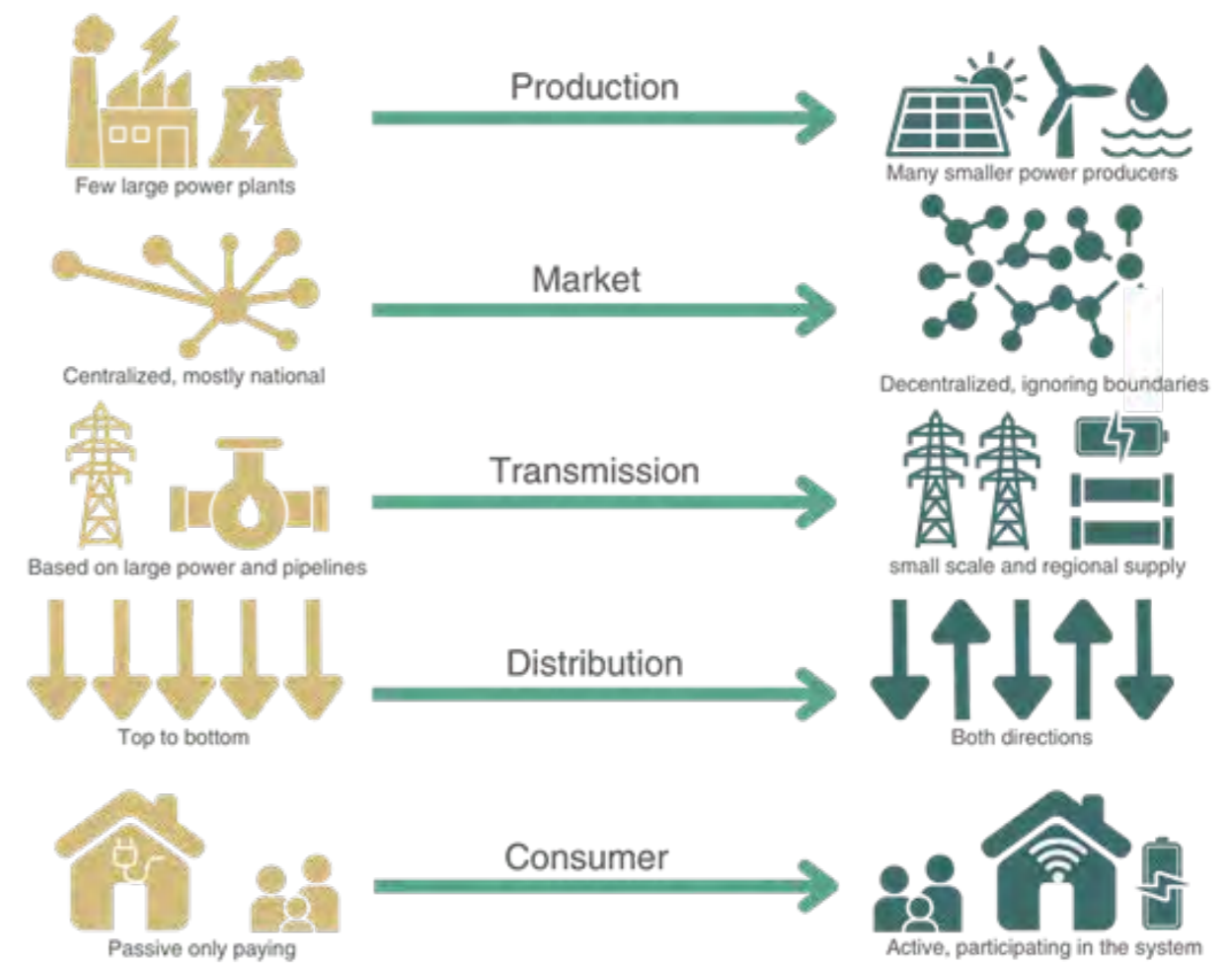
In the winter of 2022/2023, National Grid Electricity System Operator (ESO) introduced the [Demand Flexibility Service \(DFS\)](#), a demand response program designed to balance electricity supply and demand during peak periods. This service incentivises households and businesses to reduce or shift their energy usage during

specified times, thereby enhancing grid stability and facilitating the integration of renewable energy sources.

During its initial run, the DFS successfully engaged over [1.6 million households and businesses, collectively saving more than 3,300 MWh of electricity](#). This is enough to power approximately 10 million homes for an hour across Great Britain. Following this success, National Grid ESO has confirmed plans to continue the DFS for the 2023/2024 winter, aiming to further enhance grid resilience and support consumers in managing their energy usage.

