enertechnos

The Reactive Power Challenge

How better grid management can accelerate and smooth the UK's journey to net zero 2050

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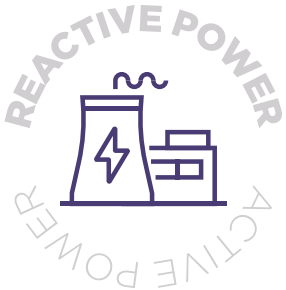
Section one:
Foreword

The UK is on its way to meet our ambitious target of reaching net zero by 2050.

The Prime Minister's Ten Point Plan and Energy White Paper, both launched late 2020, provide a necessary and welcome framework for the nation as we work to achieve this target. Greater commitment to offshore wind generation, investment in hydrogen and nuclear power and increasing electric vehicle infrastructure are all essential building blocks in the UK's transition towards net zero 2050.

However, as we move towards a decarbonised energy network, with an increasing proportion of our heat and transport fuelled by asynchronous generation such as renewables, we must consider the effect this will have on the level of reactive power produced and how this will impact the stability of our grid.

This report sets out the difference in active and reactive power, explaining the critical role reactive power plays in the grid and across many industries and sectors. It sets out the reactive power challenges the UK faces over the coming years as we move away from traditional forms of energy which produce reactive power, and discusses the solutions that need to be considered to protect reactive power availability as we move towards greater renewable energy sources and net zero 2050.



Key fact: Reactive power is only produced at scale by synchronous generators like gas, coal, hydro and nuclear power stations.

Section 2:
One grid, two types of power

There are two types of power moving around the country's electricity grid.

Reactive Power – Reactive power, which is essential for running components such as motors and transformers, has the important role of controlling the voltage throughout the grid and allowing an efficient and reliable circulation of active power.

Active Power – The power that is used in our homes to turn on lights and run electronic appliances like mobiles and microwaves is called 'active power'.

The amount of reactive power in our electricity network must be **carefully managed and balanced.**

Reactive power works across the grid like water aiding a sailing boat. Although it's the wind (active power) pushing the boat, it's the water (reactive power) keeping the boat afloat. Regardless of the strength of the wind, if there was too little water, the boat would not be able to move.

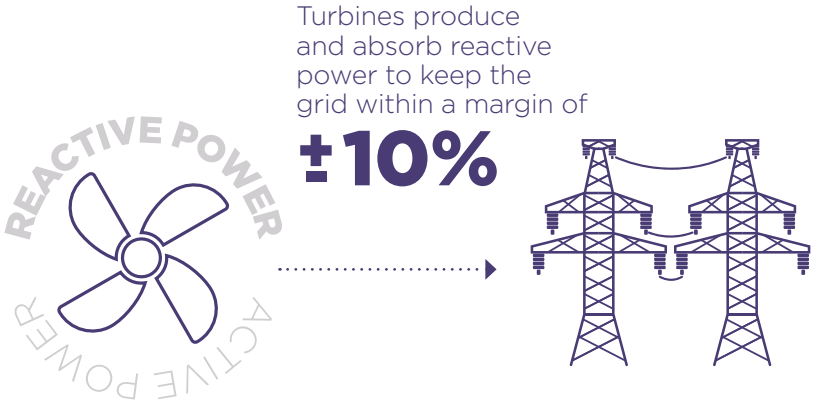
The amount of reactive power in our electricity network must be carefully managed and balanced. Too much reactive power and the voltage on the grid goes up to an unsafe level that risks breaking equipment. Too little reactive power and there's not enough pressure to push active power to where it needs to be.

The voltage on the UK's grid needs to be kept within a ±10% of the normal value and traditionally this balancing act has been supported by large, centralised turbine power stations which can generate reactive power when more is needed to meet peaks in demand for active power; and that can absorb reactive power when less pressure is needed to respond to dips in demand for active power. Just like a tap that's turned off and on.

Producing active and reactive power

Active and reactive power are also produced in different ways – a difference that we need to be aware of and carefully manage as we transition to net zero.

Whereas active power is produced by all forms of power generation, including renewable sources, and consumed by appliances such lightbulbs, reactive power is only produced at scale by synchronous generators like gas, coal, hydro and nuclear power stations. These power stations use heavy spinning turbines to generate electricity. Some kind of renewables, such as certain types of wind farms, are not able to produce reactive power, whilst the inverters in solar parks can produce a limited amount of it.

