enertechnos

The road to 2050:
Is our energy infrastructure ready to deliver net zero emissions?

A policy paper on losses and the need for efficiency in the UK energy system from Enertechnos

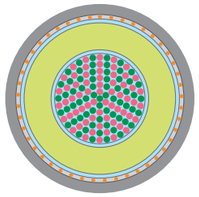


About Enertechnos

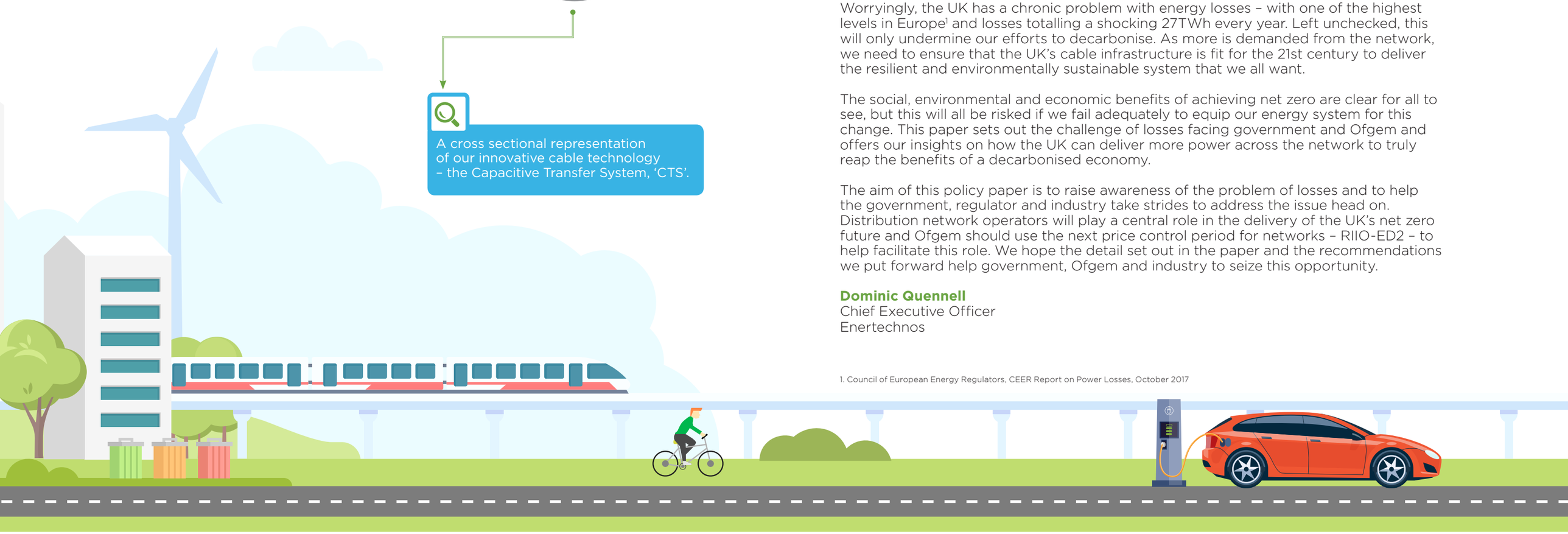
Enertechnos is a UK clean-tech company, developing innovative solutions to enable 'better electricity' and support the transition to net zero. Our innovative cable technology – the Capacitive Transfer System, 'CTS' – reduces energy losses throughout the power network, slashing carbon emissions from wasted energy.

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. Our CTS technology will soon be deployed by distribution network operator Western Power Distribution (WPD) in a real-world trial.

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A cross sectional representation of our innovative cable technology – the Capacitive Transfer System, 'CTS'.



Foreword



With our commitment to achieve net zero carbon emissions enshrined into law, the UK is on the cusp of an exciting green energy revolution.