## The Role of Smart Grids in Achieving Net-Zero Goals

Smart grids are essential to the UK's vision of a net-zero electricity grid by 2035. They enhance grid flexibility, support the decentralised generation of energy through microgrids, and empower consumers to participate in energy management. With aging infrastructure posing significant challenges, smart grids offer a pathway to modernise the grid while meeting the growing demands of electrification and renewable integration.



Structural changes to energy grid structures that are enabled by smart technologies such as real-time monitoring, AI-driven energy flow management, demand response systems and IOT sensors.

# Energy Storage as the Missing Link



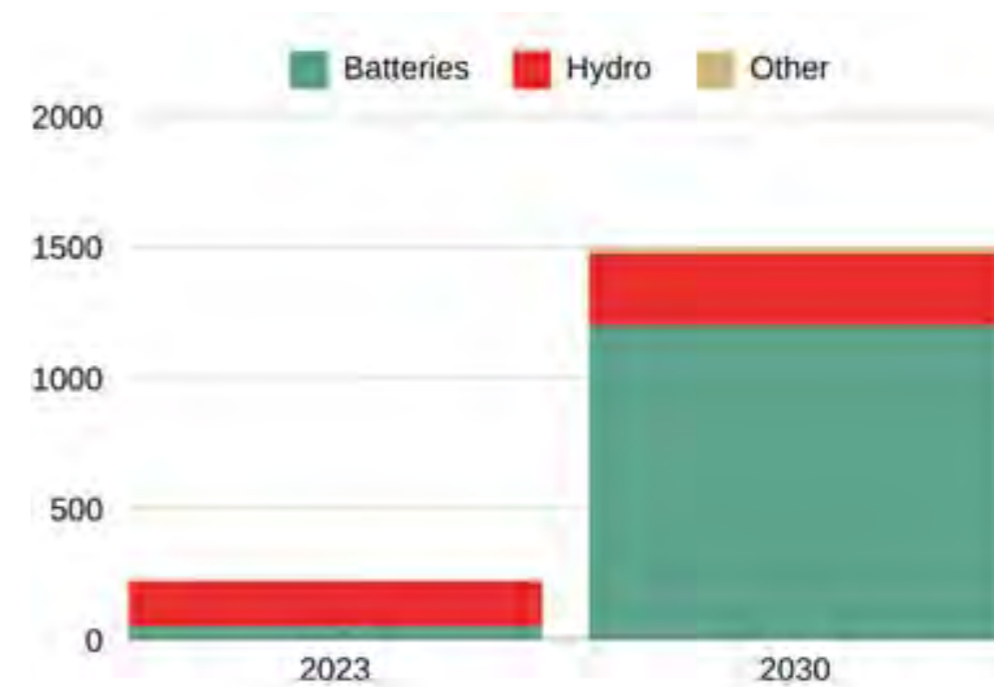
## The Role of Energy Storage

Energy storage systems are critical for managing the variability of renewable energy sources like wind and solar. These technologies store excess energy generated during periods of high production and release it during peak demand or low generation times, ensuring a steady and reliable energy supply. Without sufficient storage capacity, renewable energy often goes to waste.

Battery storage systems play an important role in stabilising grids and addressing renewable energy curtailment. Curtailment, which is the deliberate reduction of renewable energy generation to maintain

grid balance, occurs during periods of surplus generation when the grid cannot accommodate the excess energy. Battery systems store this surplus energy, ensuring it is not wasted and can be deployed during peak demand or low generation periods.

Additionally, battery storage enhances Demand Response which involves adjusting energy consumption patterns to balance supply and demand. Batteries act as a buffer, storing excess energy when demand is low and supplying it during peak periods. This dual capability reduces reliance on fossil fuel backups, improves grid efficiency, and supports the integration of variable renewable energy sources like wind and solar.



According to the [IEA](#), achieving global climate goals necessitates a x6 increase in energy storage capacity by 2030, with battery storage contributing 90%.



## Section Four

### Types of Energy Storage Technologies

There are several types of energy storage systems, each with unique applications:

#### 1 *Lithium-Ion Batteries*

Widely used in grid-scale storage, lithium-ion batteries offer flexibility, scalability, and efficiency. These systems are important for short-term energy storage and are increasingly paired with renewable energy projects in the UK.

#### 2 *Pumped Hydro Storage*

This well-established technology stores energy by pumping water to a higher elevation during low demand and releasing it to generate electricity during peak times. In the UK, facilities such as the Dinorwig Power Station in Wales exemplify the potential of pumped hydro to provide rapid-response energy.

