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Report

Review of GB energy system operation

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This report sets out the key findings from our review of GB energy system operation and advice to government. The aim of the review is to consider the current and future challenges facing GB system operation and assess whether we have the right governance framework in place to deliver the UK's net zero emissions targets.

In the report we consider:

- the energy system changes associated with achieving net zero;
- the roles and functions the GB electricity and gas system operators could be required to perform to facilitate net zero;
- the suitability of current system operation arrangements; and
- potential options for alternative system operation models.

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Foreword

Last month, we published our Forward Work Programme for 2021/22, which set out five strategic programmes where we believe Ofgem can deliver the greatest impact in the coming years, helping to build a greener energy system and deliver real change in the interests of consumers. This publication is a significant milestone for our strategic programme considering the energy system's institutional and governance structures to ensure they are fit for the future. It sets out our findings and recommendations to government following a review of energy system operation.

Meeting the UK's ambitious climate change goals requires a transformation across the energy system. This includes dramatic change to how we generate electricity, how we heat our homes and power our vehicles, and how our electricity and gas networks are built and operated. The scale and pace of change needed represents an unprecedented challenge for the energy system.

The UK Climate Change Committee's latest advice to government recommends that by the early 2030s, all new cars and vans and all boiler replacements in homes and buildings are low carbon and largely electric. It calls for a significant expansion in low carbon electricity supplies, with up to 125GW of offshore wind required by 2050 to meet increasing electricity demand.

The net zero targets are also an opportunity to design and deliver a much smarter, more flexible, and better integrated energy system. More effective strategic planning, management, and greater coordination across the energy system could deliver significant consumer savings by making the most of available resources and technologies.

Since privatisation, National Grid plc has played a leading role in delivering electricity and gas to energy consumers. It has had a unique dual-role in both owning electricity and gas transmission networks and being responsible for the operation and management of the wider electricity and gas systems.

The operation of the electricity and gas systems has a significant impact on consumers. Every day, the 'system operators' for electricity and gas undertake numerous actions that affect consumers' access to secure energy supplies and their energy bills. For example, the system operators use consumers' money to pay generators, or incentivise gas producers, to put the right amount of gas and electricity onto the system and in a way that maintains the stability of the networks.

The system operators also play important roles in planning the energy system. This includes forecasting what the system will look like in decades to come. These forecasts influence government policy, which can affect consumer lifestyles and how much we pay for our energy. Over time, Britain's electricity and gas system operators have developed extensive expertise, helping to make Great Britain's energy system one of the most reliable in the world.

Our review has not focused on historical performance, but rather looks ahead and considers how the current arrangements could best be adapted to support delivery of net zero at lowest cost. Significant benefit can be gained from the system operators playing an even greater role in transforming the energy system as it decarbonises, while maintaining security of supply.

We therefore recommend to government that the system operators are given additional responsibilities. This would include:

- providing independent advice to government, including on how best to achieve net zero;
- more direct planning of onshore and offshore electricity networks and the introduction of competition in network solutions; and
- a more active role in designing and planning the future energy system – in a way that maximises value for money and ensures a level playing field between different parts of the energy network and wider energy services.

A crucial part of our recommendation is that the system operator for electricity is made fully independent from the transmission network owner. We think there is also a good case for separating key gas network planning functions from the gas transmission owner and combining these planning functions with the electricity system operator as an independent body.

This body will proactively run the day-to-day operation of the electricity system and provide strategic direction to support the transition to net zero. We believe that full independence is crucial for the new organisation to make decisions that are impartial and in the consumer interest.

This recommendation is a further progression of existing policy. In 2019, the electricity system operator become a legally separate function within National Grid. The aim of this was to start to manage commercial conflicts of interest between National Grid's ownership of transmission networks and an expansion to its electricity system operation functions.

Our firm view is that full independence will be required if this enhanced role for the system operator is to be performed effectively while keeping costs as low as possible.

In coming to this view, we have considered alternative ownership and governance structures used internationally and in other sectors. We believe there are several alternatives that are better suited to delivering net zero at least cost for consumers.