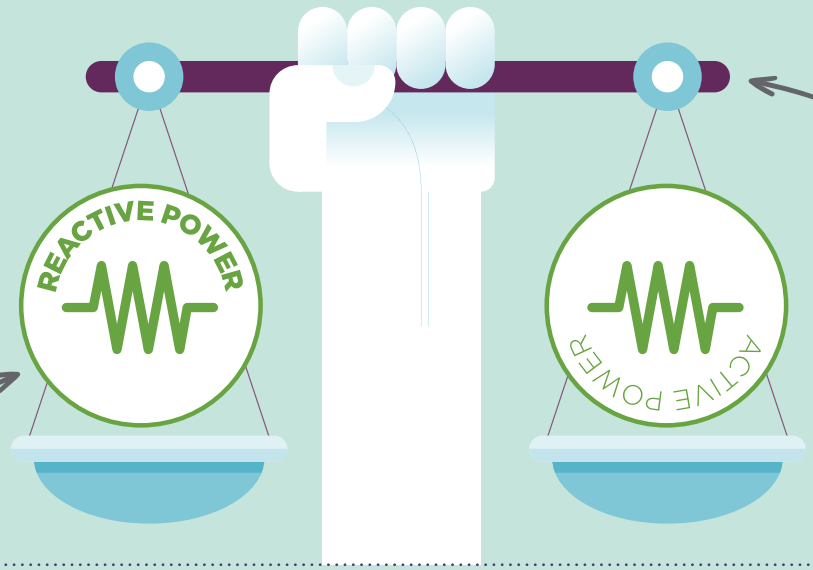


The Reactive Power Challenge

The level of reactive power needed constantly fluctuates to maintain the right balance of voltage across the grid, ensuring grid stability.

Start here to find the solution to the challenge!

Reactive power is generated or absorbed by turbine power stations to meet peaks and troughs of active power demand.



Currently supplemented by DNO balancing services

£ Expensive

Energy creation

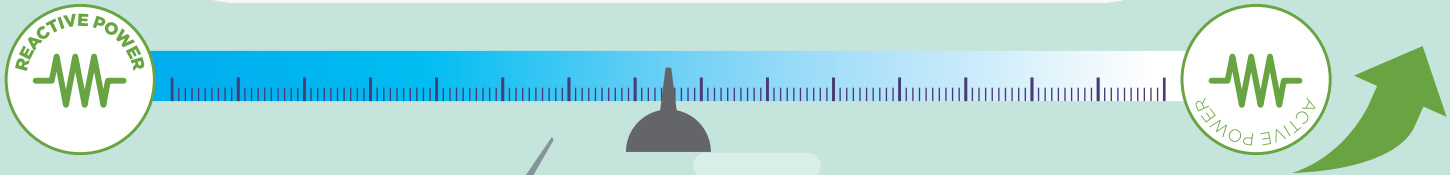
Different forms of energy creation produce different levels of active and reactive power.

High levels of reactive power production

Synchronous | VS | **Non-Synchronous**

Coal, gas, hydro, nuclear etc. | Wind, solar etc.

Very low levels of reactive power production



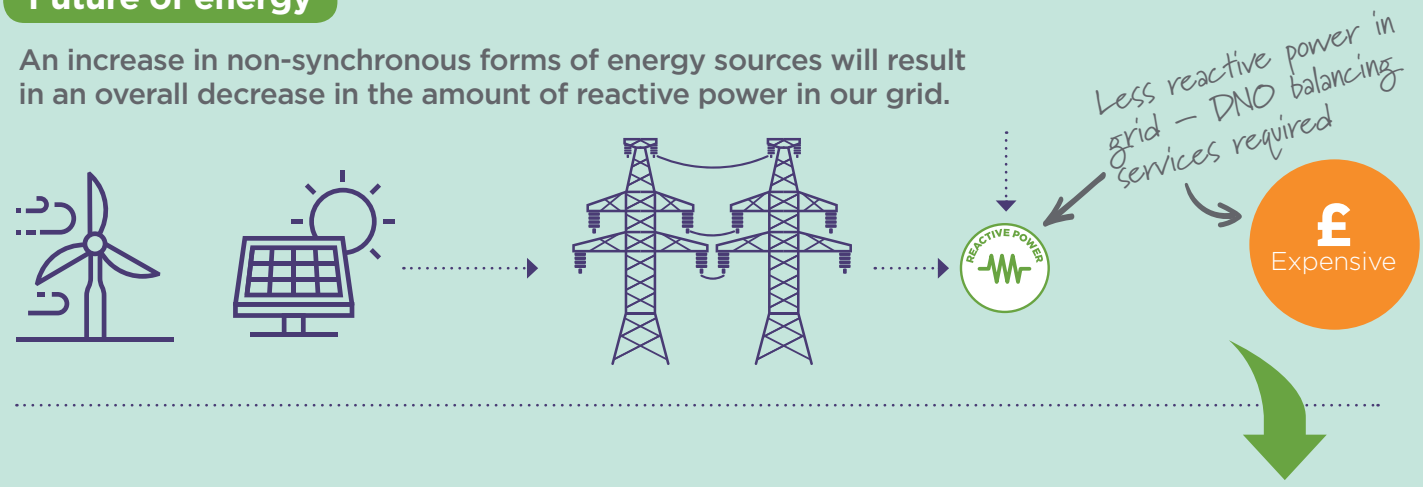
Usage

Some equipment needs more reactive power than others.

