Crossed Wires

Policy Exchange

Maintaining public support for offshore wind farms

Ed Birkett

Foreword by Rt Hon Dame Andrea Leadsom DBE MP and Rt Hon Amber Rudd

Cover Image: The cable ship Stemat Spirit begins to lay the electricity cable from Thornton Cleveleys to the Walney offshore wind farm

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The Unit includes five specialists, actively supported by Policy Exchange's team of in-house economists and policy specialists, as well as a network of experts in industry, government, academia and beyond.

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Foreword

By Rt Hon Dame Andrea Leadsom DBE MP and Rt Hon Amber Rudd

Over the last decade, the UK has rapidly invested in green infrastructure. During this time, we have seen the importance of maintaining democratic consent for development. Without this, strong local opposition risked delaying or even blocking nationally-significant projects.

Onshore wind farms saw incredible take up, but the significant local impact meant that they were rarely welcomed by the communities that hosted them. Similarly, shale gas extraction (fracking) could have improved UK energy security as we rapidly transitioned away from coal. However, whilst it was the evidence of potential seismic impacts of fracking that drove Andrea's decision to impose a moratorium, we must also recognise that some communities were vehemently against this new technology.

To date, offshore wind has avoided many of these concerns. Offshore wind farms are far from shore, where huge turbines can capture the strongest winds and produce more electricity. In addition, the cost of offshore wind farms has fallen so much that they are now cost-competitive with those onshore. So, our decision in 2015 to refocus subsidies towards offshore wind seems to have paid off.

Offshore wind does, however, generate its own problems. That we can fix giant turbines to the seabed or even float them offshore is a marvel of engineering, but they still require significant new infrastructure on land, including underground cables, new substations in some cases the size of Wembley Stadium, new electricity cables snaking under beaches, and new pylons to transmit clean electricity to customers in cities and industrial areas.

Local communities are rightly concerned about the sheer amount of infrastructure built by individual offshore wind companies and the Government must act. The Government should urgently carry out an audit of all outstanding plans for onshore infrastructure relating to offshore wind farms and consider ways to minimise the damage to precious inland areas. It is only by listening to communities and taking account of the need to protect our environment that we can maintain the huge level of support for the UK's decarbonisation efforts.

We support the concept of an offshore wind 'ring main' where neighbouring offshore wind farms will coordinate their infrastructure and coordinate timelines to reduce the burden of infrastructure on communities.

Where new onshore infrastructure is needed, we should compensate local communities through new 'Offshore Wind Wealth Funds'. We already do this for onshore wind farms through 'Community Benefit Funds', and

we were planning something similar for fracking. It's absolutely right that coastal and rural communities should be compensated for hosting new large-scale infrastructure that provides national benefits but has local negative impacts.

More coordination will not come about just by leaving it to the market. It requires Ministers to outline a clear vision for the future of the UK's onshore and offshore electricity network. The *Offshore Transmission Network Review* is a welcome first step, but Ministers also need to provide more direction to the regulator Ofgem. In addition, the time has surely come to establish a fully Independent System Operator for Great Britain.

Offshore wind provides fantastic opportunities for thousands of green jobs, from apprenticeships in manufacturing wind turbines and electricity cables to roles in construction and operations and scientific developments in technologies needed to build not just our capability at home but exports around the world.

UK companies are already winning contracts to support the development of offshore wind farms across the world but there is more that we can do to share UK expertise and accelerate the deployment of offshore wind farms to support the global transition to Net Zero.

Rt Hon Dame Andrea Leadsom DBE MP is the Member of Parliament for South Northamptonshire. Between 2019 and 2020, she served as Secretary of State for Business, Energy and Industrial Strategy.

Rt Hon Amber Rudd was the Member of Parliament for Hastings and Rye from 2010 to 2019. Between 2015 and 2016, she served as Secretary of State for Energy and Climate Change.

Andrea and Amber are Co-Charing Policy Exchange's Beyond COP26 programme.

Glossary of Terms

Term	Definition
Balancing Mechanism (BM)	Market that the ESO uses to balance supply and demand for electricity in real-time. The ESO uses the BM to resolve network constraints.
BEIS	Department for Business, Energy & Industrial Strategy. UK Government department responsible for business, energy and industrial strategy.
Climate Change Committee (CCC)	Independent statutory body advising the UK and devolved governments on emissions targets and preparing progress reports to Parliament.
Carbon dioxide (CO_2)	Carbon dioxide (CO_2) is the main greenhouse gas. The vast majority of man-made CO_2 emissions come from the burning of fossil fuels.
Constraint costs	Constraints on the electricity network occur when a power line cannot transmit any more electricity. When this happens, the network is said to be 'constrained'. To resolve constraints, the ESO pays generators to turn down. These costs are called 'constraint costs'.
Contracts for Difference (CfD)	Main support scheme for renewable energy generators in Great Britain. Generators receive a fixed price for their electricity, with payments based on the different between the wholesale price and a fixed 'Strike Price'.
DEFRA	Department for Environment, Food & Rural Affairs. UK Government department.
Electricity System Operator (ESO)	The GB Electricity System Operator, a company within the National Grid group, is responsible for balancing the electricity system's supply and demand to ensure a stable, high-quality supply of electricity. The ESO is also responsible for many aspects of network planning and procures a range of 'system balancing services' on behalf of energy users.
Electricity Market Reform (EMR)	A significant recent programme of electricity market reform in Great Britain. Implemented through the Energy Act 2013.

Emissions Trading Scheme (ETS)	A scheme that sets a cap on the maximum level of emissions from particular industries in a region. Emitters must purchase 'ETS permits' and the number of these available declines over time, in order to reduce overall emissions in that region. Companies can trade emissions permits. The EU operates an ETS.
GB electricity market	The electricity market covering Great Britain (England, Scotland and Wales).
Gigawatt (GW)	One gigawatt (1 GW) equals 1,000 megawatts (1,000 MW)
Green hydrogen	The production of hydrogen using renewable electricity sources. In the UK, the term 'green hydrogen' is typically used to describe all hydrogen produced with electricity.
Hydrogen	A clear, odourless gas which is highly flammable, the most common element in the universe which can be used as a low emission alternative fuel for power, heating and transport.
Local pricing	A wholesale electricity market split into a large number of nodes. For example, the California electricity market has approximately 10,000 pricing nodes.
Net Zero	A target of zero overall greenhouse gas emissions across an economy or for a company. For example, the UK Government has committed to Net Zero emissions across the UK by 2050. The "Net" in Net Zero refers to a balance between positive emissions (e.g. from burning fossil fuels) and negative emissions (e.g. from planting trees or capturing carbon dioxide from the air).
Megawatt (MW)	Measure of installed capacity. The maximum instantaneous output of a generator.
Megawatt hour (MWh)	Measure of energy. For example, a generator that generates 1 MW of electricity for one hour generates 1 MWh of energy.
National pricing	A wholesale electricity market with the same price in all locations in each time period (i.e. a single bidding zone). For example, Great Britain uses national pricing.
Nodal pricing	See *Local pricing*.
Ofgem	The Office for Gas and Electricity Markets (Ofgem) is the regulator for gas and electricity in Great Britain.
Regional pricing	A wholesale electricity market split into a number of zones that cover a geographical region of that market. For example, the Italian electricity market has 6 zones.

Retail electricity market	electricity supplied to customers, including domestic customers and small businesses. Retail electricity is more expensive than wholesale electricity because it includes network charges and the cost of subsidies and fuel poverty obligations.
System balancing services	The ESO procures system balancing services to manage the technical parameters of the electricity network to prevent blackouts. These services include frequency regulation, voltage control, inertia, and constraint management.
Transmission Owners (TO)	The privately-owned regional monopolies that own the electricity transmission networks in Great Britain. The TOs are National Grid Electricity Transmission (England and Wales), Scottish Power (South Scotland), and SSE Networks Transmission (North Scotland).
Uniform pricing	See *National pricing*.
Wholesale electricity market	Main market for generators and suppliers to buy and sell electricity. Only take into account energy costs, not network charges and the cost of subsidies (see r*etail electricity market).*
Zonal pricing	See *Regional pricing*.

Executive Summary

The UK's offshore wind programme is an international success story that demonstrates how governments can work with the private sector to deliver emissions reductions and grow green jobs. However, the sheer number of new wind farms now planned in the UK means that there is increasing local concern over the new 'grid connections' required to connect offshore wind farms to the onshore electricity network. In particular, there is concern that the current regime, which sees each offshore wind farm build its own new power lines and substations to connect to the existing electricity network, is not fit for purpose. Without more coordination between projects, the impact of this new infrastructure on local communities and the environment risks similar local backlash to onshore wind farms and fracking. If these local concerns are not addressed then the current political consensus on the need for offshore wind farms risks breaking down, putting at risk the Government's commitment to deliver its ambitious Carbon Budgets and target for Net Zero emissions by 2050.

New grid connections for offshore wind farms are becoming highly controversial.

As the cost of UK offshore wind farms has tumbled, falling by two-thirds since 2015,[1] the Government's targets for deploying the technology have increased. In early-2019, the Government and industry agreed to target 30 gigawatts (GW) of offshore wind by 2030.[2] Later that year, in the December 2019 General Election, the Conservative Party manifesto upped this target to 40 GW by 2030.[3] The 40 GW offshore wind target by 2030 was also a key part of the Prime Minister's 10 Point Plan, published in autumn 2020.[4]

This increased ambition has been accompanied by a significant rise in the number of new offshore wind farms under development off the UK coastline. Under current rules, each offshore wind farm has built its own 'grid connection' to the existing onshore network, without considering the opportunity to coordinate with the connections of nearby projects.[5] As a result, new underground cables are now planned that would criss-cross coastal and rural communities, accompanied by large onshore electricity substations serving different projects that would link the new cables to the existing network.

This planned new infrastructure is already causing significant concern in East Anglia and could lead to similar concerns in North Wales, Humberside and the east coast of Scotland as more offshore wind farms

1. KPMG (September 2019). Blown away: CfD round 3 delivers record low prices for offshore wind. Link
2. BEIS (March 2019), *Offshore wind Sector Deal – one year on.* Link
3. Prime Minister's Office (October 2020). *New plans to make UK world leader in green energy.* Link
4. BEIS, 10 Downing Street (November 2020). *The ten point plan for a green industrial revolution.* Link
5. The current rules do not prohibit coordination between projects. However, to date, each wind farm has built its own 'radial' connection.

are developed. Without reform, there is a risk that new projects will face growing local opposition, including through the courts, that will slow down the UK's offshore wind programme, limiting jobs and slowing down cuts to emissions.

The current rules are also likely to increase energy bills, with analysis from the Electricity System Operator showing that more coordination could save between £3bn and £6bn by 2050, depending on how quickly it can be implemented.[6]

Short-term changes by the Government can kick-start the coordination process.

The current process for planning new electricity networks suffers from a lack of accountability, a lack of long-term planning, and a lack of coordination between projects. In addition, the choice of route for new grid connections for offshore wind farms does not fully account for disruption faced to local communities, impacts on the environment, and does not include compensation for all affected parties.[7]

The Government's *Offshore Transmission Network Review* will tackle some of these weaknesses,[8] but will only work as part of a wider set of reforms that address the structure and remit of the institutions that manage Great Britain's electricity system – these reforms should remove potential conflicts of interest and ensure clear accountability for the network planning process. We believe that an evolutionary package of reforms, comprised of short-term and long-term actions, can deliver the revolution in outcomes that is needed to deliver a coordinated onshore and offshore electricity network.

In the short term, the BEIS Secretary of State should issue statutory guidance to the regulator, setting out the Government's ambition for an offshore wind 'ring main' and giving Ofgem a clear mandate to adapt the current, technocratic process of network planning. This will be crucial to delivering the Prime Minister's target for 40 GW of offshore wind by 2030.

BEIS should also produce new guidance that would help the Electricity System Operator and Ofgem to assess the negative impacts of different options for connecting offshore wind farms to the onshore network. This assessment process should be conducted at the national level, encouraging the regulator and the electricity network companies to choose coordinated approaches that minimise new infrastructure. Alongside this guidance, Ofgem and the electricity industry should increase the network planning horizon from ten years to thirty years and should review the processes used to assess which new power lines and substations are required.

To compensate local communities that host new infrastructure, the Government should require operators of offshore wind farms to establish 'Offshore Wind Wealth Funds' to fund community projects; Offshore Wind Wealth Funds could be modelled on the Government's prior plans for 'Shale Wealth Funds'.[9]

6. National Grid ESO (December 2020). *Offshore Coordination Phase 1 Final Report.* Link.
7. Project developers are required to provide compensation to those directly affected, for example farmers who lose income including farm subsidies. However, developers are not required to provide compensation for loss of visual amenity or disruption during construction.
8. BEIS (July 2020). *Offshore transmission network review.* Link
9. HM Treasury (Updated November 2017). *Shale Wealth Fund: response to the consultation.* Link

In the longer term, more radical change is needed.

In the longer term, the Government should make more substantial reforms, including new legislation, to deliver the offshore wind farms that will be needed to meet the Sixth Carbon Budget by 2035 and Net Zero emissions by 2050.

To increase accountability and to reduce potential conflicts of interest, the Government should establish a new 'Independent System Operator for Great Britain' ('ISO-GB'), fully independent from the National Grid group of companies.[10] The Government should build on Ofgem's recent review of the current arrangements.[11]

The Government should also establish a new 'UK Seas Authority' to plan the use of the UK's seas, which will require an increasingly delicate balancing act between different seabed users, including offshore wind farms, fishing, shipping, zones of environmental protection, and more. This new Authority should be accountable to the BEIS Secretary of State and should have new powers to ensure coordination, working with private companies and existing bodies like The Crown Estate, the Oil and Gas Authority, the Marine Management Organisation, and the Devolved Administrations.[12]

Finally, the Government must harness markets to ensure that energy projects like offshore wind farms are built and connected in places where they have the most value. To achieve this, the Government should reform Great Britain's wholesale electricity market to include 'local electricity pricing', which is used in many US States, Singapore and New Zealand.[13] As Policy Exchange has previously argued, local pricing is the key to a low-cost, smart electricity system, where generators, customers and energy storage providers work together to minimise the amount of new infrastructure that is required.[14]

These longer-term changes will require a new Energy Act, which should form part of the Government's legislative programme for the next Parliamentary Session (expected to cover the period 2022/23).

Changes must not delay existing projects or harm investor confidence.

The challenge for the Government is to deliver these changes without slowing down existing projects or damaging investor confidence in the UK's offshore wind sector – any delays will put at risk the Government's manifesto commitment for 40 GW of offshore wind capacity by 2030, and any harm to investor confidence will increase the cost of new offshore wind farms and lead to higher energy bills.

For projects that are close to construction, the Government must ensure that additional coordination is opt-in and that any additional costs are underwritten by the Government, including compensation for delays to projects. Even if these conditions are met, it will be difficult to convince developers to change their plans, which may have been under development for over a decade, as this would incur significant additional costs.