#### 3 *Emerging Technologies*

Innovations such as solid-state batteries, flow batteries, and hydrogen storage are gaining traction, offering longer-duration storage and addressing scalability challenges.

### The Path Forward

To fully realise the potential of renewable energy, the UK must invest in scalable and diverse storage solutions. These systems will not only stabilise the grid but also reduce reliance on fossil fuel backups, paving the way for a cleaner, more reliable energy future.



# Regional Approaches to Modernising the UK's Grid

The UK's geography, decentralised energy policies, and diverse renewable energy resources create both challenges and opportunities for grid modernisation. Tailored strategies are required to address regional disparities, ensuring equitable progress toward a unified, net-zero energy future.

## Scotland: Leveraging Offshore Wind Potential

Scotland is at the forefront of renewable energy production, with its abundant wind resources contributing significantly to the UK's energy mix. However, the challenge lies in transmitting this energy to demand centres in England and beyond. Projects like the Eastern Link, a high-voltage direct current (HVDC) subsea cable, aim to transport Scotland's surplus wind power efficiently to areas of high demand in the south.

Scotland is also exploring innovative solutions such as hydrogen production from excess renewable energy, which can be

stored and used for transport or heating. Initiatives like the Aberdeen Hydrogen Hub are paving the way for a cleaner energy economy.

## England: Addressing Urban Energy Demands

England, home to major urban and industrial centres, faces significant grid modernisation challenges to meet the growing electricity demand from cities like London, Manchester, and Birmingham. [The London Power Tunnels](#) project is one such initiative aimed at upgrading the capital's aging grid infrastructure by constructing 32 km of underground tunnels to support reliable electricity supply.

Additionally, England is embracing battery energy storage systems (BESS), such as the Minety Battery Storage facility in Wiltshire, which enhances grid flexibility by storing surplus renewable energy and deploying it during peak demand.

## Wales: Integrating Renewables with Local Grids

Wales has significant renewable energy potential, particularly in onshore wind and solar. However, rural grid infrastructure often struggles to integrate these resources. Projects such as [Brechfa Forest Wind Farm](#) highlight the region's commitment to renewable energy generation, while grid upgrades are underway to accommodate increased capacity. Wales is also exploring marine energy technologies, such as tidal power, to diversify its renewable portfolio.

## Northern Ireland: Cross-Border Energy Integration

Northern Ireland faces unique challenges due to its smaller and more isolated grid. Cross-border projects with the Republic of Ireland, such as the [North-South Interconnector](#), aim to improve grid reliability and integrate renewable energy across both jurisdictions. This collaboration is critical for balancing supply and demand in a region heavily reliant on wind energy.





### The Midlands: Supporting Industry Electrification

The Midlands is a hub for UK manufacturing and industry, where grid modernisation is essential to support electrification and decarbonisation efforts. Smart grid projects and energy storage systems are being deployed to manage demand from industrial clusters, particularly as more businesses adopt electrified heating and transport systems.

### The South West: Unlocking Solar Potential

The South West benefits from high levels of solar irradiation, making it a key region for solar energy deployment. To support grid reliability, energy storage solutions like community batteries and pumped hydro systems are being trialled. For example, the Carland Cross Solar Farm integrates storage to ensure consistent energy supply even during low-generation periods.

### The North East: Offshore Wind and Green Hydrogen

The North East is a key area for offshore wind expansion, with projects such as [Dogger Bank Wind Farm](#), which is set to become the largest offshore wind farm in the world. The region is also advancing green hydrogen production, with hubs like [Teesside Hydrogen Hub](#) supporting the decarbonisation of heavy industry and transport.

### Rural Areas and Islands: Empowering Communities with Microgrids

Remote rural areas and island communities face challenges due to their distance from the main grid. Microgrids powered by solar, wind, and battery storage are being deployed to enhance energy access and reduce reliance on fossil fuels. The Orkney Islands' [Smart Energy Islands Project](#) demonstrates how localised grids can integrate renewable energy effectively while improving energy security.

### A Unified Path Forward

While regions face distinct challenges, a unified approach to grid modernisation is essential for achieving the UK's net-zero targets. Collaborative projects like the Eastern Link and government programs such as the Smart Systems and Flexibility Plan are bridging regional gaps and ensuring equitable progress. These efforts are laying the groundwork for a cleaner, more resilient energy system that supports all regions across the UK.



Map highlighting grid modernisation projects and renewable energy hubs across the UK

# Supporting Grid Modernisation through Supplier Validation



*Achilles connects organisations to trusted suppliers, providing tools to enhance supply chains*

Modernising the UK's electricity grid requires collaboration, careful planning, and resilient supply chains to address challenges like aging infrastructure, renewable energy integration, and increased energy demand. Organisations need robust systems to manage suppliers, ensure compliance, and mitigate risks as they undertake grid modernisation projects.