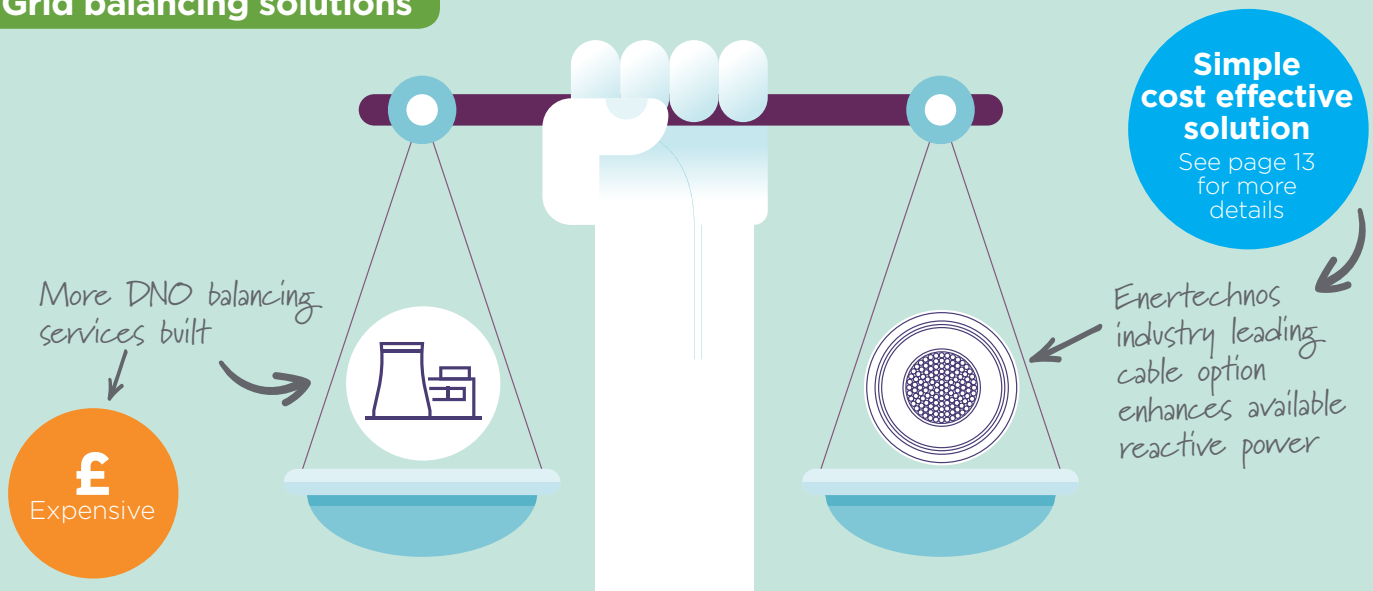
Motor/generator-powered equipment VS **Everyday appliances**

Future of energy

An increase in non-synchronous forms of energy sources will result in an overall decrease in the amount of reactive power in our grid.