We see reform of the ownership and role of the system operators as a real opportunity to bring the outstanding engineering expertise within our system operators to bear on the net zero challenge. It is a chance to create an independent body that has the power and skill to deliver a pioneering approach to managing and planning the energy transition. This body would be very well-positioned to place consumer interests at the heart of our net zero ambitions and to provide expert advice across the energy system.

We have discussed these challenges and opportunities with the senior team at National Grid, and separately with the National Grid Electricity System Operator, where the vitally important role for the system operators in achieving net zero is well understood. We look forward to working with National Grid and government to deliver the right institutional framework for net zero.

Martin Cave

Ofgem chair

Jonathan Brearley

Ofgem chief executive

Executive Summary

Background

This report sets out the key findings from our review of GB energy system operation[1] and advice to government. The aim of the review is to consider the current and future challenges facing GB system operation and assess whether we have the right governance framework in place to deliver the UK's net zero emissions targets ("net zero").

On 1 April 2019, the Electricity System Operator ("ESO") became a legally separate function within National Grid plc.[2] Legal separation aimed to minimise and mitigate conflicts of interest and better position the ESO to respond to and help facilitate the electricity system's development and transformation. We committed to reviewing the effectiveness of this separation during the course of 2020/21.

Following the net zero legislation[3] and our investigation into the 9 August 2019 power outage[4], we decided to bring forward our review of the ESO's governance framework. We also decided to broaden the scope to include gas system operation to take a whole system view of the challenges associated with the net zero targets.

Key findings

Finding 1: Net zero requires a step-change in whole system coordination and planning

Achieving the UK's legislated target of net zero emissions by 2050 represents an unprecedented challenge for the energy system and economy.[5] Radical change is required to our energy supply, how we heat our homes and power our vehicles, and how our electricity and gas networks are built and operated. The Prime Minister's recent Ten Point Plan for a Green Industry Revolution includes aims to develop hydrogen as a clean source

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[1] See Box 1 for an explanation of the energy system and the role of the system operators.
[2] Prior to legal separation, the electricity system operation role was carried out by National Grid Electricity Transmission ("NGET"), which operates and owns the transmission network in England and Wales. The ESO is now a distinct company within National Grid plc.
[3] https://www.legislation.gov.uk/uksi/2019/1056/contents/made
[4] https://www.ofgem.gov.uk/publications-and-updates/investigation-9-august-2019-power-outage
[5] In September 2019, the Scottish Parliament legislated a target of net zero emission by 2045 for Scotland, in line with advice from the UK Committee on Climate Change ("CCC"). In December 2020, the CCC updated its advice to the Welsh Government, with a recommendation for Wales to set an ambitious target to reduce emissions to net zero by 2050.

of fuel, accelerate the transition to electric vehicles and capture 10 million tonnes of carbon dioxide by 2030.[6]

The transition to net zero will fundamentally reform the physical and digital structure of the whole energy system. The electricity and gas systems are likely to become increasingly integrated as new technologies, business models and digitalisation create new links across the energy system and with heat, transport and industry. This more complex and integrated energy system is also likely to feature local approaches to developing low carbon solutions.

Current electricity and gas system functions are expected to evolve as the energy system changes and becomes increasingly integrated and new functions will emerge. Achieving net zero at least cost will require an approach to energy market development and network planning that takes the whole energy system into account.

Box 1. The energy system and the role of the System Operators

For this review, we have adopted a broad definition of the **energy system:** a system of interconnecting components that enables energy (eg electricity, gases and fuels) to be produced and supplied to end-users in homes, businesses and industry. It includes production, conversion, trading, transport and delivery.

The electricity and gas systems are part of the wider energy system. A key **role of the electricity and gas system operators** ("SO") is to ensure the respective transmission systems are operated in a secure, reliable and economically efficient way.

In GB, National Grid ESO is responsible for ensuring the stable and secure operation of the national electricity transmission system ("NETS"). Gas system operator ("GSO") functions, including operation of the National Transmission System ("NTS"), are performed by National Grid Gas Transmission ("NGGT"). NGGT is also the Transmission Owner ("TO") and operator across GB.