While Covid-19 has had a profound impact on all of our daily lives, it has also offered an opportunity to rethink our future direction. For the first time ever, renewable energy has overtaken fossil fuels in providing power to our energy network and the Prime Minister has set out 'A New Deal for Britain', which involves accelerating infrastructure projects and promoting a clean, green recovery. As we emerge from the pandemic, the UK has a unique opportunity to make strides towards our 2050 target by placing low carbon infrastructure at the heart of the Covid-19 recovery plan.

To reap the benefits of a low carbon economy, we need to prepare our energy system for the inevitable increase in demand. If we look ahead, the electrification of heat and transport will place huge demands on electricity networks, placing new pressures on the grid. Failure to prepare could see networks unable to deliver power to where it is needed most. To tackle this, we need to enable distribution network operators to invest to ensure the capacity needed to reach net zero is available.

Worryingly, the UK has a chronic problem with energy losses – with one of the highest levels in Europe[1] and losses totalling a shocking 27TWh every year. Left unchecked, this will only undermine our efforts to decarbonise. As more is demanded from the network, we need to ensure that the UK's cable infrastructure is fit for the 21st century to deliver the resilient and environmentally sustainable system that we all want.

The social, environmental and economic benefits of achieving net zero are clear for all to see, but this will all be risked if we fail adequately to equip our energy system for this change. This paper sets out the challenge of losses facing government and Ofgem and offers our insights on how the UK can deliver more power across the network to truly reap the benefits of a decarbonised economy.

The aim of this policy paper is to raise awareness of the problem of losses and to help the government, regulator and industry take strides to address the issue head on. Distribution network operators will play a central role in the delivery of the UK's net zero future and Ofgem should use the next price control period for networks – RIIO-ED2 – to help facilitate this role. We hope the detail set out in the paper and the recommendations we put forward help government, Ofgem and industry to seize this opportunity.

Dominic Quennell
Chief Executive Officer
Enertechnos

1. Council of European Energy Regulators, CEER Report on Power Losses, October 2017

The invisible problem:
Losses in the energy system

Losses present one of the biggest challenges to the UK's energy sector, threatening to undermine the shift to net zero and ambitions for a low carbon, green future. However, despite their impact and cost, they go largely unacknowledged in the energy policy space, owing to their 'invisibility' and the conventional wisdom that they're inevitable. The purpose of this paper is to make the problem visible and tear up that conventional wisdom.

As it stands, we are losing an enormous amount of energy. Every day energy is generated and never reaches its intended destination. It is simply lost.

The losses in our system are uneconomical, inefficient, and undermine our transition to net zero. This paper sheds a light on the problem of losses and sets out a series of proposals for government, regulator and industry to take forward to tackle losses head on in support of our journey to net zero.

Defining the problem and the consequences

There are different types of losses in the energy system, but this paper focuses on distribution losses. The reason for this is simple: most losses occur on distribution networks as energy is being transported from the high voltage transmission grid to end users – industrial, commercial, and domestic. They are the costliest losses, but they are also the losses that can be tackled most effectively with more efficient infrastructure.

Distribution losses can broadly be defined as the difference between the electrical energy entering the distribution network and the energy exiting it for consumption.[3] As electricity moves around networks, energy is lost.

'Non-technical losses' also occur on the grid, but they refer to energy which has been stolen (unidentified) or energy which has been misallocated or measured inaccurately. These make up a tiny proportion of losses and cannot be addressed by using more efficient infrastructure.

2. Department for Business, Energy and Industrial Strategy, Digest of UK Energy Statistics, 2020.
3. CIRED WG CC-2015-2 Report on Losses Reduction, 2017

Why does this happen?

'Technical losses' that occur on these networks are also known as 'physical losses'. This is because they refer to energy which is transformed to heat and noise through the process of distributing it across the network and is therefore physically lost – it never reaches its intended destination.

There are two main causes of 'technical/physical losses', that from now on we will refer to simply as 'losses'. 'Iron losses' which occur in transformers which transfer electrical energy from the transmission grid to the distribution grid; and 'copper losses' which occur in the lines and cables which make up the backbone of our grid.