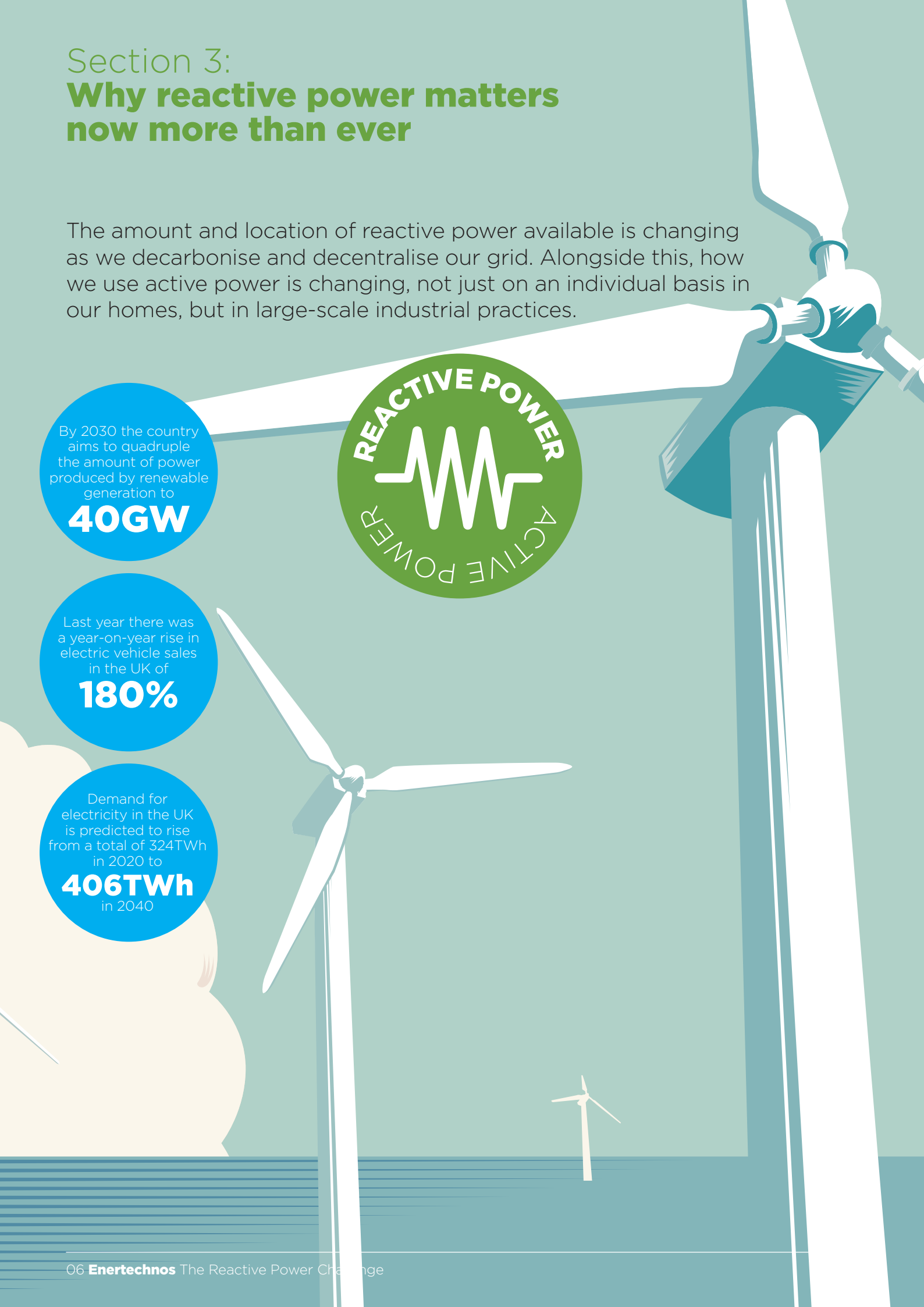
Grid balancing solutions



Section 3:

Why reactive power matters now more than ever

The amount and location of reactive power available is changing as we decarbonise and decentralise our grid. Alongside this, how we use active power is changing, not just on an individual basis in our homes, but in large-scale industrial practices.



By 2030 the country aims to quadruple the amount of power produced by renewable generation to **40GW**

Last year there was a year-on-year rise in electric vehicle sales in the UK of **180%**

Demand for electricity in the UK is predicted to rise from a total of 324TWh in 2020 to **406TWh** in 2040

Getting renewable power to where it needs to be

The grid includes growing levels of solar and wind generation as we decarbonise and decentralise our energy system. This positive trend of a greater proportion of renewable generation at work on the grid is only set to continue as the country aims to quadruple the amount of power produced in this way to **40GW by 2030**.

The graph below sets out the UK's projected electricity generation over the coming few decades. It shows that in October 2020, 39% of the nation's electricity came from UK generated renewable sources, up from 6% in 2008, and projects this to increasing to 46% in 2040.

Alongside this we are increasingly using electricity in areas of the economy historically powered by fossil fuels. The Government is proposing to ban the sale of new petrol and diesel cars by 2030 and in tune with this, last year there was an 180% year-on-year rise in electric vehicle sales in the UK, according to the SMMT, pushing electric vehicles up to 6.6% of the overall market. This trend is expected to continue with National Grid forecasting up to **36 million electric vehicles** on the road **by 2040**. In addition to this, the Government is considering a **ban on new gas boilers by 2035** in an effort to promote mass switching to green heating alternatives such as electric heat pumps. Around 85% of UK homes currently rely on gas for heating and about 1.5 million boilers are replaced each year.