Therefore, for these 'in-flight' projects, the Government should

10. Reforms to the existing ESO should continue in parallel with the process to establish the new 'ISO-GB'.
11. Ofgem (January 2021). *Review of GB energy system operation*. Link
12. For more details, see Policy Exchange (November 2020). *Future of the North Sea*. Link
13. Note that local pricing will not fully resolve complex issues around locational signals, including the appropriate regime for transmission network charges. These issues are discussed in more detail later in this report.
14. For more details, see Policy Exchange (December 2020). *Powering Net Zero*. Link

focus only on the projects where coordination could bring the biggest benefits. The Government should use East Anglia as a pilot region for early coordination, as there are six new offshore wind farms planning to connect to the onshore electricity network in the mid-2020s, with plans for several new underground cables and new substations in the region. The Government will still need to convince the developers in East Anglia, or a subset of them, to opt into the coordination pilot.

Because offshore wind projects and upgrades to the onshore electricity network take many years to develop, any changes will take time to feed through, so stakeholders will need to be patient with the Government. However, without reform, there is now a serious risk that grid connections for offshore wind farms will become a major barrier to the Government's manifesto commitments on offshore wind and Net Zero. With the right changes, there is no reason why the UK cannot develop a coordinated onshore and offshore electricity network that reduces bills, minimises disruption and protects the local environment.

Policy recommendations

This report makes ten specific policy recommendations for the UK Government, grouped into four themes that aim to address the weaknesses of the existing process (Table 1).

Table 1: Policy recommendations to deliver a coordinated onshore and offshore electricity network.

Theme	Time-frame	Recommendation
Establish clear accountability for network planning	Short term	#1: The BEIS Secretary of State should use the 'Strategy and Policy Statement' to issue guidance to Ofgem on the Government's ambitions for a coordinated approach to developing Great Britain's onshore and offshore electricity network, including an offshore wind 'ring main' for new offshore wind farms.
	Long term	#2: The Government should establish a new 'Independent System Operator for Great Britain' ('ISO-GB'), modelled on examples in the United States and beyond. ISO-GB should have overall responsibility for planning the GB transmission network, including the responsibility to develop a coordinated onshore and offshore network.
Minimise disruption and compensate communities	Short term	#3: The Government should continue to develop an 'opt-in' mechanism to coordinate late-stage offshore wind projects, focusing on the East Anglia region. This coordination could include sharing underground cable routes or coordinating construction timelines.
	Short term	#4: Where the impact of new offshore wind farms cannot be reduced, for example because projects have already secured planning permission, the Government should compensate communities impacted by the construction of offshore wind farms and associated infrastructure such as substations and cable routes.
	Short term	#5: BEIS should produce new guidance that would help Ofgem and the ESO to assess the negative impact of different connection options for offshore wind farms. This assessment should be conducted at the national level, with the aim of reducing the burden of new infrastructure on the environment and local communities.
	Long term	#6: The Government should establish mandatory 'Offshore Wind Wealth Funds' for new offshore wind farms, as a condition of receiving support in future Contracts for Difference auctions. Offshore wind farms should pay a minimum community benefit of £0.50 per MWh (approximately £2m per year for a 1 GW offshore wind farm).

Establish a long-term plan to deliver a Net Zero electricity network by 2050.	Short term	#7: The BEIS Secretary of State and Ofgem should jointly request the ESO to produce a long-term plan for Great Britain's electricity network out to 2050, under a range of scenarios, to guide network planning decisions moving forward.
	Short term	#8: Ofgem should review the main network planning methodology ('least-worst regrets') to ensure that it is fit for purpose for a coordinated onshore and offshore electricity network and Net Zero. Ofgem should also work with the ESO to develop new approaches to assess which network projects should have the highest priority.
	Long term	#9: The Government should establish a new 'UK Seas Authority' to coordinate the development of the UK's seas across all users, including offshore wind, fishing, shipping, environmental protection and more.
Encourage developers to build and connect projects in places where they will reduce energy bills the most.	Long term	#10: To ensure that offshore wind farms are built in places where they will reduce energy bills the most, the Government should implement 'local electricity pricing' in Great Britain's wholesale electricity market. This will encourage project developers to build and connect projects closer to customers.

1. Introduction

Since the first UK offshore wind farm was built twenty years ago, installed capacity has grown substantially, doubling in the last five years from 5.1 gigawatts (GW) in 2015 to 10.4 GW in 2020 (Figure 1).

To meet the Government's targets, capacity will need to double again by 2025, to 20 GW, and double again by 2030 to reach 40 GW. One estimate suggests that the UK will need to install one wind turbine every weekday during the 2020s.[15]

Meeting these ambitious offshore wind targets is only possible due to rapidly falling prices and new, larger turbines; the newest turbines can each produce 14 megawatts (MW) of electricity and are 250 metres tall.[16,17] These turbines have double the maximum output of the 7 MW turbines used in recent projects.[18]

The UK's offshore wind rollout is a good news story on jobs, climate change and falling costs, but there are several barriers that could delay the next phase of the offshore wind programme. These include: legal challenges to planning consents;[19] interference with military radar systems;[20] and conflicts with shipping lanes and fishing grounds.[21]

However, the biggest political risk to the UK's offshore wind programme is now the development of the onshore and offshore electricity networks that will be needed to transmit the electricity generated by offshore wind farms to customers in urban and industrial areas.

This section provides an overview of the current and planned development of offshore wind farms in the UK, including the impacts on Great Britain's electricity network.

Offshore wind targets

In early 2019, the UK Government and the offshore wind industry set a target to build 30 GW of offshore wind capacity by 2030, subject to costs continuing to fall.[22] In the deal, the industry has set a target for 60% lifetime UK content in domestic projects by 2030, compared to around 50% today.

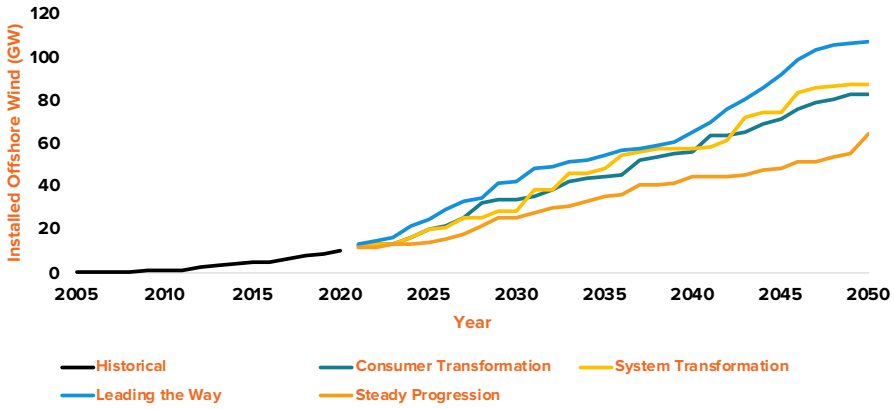
At the December 2019 election, the Conservative Party manifesto included a commitment to increase the offshore wind target to 40 GW by 2030.[23] In October 2020, the Government officially raised the 2030 offshore wind target to 40 GW, including 1 GW of floating offshore wind.[24]

The Government has also committed to invest £160m in new and upgraded port infrastructure to promote offshore wind manufacturing in the UK. In March 2021, the Government awarded the first £95m of the

15. Aurora Energy Research (February 2020). *Reaching the UK Government's target of 40 GW of offshore wind by 2030 will require almost £50bn in investment.* Link
16. GE Renewable Energy (undated). *Haliade-X offshore wind turbine.* Link
17. Siemens Gamesa (June 2020). *Siemens Gamesa's flagship 14 MW turbine to power 1.4 GW Sofia offshore wind power project in the UK.* Link
18. Orsted (June 2019). *Operations start on Hornsea One, the world's largest offshore wind farm.* Link
19. RE News (February 2021). *Judge quashes consent for Norfolk Vanguard.* Link
20. Ministry of Defence (Defence and Security Accelerator) (Updated June 2021). *Windfarm Mitigation for UK Air Defence (Phase 2).* Link
21. The Crown Estate (August 2016). *Changes to fishing practices around the UK as a result of the development of offshore windfarms – Phase 1.* Link. See page 8: *"The relationship between fishermen and wind farm developers and their service companies was often described as poor in terms of communication and information exchange."*
22. BEIS (March 2019), *Offshore wind Sector Deal – one year on.* Link
23. Conservative and Unionist Party (2019). *Manifesto 2019.* Link. Page 55.
24. Prime Minister's Office (October 2020). *New plans to make UK world leader in green energy.* Link

fund, split between ports in the Humber and Teesside.[25] As part of this funding, GE Renewable Energy announced plans to build a new blade manufacturing plant on Teesside.[26] By 2050, National Grid ESO forecasts that UK offshore wind capacity could rise to between 60 GW and 100 GW, potentially including offshore wind farms directly connected to offshore production facilities for green hydrogen (Figure 1).

Figure 1: UK installed offshore wind capacity – historical and forecast to 2050.



Source: (Historical) BEIS: Renewable Energy Planning Database.[27] (Forecasts) National Grid ESO: Future Energy Scenarios.[28]

The UK's advanced pipeline of offshore wind projects is approximately 30 GW, including projects that are operational, under construction, or in the planning system; the advanced pipeline includes 5.5 GW of projects awaiting a planning decision, and 5.5 GW of projects that have secured planning permission but are yet to secure a 'Contracts for Difference' support contract from the Government (Figure 2).

The earlier-stage pipeline includes several extensions to existing wind farms, including extensions to the Greater Gabbard, Galloper, Sheringham Shoal and Dudgeon offshore wind farms off East Anglia, the Rampion extension off Brighton, and the Gwynt y Mor extension (Awel y Mor) off North Wales. Larger projects that are expected to enter the planning process soon include Hornsea Project Four off Humberside and further phases of the Seagreen project in the Firth of Forth.[29] These projects should start operating by 2030, subject to favourable planning decisions and any required upgrades to the electricity network.

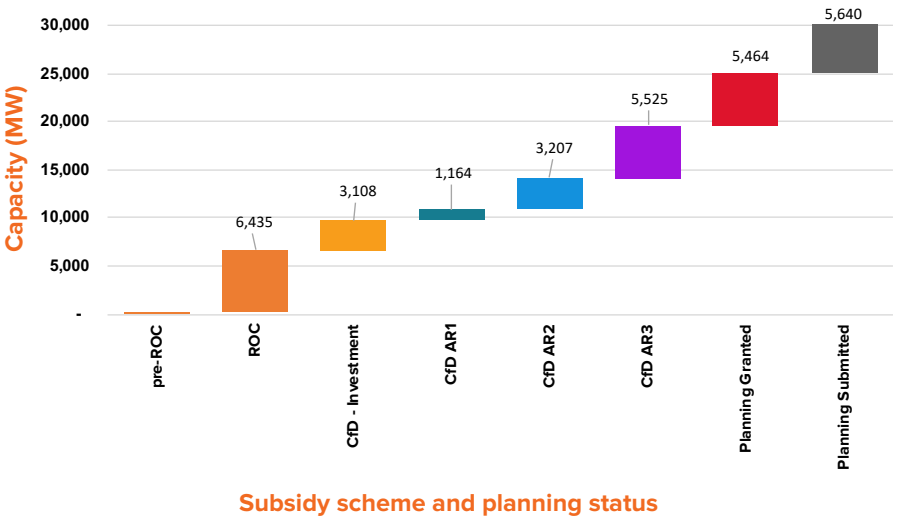
Projects aiming to connect post-2030 include some of the 8 GW of projects in England and Wales that recently signed 'option-to-lease' agreements with the Crown Estate as part of 'Leasing Round 4',[30] and option agreements that will be awarded as part of The Crown Estate Scotland's upcoming 'Scotwind' leasing round.[31]

Including these earlier-stage projects, the UK's total offshore wind pipeline is over 50 GW. Further leasing rounds will be required to meet

25. BEIS (March 2021). *Second wind for the Humber, Teesside and UK energy industry.* Link
26. GE (March 2021). *GE Renewable Energy plans to open new offshore wind blade manufacturing plant in Teesside, UK.* Link
27. BEIS (Updated March 2021). *Renewable Energy Planning Database quarterly extract.* Link.
28. National Grid ESO (July 2020). *Future Energy Scenarios 2020.* Link
29. Seagreen Wind Energy (undated). *About us.* Link
30. The Crown Estate (updated February 2021). *Offshore Wind Leasing Round 4.* Link
31. Crown Estate Scotland (undated). *Scotwind Leasing.* Link

the ESO's forecasts of installed offshore wind capacity by 2050; these leasing rounds are likely to include floating offshore wind projects, which are expected to become cheaper over time.[32]

Figure 2: Subsidy scheme and planning permission status of UK offshore wind farms.



Source: BEIS and Low Carbon Contracts Company.[33]

32. Floating offshore wind farms could be particularly valuable because they can be installed in areas of the seabed that are too deep for conventional offshore wind farms.

33. BEIS (Updated March 2021). *Renewable Energy Planning Database quarterly extract.* Link. Low Carbon Contracts Company (undated). *CfD Register.* Link

2. Connecting offshore wind farms to the onshore electricity network

To transmit power to customers, offshore wind farms must be connected to the existing onshore electricity network. Under the current system, each offshore wind farm has built its own connection to the onshore network, known as a 'radial connection'. One consequence of this approach is that certain areas of the UK are set to be criss-crossed with underground electricity cables.

Current and planned connections

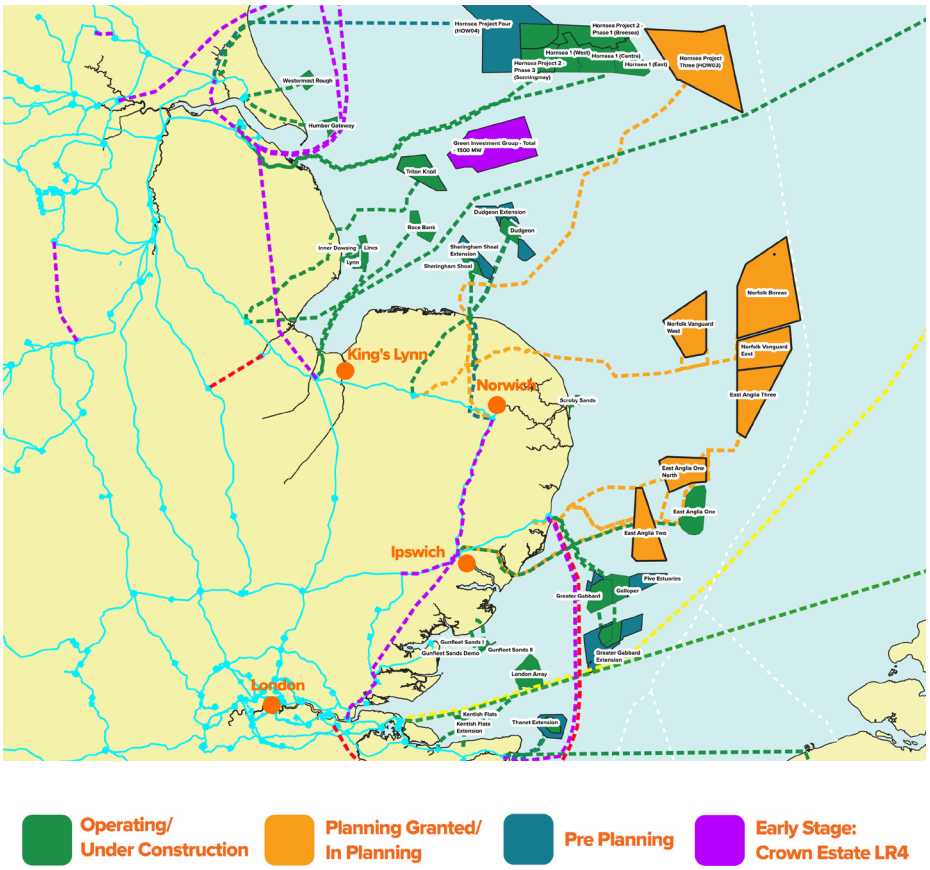
In Norfolk, there are already underground cables that connect the Dudgeon and Sheringham Shoal offshore wind farms to the grid. These are set to be joined by a connection for the Hornsea Three project and a shared connection for the Norfolk Vanguard and Norfolk Boreas wind farms. Longer term, an additional, shared connection is proposed for extensions to the Sheringham Shoal and Dudgeon wind farms (Figure 3).