The cabling which makes up our system is little changed from the cables installed by the Victorians, built for a bygone era where electricity travelled one way and to fewer end points. These cables are inefficient with high levels of resistance. Resistance causes a form of friction for the electricity passing through, meaning the electricity intended for our homes and businesses converts into other forms of energy (heat and noise) and is physically 'lost'.

What does this mean?

Every year, almost 27 TWh of energy is generated and then lost. That's enough energy to power 7 million homes for an entire year, or charge 6.8 million electric vehicles – and makes up 1.5% of our carbon emissions.

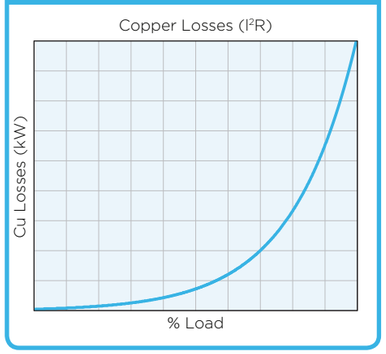
This is incredibly inefficient at a time when our energy system needs to be as efficient as possible to decarbonise and keep consumer costs as low as possible.

The problem is only going to get worse. As demand grows and more electricity flows through our networks, losses will rise. The losses in cabling caused by resistance rise as more energy passes through the cables. The more energy passing through, the more impact resistance has. The effect is that losses don't increase at a constant rate, but instead they multiply.

Electricity demand is set to increase dramatically as we rethink our energy system and move to decarbonise heat and transport through electrification. National Grid's Future Energy Scenarios 2020 predicts that peak demand could rocket from 59 GW today to 96 GW by 2050.[4] To service this demand, networks will need to increase their capacity so more energy can pass through. As well as having a cost and carbon impact, losses threaten to undermine the ability of networks to deliver on an increased need for electricity.

The UK should be looking to make every watt of energy count to help service the need of the future; we cannot afford to have an unreliable and inefficient network which loses this amount of energy.

This is because losses are squared (I^2R, where I is current and R is resistance)



4. National Grid, Future Energy Scenarios, July 2020

Energy losses in 2019 totalled 26,412 GWh.[2]

That's enough energy to...

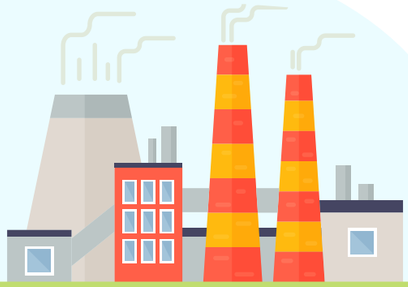


....power **7 million** UK homes for an entire year



...or charge **6.8 million** electric vehicles





...it also makes up **1.5%** of our carbon emissions

...and bears an annual cost of

£1.5 billion

The invisible problem:
Losses in the energy system

Who pays for losses? Consumers

The CMA's 2016 energy market investigation found that 70% of domestic customers could potentially save £300 by switching to a cheaper deal. The government has intervened in the retail market through the introduction of an energy price cap in a positive effort to protect the consumer, but bill payers are still picking up the tab for energy losses. There is also a series of government initiatives which look at using home efficiency measures as a means to reduce household energy bills. These measures are to be welcomed, but it is equivalent to a homeowner putting in a more efficient bathroom tap as outside the front door a water utility leaves a broken mains pipe unfixed.

What is the real cost of losses for consumers?

In 2013, Ofgem calculated the 'societal cost of losses' at £48.42/MWh. Updating this figure to reflect today's prices (£56.51), losses in the energy system cost the UK £1.5 billion in 2019 alone.

A more accurate reflection would be the current retail cost of energy, at around £125 per MWh. Ultimately, the consumer pays for losses concealed in their bills and customers do not pay wholesale prices (on which Ofgem's figure is based).

The amount of billable energy lost every year is over £3.3 billion. If this extra energy were to arrive at consumers' meters, how much could it drive down the price of electricity?