The **ESO and NGGT perform a wide variety of unique roles, functions and activities** including real-time operation of the electricity and gas transmission systems, efficient market facilitation and longer-term development of the gas and electricity systems. The SOs interact with a large number of different industry parties and, as natural monopolies, are subject to price control regulation by Ofgem. The electricity and gas systems are governed by separate legislative and regulatory arrangements meaning the ESO and NGGT only have roles and functions in their respective sectors.

Both the **ESO and NGGT are part of National Grid plc**, one of the world's largest investor-owned energy companies that operates in the UK and US. National Grid plc also has a range of other subsidiary companies. This includes companies that develop, own and operate electricity interconnectors between the GB and European markets, and a liquefied natural gas ("LNG") importation terminal.

[6] https://www.gov.uk/Government/publications/the-ten-point-plan-for-a-green-industrial-revolution/title

Greater coordination of network planning across the networks, competition and market facilitation across fuels are needed to make the most effective use of available technologies and resources. Key strategic decisions (eg whether green power-to-gas plants should be built beside wind farms to manage constraints and use excess renewable energy to power homes with green gas) will need to be informed by whole system insight and impartial, technical advice.

Finding 2: The system operators are uniquely positioned to play a critical role in achieving net zero

The electricity and gas SOs sit at the heart of the respective electricity and gas systems. They are natural monopolies that manage risk for consumers by applying technical expertise across a range of real-time system operation, market development and transmission network planning roles and functions.

There is a strong case for enhancing the roles and functions of the SOs to harness their position and build upon their expertise. Stakeholders interviewed for the review generally supported an expansion of current SO roles and functions to facilitate net zero.

There are important synergies between the SOs' current control room operation, market development and network planning functions. The "feedback loop" between these functions enables the sharing of information, technical knowledge and expertise vital for performing these functions effectively. This feedback loop is particularly important for the electricity system, given the dynamic and real-time nature of electricity system balancing. The significance of the feedback loop is expected to increase for both the electricity and gas systems as they become increasingly complex and integrated, and as innovative approaches, such as the use of smart grid technologies and other non-network reinforcement solutions, are trialled and rolled out.

The SOs' established expertise in real-time system operation and, to a certain extent, market development and network planning mean they are well placed to take on enhanced roles required to achieve net zero. This could include greater responsibility for the coordination, planning and design of network and market developments to bring greater efficiency to the delivery of net zero.

A body responsible for both system planning and real-time balancing would have the skills and capability to ensure the energy system develops efficiently and safely. This is particularly important for the electricity system given the dynamic and real-time nature of electricity system balancing. This body would be best placed to anticipate the challenges of new technologies, identify cross-system solutions for operating the system and proactively consider opportunities for developing energy markets and networks to facilitate them.

Developing enhanced electricity and gas SO functions to enable greater coordination and strategic alignment across the electricity and gas systems would position the SOs to better understand the interactions and effects that different elements of the energy system have on each other. The SOs could use this whole system insight and their access to relevant commercial data to efficiently plan long-term system development and provide policy advice.

Finding 3: An Independent System Operator (ISO) with enhanced functions will be required to enable and facilitate an integrated, flexible energy system

Features of the current system operation arrangements are expected to limit the SOs' ability to perform new and enhanced roles required to achieve net zero effectively. These features include potential asset ownership conflicts of interest and regulatory challenges aligning the commercial interests of the SOs' shareholders with consumer interests, which could undermine trust in the information, advice and decisions the SOs' could provide.

Stakeholders interviewed for this review agreed that current ownership arrangements particularly act as a barrier to the SOs taking on enhanced roles, principally in relation to network planning and competition.

In electricity, full independence from the TO and the wider National Grid plc corporate structure would address the asset-ownership barrier to the SO taking on new and enhanced functions which could bring significant consumer benefit.