## Ensuring Supplier Quality and Compliance

Grid modernisation projects depend on reliable access to materials like batteries, transformers, and advanced grid technology components. Ensuring that these materials

come from trustworthy, compliant sources is essential to avoid delays or quality issues. A centralised platform for vetting suppliers and managing relationships can streamline this process and reduce risks. Solutions such as [Achilles Prequalified Supplier Network](#) ensure that partners meet regulatory, safety, and ESG standards before contracts are finalised.

## Mitigate Supply Chain Disruptions

Supply chains for energy infrastructure often span multiple regions, creating vulnerabilities to disruptions from geopolitical events, material shortages, or delivery delays.

Proactively identifying these risks through advanced supply chain management tools can help mitigate potential problems. Platforms such as [MyAchilles](#) that provide visibility into supplier performance and risks enable energy companies to plan ahead and secure their projects against unexpected disruptions.

## Enhance Collaboration and Compliance

Large-scale projects require close collaboration between developers, governments, and utilities. Transparency is essential to ensuring that all stakeholders are aligned on regulatory compliance,

timelines, and sustainability goals. Centralised data-sharing platforms can simplify communication and performance tracking, helping to keep projects on schedule and meeting their goals.

## Building Transparent Collaboration

Grid modernisation involves collaboration among various stakeholders, including governments, utilities, and private developers. Achilles' solutions facilitate transparency, risk management and sustainability, ensuring stakeholders are aligned on compliance, timelines, and performance goals.

# Actionable Steps to Modernise the UK's Grid

Grid modernisation is a complex process, but a clear roadmap can guide developers and utilities toward success. These actionable steps address the critical areas of planning, collaboration, and technology deployment, ensuring that projects meet both operational and sustainability goals.

## 1 Step 1: Assess Current Grid Capacity and Future Needs

A comprehensive evaluation of existing infrastructure is the first step in modernising the grid. This includes analysing transmission line capacity, aging components, and the ability to integrate variable renewable energy sources. Developing detailed forecasts of electricity demand accounting for population growth, industrial electrification, and renewable capacity is important for setting realistic goals.

## 2 Step 2: Strengthen Supply Chain Resilience

Securing access to critical materials and components like batteries, transformers, and grid-monitoring technologies is essential for timely project delivery. Engaging with pre-qualified suppliers through trusted platforms can help developers navigate

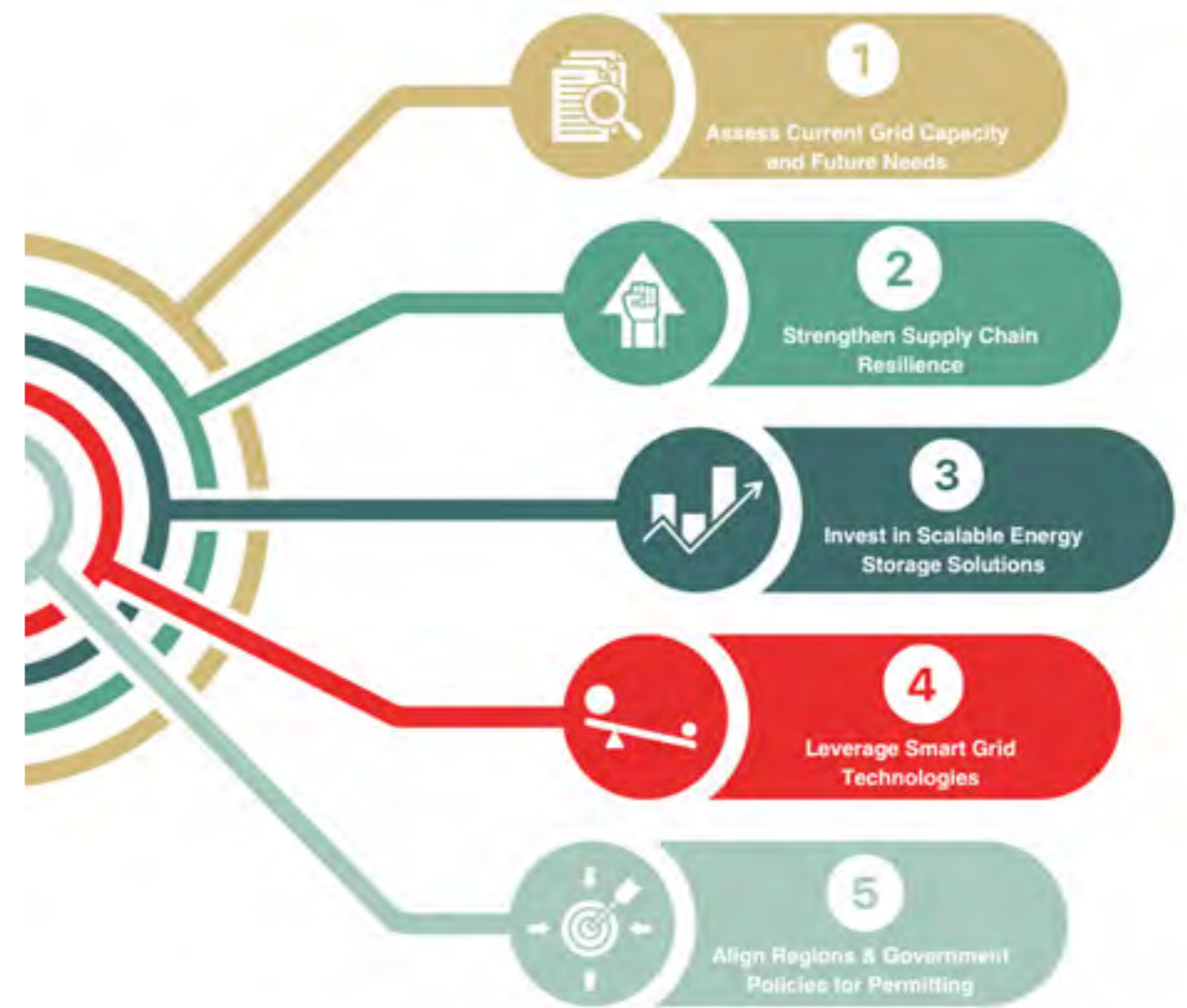
risks such as material shortages and price volatility. Diversifying sourcing strategies and maintaining a robust network of suppliers ensures that projects remain on track despite external challenges.