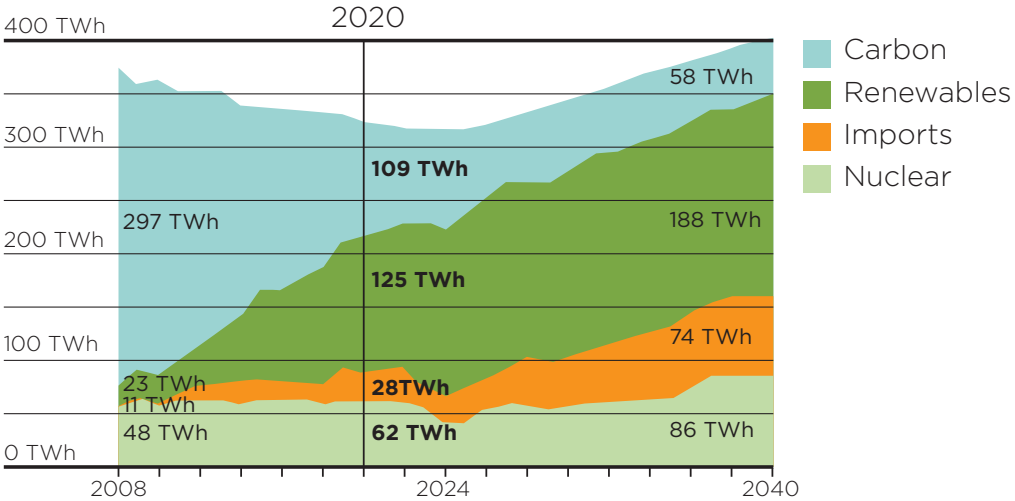
The result is that we can expect a sustained increase in the demand for electricity in the UK, even with improved levels of energy efficiency. Data from BEIS predicts that **demand will rise** from a total of **324TWh in 2020 to 406TWh in 2040**.[1]

This Government is rightly pursuing a green industrial revolution and putting the country on the path to net zero. But, simply put, without reactive power, we won't be able to 'push' renewable power to where it needs to be and to keep the voltage at the correct level.

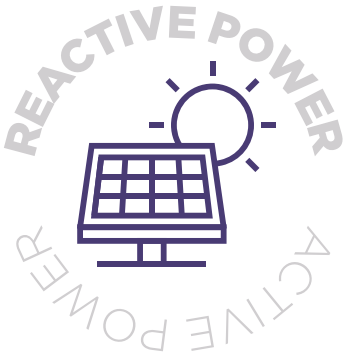
As demand continues to rise and renewable energy sources are increasingly integrated into the grid, managing reactive power is becoming increasingly important.

1. https://www.icaew.com/insights/viewpoints-on-the-news/2020/nov-2020/chart-of-the-week-uk-electricity-projections

UK's projected electricity generation



6 November 2020. Chart by Martin Wheatcroft FCA, design by Sunday.
Source: BEIS, 'Updated energy and emissions projections 2019: Reference scenario; 30 October 2020.