A similar case can be made for the gas SO but there is added complexity in untangling the current fully integrated SO-TO model given certain physical characteristics of the gas system. Based upon work done to date, we think there is a good case for separating key gas network planning functions from the TO and combining in a new energy ISO. We will work with government on its forthcoming review of energy system governance to consider the appropriate roles, functions and responsibilities for a future SO, including in relation to gas.

An ISO with enhanced electricity and gas functions would create a new overarching strategic energy body. This body would be uniquely positioned to develop and apply whole system insight, make better, more coordinated decisions and enable effective optimisation across the energy system. This new body can build upon the SOs' current excellent engineering and system operation capabilities to deliver a pioneering approach to decarbonising the GB energy system.

Finding 4. We believe there are several alternatives to the current model that would be better suited to delivering net zero at least cost for consumers

Establishing an independent body with a new sense of purpose and enhanced role in leading the energy system transition would present an opportunity to deliver a GB model of system operation uniquely designed to meet the challenges of net zero.

This body should be fully independent from the TOs and potentially distortive commercial interests in energy assets. Alternative models to the current profit-distributing private limited company model should be considered. An initial review of international SO models and relevant GB sectors indicates there are several alternative models but any decision by government would require consideration of complex trade-offs. We will work with government to consider practicable options.

Recommendations

We recommend to government that the system operators are given additional responsibilities. A crucial part of our recommendation is that the system operator for electricity is made fully independent from the transmission network owner.

We think there is also a good case for separating key gas network planning functions from the gas transmission owner and combining to create a new independent energy system operator.

We will work with government on its forthcoming review of energy system governance but see considerable benefit from an ISO undertaking the following non-exhaustive functions:

- core electricity system balancing functions and establishing and reforming markets to enable electricity system balancing;
- coordinating the planning of the GB electricity network (including offshore) and developing competition for network solutions and delivery;
- make recommendations on the future capability needs of existing assets and new gas investment proposals;
- facilitate an integrated approach to the development of networks across the energy system and with other areas including heat and transport; and
- provide trusted policy advice to government on the costs and trade-offs of different low carbon pathways.

Once established, and as the energy system continues to evolve, the ISO could be given additional roles and functions.

Next steps

The BEIS Energy White Paper included a commitment to consult on system operation governance arrangements in 2021.[7] We will continue to work with government and industry to build upon our initial assessment and support the government's forthcoming review of energy system governance.

[7] https://assets.publishing.service.gov.uk/Government/uploads/system/uploads/attachment_data/file/943807/201214_BEIS_EWP_Command_Paper_LR.pdf

1. Introduction

Background

1.1. In June 2019, the UK Parliament legislated for a net zero greenhouse gas emissions target by 2050 ("net zero").[8] As highlighted in our Decarbonisation Act Plan[9], the UK has already made significant progress in decarbonising the economy but significant challenges remain.

1.2. Transforming the ways in which we heat our homes and power our vehicles will require radical changes across the energy system. For this review, we have adopted a broad definition of the energy system: a system of interconnecting components that enables energy (eg electricity, gases and fuels) to be produced and supplied to end-users in homes, businesses and industry. It includes production, conversion, trading, transport and delivery.[10] Net zero requires fundamental change across all these components in particular to our energy supply, how our electricity and gas networks are built and operated and the approach to maintaining reliable operation of an increasingly complex system.

1.3. Realising this transformative change will require existing energy system functions to evolve and reflect a greater breadth of system interactions and system change requirements. New functions are already emerging and will need to be undertaken by those with the right expertise and capabilities and with consideration given to synergies with existing system functions. In line with this, the UK Government's Department for Business, Energy and Industrial Strategy ("BEIS") published on 14 December 2020 an Energy White Paper that considers the institutional arrangements governing the energy system.[11]

1.4. As the regulator, our aim is to facilitate a path to net zero at the lowest cost to consumers within the context of government policy. Broadly, we will work to put in place