With the actual cost of electricity consumed only forming a third of customers' bills, much of what customers pay are hidden costs. Network charges form around 23% of the average household dual fuel bill – including the cost of generated energy which is lost during transmission and distribution.[5]

The simple question to ask is why do we focus on switching to efficient lightbulbs or insulating our homes to save money on bills but ignore network efficiency?

5. Ofgem, Breakdown of an electricity bill, August 2019



Consumers footing the bill

The UK has introduced a number of measures to begin to protect consumers against rising consumer bills, yet little or no action has been taken to address the fact that customers are paying for energy which simply never reaches their homes.

Undoubtedly, lowering consumer bills is a key priority for Ofgem and government, however the evidence is telling: energy losses leave customers out of pocket. By reducing costly losses, customers will get more for their money instead of paying for wasted energy.

Ofgem's Forward Work Programme for 2020-22 sets out its position to strike a tough but fair settlement for consumers through the RIIO-ED2 framework.[6] At the heart of the framework will be improvements to efficiency and lowering costs to consumers. Ofgem has been clear that short term investments will need to be made now to save money in the medium and long-term if the UK is to be successful in reaching net zero and have sufficient power to drive our economy. Meeting these objectives will require the energy system to deliver more power and more efficient power if the regulator is to guard against rising consumer costs.

For Ofgem, the road to achieving net zero is a key part of securing the UK's economic recovery from Covid-19. To make this possible, it is essential that steps are taken to make the energy system more efficient, as consumers are currently paying for energy that never reaches their homes.

Without action, as demand increases, there will be a disproportionate increase in losses. It is therefore essential that Ofgem and government drive efficiency in the network now to help the UK reach net zero by 2050 and to safeguard consumers against unnecessary increases in the cost of energy bills.

It is therefore essential that Ofgem and government drive efficiency in the network now to help the UK reach net zero by 2050

6. Ofgem, Decarbonisation Programme Action Plan, February 2020

Business as usual cannot be an option:
Why improving network efficiency must underpin our ambitions

The government has set out an ambitious blueprint for the UK's low carbon future, including through its Clean Growth Strategy.[7] Since then, government has accelerated its ambitions, enshrining the 2050 net zero target in law – emphasising the importance of action now.

At the heart of government's approach is a commitment to accelerate the shift to low carbon technologies, deliver clean power and enhance the benefits and value of our natural resources.

Changes to how we generate and use electricity to power low carbon technologies will create a capacity problem for the grid. To meet increased demand, our energy grids must adapt – including significantly increasing capacity, as well as making better use of what we already have. The solution is not simply to build more expensive infrastructure to ease capacity constraints, we must also ensure the infrastructure which makes up our grid is as efficient as possible. However, there are no mentions of network efficiency or losses in the strategy – or indeed any other government strategies to date – and lack of action risks undermining the objectives government has set out.

In this section we take you through how a business-as-usual approach to losses is not sustainable if we are to create the additional capacity we need to meet our clean energy and infrastructure ambitions, using the examples of renewables and electric vehicles.

Maximising the impact of clean power

The UK's transition to net zero relies heavily on shifting to low-carbon and renewable generation. So far, the UK has made impressive strides in renewable energy generation and is now seen as a leader in offshore wind.

However, losses are holding the renewables sector back from having maximum impact.

At the most straightforward level, as losses increase, generation also has to increase to meet the same level of demand, meaning existing renewables make up less of our overall generation mix. Losses also mean we need to rely more on peaking plants – power plants that are mainly fossil fuel powered and come online when there is a high demand for electricity. **Losses alone account for a shocking 1.5% of the UK's overall carbon emissions.**

Boosting capacity to meet demand: The challenge of electric vehicles

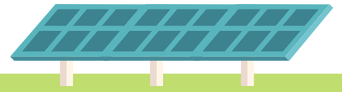
Alongside decarbonisation of our homes and other sectors, the transition to electric vehicles (EVs) is fundamental to the UK's efforts to decarbonise transport and reach net zero. However, these shifts come with enormous implications for demand and will require a major boost to distribution network capacity.