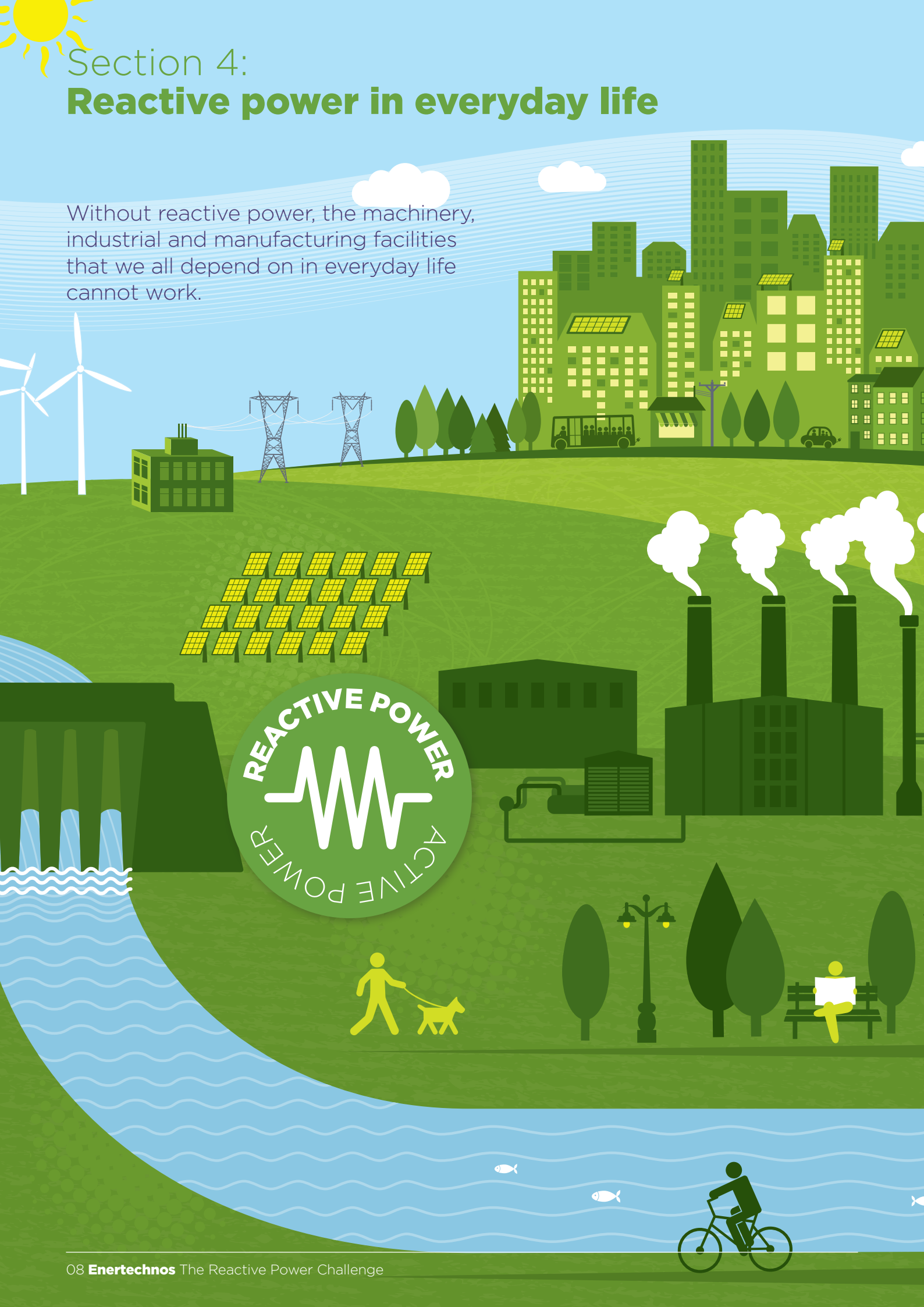


Key fact: As we pursue a green industrial revolution we need to be mindful that without reactive power, we won't be able to 'push' renewable power to where it needs to be.

Section 4:

Reactive power in everyday life

Without reactive power, the machinery, industrial and manufacturing facilities that we all depend on in everyday life cannot work.



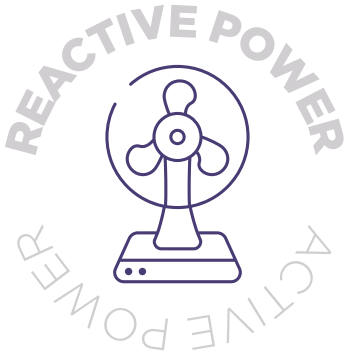
Critical to powering industry

Reactive power is needed to operate equipment such as motors. Without it, the machinery, industrial and manufacturing facilities that we all depend on in everyday life cannot work, as active power alone is not able to spin these motors.

It's not just heavy industry that will be impacted: many other consumer facing sectors such as retail, leisure and hospitality, and healthcare services rely on turbines and motors. Many of the fundamentals of day-to-day life such as lifts, escalators, refrigerators, and fans need reactive power to help power their spinning motors.

Where there is a weaker grid, with a reduced ability to regulate its voltage, industrial users will end up paying more as they will be required to adapt their connection network to ensure it works efficiently and within the normal values. This means adding additional electrical systems such as compensation equipment.

Above all, reactive power is vital to control and compensate voltage fluctuations of the grid – which can be harmful for efficiency and, in the worst cases, can make the grid unstable.