## 3 Step 3: Invest in Scalable Energy Storage Solutions

Energy storage is key to stabilising the grid and integrating renewables effectively. Developers should prioritise scalable solutions such as lithium-ion batteries, pumped hydro, and emerging technologies like flow batteries. These systems not only address renewable energy variability but also reduce reliance on fossil fuel backups during peak demand. Identifying locations and projects where storage solutions can deliver maximum impact will optimise returns and enhance grid reliability.

## 4 Step 4: Leverage Smart Grid Technologies

Adopting smart grid technologies enables real-time energy flow management, minimises losses, and enhances grid efficiency. Key components include advanced sensors, AI-driven analytics, and demand response systems that balance



supply and demand. By implementing these technologies, utilities can optimise renewable integration and future-proof the grid.

## 5 Step 5: Align Regional and Government Policies for Streamlined Permitting

Navigating the UK's regulatory landscape can be a challenge, as energy governance varies across regions. Developers should actively engage with both local and national authorities to align permitting processes with project timelines. Policy incentives for renewables, grid upgrades, and energy

storage can be leveraged to secure financial and operational support.

## Where Achilles Can Assist

Achilles supports organisations by providing the serious analysis and expert supply chain insight necessary to comply with ESG regulations, meet stakeholder requirements and achieve ambitious ethical and sustainability goals. These resources streamline procurement, mitigate risks, and ensure compliance with regulatory and sustainability standards, enabling smoother project execution.

# The Path Forward: Achieving a Net-Zero Grid

The UK's journey toward a net-zero electricity grid by 2035 is ambitious but achievable. Modernising the grid is not just a technical challenge but an opportunity to create a cleaner, more reliable, and resilient energy system. By addressing aging infrastructure, integrating renewable energy sources, and adopting innovative technologies like smart grids and energy storage, the UK can meet its climate goals while ensuring energy security for future generations.

The key to success lies in collaboration. Developers, utilities, and policymakers must work together to streamline permitting, strengthen supply chains, and deploy scalable solutions that bridge the gap between current capabilities and future needs. Tailored strategies that address regional disparities will ensure that all areas of the UK contribute to and benefit from a unified energy vision.

Achilles is ready to support organisations on this path. By connecting you with trusted suppliers, providing visibility into supply chain risks, and enabling compliance with ESG and regulatory standards, Achilles helps build the foundation for successful grid modernisation projects.

## Ready to strengthen your grid modernisation efforts?

Contact Achilles today to learn how our supply chain solutions can help you achieve your energy goals while meeting compliance and sustainability requirements.

[Talk to an expert](#)



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