EVs can help to improve air quality, reduce noise pollution and support efforts to reduce carbon emissions. They will play a key role in the shift to a more flexible low-carbon energy system, with innovative solutions such as 'vehicle to grid' technology enabling energy stored in EVs to be fed back into the electricity grid to help supply energy at times of peak demand.

The government is currently consulting on bringing forward the date for ending the sale of petrol and diesel vehicles to 2035 [8], and its ambition is that almost every car and van will be zero emission by 2050.[9] Meanwhile, many are calling for government and industry to go faster and harder, with the government's climate advisers, the Committee on Climate Change, calling for the phase out date to be brought forward to 2032.[10]

EVs are the future and the race to decarbonise transport is on. To facilitate this transition, the UK requires a transformation of its infrastructure – both in rolling out enough chargepoints to make EVs a practical alternative and bolstering our energy networks to ensure they have the necessary capacity to cope with additional demand.





7. Department for Business, Energy and Industrial Strategy, Clean Growth Strategy, October 2017
8. Department for Transport, Consulting on ending the sale of new petrol, diesel and hybrid cars and vans, February 2020
9. Department for Transport, The Road to Zero, July 2018
10. Committee on Climate Change, Progress Report to Parliament 2020, June 2020



How will losses impact the UK's clean growth plans?

The Clean Growth Strategy focuses on five key areas:

1. Improving business and industry efficiency

We talk about generation and endpoint efficiencies of power-intensive industries andbusinesses, but what about the bit in the middle – networks?



2. Improving our homes

Making our homes green is important, but losses in transmission and distribution undermine gains.



3. Accelerating the shift to low carbon transport

Decarbonisation of home heating and transport will send electricity demand through the roof – every bit of energy we generate will be needed.



4. Delivering clean, smart, flexible power

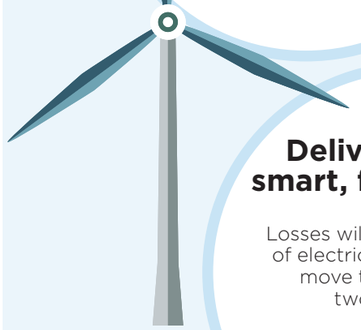
Losses will multiply as the flow of electricity changes and we move towards a flexible two-way system



5. Enhancing the benefits and value of our natural resources

To fully maximise the benefit of our country's natural energy resources, we must be as efficient as possible.





Business as usual cannot be an option:
Why improving network efficiency must underpin our ambitions

Additional demand and avoiding a capacity crunch

The government's ban on the sale of petrol and diesel paves the way for EV ownership to become the norm. If government is successful in driving demand for EVs and the UK's stock reaches anywhere like the 10.6 million by 2030 and 36 million by 2040 projected by National Grid[11], increased electricity demand will place significant pressure on the distribution networks and their capacity to deliver energy to businesses and consumers.

Every single day last year, UK drivers poured 100 million litres of fossil fuel into cars, vans, and trucks. This energy needed to power our roads must be replaced by cleaner electricity.

The annual electricity demand from road transport is expected to reach between 81 and 87 TWh in 2050, according to National Grid's Future Energy Scenarios 2020. For comparison, in 2019 electricity demand from road transport was 0.8 TWh.

At the same time, peak demand is set to increase from 58.7 GW now to anywhere between 76 GW to 96 GW in 2050.[12] Just to meet the lowest demand prediction in FES, we will need an additional 14.1GW. For comparison, that's the equivalent of four and a half Hinkley Point C nuclear power stations.

Delivering this power will push our grid way beyond the capacity it can currently deliver – particularly at peak times – leading to grid failures and blackouts.

This is not just a problem for metropolitan centres. Cities have more power supplied to them, but EVs are expected to be most popular in these areas, putting an additional strain on cities' power grids which will require careful balancing and management on top of measures to boost capacity. Rural and suburban areas face a different problem. While fewer people in these areas will be early adopters, a small number of EVs will create a big problem for areas which already have lower capacity. As numbers climb across the country, the problems and risks only worsen.