Once operating, these underground cables have limited impact on local communities; however, there can be significant disruption during the construction process, for example because of road closures and heavy-duty construction vehicles on small, rural roads. Construction can be particularly disruptive where the cables come onshore, known as 'landing points', as these areas are often environmentally sensitive and/or reliant on income from tourism, which some fear will be reduced during the construction period.

One long-term onshore impact of an offshore wind farm is the electricity substation that connects it to the onshore electricity network. As multiple offshore wind farms can connect to a single onshore substation, the onshore substations may need be substantially expanded over time; one example is the planned expansion of the Necton substation in Norfolk, which has met with resistance from local residents.[34] The onshore substations are often in rural areas that do not have a history of large-scale infrastructure, except for the existing overhead power lines that the substations are connected to.

34. Eastern Daily Press (December 2017). *'Ignored and disregarded' – villagers hit out at plans to build huge substations for offshore wind farms.* Link

Figure 3: Offshore wind farms under development in East Anglia.



Source: Crown Estate, project websites and planning submissions.

As well as the connections to the existing network, offshore wind farms create a need for additional power lines to transit electricity to customers in urban and industrial areas. For example, the ESO has recommended four new subsea electricity cables off the east coast of Great Britain that will predominantly transmit excess wind power from Scotland to customers in England.[35] Without these new cables, wind farms in Scotland will increasingly need to be turned down or switched off to avoid overloading the power lines that run between Scotland and England.

Subsea electricity cables can reduce the number of onshore power lines that are required; however, they do not fully remove the need for onshore infrastructure. For example, the proposed subsea cable from Peterhead (Aberdeenshire) to Drax (North Yorkshire) requires at least 37 miles (60 km) of onshore cables between Drax and the coast.

In addition, the ESO has recommended a number of new onshore power lines, mainly driven by offshore wind projects. Figure 5 shows the new power lines that the ESO currently forecasts will be required by around 2030. New onshore power lines are planned between Chesterfield (Derbyshire) and Ratcliffe-on-Soar (Nottinghamshire), between Grimsby (Lincolnshire) and Walpole (Suffolk), and under the Humber estuary.[36] The ESO is also considering new power lines between Norwich and

35. Ofgem (June 2021). *Eastern HVDC – Consultation of the project's Initial Needs Case and initial thinking on its suitability for competition.* Link

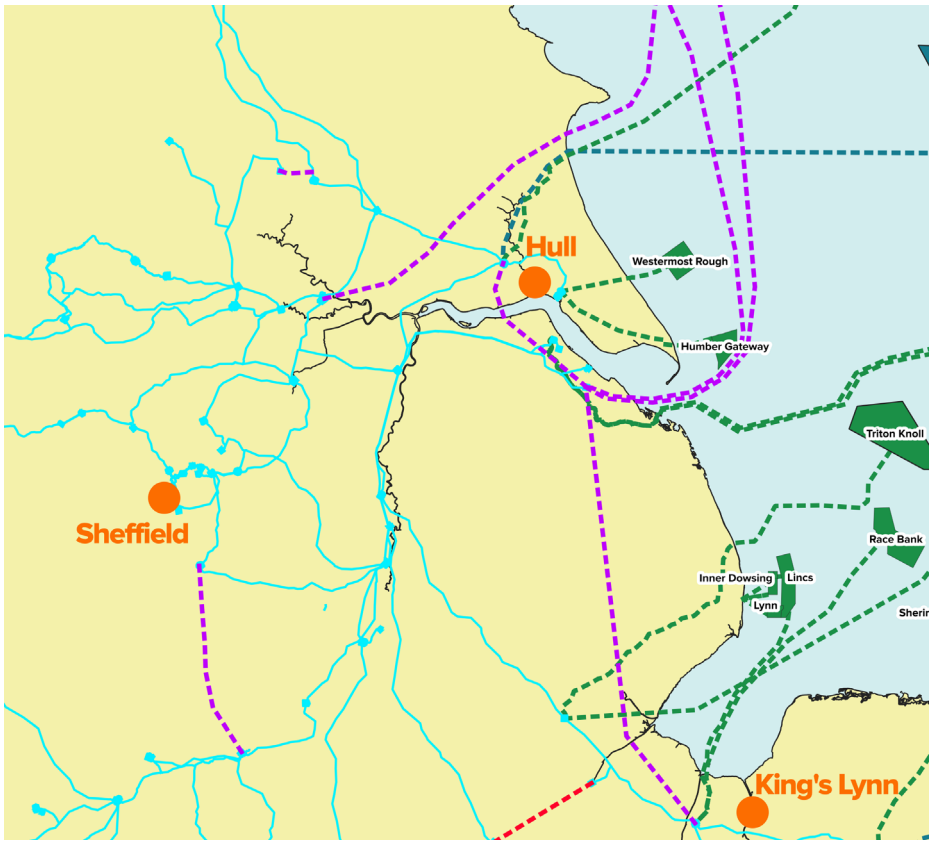
36. See Network Options Assessment 2020/21. Link. Proposed projects referenced are EDNC, GWNC, and CGNC, respectively.

London to transmit electricity generated by offshore wind farms off East Anglia.[37]

New power lines are not only required for new offshore wind farms. Any new, large-scale generator can create the need for new power lines; for example, the under-construction Hinkley Point C nuclear power station will require new power lines between Hinkley and the Seabank substation, which is 31 miles (50 km) away.[38]

The ESO's latest Network Options Assessment (2020/21) recommends that fifteen power lines will need to start operating between 2027 and 2031; of these, ten are onshore and five are offshore (Figure 5). These new power lines are in addition to the individual connections for offshore wind farms, which are currently planned separately.

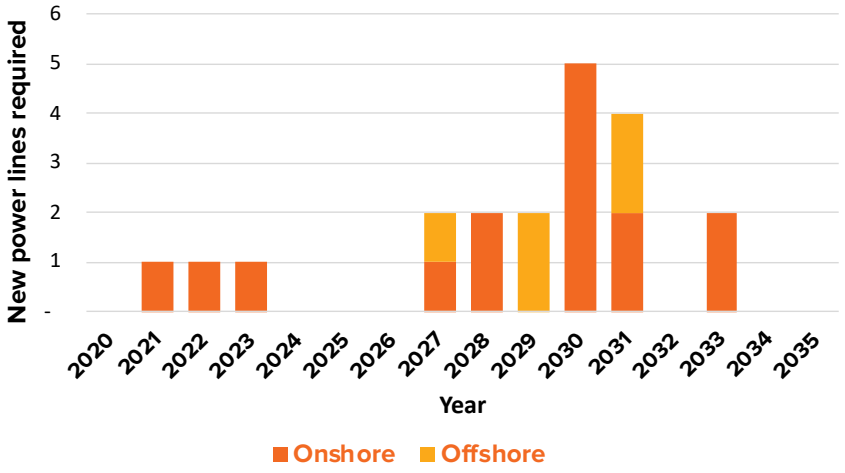
Figure 4: Possible network upgrades in the Humber region (purple)



Source: Network Options Assessment (NOA) 2020/21.[39]

37. See Network Options Assessment 2020/21. Link. See proposed projects AENC, ATNC, and BTNO.
38. Ofgem (undated). *Hinkley – Seabank*. Link
39. National Grid ESO (undated). *Network Options Assessment (NOA)*. Link. See NOA 2020/21

Figure 5: Expected new power lines required in Great Britain, by type and year.

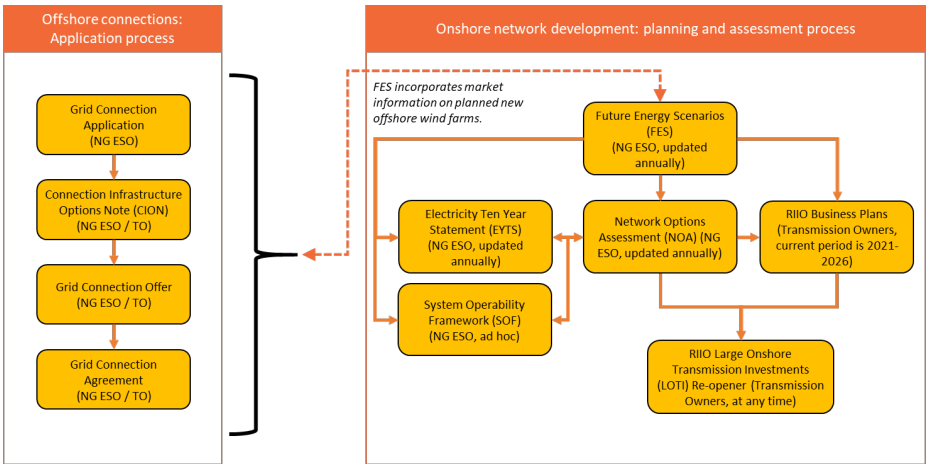


Source: Network Options Assessment (NOA) 2020/21.[40]

Current connections policy

The current connections process for large generators like offshore wind farms is largely separate from the process for upgrading the onshore electricity network (Figure 6). Each process is explained in more detail in Box 1.

Figure 6: Connections and grid development process in Great Britain. (Left) Connections for offshore wind farms. (Right) development of the onshore network.



40. National Grid ESO (undated). *Network Options Assessment (NOA).* Link. See NOA 2020/21

Box 1: Description of the connection process for offshore wind projects, and for upgrades to the onshore electricity network.

Offshore wind projects

For offshore wind projects, the developer first applies to the ESO for a grid connection. The ESO then works with the project developer and the relevant Transmission Owner to assess the options for connecting the project to the onshore network; this stage includes identifying the optimal landing point where the cables should meet the shore.[41] The 'optioneering' process is summarised in the Connection and Infrastructure Options Note (CION).[42]

Once the optimal connection method has been identified, the ESO issues a 'Connection Offer' to the project developer; the developer has ninety days to accept the offer. Once the offer is accepted, there is a binding 'Connection Agreement' between the developer and the ESO, and a separate binding agreement between the ESO and the relevant Transmission Owner.

Onshore electricity network

The planning and assessment process for the onshore electricity network is significantly more complicated than for an offshore wind farm. The process starts with the Future Energy Scenarios, produced annually by the ESO.[42] These scenarios explore a range of future outcomes for the development of Great Britain's energy system, based on different technology costs, societal preferences, and rates of decarbonisation. The Future Energy Scenarios aim to incorporate the latest information on new generation projects, including planned offshore wind farms.[43]

The Future Energy Scenarios are used by the ESO to assess:

- Future flows on the electricity network, via the Electricity Ten Year Statement (ETYS);[45]
- Future operational requirements, via the System Operability Framework (SOF);[46]

The ESO uses these two documents, combined with the Future Energy Scenarios, to recommend options for upgrading the onshore electricity network, through the Network Options Assessment (NOA).[47] The NOA recommends network upgrades (for example new power lines, substations or non-network 'commercial solutions') that can reduce customer bills by integrating new sources of generation whilst minimising constraints on the electricity network.[48]

Finally, the Transmission Owners and Ofgem use the NOA as part of the process to approve individual investments in new and upgraded power lines and substations, through the 'RIIO' regulations.[49,50]

Strengths of the current connections policy

The UK has installed more offshore wind farms than any other country, supported by the current system of individual grid connections for each offshore wind farm.[51] The current connections policy has several benefits, namely:

51. Global Wind Energy Council (March 2021). *Global Wind Report 2021*. Link. Page 52. UK is home to 29% of global installed offshore wind capacity; China 28%; Germany 22%.
41. The relevant Transmission Owner (TO) is: (England and Wales) National Grid Electricity Transmission; (South Scotland) SP Energy Networks Transmission; (North Scotland) SSE Networks Transmission.
42. National Grid ESO (updated November 2018). *The Connection and Infrastructure Options Note (CION) process*. Link
43. National Grid ESO (undated). *ESO Future Energy Scenarios*. Link
44. National Grid ESO (July 2020). *FES Modelling Methods 2020*. Link. Pages 16 and 17.
45. National Grid ESO (undated). *Electricity Ten Year Statement (ETYS) 2020*. Link
46. National Grid ESO (undated). *System Operability Framework (SOF)*. Link
47. National Grid ESO (undated). *Network Options Assessment (NOA)*. Link
48. Technically the process aims to final the 'optimal' level of constraint costs. The optimal level of constraints is greater than zero because it would cost more to upgrade the network to avoid all constraints. Commercial solutions include the 'Power Potential' project run by the ESO and UK Power Networks, which aims to use small-scale generators on the distribution network to manage voltage issues on the transmission network. If successful, this will release additional network capacity, which reduces constraints on the network and therefore reduces customer bills. Link to Power Potential.
49. Ofgem (December 2020). *RIIO-2 Final Determinations for Transmission and Gas Distribution network companies and the ESO*. Link. Note: network upgrades can either be approved at the start of each 6-year 'RIIO Business Plan' or at any time through the 'Large Onshore Transmission Investment' (LOTI) or Medium Sized Investment Projects (MSIP) processes.
50. Ofgem's approval process also includes project-specific cost-benefit analysis and an engineering review.

#1: Minimises delivery risk for developers:

UK offshore wind farms typically build their own grid connection.[52] This means that the developer has more control over the connection timeline, minimising the risk of unexpected delays to the grid connection.[53]

Because risks are reduced, owners of offshore wind farms are able to access cheaper sources of finance (both debt and equity), which puts downwards pressure on the prices that offshore wind farm developers bid into the Contracts for Difference subsidy auctions.

In markets where the grid connection is not built by the developer of the offshore wind farm, complex contracts may be needed to indemnify the project (partially or fully) against delays to the grid connection.

The current system also minimises the risk of overinvesting in coordinated grid connections that are never used due to future projects not being built, for example if proposed wind farms are unexpectedly refused planning permission.

#2: Harnesses competition:

Under the UK's Offshore Transmission Owner (OFTO) regime, each offshore wind farm builds their own grid connection; once operational, the developer is required to sell the asset to a third-party, which owns and operates the connection for the lifetime of the grid connection; this is partly because the grid connection may outlast the wind farm.[54] The ownership of the each grid connection (the OFTO) is allocated through competitive tenders run by Ofgem, which promote competition and reduces costs.[55] Unlike these offshore networks, the onshore network is built, owned and operated by regional monopolies (the Transmission Owners).

#3: Free from political interference:

The current network planning process operates independently of the Government and Ministers; it is run by a combination of Ofgem, the ESO and the Transmission Owners. This encourages the industry to pursue least-cost solutions, rather than being subject to the changing preferences of different Ministers or political parties; the electricity networks are still subject to marine and terrestrial planning laws set by Parliament, which, for example, discourage or even ban the construction of electrical infrastructure in areas that are environmentally sensitive or have high visual amenity, such as designated 'Areas of Outstanding Natural Beauty' (AONB). However, this technocratic system leads to a lack of political accountability, as discussed below.