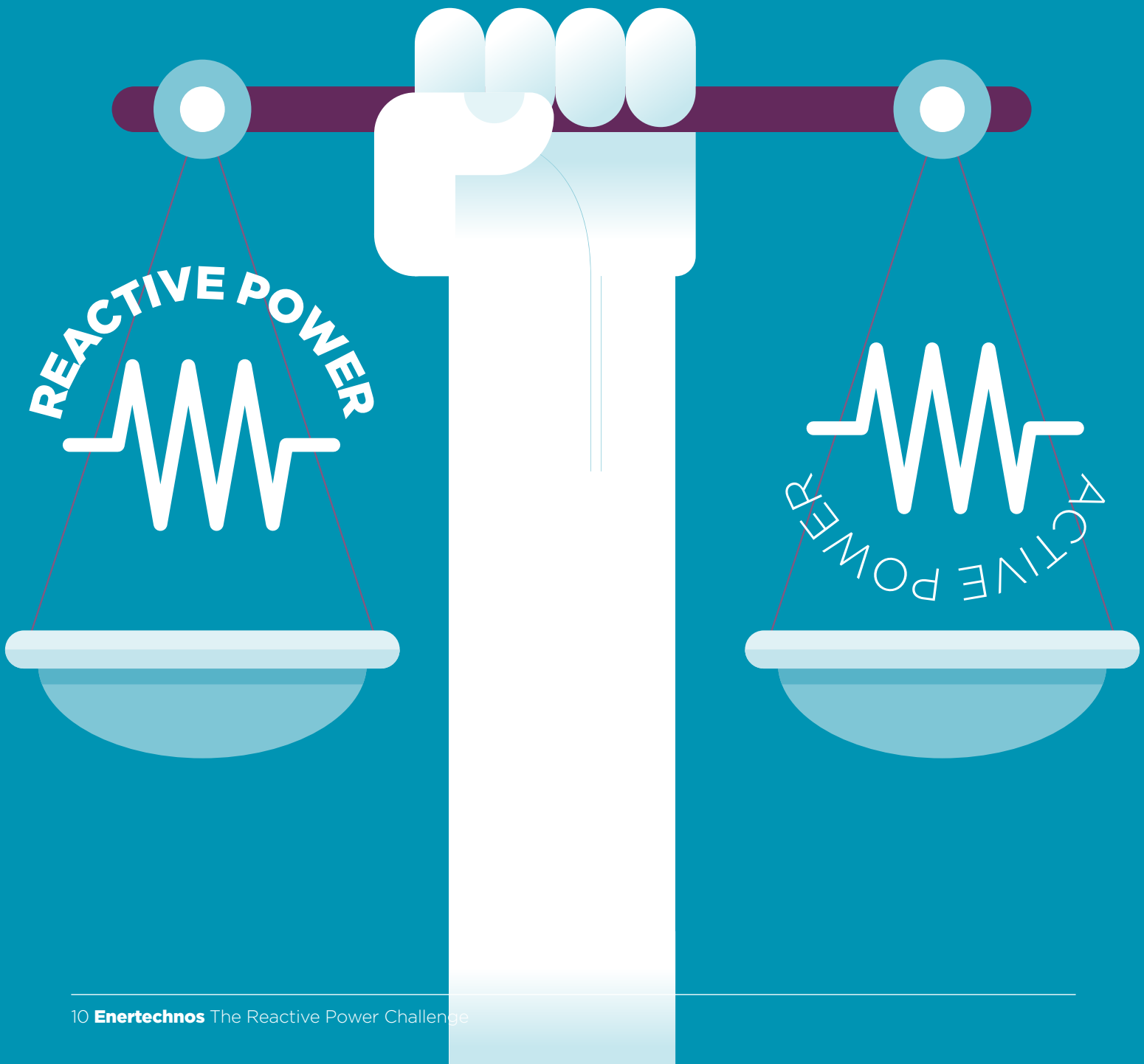
Key fact: Many of the fundamentals of day-to-day life such as lifts, escalators, refrigerators, and fans need reactive power to help power their spinning motors.

Section 5:

Getting ahead of the Reactive Power Challenge

The national picture of our energy mix and use is changing but unlike active power, reactive power cannot travel far. This means that reactive power needs to be managed on a regional level.

National Grid spends **£150m** every year on reactive power balancing services



The national picture of our power mix and use is changing but unlike active power, reactive power cannot travel far. This means that reactive power needs to be managed on a regional level.

Managing reactive power comes in the shape of 'balancing' the amount that is on the grid. Too much and the voltage on the grid goes up to a level that threatens to break apparatus, too little and there's not enough pressure to push active power to where it needs to be.

Historically, balancing has been easier because synchronous power stations can be controlled to produce reactive power as they generate active power, and they can also absorb reactive power when needed. This has been a cost-effective way of managing the grid when distributed or "embedded" generation wasn't necessary.

However, as we have outlined, more and more of this type of generation is being replaced by so-called asynchronous generation as more renewables come on to the grid, making the production and absorption of reactive power more difficult. At the same time, demand for electric power is increasing.

The result is that National Grid and the Distribution Network Operators (DNOs) have had to find new ways to balance reactive power. These are called 'balancing services' and typically see generators being paid or forced to generate or absorb reactive power by installing additional equipment, rather than it being a by-product of their operation.

The amount spent on reactive power balancing services has increased over the last decade. National Grid currently spends £150 million every year on reactive power balancing services[1] and it wants to reduce its exposure by 'optimising the network configuration'.