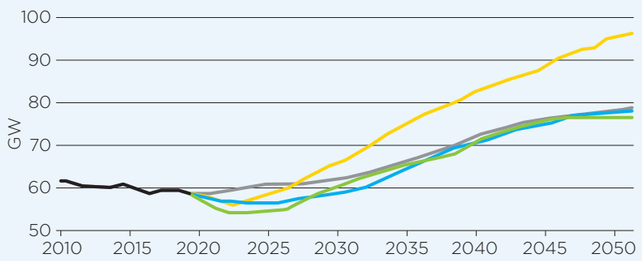
Ahead of this potential crunch point, the spotlight must turn to how we can make efficiencies within the system to cope with added pressures. Tackling the losses alone will not solve the whole capacity problem. However, increases in the efficiency of the network enhance the benefit brought by each new generation project.

Transmission and distribution losses total enough power to charge 6.8 million EVs – if we don't tackle losses, we need to pump over and above that amount of electricity into the system to meet additional demand and power the EV revolution.



11. House of Commons Library, Electric vehicles and infrastructure, March 2020
12. National Grid, Future Energy Scenarios, July 2020

The scale of the problem: Rising electricity peak demand



This graph is taken from National Grid's Future Energy Scenarios 2020 and charts predicted electricity peak demand in 4 different pathways to net zero

The gap that needs to be filled between now and 2050



The loss of potential energy:
Using network efficiency to maximise the value of natural, carbon-free energy sources

This paper focuses on losses, but it is important to note how tackling losses through investing in efficient infrastructure has twin benefits in terms of maximising renewable generation. Our out of date infrastructure is causing us to waste the potential energy of renewable sources. From wind to solar and hydro, these sources of energy are crucial to our net zero ambitions and we are failing to harness them as effectively as possible.

Let's take the example of wind power. With the government's Offshore Wind Sector Deal aiming for a third of British electricity to be produced by offshore wind generation by 2030*, it is becoming ever more important that the output of windfarms is maximised to make investment in the industry viable and ensure renewable resources are fully optimised.

Resistance and reactance in conventional cabling mean there is a threshold of power generation required before any usable electricity is produced at the output end. Therefore, when wind or solar levels are low, transmission ceases, so the asset is not used.

Updating our infrastructure so it is as efficient as possible would allow more energy to be generated from sources such as wind and solar, and for more of the time.

We must also consider losses in transporting renewables across the grid to ensure we fully utilise these valuable assets. It is necessary therefore that we ensure power generated in remote areas reaches the end-point where it needs to be delivered.

A new 1.2GW offshore windfarm located 100km offshore could see losses of 150GWh a year. That's enough energy to power nearly 42,000 homes for a year and, at a strike price of £44/MWh, totals a loss of £6.6 million a year. Over a typical 25-year project lifetime, this figure rises to £165 million.

This is based on modelling assuming a 30% utilisation rate and a losses rate of 4% in HVAC export cables from offshore windfarms.**