Weaknesses of the current connections policy

Despite the UK's relatively successful offshore wind rollout so far, the current system of grid connections suffers from a number of weaknesses that have been exposed by the UK's increasingly ambitious offshore wind targets. These are:

52. Ofgem (undated). *Offshore transmission policy design.* Link. *"Under the enduring regime, offshore developers have the flexibility to choose whether they or an OFTO design and construct transmission assets."*
53. There is still a risk of delays caused by the onshore Transmission Owner (TO); however, experience shows that this is unlikely.
54. Ofgem (undated). *Offshore transmission.* Link
55. Ofgem (undated). *Offshore transmission tenders.* Link

#1: Lack of accountability.

Under the current system, responsibility for planning Great Britain's onshore and offshore electricity network is split across the following organisations:

- Transmission Owners: Proposing options to upgrade the network, including as part of the Network Options Assessment (NOA).
- National Grid ESO: Preparing grid connection offers, including through the CION process, and evaluating options to upgrade the onshore network through the NOA.
- The Crown Estate: Leasing areas of the seabed to offshore wind farm developers, including cable routes.[56]
- BEIS: Granting planning permission (Development Consent Orders) for offshore wind farms and associated infrastructure, including onshore substations.[57,58]
- Ofgem: Approving the cost of connections for offshore wind farm (OFTOs); approving the business plans of the Transmission Owners through the RIIO regulatory framework,[59] and ad-hoc applications for network upgrades through the Large Onshore Transmission Investment' (LOTI) Re-opener or 'Medium Sized Investment Projects' (MSIP) Re-opener processes, depending on the value of the proposed investment.[60]

Because responsibility is shared, there is no organisation or individual that is wholly responsible for planning the onshore and offshore electricity network in Great Britain. This split accountability creates a lack of clear strategic planning, which risks delivering piecemeal infrastructure rather than the step changes needed to deliver a network fit for Net Zero by 2050. Split accountability also makes it difficult for Parliament, the Government, the public, and the electricity industry to scrutinise planned network upgrades.

The current system of network planning also suffers from limited input from Ministers. Arguably this is a strength because, as described above, it avoids the risk of changing Government preferences as successive Ministers come and go. However, a lack of political involvement means that there can be a disconnect between the Government's aims, for example Net Zero, and the assumptions used to plan the network.

For example, in the ESO's 2015 Future Energy Scenarios, only one of the four planning scenarios met the Government's legally-binding target for an 80% reduction in carbon emissions by 2050.[61] In the 2020 Future Energy Scenarios, three of the four planning scenarios met the Government's updated legally-binding target for Net Zero emissions by 2050, but one did not.[62] This doesn't suggest that there are any inherent deficiencies in the FES process, but it is important to understand how these scenarios impact on the network planning process.

There is also split responsibility for planning the use of the UK's seas; the Marine Management Organisation (MMO) is responsible for the statutory

56. In Scotland, responsibility of Crown Estate Scotland.
57. In Wales and Scotland, responsibility of the Welsh and Scottish Governments, respectively.
58. BEIS (updated June 2021). *Energy infrastructure development applications: decisions.* Link
59. Ofgem (undated). *Current network price controls (RIIO-1).* Link
60. Ofgem (March 2021). *Large Onshore Transmission Investments (LOTI) Re-opener Guidance.* Link
61. National Grid ESO (July 2015). *Future Energy Scenarios (2015).* Link. Page 5.
62. National Grid ESO (July 2020). *Future Energy Scenarios (2020).* Link. Page 6.

'marine planning' process in England,[63] but The Crown Estate and Crown Estate Scotland have a powerful role in determining which areas of the seabed are leased to developers of offshore wind farms through their various leasing rounds. As with the network planning process, the marine planning process would benefit from more input from politicians to guide the trade-offs across different seabed users.

#2: Doesn't fully account for disruption to local communities.

Today, network planning aims to reduce the cost paid by customers for new network infrastructure. However, it is not clear that the process fully considers non-monetary costs such as disruption to local communities during the construction process and the visual impact of new power lines and substations.[64] This means the chosen connection method may be cheaper, benefitting all customers in Great Britain, but have worse impacts on the communities that host new infrastructure.

There are protections for local communities, including planning laws; however, it is clear that some communities feel like they are bearing a disproportionate impact of new infrastructure.[65] Today, this new infrastructure is concentrated in East Anglia; however, as more offshore wind farms are installed there could be similar issues in North Wales, Humberside and the east coast of Scotland, as described below.

In some cases, Ofgem has a clear policy to minimise disruption to the communities that host electricity infrastructure. For example, under Ofgem's *Visual Amenity* policy, Transmission Owners can apply for funding to reduce the impact of electricity infrastructure on Areas of Outstanding Natural Beauty (AONBs), for example by burying existing power lines.[66] However, this policy does not apply to connections for new offshore wind farms, which are typically underground.

In other cases, Ofgem implicitly values connection methods than can be delivered faster and have less visual impact. For example, Ofgem has not challenged offshore wind farms developers when they have pursued underground cables to connect their projects to the onshore network, even though overhead power lines would almost certainly be cheaper; overhead lines are more likely to suffer delays due to planning hurdles and legal challenges.[67]

Where new network infrastructure is required, the current network planning process does not automatically provide compensation for affected communities.[68,69] This is out of sync with the Government's guidance for onshore wind farms in England, which are advised to make an annual payment of £5,000 per MW per year to community projects through a 'Community Benefit Fund'; under the guidance, a typical 30 MW onshore wind farm would pay £150,000 per year to local projects.[70]

Community Benefit Funds can be used to upgrade village halls and sports facilities or to provide enhanced local services. There is no reason why the Government's approach to Community Benefit Funds for onshore wind farms could not be extended to communities that host new network infrastructure.

63. In Scotland, responsibility of "regional Marine Planning Partnerships (Link). In Wales, responsibility of the Welsh Government (Link). In Northern Ireland, responsibility of the Department of Agriculture, Environment and Rural Affairs (Link).
64. When planning new infrastructure, the TOs do take into account environmental and socio-economic factors. However, it is not clear that these are fully accounted for or that the TOs put the appropriate weight on these factors. See: National Grid (2012). *Our approach to Options Appraisal.* Link. Page 11.
65. Eastern Daily Press (December 2017). *'Ignored and disregarded' – villagers hit out at plans to build huge substations for offshore wind farms.* Link
66. Ofgem (undated). *Visual Amenity.* Link
67. For example, a proposed overhead line between Northern Ireland and the Republic of Ireland has been repeatedly delayed due to legal challenges in both jurisdictions. See: Ulster Business (September 2020). *Long-awaited North-south interconnector given green light for Northern Ireland.* Link
68. Project developers do provide compensation to those directly affected by the works, for example farmers who lose income including farm subsidies. However, developers are not required to provide compensation for loss of visual amenity and disruption during construction.
69. Transmission Owners also make voluntary payments to affected communities. For example, National Grid provides grants of up to £20,000 to community organisations and charities in areas affected by major infrastructure projects. See: National Grid (undated). *Community Grant Programme.* Link
70. Department for Energy and Climate Change (2014). *Community Benefits from Onshore Wind Developments: Best Practice Guidance for England.* Link

#3: Lack of long-term planning.

The Future Energy Scenarios cover the period from now to 2050; however, the ESO only plans the electricity network approximately ten years ahead of time, through a combination of the Network Options Assessment (NOA), the Electricity Ten Year Statement (ETYS), and the System Operability Framework (SOF).

In a slowly changing electricity system with few new generators, a ten-year planning horizon was sufficient. However, the Net Zero target and the falling cost of renewables means that the electricity system is changing rapidly, and significant new network infrastructure is needed.

Some of this network infrastructure could have a lifetime of over fifty years. It is therefore critical that network planners consider the long-term impact of infrastructure that is approved and/or built in the next few years.[71] For example, without long-term planning, network infrastructure built to meet the 2030 offshore wind target (40 GW) may make it more expensive to meet the UK's longer term decarbonisation goals, which the ESO forecasts will require 80-100 GW of offshore wind.[72]

In addition, the current system does not encourage projects to coordinate with each other. For example, an offshore wind farm expecting to commission in 2025 could construct an oversized grid connection that could also be used by a nearby offshore wind farm that would connect in 2030 – known as 'anticipatory investment'.

However, the current system does not encourage the developer of the first project to build the larger connection. It is not always clear whether Ofgem would approve the cost of the larger grid connection, which would leave the first project with no guarantee that they would be paid back if the second wind farm is delayed or not built for any reason.[73]

As described above, some of the ESO's Future Energy Scenarios do not meet the Government's legal-binding decarbonisation obligations. Because these scenarios play a critical role in the network planning process, the presence of these higher-emission scenarios risks delays to projects that would reduce the cost of meeting Net Zero.[74]

This problem is exacerbated by the main network planning methodology ('least-worst regrets'), which is used by Ofgem and the ESO to evaluate investments in the electricity network; the outcome of least-worst regrets analysis is driven by the most extreme scenarios, including the 'Steady Progression' Future Energy Scenario that does not achieve Net Zero by 2050.[75,76]

Ofgem has recently published independent research that expresses particular concern about the use of 'least-worst regrets' analysis for network planning.[77] The report suggests that new approaches are needed to plan Great Britain's electricity network, including more traditional probability-based analysis that assigns a different probability to each planning scenario.[78]

In the latest Network Options Assessment (NOA 2020/21), Ofgem approved the ESO's proposal to trial an amended 'least-worst regrets' (LWR) methodology known as 'least-worst weighted regrets' (LWWR).[79]

71. The NOA does consider the lifetime benefit of the options that it recommends. The point here is that the planning horizon must be sufficiently long that options recommended now are complementary to options that might be recommended in 3-, 5- or 10-years' time.
72. National Grid ESO (July 2020). *Future Energy Scenarios 2020.* Link. Range quoted for the three scenarios that meet Net Zero.
73. The current rules do allow for this type of 'anticipatory investment'. However, in practice, this provision has never been used, which suggests that it is not currently an attractive option for developers of offshore wind farms.
74. There is clearly a role for planning scenarios that have a slower or faster pace of decarbonisation; however, network planners must ensure that these scenarios do not have undue influence.
75. National Grid ESO (January 2021). *Network Options Assessment 2020/21.* Link. See dates when individual upgrades are required on pages 32 to 52. The date required in the "Steady Progression" scenario (which doesn't meet Net Zero) is often several years later than the date required in the scenarios that meet Net Zero. Note that the NOA process includes additional checks that aim to ensure that recommendations are robust, including applying additional scrutiny to recommendations driven by a single scenario.
76. NERA Economic Consulting (December 2016). *Methods for Planning Under Uncertainty (Cambridge EPRG Winter Conference).* Link
77. Ofgem (December 2020). *Decision making for future energy systems.* Link
78. Unlike least-worst regrets, which has no probabilities, leading to outcomes dominated by extreme scenarios.
79. Ofgem (December 2020). *Approval of 2020 Network Options Assessment methodology (letter).* Link

This new methodology includes probability weighting to guard against outcomes being driven by one extreme scenario. For future iterations of the NOA, the ESO plans to use the new LWWR technique as a business-as-usual process.[80]

#4: Doesn't sufficiently encourage developers to build and connect projects near to customers.

There are currently relatively weak incentives for developers to build and connect their offshore wind farms near to customers; this is one reason why so much new electricity network infrastructure is needed. Developers are incentivised to connect to the electricity grid as cheaply as possible, leaving the ESO to work out how to get that electricity to customers.

If electricity generated by an offshore wind farm cannot reach customers because the local network is overloaded, then the ESO pays the wind farm to switch off, raising electricity bills through 'constraint costs'. As more wind farms have been connected to the grid, constraints costs have risen from approximately £200m in 2014/15 to approximately £450m in 2018/19.[81]

Today, these constraints costs are mainly incurred when the ESO pays wind farms in Scotland to turn down or switch off to stop the power lines between Scotland and England from becoming overload. In future, the electricity network in East Anglia is likely to be increasingly constrained as more offshore wind farms connect there; therefore, each new wind farm built in these 'constrained' areas provides less overall value to the electricity system unless and until the network is upgraded.[82] If the electricity market rules were reformed to encourage developers to build projects in place where they are most valuable and can therefore reduce energy bills the most, then it is possible that these wind farms off East Anglia would have sought a grid connection nearer to London, where demand for electricity is higher.

Despite significant investment in new network infrastructure, the ESO expects constraint costs to rise to up to £2bn per year by the late-2020s, before falling again in the early-2030s as new power lines are built.[83]

Regional transmission charges and transmission losses encourage developers to build projects nearer to customers; however, the current system has weaknesses that will be hard to address.

All large generators pay annual network charges to connect to Great Britain electricity transmission network.[84] Network charges are higher in Scotland, reflecting an excess of generation that needs to be exported to England and Wales.[85] Network charges therefore encourage project developers to build projects further south in Great Britain, which contributes to reducing network constraints. The GB electricity market also includes transmission losses that vary by region. This encourages generation and demand to locate closer to each other. Regional transmission losses were introduced in April 2018,[86] following an investigation by the Competition and Markets Authority.[87]

80. National Grid ESO (May 2021). *Network Options Assessment Methodology: for consultation.* Link
81. Cornwall Insight (January 2020). *Constraints – Can't stop loving you.* Link
82. The coming constraints in East Anglia are demonstrated by the ESO recommendation in the NOA for new onshore and offshore power lines between East Anglia and the London area.
83. National Grid ESO (June 2021). *Modelled Constraint Costs – NOA 2020/21.* Link
84. National Grid ESO (undated). *Transmission Network Use of System (TNUoS) charges.* Link
85. National Grid ESO (April 2019). *TNUoS guidance for generators.* Link
86. Elexon (undated). *Glossary: Transmission Losses.* Link
87. Competition and Markets Authority (June 2016). *Energy market investigation: final report.* Link

Network charges and transmission losses both provide locational signals to generators and demand. However, there are two major limitations of this approach:

1. Locational network charges do not encourage generators and demand to react to local supply and demand for electricity, because they are mostly fixed charges.[88] For example, a battery or a green hydrogen producer in Scotland sees the same wholesale price as one in the southwest of England, even though local supply and demand could be very different.
2. The current network charging regime discourages developers from building energy storage projects in Scotland, even though storage could help to reduce transmission constraints. Ofgem's ongoing Significant Code Review could resolve this issue with energy storage;[89] however, it will remain inefficient to use network charges, which are set ahead of time, to resolve network constraints, which occur in real time and vary from hour to hour. The only way to address this weakness is to vary network charges in real-time, which is effectively equivalent to implementing local electricity pricing in the wholesale electricity market.