In addition to making the market for balancing services more efficient and transparent, it is vital to future-proof the grid's physical infrastructure by making better use of innovative and less expensive assets. This will help reduce our growing over-reliance on costly balancing services.

1. https://www.nationalgrideso.com/sites/eso/files/documents/National%20Grid%20SO%20Product%20Roadmap%20for%20Reactive%20Power.pdf

Cabling solutions

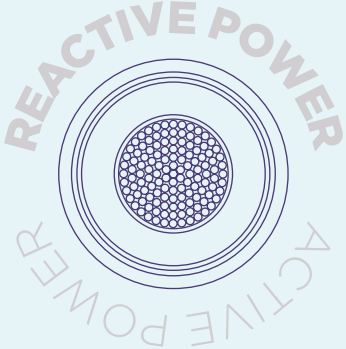
Improving the quality of the UK's transmission cables could have a significant impact. Traditionally cables have been used to simply move electricity from one area to another. Today British engineering is opening the possibility of cables deep beneath our feet being used for much more in support of decarbonisation.

By balancing the contribution of capacitors and inductors in the cables and wires that form the electrical grids, both reactive and active power can flow through the cables and move more smoothly around the grid.

Enertechnos' industry leading cable has been designed to provide this essential balance. Through its patented technology, the cable acts as a capacitor, and provides capacitive reactive power which offsets most of the inductive reactive power of the cable itself. This supports the transportation of reactive power across the grid.

This means Enertechnos' cable will make better use of the reactive power that we have on the grid and will allow us to manage reactive power across regions. This latter point is something that has not been possible before now but will become increasingly needed as more renewables come on to the grid and reactive power becomes scarcer.

By investing in the best available infrastructure today we will guarantee the long-term sustainability of electricity supply and resilience of the grid as we transition to net zero



Key fact: Enertechnos industry leading cable provides capacitive reactive power which offsets most of the inductive reactive power of the cable itself.

Section 6:
Recommendations

The reactive power challenge the grid can be managed, and there are solutions for policy makers and grid operators to consider.

Enertechnos believes the following recommendations should be put into place to effectively manage the UK's reactive power resources:

→ **Require** National Grid to provide a regional breakdown of costs associated with the cost of balancing reactive power, improving transparency.

→ **Oblige** DNOs to consider the impact of infrastructure upgrades on reactive power management in the cost benefit analysis, enhancing the commercial incentive to invest for the long-term.

→ **Increase** coordination between National Grid and the DNOs, improving forecast of active and reactive power needs and planning for cost effective installations to future proof the energy networks towards the electrification of transport and home heating.

→ **Conduct** a trial of how cable infrastructure can be used to improve reactive power management, enabling an assessment of the technical and commercial feasibility of using this innovative technology at scale.

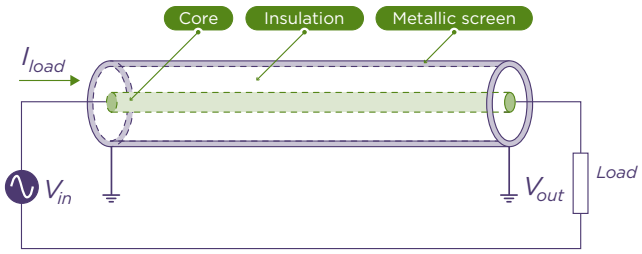
About Enertechnos

Enertechnos is a pioneering UK clean-tech company, dedicated to developing innovative solutions to enable 'better electricity' and support the transition to net zero. Our innovative cable technology – the Capacitive Transfer System, 'CTS' – reduces energy losses throughout the power network, slashing carbon emissions from wasted energy. More importantly, the CTS cable can deliver more power through the same mass of conductor.

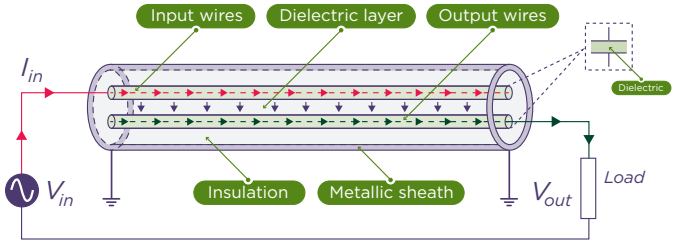
We have received backing from several government programmes and are currently working with the Department for Business, Energy and Industrial Strategy to revolutionise electric vehicle charge times. We're also working with industry to help tackle the problem of losses. It is planned that our CTS technology will soon be deployed by distribution network operator Western Power Distribution (WPD) in a real-world trial.

Comparison: Conventional Cable and CTS Cable

Conventional Cable



CTS Cable



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