Using innovative technologies to increase the uptime of renewable sources

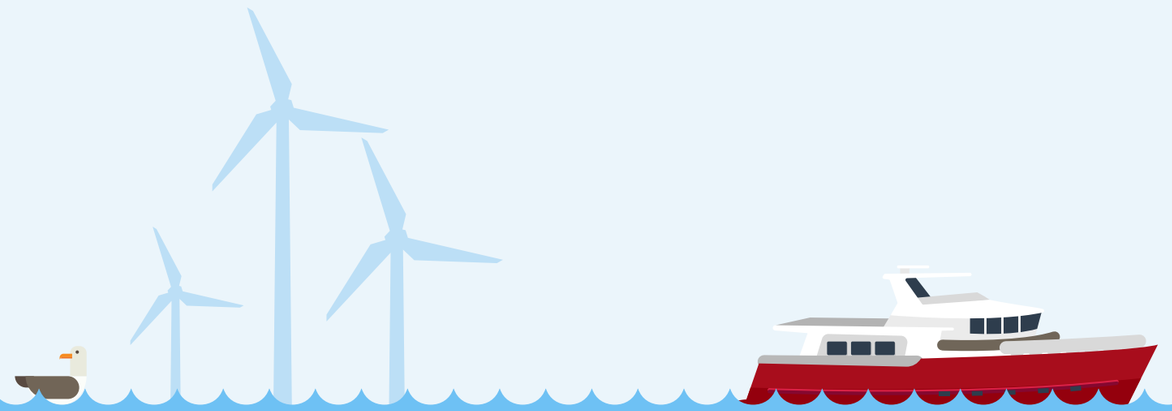
There is a multitude of innovative solutions that are in development or on the market which can help to tackle the problem of wasting energy as a result of inefficient infrastructure.

Most windfarms operate only 30% of the time. This is because inefficient conventional cabling means energy generation must reach a certain threshold for any power to be delivered into the grid.

The lower reactance in low-loss CTS-enabled cable has the potential to increase the availability of a windfarm by up to 50%.

This equates to hundreds of millions of pounds in value of additional energy delivered over the lifetime of a large-scale windfarm and would significantly reduce the negative impact that intermittency has on networks' resilience.

* Department for Business, Energy and Industrial Strategy, Offshore Wind: Sector Deal, 7 March 2019
** Papadopoulos, A., Delf University of Technology, Modelling of Collection and Transmission Losses of Offshore Wind Farms for Optimization Purposes, 2015)



How can we prevent losses?

Losses are often seen as an inevitable consequence of transporting power around the grid. While this is true, the severity of the problem can be reduced.

Innovative solutions now exist which can be incorporated into the grid to stem losses, protecting the energy system and contributing to reaching net zero.

However, these solutions must be installed now, or we risk it being too late. New investment in long term infrastructure must anticipate and reflect the needs of tomorrow.

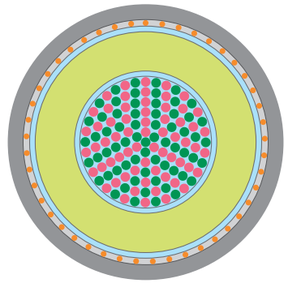
Much of our cable infrastructure design dates back to the 19th and early 20th centuries and is no longer fit for purpose. The energy system of the future will look totally different from the one-way Victorian system – it will be flexible, decentralised and low carbon.

This is already happening but will accelerate at breakneck speed and the networks that underpin this system must not be left behind or they will hold this energy revolution back.

The typical lifetime of an underground cable is around 40 to 50 years.[13] Replacement programmes replace around 2% of cabling a year and the overall installed distribution line length grows by an average of 2.6% annually, as new infrastructure is built and connected. This might not sound like a lot, but it's an enormous amount of new cable going into the ground when you take the network as whole.

New cables installed now must be able to cope with future demand. Using more efficient cables will prepare our system and mitigate the need for extensive costly grid reinforcement down the line.

We believe that DNOs should be empowered to use strategic investment in technologies which improve network efficiency, such as low-loss cable technology. Doing so is in line with the National Infrastructure Commission's (NIC's) recommendation that Ofgem take a more proactive approach to preparing the grid.[14] The Committee on Climate Change's recommendation is that when network infrastructure is upgraded, its capacity should be augmented sufficiently to avoid the need for further upgrades to 2050.[15]



Find out more about Enertechnos CTS technology at **www.enertechnos.com**

13. Valle Y.D, Hapton N., Perkel J., Riley C., Underground Cable Systems in Meyers, R. A. (ed), Encyclopaedia of Sustainability Science and Technology, 2012
14. National Infrastructure Commission, National Infrastructure Assessment – Revolutionising road
15. Committee on Climate Change, Reducing UK emissions – 2019 Progress Report to Parliament, 2019



Recommendations

In light of the challenges outlined in this paper, we believe that through the ongoing RIIO-ED2 framework, Ofgem has an excellent opportunity to ensure network operators are supported and adequately equipped to play their role in delivering enough power across their networks to support the government's legally binding decarbonisation commitments.