As discussed in Policy Exchange's recent report, *Powering Net Zero*, unless these locational issues are addressed, socialised 'system balancing costs' will continue to rise as more offshore wind farms are built. Without reform, cost increases during coronavirus lockdown in spring and summer 2020 could become the norm, meaning that customers won't benefit fully from the falling cost of offshore wind farms.[90]

Risks from continuing with the current system

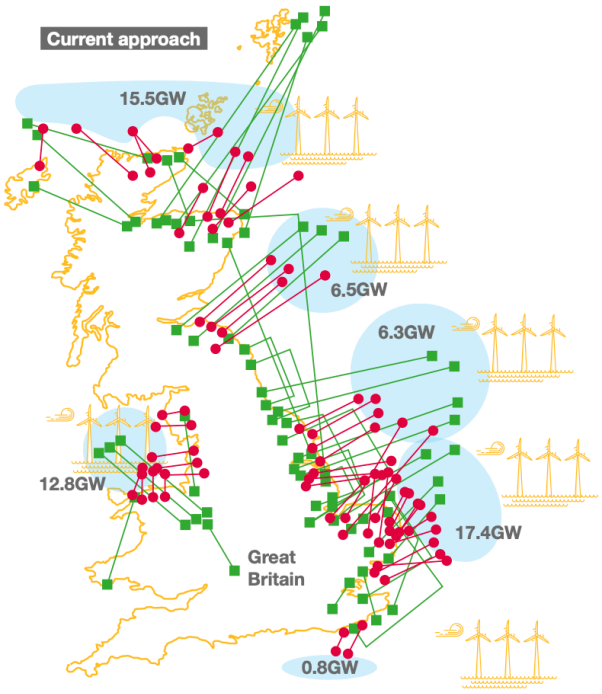
The first phase of the ESO's 'Offshore Coordination Project', published in December 2020, provides the first view of how the electricity network could look in 2050 under the current network planning rules (Figure 7). The ESO's study shows that the current rules would lead to unacceptable outcomes, including:

- Significant disruption for coastal and rural communities caused by the new network infrastructure required for each offshore wind farm;
- Risk of environmental degradation in environmentally sensitive areas offshore, onshore and at landing points for subsea cables; and
- Higher costs and therefore higher bills compared to a coordinated onshore and offshore electricity network, as described below.

Uncoordinated development will also affect communities further onshore as more new power lines will be needed to bring wind power to customers in urban centres like London.

88. I.e. there is poor 'dispatch efficiency'.
89. Ofgem (undated). *Reform of network access and forward-looking charges.* Link
90. See Policy Exchange (December 2020). *Powering Net Zero.* Link. Pages 29-33.

Figure 7: Illustrative network design in 2050 (current policy).



Source: National Grid ESO.[91]

Without reform, the Government risks growing public resistance to offshore wind farms, including through the courts;[92] this could put the Government's offshore wind targets at risk. In an extreme scenario, concerns over network infrastructure for offshore wind farms could lead to severe delays or even a pause on development, similar to restrictive planning rules enacted for onshore wind farms in England or the moratorium on fracking.[93]

Benefits of an integrated approach

To reduce the negative impacts of new network infrastructure, several parties have called for reform, including in Parliament.[94,95] Advocates argue that a coordinated offshore electricity network, sometimes called an offshore wind 'ring main', should be used to connect multiple wind farms to customers in demand centres like London via fewer, larger cables.

A coordinated offshore electricity network would reduce the number of landing points, underground cables, and overhead power lines that will be needed to transmit wind power to customers in urban and industrial centres. Even with a coordinated approach offshore, there will still need to be reinforcements to the onshore electricity network to transmit electricity from the coast to customers further inland. It is critical important that coordination includes both the onshore and offshore network.

91. National Grid ESO (December 2020). *Offshore Coordination Phase 1 Final Report.* Link. Page 20.
92. RE News (February 2021). *Judge quashes consent for Norfolk Vanguard.* Link
93. BEIS, Oil and Gas Authority (November 2019). *Government end support for fracking.* Link
94. Eastern Daily Press (September 2019). *Hope grows that Norfolk countryside won't have to be dug up for every new wind farm.* Link
95. Hansard (November 2020). *Adjournment Date: Offshore Wind Transmission Connections.* Link

A coordinated offshore electricity network was considered and rejected in the early 2010s.

In 2011-2012, the Department for Energy and Climate Change (DECC) and Ofgem ran a project, the *Offshore Transmission Coordination Project*, to assess the possible benefits of developing a coordinated offshore electricity network.[96] The project found that a coordinated approach could save £0.5bn – £3.0bn by 2030 (8-15% of costs), compared to the existing approach of individual (radial) connections for each offshore wind farm.

However, the project also noted significant risks from pursuing a coordinated approach, including: risks to security of supply due to relying on fewer, larger cables; reliance on transmission technologies that were not yet commercially proven; and the risk of stranded investments in larger grid connections that may not be required.[97] The project also found that the benefits of coordination varied between zones, and that in some zones the current approach was still the most cost-effective solution.

Ofgem and DECC concluded that:

> *"These findings, in combination with the high levels of uncertainty surrounding long-term offshore generation build-out, supports an incremental, evolutionary approach to network development rather than the building of a large-scale, meshed network from the outset."*

This decision was understandable given that offshore wind technology was nascent, and offshore transmission technology was relatively unproven. Other countries, such as Belgium, took a different approach, planning and implementing a coordinated offshore network earlier (Box 2).

96. Ofgem, DECC (March 2012). *DECC/Ofgem Offshore Transmission Coordination Project.* Link

97. Ofgem and DECC (March 2012). *DECC/Ofgem Offshore Transmission Coordination Project.* Link. Pages 5 and 6.

Box 2: Belgium's 'Modular Offshore Grid' (MOG)

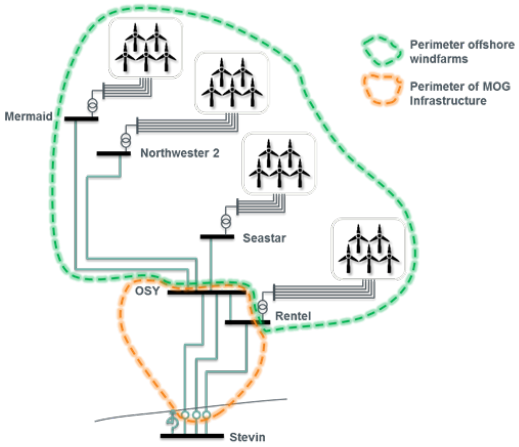
The Belgian Transmission Owner, *Elia*, has recently built an offshore substation that will be used to connect at least four offshore wind farms to the onshore electricity network. The offshore substation is the backbone of Belgium's 'Modular Offshore Grid'.

The first offshore wind farms built in Belgium each have their own connection to the onshore electricity network, similar to the current system in Great Britain. As more wind farms were developed, Elia developed plans for the Modular Offshore Grid, which will reduce the impact of new cables on the local environment; Elia estimates that the coordinated offshore network uses 30-40km less cable compared to an uncoordinated approach.

The coordinated offshore network could be expanded to include more offshore wind farms or new interconnectors, for example between Belgium and Great Britain. Belgium's Modular Offshore Grid could also be integrated into a future 'offshore supergrid' in the North Sea.

Belgium's Modular Offshore Grid is currently a similar size to the proposed Hornsea 3 offshore wind farm in the UK (2.4 GW). This suggests any modular offshore grid in the UK will need to have more capacity than currently planned in Belgium, which may require new HVDC equipment to be developed.

Figure 8: Network diagram of Belgium's 'Modular Offshore Grid'.



Source: Elia.[98]

Increasing deployment of offshore wind means that the Government, Ofgem, and the ESO are now looking again at a coordinated approach to Great Britain's onshore and offshore electricity network.

In spring 2020, the ESO started its *Offshore Coordination Project* to explore the potential for more coordination.[99] The first phase of the project analysed the potential impact of connecting over 80 GW of offshore wind to Great Britain's electricity network by 2050, which the ESO's Future Energy Scenarios suggest is needed to achieve Net Zero. The ESO analysed the

99. National Grid ESO (undated). *Offshore Coordination Project*. Link

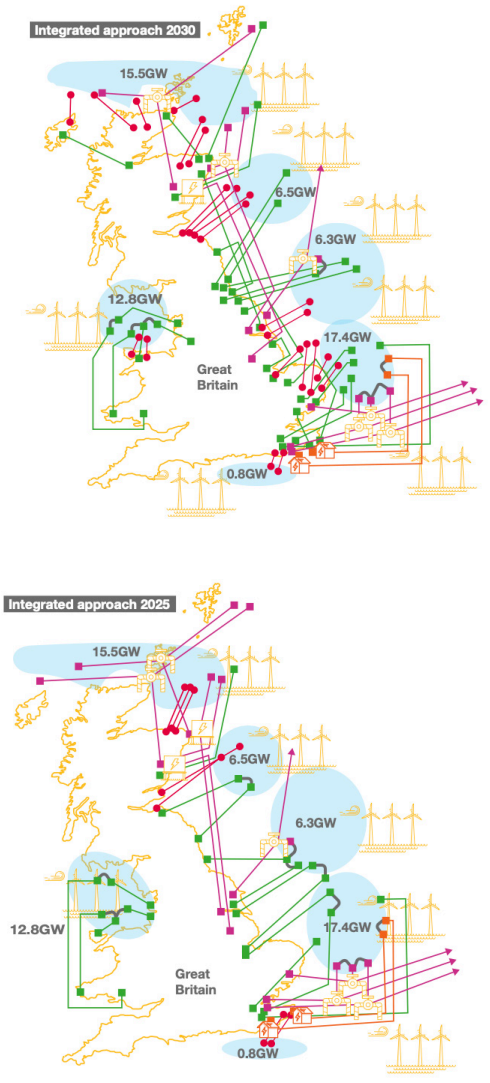
98. Elia (undated). *Modular Offshore Grid*. Link

current approach (Figure 7) and alternative illustrative scenarios where a coordinated approach is delivered for projects connecting from 2030 onwards or from 2025 onwards (Figure 8).

The ESO's analysis shows that an integrated approach could significantly reduce the new infrastructure required onshore and offshore, as well as reducing the number of landing points. The ESO found that an integrated approach could reduce the number of landing points by 50% if delivered by 2025, or 30% if delivered by 2030 (Table 2).

The ESO's study also found that a coordinated approach could reduce the cumulative cost of building and operating new network infrastructure by £3bn-£6bn by 2050 (8%-18%), depending on how quickly coordination can be delivered.

Figure 9: Illustrative network design in 2050. (top) Integrated approach for projects connecting from 2030 onwards. (bottom) Integrated approach for projects connecting from 2025 onwards.



Source: National Grid ESO.[100]

100. National Grid ESO (December 2020). *Offshore Coordination Phase 1 Final Report.* Link. Page 20.

Table 2: Impact of an integrated approach.

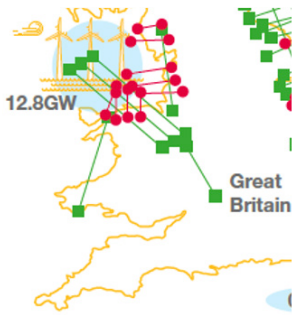
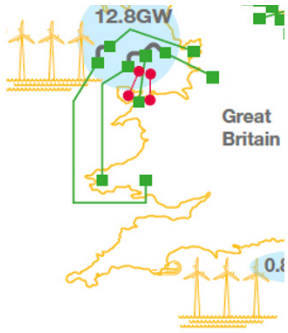
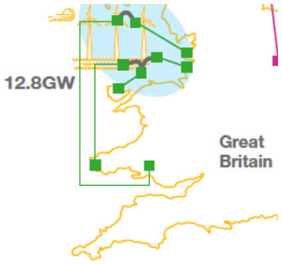
Year that integrated approach is delivered from.[101]	Cumulative savings by 2050 (capital and operating costs)	Reduction in cable landing points
2025	£6bn (18%)	50%
2030	£3bn (8%)	30%

Source: National Grid ESO.[102]

The impact of a coordinated approach can be clearly seen by focusing on individual UK regions.

In Wales, a coordinated approach could see offshore wind farms in the Irish Sea off North Wales connected to the onshore electricity network in South Wales, where the grid is stronger and there are more customers (Table 3). Without coordination, new electricity networks will be needed across North Wales to transmit power to stronger parts of network in the English Midlands.

Table 3: Illustrative design of the electricity network in 2050: Wales.

Current approach	Coordinated approach from 2030 onwards	Coordinated approach from 2025 onwards
		

Source: National Grid ESO.[103]

There is a similar situation on the east coast of England, where a coordinated approach would significantly reduce the number of new connections and other grid upgrades (Table 4).[104] If a coordinated approach could be delivered for projects connecting from 2025 onwards, then new subsea cables could be built to transmit electricity directly to London via the Thames Estuary, rather than over land across East Anglia. This proposed offshore network is sometimes known as an offshore wind 'ring main'.

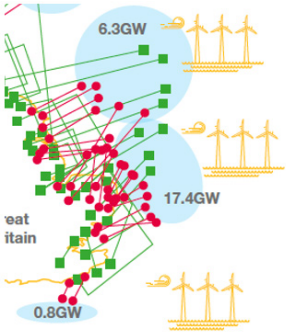
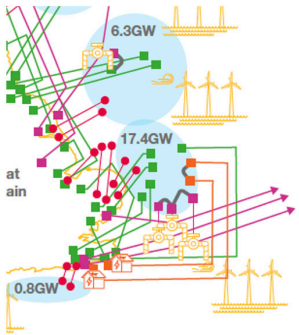
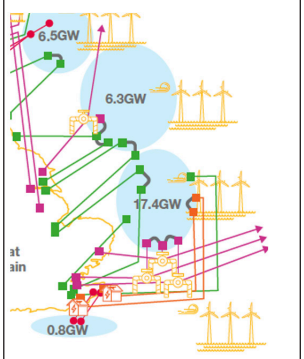
102. National Grid ESO (December 2020). *Offshore Coordination Phase 1 Final Report.* Link. Page 4.

103. National Grid ESO (December 2020). *Offshore Coordination Phase 1 Final Report.* Link. Page 20.

104. Note that the ESO's analysis does not show existing connections for offshore wind farms; in East Anglia this includes the following wind farms: East Anglia One, Galloper, Greater Gabbard, Sheringham Shoal and Dudgeon (Figure 3: Offshore wind farms under development in East Anglia.).

101. Note that the 'year' is the date that the offshore wind farm starts operating. Construction may begin several years earlier. I.e. for an integrated approach by 2025, construction may need to start in 2022 or 2023.

Table 4: Illustrative design of the electricity network in 2050: East coast of England.

Current approach	Coordinated approach from 2030 onwards	Coordinated approach from 2025 onwards
		

Source: National Grid ESO.[105]

The main caveat to the ESO's analysis is that it would be incredibly difficult to deliver a coordinated approach for projects connecting by 2025, without delaying the connection dates for those projects. Many of the projects aiming to connect by 2025 have been under development since at least 2010, when the Crown Estate awarded leases to developers as part of the third seabed leasing round (Leasing Round 3).[106]

Some of these projects have already secured planning permission or are hoping to secure planning permission during 2021, in advance of the fourth round of the Contracts for Difference auctions due to open December 2021.[107]

Implementing a coordinated approach for these projects would require the Government to underwrite any new risks faced by project developers, including the risk of delays to the coordinated network. Otherwise, the Government risks damaging hard-won investor confidence in the UK's offshore wind sector, which would raise the cost of future offshore wind farms.

If the design of projects cannot be changed without risking major delays and cost increases, then the Government and industry can consider other measures to reduce the impact on affected communities. For example, projects can coordinate construction timelines and reduce visual impact through measure such as additional tree planting; alternatively, the Government could provide compensation.