Similarly, the upcoming Energy White Paper and the focus on the Prime Minister's 'New Deal for Britain' present government with an opportunity to set a clear course for the regulator. Ensuring that losses, efficiency, and capacity are a focus for Ofgem and industry will be crucial in meeting government's other policy commitments, such as the decarbonisation of heat and transport.

To achieve these positive outcomes and priorities, the UK will need to deliver more electricity whilst losing less power. In order to deliver more power to facilitate our journey towards net zero, the regulator and industry should fundamentally change their approach to losses and ensure DNOs can take concrete and measurable steps to reduce them.

To help Ofgem develop a framework in RIIO-ED2 which rewards DNOs to deliver more power by driving efficiency, we believe the regulator should consider two areas of action:

1. Adjust the cost benefit analysis to account for losses over the lifetime of assets

It is crucial that cabling being planned now, both in new build infrastructure and replacement programmes, is future-proofed so that it is able to deliver extra capacity. This will also enable the transition to a smart, flexible system.

Ofgem has proposed an increased focus on anticipatory investment, which is welcome. As part of this, Ofgem should ensure DNOs are able to use strategic investment to invest in technologies which improve network efficiency and reduce carbon costs over the long term, such as low-loss cable technology.

Ofgem should introduce an obligation for DNOs to provide two models as part of cost benefit analysis – one looking at business-as-usual technology and another providing an alternative plan which uses innovative equipment, such as low-loss cable and/or low-loss transformers, to reduce losses and increase capacity. This will allow DNOs to show the regulator the carbon costs of each technology and its benefit, justifying any additional spend.

To ensure the full cost of losses is considered and accurate benefits are identified, the financial indicator Ofgem uses, the 'societal cost of losses', should also be updated. Currently the figure is set at £48.42/MWh as per 2012/13 prices – this should be updated to reflect today's prices and updated on an annual basis.

2. Incentivise DNOs to explore and adopt cost-effective solutions to reduce losses

We welcome Ofgem's proposals to include losses in the scope of Environmental Action Plans which companies will be required to submit as part of their business plans, outlining activities they will undertake to achieve an environmentally sustainable network.

These EAPs will draw together Engineering Justification Papers (EJP) and cost benefit analysis (CBA) submissions, in which Ofgem should ensure that companies consider low-loss options as part of them – as set out in our first recommendation.

Tackling losses should be at the heart of operators' approach to building an environmentally sustainable and resilient network. Therefore, to encourage ambitious strategies and action on losses, **Ofgem should include loss-reduction in the criteria for Consumer Value Proposition (CVP) rewards** which networks can be awarded for plans that deliver additional value for consumers and have the potential to raise the bar across the industry. **Similarly, insufficient action on losses should incur a penalty through the Business Plan Incentive (BPI).**

Conclusion
A golden opportunity

The issue is clear – the UK has a problem with energy losses which will only get worse and risks threatening our 2050 net zero target and stifling economic growth. If the UK is serious about its ambition to be a global leader in clean tech and decarbonisation, we must develop an infrastructure system that is capable of underpinning such an ambition. We cannot afford to maintain such a high level of losses, and instead should thrive to be a leader in network efficiency like we are a leader in offshore wind.

Luckily, the solution is also clear. The UK is a leader in R&D and companies are developing innovative solutions which can be deployed across networks to reduce losses. From Enertechnos' CTS cabling solution to low-loss transformers, it is abundantly clear that we do not need to accept this level of losses as an inevitable consequence of transporting energy.

This doesn't involve unnecessarily ripping up infrastructure from the ground. Instead, if government, regulator and industry act now to ensure that infrastructure installed from now on is as efficient as possible, we will have taken strides towards meeting net zero and preparing our energy network for the future.

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