Any coordinated approach will also need to demonstrate that it is compatible with security of supply, a concern that was raised during DECC and Ofgem's assessment of a coordinated approach in the early 2010s.[108]

To address these thorny issues, the Government established the Offshore Transmission Network Review (OTNR) in July 2020.[109] The OTNR is explored in detail in the next section.

105. National Grid ESO (December 2020). *Offshore Coordination Phase 1 Final Report.* Link. Page 20.
106. Crown Estate (2020). *Playing our part in the growth of UK offshore wind.* Link
107. BEIS (Updated April 2021). *Contracts for Difference (CfD): Allocation Round 4.* Link
108. Ofgem and DECC (March 2012). *DECC/Ofgem Offshore Transmission Coordination Project.* Link. Page 37.
109. BEIS (July 2020). *Offshore transmission network review.* Link

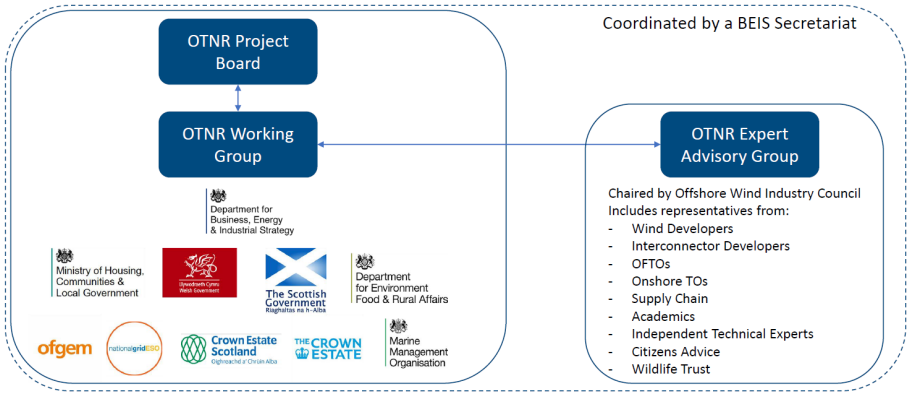
3. The Offshore Transmission Network Review (OTNR)

The benefits of a coordinated approach are now well-known; however, there are still major barriers to planning and implementing a coordinated onshore and offshore electricity network. To enable coordination, the Government, Ofgem and the ESO will need to overhaul the entire grid connections process, with knock-on impacts on marine planning, seabed leasing, consenting (planning permission), network planning, offshore wind auctions (CfDs), the delivery model for onshore transmission, and the regulation and ownership of grid connections for offshore wind farms.

Structure of the OTNR

In July 2020, the Government established the Offshore Transmission Network Review (OTNR) to bring together the various Departments, regulators and companies involved in the development of offshore wind farms and Great Britain's electricity network (Figure 9).

Figure 10: Structure of the Offshore Transmission Network Review.



Source: BEIS.[110]

The aim of the OTNR is:

> *"[To] ensure that the transmission connections for offshore wind generation are delivered in the most appropriate way, considering the contribution offshore wind is expected to make towards net-zero by 2050. This will be done with a view to finding the appropriate balance between environmental, social and economic costs".* [111]

110. BEIS (December 2020). *Offshore Transmission Network Review Webinar (17th December 2020).* Link. Page 9.

111. BEIS (December 2020). *Offshore Transmission Network Review Webinar (17th December 2020).* Link. Page 7.

This explicitly recognises the environmental and social impacts of grid connections for offshore wind farms, something that is not fully accounted for in the current approach, as described earlier in this report. The main challenge for the OTNR is to address the known weaknesses of the current system without losing its current strengths.

The OTNR must also find solutions that can reduce the social and environment impact of projects under development ('in-flight'), without risking delays or harming investor confidence. Recognising this challenge, the OTNR is split into four workstreams, each of which is developing different approaches for projects at each stage of development (Table 5). The OTNR also includes an overarching workstream that will focus on 'multi-purpose interconnectors'.

Table 5: The four workstreams in the OTNR.[112]

Workstream	Connection dates	Description
1. Early Opportunities	2026-30	Focuses on projects that are close to construction but do not yet have planning permission ('in-flight'). Any coordination must primarily rely on existing legislation and regulation, as there is insufficient time to make significant changes without risking delays. This phase could include projects that are aiming to secure CfD contracts in Allocation Round 4 (AR4), which is due to open in December 2021. For example, there are six projects off East Anglia that either have planning permission or are awaiting a planning decision.[113]
2. Pathway to 2030	2026-30	Focuses on projects that can connect by 2030 but are early enough in the development process to accommodate changes to the design of their grid connection. The workstream is likely to rely on existing primary legislation, plus some changes to Ofgem's investment approval process and possibly small regulatory changes. BEIS, Ofgem and the ESO will work with others to develop a map of likely offshore wind projects and identify priority regions for coordination. With more certainty over where projects will be built, Ofgem may be able to approve more 'anticipatory investment' in the onshore and offshore electricity network. This phase could include the 3.5 GW of projects in the Irish Sea that were awarded options-to-lease in the Crown Estate's Leasing Round 4 or options-to-lease that will be awarded in Crown Estate Scotland's upcoming ScotWind leasing round.

112. BEIS (December 2020). *Offshore Transmission Network Review Webinar (17th December 2020)*. Link. Page 43.

113. Hornsea Project Three, Norfolk Vanguard, Norfolk Boreas, East Anglia Three, East Anglia One North and East Anglia Two.

3. Enduring regime	2030 onwards	For projects connecting post-2030, the Government and Ofgem can completely redesign the development process for offshore wind farms without risking delays to projects under development. This will include changes to the seabed leasing process, consenting, network planning, ownership of grid connections and more. The workstream will require both legislative and regulatory changes. Legislative changes could be implemented through an Energy Act in 2022 or 2023.
4. Multi-purpose interconnectors	2026 onwards	Multi-purpose interconnectors (MPIs) combine connections for offshore wind farms with electricity interconnectors between neighbouring markets. MPIs could offer substantial savings and reduce onshore network infrastructure, including landing points, compared to existing approaches. However, there are significant commercial, regulatory and technical barriers to developing MPIs, which will need to be addressed by BEIS and Ofgem, working with counterparts in the EU and Norway.

There are several other recent and ongoing programmes that are either part of the OTNR or support its wider objectives. These are summarised in the Appendix.

Next steps

Over the last year, the OTNR has analysed the potential savings from coordination, sought feedback from project developers on perceived barriers to coordination and to identify potential 'pathfinder' projects, and consulted with industry to inform the design of all parts of the OTNR.[114]

During summer 2021, the OTNR is expected to consult on the Early Opportunities and Pathway to 2030 workstreams. This work will be crucial for delivering the networks required to achieve the Government's target for 40 GW of offshore wind by 2030, as set out in the Prime Minister's 10 Point Plan.[115]

In the autumn of 2021, the OTNR is expected to consult on the Enduring Regime, which is likely to require changes to primary legislation that would be included in any Energy Bill that comes forward, possibly during 2022 or 2023.

114. BEIS (March 2021). *OTNR Update (Newsletter)*. Link. Pages 1 and 2.

115. BEIS, 10 Downing Street (November 2020). *The ten point plan for a green industrial revolution*. Link

4. Policy recommendations

The UK's increasing ambition on offshore wind requires a revolution in the design of Great Britain's onshore and offshore electricity network. Some might argue that this revolutionary change can only be delivered through root-and-branch reform of the institutions that currently plan, own and operate Great Britain's electricity network.

However, experience shows that evolutionary changes can lead to a revolution in outcomes. For example, the evolution of the UK's subsidy regime for renewables, from Feed-in Tariffs (FiTs) to the Renewables Obligation (RO) and finally the Contracts for Difference (CfD) auctions, led to revolutionary changes in outcomes by putting competition at the heart of the Government's strategy.

Similarly, evolutionary changes to network planning could lead to the revolutionary changes in outcomes that are needed to avoid the disruption and higher costs caused by the current approach.

We have split our recommendations into short-term and long-term recommendations, recognising that there is a need for immediate action in advance of the legislative changes that are needed to deliver an enduring regime. These recommendations are grouped under four themes, each addressing one weakness of the current system.

Theme #1: Establish clear accountability for planning Great Britain's electricity networks.

Under the current system, there is no one individual or organisation in charge of the end-to-end planning process for Great Britain's electricity network. This makes it difficult for stakeholders to scrutinise decisions, including the Government, Parliamentarians, the public, and the electricity industry. We believe that these reforms can be delivered by focusing on the roles of the Government, through *BEIS*, the independent regulator, *Ofgem*, and the Electricity System Operator, *National Grid ESO*.

In the short term, the Government should provide more guidance to Ofgem on how to interpret its statutory duties; Ofgem's duties involve delicate trade-offs, for example between reducing costs for current versus future customers and the role that the Government wants Ofgem to play in facilitating Net Zero.

Under existing legislation, the Government can publish a *Strategy and Policy Statement* (SPS) that sets out "*the Government's strategic priorities and other main considerations of its energy policy*".[116] Ofgem would be required to take the SPS into account when planning its future work programme.

The Government held a consultation on a Strategy and Policy Statement

116. DECC (Updated March 2015). *Strategy and policy statement.* Link

in 2014-2015, but never completed the consultation process or published the SPS.[117] In the 2020 Energy White Paper, the Government committed to consult on the Strategy and Policy Statement during 2021.[118]

The Government could use the SPS to reiterate its targets for 40 GW of offshore wind by 2030; to set out its preference for a coordinated offshore network to reduce disruption to coastal and rural communities; and to set out the Government's preference to build a coordinated onshore and offshore electricity network ahead of need, including an offshore wind 'ring main'.

The guidance would help Ofgem to assess the relative importance of reducing overall costs, compared to reducing disruption for communities and the environment. These trade-offs are ultimately a political judgement; as an independent regulator, Ofgem is not well-placed to make political judgements. The SPS could also provide Ofgem with additional political cover to approve more 'anticipatory investment' in the onshore and offshore electricity network. With all investment ahead of need, there is a risk that future projects will not materialise and money will be wasted. Arguably, the risk tolerance for this type of investment is a political judgement, and hence the Secretary of State should provide guidance to Ofgem in this area.

The Strategy and Policy Statement provides an opportunity for the BEIS Secretary of State to set out his priorities through a comprehensive and accountable framework, in line with the recommendations from Policy Exchange's recent report, *Government Reimagined*.[119]

A clear vision from the BEIS Secretary of State, articulated in the Strategy and Policy Statement, could also accelerate work on the technical standards that will be needed to develop an interoperable (or 'plug and play') offshore electricity network. Any new technical standards must allow future connections to neighbouring markets through 'Multi-Purpose Interconnectors', for example in the North Sea. This vision could also act as a catalyst to develop UK supply chains and technical expertise in offshore electricity networks, including through The National HVDC Centre near Glasgow.[120]

The main risk with the Strategy and Policy Statement is that Ofgem and BEIS may start trying to tackle the same problems in different and conflicting ways. For example, if Ofgem is given an explicit mandate to deliver Net Zero, then it may be encouraged to take actions that conflict with its other duties or with Government policy.

For example, Ofgem may decide that, to deliver Net Zero, certain technologies should be exempt from paying for the use of the electricity network; higher network charges in Scotland are currently a major concern for developers of Scottish onshore and offshore wind projects.[121,122] However, any changes need to be considered in light of Ofgem's duty to protect customers by reducing costs through competitive, technology-neutral markets and by recovering costs using cost-reflective charges. Any changes may also cut across Government policy, which is sometimes technology-neutral (e.g. carbon pricing) and sometimes technology-

117. DECC (Updated March 2015). *Strategy and policy statement*. Link
118. BEIS (December 2020). *Energy White Paper: Powering our net zero future*. Link. Page 86.
119. Policy Exchange (May 2021). *Government Reimagined*. Link
120. The National HVDC Centre (undated). *Our Centre*. Link
121. Scottish Renewables (February 2021). *Electricity network charging report. Reaction*. Link
122. Renewable UK (May 2021). *"Charging the Wrong Way" report on grid transmission charges*. Link

specific (e.g. a dedicated 'Pot 2' for offshore wind in the CfD auctions). The Secretary of State should ensure that his guidance is clear in this area.

Recommendation 1: The BEIS Secretary of State should use the 'Strategy and Policy Statement' (SPS) to issue guidance to Ofgem on the Government's ambitions for a coordinated approach to developing Great Britain's onshore and offshore electricity network, including an offshore wind 'ring main' for new offshore wind farms.

In the long term, network planning will become an increasingly important part of the electricity system. Network planning is also likely to become more controversial as its impacts grow on developers of offshore wind farms and electricity interconnectors, owners of the electricity transmission and distribution networks, local communities affected by network upgrades, and the flexibility providers that provide alternatives to new power lines, for example through smart charging for electric vehicles.

In this context, it is clear that network planning must be delivered by a body that is both independent and seen to be independent (i.e. no perceived or actual conflicts of interest). Today, responsibility for network planning is split between the Transmission Owners and the Electricity System Operator, *National Grid ESO*, a legally separate business within the National Grid group of companies.[123]

The legal separation of the ESO provides assurances over its independence; however, the ESO remains part of a wider group that owns the high-voltage electricity network in England and Wales, develops and owns the majority of the UK's electricity interconnector projects, and has agreed to acquire one of Great's Britain's regional Distribution Network Operators.[124]

To address concerns over conflicts of interest, many governments and regulators have established an 'Independent System Operator' to plan and operate their electricity systems. Examples in the United States include those in New England (ISO-NE),[125] New York (NY-ISO),[126] California (CAISO),[127] Texas (ERCOT),[128] and the Midcontinent ISO (MISO).[129]

Many of these organisations have the type of enhanced planning roles that Ofgem's recent review suggested would be beneficial in Great Britain.[130] Ofgem's review also highlighted potential conflicts of interest in three areas: asset ownership; aligning the interests of the ESO's shareholders with those of billpayers; and separate frameworks for operating Great Britain's electricity and gas systems. As part of the Energy White Paper, BEIS committed to *"review the right long-term role and organisational structure for the ESO"* through a consultation in 2021.[131]

We recommend that the Government establishes a new 'Independent System Operator for Great Britain' (ISO-GB), which would take on the current operational and planning duties of National Grid ESO, plus additional responsibility for planning Great Britain's onshore and offshore electricity network; for example, there should be a new obligation on the ESO to coordinate development.

123. National Grid ESO (undated). *Who we are.* Link
124. Current News (March 2021). *National Grid to acquire WPD as it shifts from gas to a more electrified asset base.* Link
125. ISO New England (undated). *About us.* Link
126. New York ISO (undated). *What we do.* Link
127. California ISO (undated). *About us.* Link
128. ERCOT (undated). *Twitter feed.* Link. Website not accessible outside the United States.
129. MISO Energy (undated). *About MISO.* Link
130. Ofgem (January 2021). *Review of GB system operation.* Link
131. BEIS (December 2020). *Energy White Paper: Powering our net zero future.* Link. Pages 85 and 86.

Over time, the role of ISO-GB should be expanded to include the elements of the gas system, new energy vectors such as hydrogen and carbon capture and storage, and enhanced responsibility for electric vehicle charging.[132] The Government and Ofgem should also consider giving ISO-GB responsibility for the planning and operation of Great Britain's electricity distribution networks, a function that currently sits within the Distribution Network Operators (DNOs); this could be delivered by establishing regional Distribution System Operators (DSOs) as subsidiaries of ISO-GB.

The BEIS Secretary of State should issue guidance to ISO-GB, through a mechanism similar to the Strategy and Policy Statement. We believe that this strikes the right balance between Ministerial accountability and the independence of the existing ESO, which has generally served billpayers well.

Recommendation 2: The Government should establish a new 'Independent System Operator for Great Britain' ('ISO-GB'), modelled on examples in the United States and beyond. ISO-GB should have overall responsibility for planning the GB transmission network, including the responsibility to develop a coordinated onshore network.

Theme #2: Minimise disruption faced by communities and introduce compensation.

Large-scale energy projects provide national benefits but can have negative local impacts.[133] In some cases, these local impacts can be avoided, for example through placing more of the required electricity network offshore. In other cases, impacts can be reduced, for example by running the electricity cables for multiple wind farms through a single trench. Finally, impacts can be mitigated, for example through enhanced tree planting to screen new onshore substations.

The current system of network planning does not fully account for the disruption faced by local communities during both construction and operations. The current system does partially account for negative impacts through planning regulations and a preference for offshore wind farms to use underground cables rather than overhead lines. This system has had some positive results, including encouraging the proposed Norfolk Boreas and Norfolk Vanguard offshore wind farms to share a single cable route, reducing the impact onshore.[134] The current system also encourages developers to minimise disruption by using techniques like Horizontal Directional Drilling to cross under roads and railways without having to close them.[135] However, it is clear that more can be done to reduce the impact of new infrastructure on coastal and rural communities, for example by developing a coordinated offshore electricity network.

In the short term, it will be extremely challenging to implement coordination for projects that have secured planning permission or have submitted planning applications; these projects may have been under development for over a decade and will have completed expensive and

132. On the gas system, Ofgem's review of GB system operation noted that it is more difficult to separate the operation or the gas system from its ownership, in part due to safety concerns. Link. Page 96-97.
133. Offshore wind farms do of course bring a number of local benefits, including the potential for employment in manufacturing, construction and operation of the wind farm.
134. Vattenfall (Autumn 2018). *Consultation Summary Document: Norfolk Boreas Offshore Wind Farm.* Link
135. See Vattenfall (June 2019). *Norfolk Boreas offshore Wind Farm: Environmental Statement (Chapter 4).* Link

time-consuming environmental studies. Coordinated approaches may also require using different technologies, for example High Voltage Direct Current (HVDC) rather than Alternating Current (AC) subsea cables, which is an additional barrier to coordination in the short-term. Any coordinated solution is likely to require additional surveys and planning consents, which could lead to lengthy delays.

The OTNR's *Early Opportunities* workstream focuses on these 'in-flight' projects and has invited expressions of interest from project developers to participate in 'pathfinder' projects. This offer is only likely to be attractive to developers if the Government does the following:

1. Underwrites all additional costs incurred by the developers, including the cost of any delays to their projects such as lost CfD payments.
2. Allows developers to continue developing their existing proposals for their own grid connection in case the coordinated option does not materialise.

Given the potentially large costs involved in encouraging projects to coordinate, we recommend that the Government focuses only on the projects where early coordination could have the biggest benefits; the Government should focus on the East Anglia region, where there are six new offshore wind farms that are looking to connect to the onshore electricity network in the mid-2020s and where proposals include new substations and many miles of underground cables onshore.[136]

If the Government cannot convince projects to coordinate, or if it proves too expensive, then the Government should take the following steps for projects commissioning in the mid-2020s:

1. **Reduce** the impact on local residents by encouraging projects to align their construction timelines; for example, ensuring that road closures are coordinated so that key routes are not blocked for long periods. This could also include paying developers to build temporary tracks for construction traffic to avoid pinch points on rural roads and in small towns and villages.
2. **Mitigate** the impact of new infrastructure, for example through enhanced tree planting to screen new substations or accelerated remediation of construction sites.
3. **Compensate** local residents, either directly or through community payments that benefit local assets such as village halls and sports clubs (see Recommendation 4 and Recommendation 6).

136. Hornsea Project Three, Norfolk Vanguard, Norfolk Boreas, East Anglia Three, East Anglia One North and East Anglia Two.

Recommendation 3: The Government should continue to develop an 'opt-in' mechanism to coordinate late-stage offshore wind projects, focusing on the East Anglia region. For projects that agree to coordinate, the Government should underwrite developers' costs. The Government should also take steps to reduce the impact of construction, mitigate visual impacts and compensate local residents.

In some cases, it will not be possible to avoid or reduce the impacts of new electricity networks. In these cases, communities should be compensated for hosting nationally-significant infrastructure. The UK Government has already accepted this principle as part of the planned Shale Wealth Fund, which would have distributed a share of tax revenues from shale development to local communities.[137,138]

In the short term, the Government should pay this compensation rather than developers of offshore wind farms, as it would be unreasonable to levy a charge on offshore wind projects that have already secured a support contract with the Government as part of the Contracts for Difference auction.[139] In the longer-term, this compensation should take the form of 'Offshore Wind Wealth Funds' (see recommendation 6).

Recommendation 4: Where the impact of new offshore wind farms cannot be reduced, for example because projects have already secured planning permission, the Government should compensate communities impacted by the construction of offshore wind farms and associated infrastructure such as substations and cable routes.

For future projects, the Government should also ensure that negative impacts are fully accounted for by developers, the Transmission Owners, Ofgem and the ESO. Once these impacts are considered, coordinated solutions will be viewed more favourably in the network planning process.

We recommend that BEIS produces new guidance that would help Ofgem and the ESO to assess the negative impact of different connections options for offshore wind farms; this assessment should consider impacts on the environment, visual amenity and disruption to local residents, for example disruption caused by construction traffic. This assessment should be conducted at the national level, with the aim of reducing the burden of new infrastructure on the environment and local communities.

Recommendation 5: BEIS should produce new guidance that would help Ofgem and the ESO to assess the negative impact of different connection options for offshore wind farms. This guidance will provide clear direction to project developers, the Transmission Owners, Ofgem and the ESO on the value of minimising disruption to the environment and affected communities.

In the long term, the Government should establish 'Offshore Wind Wealth Funds' that make payments to local communities affected by offshore wind farms and associated onshore infrastructure. Many developers have already established voluntary 'Community Benefit Funds'; for example, the 659 MW Walney Extension project in the Irish Sea pays £600,000 per

137. HM Treasury (Updated November 2017). *Shale Wealth Fund: response to the consultation.* Link

138. The moratorium on fracking in England means that the Shale Wealth Fund was never implemented.

139. If the Government does want to put a levy on existing wind farms, then it should increase the CfD 'Strike Price' by the same amount so that investors are no worse off.

year to community projects (around £1,000 per MW per year).[140]

As Policy Exchange recommended in a recent report, *The Future of the North Sea*, the Government should make community benefits mandatory for all new offshore wind farms that participate in the Government's Contracts for Difference auctions; these community benefit funds should be called 'Offshore Wind Wealth Funds', echoing the Government's previous plans for 'Shale Wealth Funds'. We recommend that the minimum community benefit is set at £0.50 per MWh;[141] this would raise around £2,000,000 per year for a typical 1 GW offshore wind farm (£2,000 per MW per year).[142]

This proposed levy on offshore wind farms (£0.50 per MWh or approximately £2,000 per MW per year) is significantly less that the Government's recommendations for onshore wind Community Benefit Funds (£5,000 per MW per year); this reflects the reduced visual impact and disruption of an offshore wind farm compared to an equivalent onshore wind farm.

Additionally, the Government could consider new conditions in the planning regime (Development Consent Orders) that would require project developers to compensate affected communities, using BEIS' guidance on how to assess the negative impact on local communities (see Recommendation 5). The Government could also impose new obligations on developers to coordinate, for example through changes to the National Policy Statements (NPS).[143]

Recommendation 6: The Government should establish mandatory 'Offshore Wind Wealth Funds' for new offshore wind farms, as a condition of receiving support in future Contracts for Difference auctions. Offshore wind farms should pay a minimum community benefit of £0.50 per MWh (approximately £2m per year for a 1 GW offshore wind farm).

Theme #3: Establish a long-term plan to deliver a Net Zero electricity network by 2050.

The UK's Net Zero target requires long-term planning. However, under current policy, Great Britain's electricity network is only planned up to ten years ahead of time. In the old electricity system this made sense, as only small, incremental network upgrades were required to accommodate relatively slow changes in generation and demand patterns.

Today, the electricity system is changing rapidly, as coal-fired power stations close and new wind and solar projects are built across the UK; this new electricity system demands a longer-term approach, which considers the needs of both current and future projects. The network upgrades that are built today could operate for fifty years or more, so it may make economic sense to build assets now that will only be needed in five- or ten-years' time, when the Government's ambitious targets for Carbon Budget 5 and Carbon Budget 6 start to bite.

In the short term, the BEIS Secretary of State and Ofgem should jointly

140. Walney Extension (Orsted) (undated). *About the project.* Link

141. The community benefit should be per MWh of output rather than per MW of capacity because the CfD payments are per MWh. This reduces risks for project developers as the community benefit payment is 'back-to-back' with the terms of the CfD contract.

142. Assuming an average load factor of 50%. Annual payments for a 1 GW offshore wind farm = 1,000 MW * (50% * 8,760 hours/year) * (£0.50/MWh) = £2.19m per year.

143. DECC (June 2011). *National Policy Statements for energy infrastructure.* Link

request the ESO to produce a long-term plan for Great Britain's electricity network out to 2050, under a range of scenarios. The plan would help to identify high-priority projects, and to explain to the public why certain new infrastructure is required. Today it can feel like infrastructure is planned in a haphazard and suboptimal manner, which is hard to justify to affected communities.

This 30-year plan would build on the ESO's *Offshore Coordination Project*, which explored for the first time the likely impact of the UK's Net Zero target on the electricity network, and ongoing work by The Crown Estate to assess where new offshore wind farms will be built.[144,145]

A long-term plan will also help to ensure that infrastructure built now does not conflict with infrastructure that will be needed post-2030. For example, one option in the ESO's analysis suggests connecting wind farms off North Wales to the onshore network in South Wales, via a subsea electricity cable around the west coast (Table 3). Whilst this may be an optimal solution in the medium term, scenarios in the 30-year plan could assess whether this would hinder the development of floating offshore wind in the Celtic Sea off South Wales, which may be cost competitive in the long term.

To implement these changes, the ESO should increase the horizon of its various plans from ten years to thirty years. This includes the Electricity Ten Year Statement (ETYS), the Network Options Assessment (NOA), and the System Operability Framework (SOF); the ESO should also reform these processes to put more focus on a wider assessment of the environmental and social impacts of its proposals. Each of these documents is linked to the ESO's Future Energy Scenarios (FES), which also need reform.

A long-term plan would allow Ofgem and the new ISO-GB to take new approaches to the development of a coordinated onshore and offshore electricity network. For example, upgrades could be structured as a number of phased work packages to build out the network, similar to how 'Renewable Energy Zones' (REZs) have been linked to infrastructure development in markets like Texas.[146] The grid connections for the Renewables Energy Zones could be built by the incumbent Transmission Owners, developers of offshore wind farms, or allocated through competition – potentially using the existing 'OFTO' regime.

Over time it may be possible to merge the regulatory regimes and for the onshore and offshore electricity network, for example through a single competition framework. In the Energy White Paper 2020, the Government committed to legislate to allow competitive tendering for onshore networks, possibly through a 'Competitively Allocated Transmission Owner' (CATO) regime, which could act a precursor to a coordinated regulatory regime for the onshore and offshore network.[147]

144. National Grid ESO (undated). *Offshore Integration Project*. Link

145. The Crown Estate (December 2020). *New partnerships to unlock offshore energy ambitions and protect the nation's marine environment*. Link. See *East Coast Grid Spatial Study* and *Future Offshore Wind Scenarios project*.

146. NREL (May 2016). *Renewable Energy Zones: Delivering clean power to meet demand*. Link

147. Ofgem (November 2016). *Quick Guide to the CATO Regime – November 2016*. Link

The Future Energy Scenarios (FES) should be complemented by new, bottom-up approaches.

The Future Energy Scenarios provide comprehensive analysis of how Great Britain's energy system could evolve between now and 2050, depending on various pathways for technological progress, societal preferences and Government ambition on decarbonisation. The FES aims to model the entire energy system, including future deployment of electric vehicles and electric heating systems, adoption of rooftop solar, and deployment of new technologies like low-carbon hydrogen and carbon capture and storage.

This type of modelling is valuable to understand the high-level drivers of the future energy system. However, the wide scope of these scenarios means that they are not well-suited to answer the highly-granular, highly-locational questions that network planners need to answer.

The FES methodology assumes there are "no internal constraints on the GB network",[148] yet the Network Options Assessment uses outputs from the FES to assess which new network investments are required.[149] It is not completely clear how the modelling in the FES is translated to the detailed modelling in the rest of the network planning process, or whether modelling for the FES takes into account the powerful feedback effect between where networks are built and where project developers choose to build and connect their projects.[150]

We recommend that the FES is complemented by a new set of scenarios that focus more on where projects will be built, and how they might connect to the electricity network; these scenarios should include less detail on the rest of the energy system. These scenarios should also consider constraints on marine space and environmental constraints, which the OTNR will consider as part of the Enduring Regime workstream. The OTNR is already adopting bottom-up approaches by seeking to "develop a map of upcoming generation to early 2030s"; this bottom-up 'generation map' will provide a useful complement to the largely top-down Future Energy Scenarios.

The Government, Ofgem and the ESO also need to grapple with how they should use scenarios that do not meet the Government's legally-binding commitment to achieve Net Zero emissions by 2050. In the 2015 Future Energy Scenarios, only one of the four planning scenarios met the Government's legally-binding target for an 80% reduction in carbon emissions by 2050.[151] In the 2020 Future Energy Scenarios, three of the four planning scenarios met the Government's updated legally-binding target for Net Zero emissions by 2050, but one did not.[152] Given the importance of the most extreme scenarios in the network planning process (see Recommendation 8), the parties should review whether these scenarios should be given a lower weighting or considered separately.

148. National Grid ESO (revised June 2021). *FES Modelling Methods 2020*. Link. Page 16.
149. National Grid ESO (undated). ETYS 2020: *Network Development Inputs*. Link. Card 1 (Future Energy Scenarios).
150. If new power lines are substations are built, then these locations are immediately more attractive to developers of future projects.
151. National Grid ESO (July 2015). *Future Energy Scenarios (2015)*. Link. Page 5.
152. National Grid ESO (July 2020). *Future Energy Scenarios (2020)*. Link. Page 6.

Recommendation 7: The BEIS Secretary of State and Ofgem should jointly request the ESO to produce a long-term plan for Great Britain's electricity network out to 2050, under a range of scenarios. These scenarios should be bottom up and should complement the ESO's existing Future Energy Scenarios (FES).

A further barrier to long-term planning is the methodology that Ofgem, the Transmission Owners and the ESO use to assess new network projects, known as 'least-worst regrets'. This methodology is used in conjunction with the Future Energy Scenarios to assess which new network projects should be built. One downside of the least-worst regrets methodology is that the outcomes are dominated by the most extreme scenarios, which may delay the approval of new power lines that are needed for Net Zero.[153]

For example, a new power line may be required in the three FES scenarios that meet the Government's legally-binding Net Zero target but not in the one that does not. Under the current methodology, this project may be rejected because it would lead to high "regret" in the higher-emission scenario.

The Network Options Assessment (NOA) process does include additional checks to ensure that the recommendations are robust, including applying additional scrutiny to recommendations driven by a single scenario. However, in an independent report commissioned by Ofgem, a group of academics recently recommended that Ofgem treats higher-emission scenarios as "non-core".[154]

Other approaches are available, including standard probability-based scenarios that assign probabilities to individual scenarios. One reason why these approaches are not currently used is that it is difficult to apply probabilities to the wide range of possible outcomes for the future energy system. The bottom-up approaches recommended above will help (Recommendation 6). We recommend that Ofgem reviews the use of the 'least-worst regrets' methodology in network planning to ensure that it is fit for purpose to deliver a coordinated onshore and offshore grid, and to ensure that it is consistent with delivering Net Zero at least cost.

The ESO has trialled a new methodology, 'least-worst weighted regrets' (LWWR), which aims to guard against outcomes dominated by extreme scenarios.[155] This is a positive step, which Ofgem and the ESO should build on when reviewing the existing methodology.

Recommendation 8: Ofgem should review the main network planning methodology ('least-worst regrets') to ensure that it is fit for purpose to deliver a coordinated onshore and offshore electricity network and Net Zero. Ofgem should also work with the ESO to develop new approaches to assess which network projects should have the highest priority.

In the long term, there will be increasing pressure on the use of UK's seas, with more conflicts between low-carbon energy projects like offshore

153. NERA Economic Consulting (December 2016). *Methods for Planning Under Uncertainty (Cambridge EPRG Winter Conference).* Link
154. Ofgem (December 2020). *Decision making for future energy systems.* Link. Page 3
155. Ofgem (December 2020). *Approval of the 2020 Network Options Assessment methodology (letter).* Link

wind, low-carbon hydrogen and carbon capture, and traditional activities like fishing, shipping, and military radar. Additional pressure will come from the Government's ambition to increase the size and scope of the UK's Marine Protected Areas (MPAs).[156]

Without more coordination, there will be more conflicts between users of the UK's seas, which may limit the potential of the UK's seas to contribute to Government's aims on the economy, the environment, and Net Zero. These issues are explored in more detail in Policy Exchange's recent report, *The Future of the North Sea*.[157]

To address these issues, we recommend that the Government establishes a new 'UK Seas Authority' to coordinate the development of the UK's seas. This new Authority would build on existing work by the Marine Management Organisation (MMO), which is responsible for marine planning in England, and its equivalents in the Devolved Nations.

The new UK Seas Authority would also help to establish clear accountability for the planning of the UK's marine space. Today, the MMO is responsible for marine planning, but other organisations like The Crown Estate, Crown Estate Scotland and the Oil and Gas Authority also play a major role in deciding what projects are built where. As with Ofgem and the new ISO-GB, the BEIS Secretary of State should provide guidance to the UK Seas Authority through a policy statement, which should include a clear explanation of which body is responsible for each element of the marine planning process.

Recommendation 9: The Government should establish a new 'UK Seas Authority' to coordinate the development of the UK's seas across all users, including offshore wind, fishing, shipping, environmental protection and more.

Theme #4: Encourage developers to build and connect projects where they will reduce electricity bills the most.

In the long term, the Government must embed coordination in every stage of the development process for offshore wind farms, including seabed leasing, windfarm design, offshore wind auctions (CfDs), consenting (planning permission) and construction. The previous recommendations in this report would help this process by increasing accountability, fully accounting for disruption to local communities, and creating a long-term plan for Great Britain's electricity network. However, the Government and Ofgem must not ignore the potential for market signals to ensure that projects are built and connected in the places where they have the most value.

Today, grid connections for offshore wind farms are primarily designed to reduce the cost of the grid connection itself, with only relatively minor consideration given to the impact on the wider electricity network.

For example, offshore wind farms off Scotland and East Anglia are planning to connect to nearby substations on the onshore electricity network. This minimises the cost of the grid connection but is expected

156. Gov.UK (undated). *Global Ocean Alliance: 30by30 initiative*. Link

157. Policy Exchange (November 2020). *The Future of the North Sea*. Link

trigger upgrades to the onshore network that will be needed to transmit electricity to customers in urban and industrial areas. In Scotland, planned upgrades include four subsea electricity cables connecting to various places on the east coast of England.[158] In East Anglia, planned upgrades include new onshore power lines to transmit electricity to customers in London.[159] Some of these upgrades could undoubtedly have been avoided if offshore wind farm developers had a stronger incentive to connect their projects closer to customers.

The existing transmission charging regime (TNUoS) does provide incentives for developers to build and connect projects closer to customers; however, as discussed earlier in this report, we believe that the weaknesses of the current TNUoS regime will be difficult to address. Alongside trying to improve the TNUoS regime, we recommend that the Government and Ofgem reform Great Britain's wholesale electricity market.

Under current market rules, generators receive the same price for electricity across the whole of Great Britain, regardless of whether the electricity can actually be transmitted to customers; this system is known as 'national pricing'. Other pricing systems are possible, including 'local electricity pricing'.[160] With local pricing, prices rise in areas with low supply and high demand, and fall in areas with high supply and low demand.

This would lead to lower prices in areas with lots of wind farms, such as Scotland, whereas urban areas like London would see higher prices; note that these locational prices do not necessarily need to be passed on residential customers. For more discussion of this issue, please see Policy Exchange's recent report, *Powering Net Zero*.[161]

With local pricing, offshore wind farms would be encouraged to seek a grid connection closer to customers, where prices are higher. As an added benefit, new sources of industrial electricity demand would be encouraged to locate near to the UK's cheap and abundant offshore wind resources. For example, lower prices could benefit car manufacturers in Sunderland and encourage new green hydrogen production in Grangemouth, green steel production on Teesside, and new data centres on Humberside.

As part of Policy Exchange's recent report, *Powering Net Zero*, modelling by Aurora Energy Research found that regional or local pricing could save customers £2bn per year by encouraging more coordination between supply and demand.[162] Local pricing is already used in many US States, New Zealand and Singapore.

Some may have concerns that a more coordinated approach to network planning will give less choice to developers over where they build and connect their projects, thus undermining the rationale for local electricity pricing. Even if this were true, local pricing would still send strong signals to energy storage facilities, green hydrogen producers, and possibly electric vehicle owners on when to use more electricity, providing significant benefits to the electricity system. In addition, we believe that local pricing would encourage developers of offshore wind farms to work with the new ISO-GB to plan wind farms and the onshore and offshore electricity

158. National Grid ESO (January 2021). *Network Options Assessment (NOA) 2021*. Link. See Page 61, options E2DC, E4D3, E4L5 and TGDC.

159. National Grid ESO (January 2021). *Network Options Assessment (NOA) 2021*. Link. See Page 56, options AENC, ATNC, BTNO, SCD1, and TENC.

160. As known as nodal pricing.

161. Policy Exchange (December 2020). *Powering Net Zero*. Link

162. Policy Exchange (December 2020). *Powering Net Zero*. Link

network to more easily transmit electricity to urban and industrial areas. In Texas, a coordinated network (Renewable Energy Zones) has been developed in a market with local electricity pricing.[163]

Recommendation 10: To encourage project developers to build offshore wind farms in places where they will reduce energy bills the most, the Government should implement local electricity pricing in Great Britain's wholesale electricity market. This will encourage project developers to build and connect projects closer to customers.

Summary of policy recommendations

Table 6: Policy recommendations to deliver a coordinated onshore and offshore electricity network.

Theme	Time-frame	Recommendation
Establish clear accountability for network planning	Short term	#1: The BEIS Secretary of State should use the 'Strategy and Policy Statement' to issue guidance to Ofgem on the Government's ambitions for a coordinated approach to developing Great Britain's onshore and offshore electricity network, including an offshore wind 'ring main' for new offshore wind farms.
	Long term	#2: The Government should establish a new 'Independent System Operator for Great Britain' ('ISO-GB'), modelled on examples in the United States and beyond. ISO-GB should have overall responsibility for planning the GB transmission network, including the responsibility to develop a coordinated onshore and offshore network.
Minimise disruption and compensate communities	Short term	#3: The Government should continue to develop an 'opt-in' mechanism to coordinate late-stage offshore wind projects, focusing on the East Anglia region. This coordination could include sharing underground cable routes or coordinating construction timelines.
	Short term	#4: Where the impact of new offshore wind farms cannot be reduced, for example because projects have already secured planning permission, the Government should compensate communities impacted by the construction of offshore wind farms and associated infrastructure such as substations and cable routes.
	Short term	#5: BEIS should produce new guidance that would help Ofgem and the ESO to assess the negative impact of different connection options for offshore wind farms. This assessment should be conducted at the national level, with the aim of reducing the burden of new infrastructure on the environment and local communities.
	Long term	#6: The Government should establish mandatory 'Offshore Wind Wealth Funds' for new offshore wind farms, as a condition of receiving support in future Contracts for Difference auctions. Offshore wind farms should pay a minimum community benefit of £0.50 per MWh (approximately £2m per year for a 1 GW offshore wind farm).

163. NREL (May 2016). *Renewable Energy Zones: Delivering clean power to meet demand.* Link

Establish a long-term plan to deliver a Net Zero electricity network by 2050.	Short term	#7: The BEIS Secretary of State and Ofgem should jointly request the ESO to produce a long-term plan for Great Britain's electricity network out to 2050, under a range of scenarios, to guide network planning decisions moving forward.
	Short term	#8: Ofgem should review the main network planning methodology ('least-worst regrets') to ensure that it is fit for purpose for a coordinated onshore and offshore electricity network and Net Zero. Ofgem should also work with the ESO to develop new approaches to assess which network projects should have the highest priority.
	Long term	#9: The Government should establish a new 'UK Seas Authority' to coordinate the development of the UK's seas across all users, including offshore wind, fishing, shipping, environmental protection and more.
Encourage developers to build and connect projects in places where they will reduce energy bills the most.	Long term	#10: To ensure that offshore wind farms are built in places where they will reduce energy bills the most, the Government should implement local electricity pricing in Great Britain's wholesale electricity market. This will encourage project developers to build and connect projects closer to customers.

5. Conclusion

The Government's target to install 40 gigawatts (GW) of offshore wind by 2030 requires a step change in the development of Great Britain's onshore and offshore electricity networks. Without reform, there is now a significant risk that local backlash against grid connections for offshore wind farms will grow, spreading from East Anglia to North Wales, Humberside, and the east coast of Scotland.

With the right reforms, the Government can ensure that offshore wind maintains the strongest possible support across the UK, recognising that compensation should be forthcoming for those local communities that will be inevitably impact by new infrastructure, even under a coordinated approach.

As the offshore wind rollout continues, there will be plenty of opportunities for British businesses to participate, whether manufacturing of wind turbines and subsea cables, constructing and operating wind farms, or developing the new technologies that will unlock an offshore electricity grid in the North Sea. Therefore, alongside the reforms proposed in this report, the Government should ensure that British businesses have the right opportunities to win contracts, grow green jobs and expand the export potential of the UK's world-leading offshore wind industry.

Appendix: Other ongoing reviews

The following reviews are relevant to the Offshore Transmission Network Review (OTNR) and related issues raised in this report. Please note that this list is not exhaustive.

Review	Organisation	Description
Decarbonisation Action Plan.[164]	Ofgem	In February 2020, Ofgem published an action plan for an 18-month programme of work. The action plan includes work on cost-effective network for Net Zero and on 'anticipatory investment.
Interconnector Policy Review.[165]	Ofgem	In August 2020, Ofgem announced a review of its policies on interconnectors, inlcuding a review of the 'cap and floor' regime that supports investment in new interconnectors, and a workstream on Multi-Purpose Interconnectors that is highly relevant to the OTNR.
Review of GB system operation.[166]	Ofgem	In January 2021, Ofgem published a review of GB system operation. In this review, Ofgem recommended that the Electricity System Operator is given full independence from the National Grid group.
Review of GB system operation.[167]	BEIS	In the Energy White Paper 2020, the Government committed to consult during 2021 on the 'institutional arrangements governing the energy system', including system operation.
Offshore Coordination Project.[168]	National Grid ESO	In Spring 2020, National Grid ESO started a project on offshore coordination. The first phase analysed illustrative scenarios for Great Britain's electricity network in 2050 under current policies compared to a coordinated approach for connecting offshore wind farms. Phase 2 of this project is being delivered in conjunction with the OTNR.

164. Ofgem (February 2020). *Ofgem's Decarbonisation Action Plan*. Link
165. Ofgem (August 2020). *Open letter: Notification to interested stakeholders of our interconnector policy review*. Link
166. Ofgem (January 2021). *Review of GB energy system operation*. Link
167. BEIS (December 2020). *Energy White Paper*. Link. Page 85.
168. National Grid ESO (undated). *Offshore Coordination Project*. Link

Early Competition Plan.[169]	National Grid ESO	In April 2021, National Grid ESO published a plan to introduce competition for onshore networks. This plan is subject to the Government passing new legislation, which BEIS committed to as part of the Energy White Paper, published in December 2020.
Offshore Wind Evidence and Change Programme.[170]	Crown Estate, BEIS, DEFRA	In December 2020, The Crown Estate established a new programme to facilitate increase offshore wind capacity alongside environmental goals. DEFRA and BEIS are project partners. Early outputs from the project include: - East Coast Spatial Grid Study (with Aecom).[171] - Future Offshore Wind Scenarios (with Arup).[172]
Windfarm Mitigation for UK Air Defence.[173]	BEIS, MoD	Offshore wind farms can conflict with radar signals, including those used by the UK's Ministry of Defence. This competition will fund innovative solutions that could allow future offshore wind farms to coexist alongside the UK's radar systems for air defence.
The National HVDC Centre.[174]	Part of SSE Networks	Opened in 2017, the National HVDC Centre conducts research and tests High Voltage Direct Current (HVDC) electrical systems, for example those used to connect offshore wind farms to the onshore electricity network. In 2020, Ofgem approved funding for the National HVDC Centre for the period 2021-26.[175]
Ministerial Delivery Group for renewable energy projects.[176]	BEIS, DEFRA, MoD, HMT, MHCLG.	In the Energy White Paper 2020, the Government committed to establish a 'Ministerial Delivery Group' for renewable energy projects. This group includes Ministers from BEIS, DEFRA, Ministry of Defence, HM Treasury and MHCLG. This cross-Departmental working group aims to deliver a step change in coordination between Departments to remove barriers to new large-scale renewable energy projects such as offshore wind farms.

169. National Grid ESO (April 2021). *Early Competition Plan.* Link
170. The Crown Estate (undated). *Offshore Wind Evidence + Change Programme.* Link
171. Aecom for Crown Estate (April 2021). *East Coast Grid Spatial Study.* Link
172. RE News (February 2021). *Arup to scope future UK offshore wind scenarios.* Link
173. Defence and Security Accelerator (UK Government) (Updated June 2021). *Windfarm Mitigation for UK Air Defence Phase 2: Competition Document.* Link
174. The National HVDC Centre. (undated). *Our centre.* Link
175. Ofgem (July 2020). *Decision on the future of the HVDC centre following the end of NIC-funding period.* Link
176. BEIS (December 2020). Energy *White Paper.* Link. Page 47.

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