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[8] Net zero surpasses the UK's prior commitment to an 80% reduction on 1990 emissions levels. https://www.legislation.gov.uk/uksi/2019/1056/contents/made In September 2019, the Scottish Parliament legislated a target of net zero emission by 2045 for Scotland, in line with advice from the UK Committee on Climate Change ("CCC"). In December 2020, the CCC updated its advice to the Welsh Government, with a recommendation for Wales to set an ambitious target to reduce emissions to net zero by 2050. https://www.theccc.org.uk/wp-content/uploads/2020/12/Advice-Report-The-path-to-a-Net-Zero-Wales.pdf
[9] https://www.ofgem.gov.uk/system/files/docs/2020/02/ofg1190_decarbonisation_action_plan_revised.pdf
[10] In referring to the 'energy system' in this review, we are specifically referring to the gas and electricity sectors within the wider system unless specified.
[11]https://assets.publishing.service.gov.uk/Government/uploads/system/uploads/attachment_data/file/943807/201214_BEIS_EWP_Command_Paper_LR.pdf

the market arrangements and network regulation that supports the Prime Minister's Ten Point Plan for a Green Industrial Revolution.[12] Our Decarbonisation Action Plan, published in February 2020, set out the priority actions we would take over the following 18 months. The Action Plan highlighted the key role the electricity and gas system operators ("SO") will play in enabling the transition to net zero.

1.5. On 1 April 2019, the Electricity System Operator ("ESO") became a legally separate function within National Grid plc.[13] Legal separation aims to minimise and mitigate conflicts of interest and better position the ESO to respond to and help facilitate the electricity system's development and transformation. We committed to reviewing the effectiveness of ESO legal separation during the course of 2020/21.

1.6. Our investigation into the power outage of Friday 9 August 2019 underlined the importance of having a proactive SO that is able to adapt to the complex and changing world in which it operates.[14] In light of our findings and the net zero challenge, we decided to begin our review of the ESO governance framework in February 2020 and broaden the scope of this review to assess both gas and electricity system operation.[15]

1.7. Our recent consultation on Ofgem's Forward Work Programme for 2021/22 further highlights our desire to support government in developing a clear view of areas for potential institutional reform, grounded in the changes we are seeing across the energy system.[16]

Purpose and scope

1.8. Our review considers the current and future challenges facing GB system operation and assesses whether we have the right governance framework in place to deliver net zero

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[12] https://www.ofgem.gov.uk/publications-and-updates/ofgem-response-prime-minister-s-ten-point-plan-green-industrial-revolution
[13] National Grid plc is an investor-owned electricity and gas company. In the UK, its businesses include ownership of the GB electricity and gas transmission networks as well as the operation of those networks. Legal separation was achieved through agreement with National Grid plc to transfer the system operation activities and associated parts of the licence from National Grid Electricity Transmission plc (NGET) to a newly formed company, National Grid Electricity System Operator (NGESO).
[14] https://www.ofgem.gov.uk/publications-and-updates/investigation-9-august-2019-power-outage
[15] https://www.ofgem.gov.uk/publications-and-updates/ofgem-review-gb-system-operation-terms-reference
[16] https://www.ofgem.gov.uk/publications-and-updates/forward-work-programme-202122-consultation#Point 8: energy system governance

at least cost to consumers. Its purpose is to provide advice on the system operation framework to government who would make decisions that involve legislative change.

1.9. The scope of the review covers:

(i) the energy system changes required to achieve net zero;

(ii) the roles and functions the GB electricity and gas SOs could be required to perform to facilitate net zero;

(iii) the suitability of the current arrangements for the future system operation requirements we have identified; and

(iv) potential options for alternative system operation models.

1.10. This review is focused on the transmission SOs. Distribution system operation ("DSO") functions and arrangements are not included within the scope and decisions on these issues are being considered elsewhere. However, as noted in Section 2, it will be important to consider the adaptability of alternative SO models to any future DSO models to identify arrangements that may better unlock the benefits to the whole system from better coordination and planning.

1.11. This report provides an overview of the key findings from our review and advice to government on how the system operation arrangements should evolve to facilitate net zero at least cost. It is structured as follows:

1.12. Sections 2 to 5 provide an assessment of the suitability of current system operation arrangements for the challenges presented by net zero.

- Strategic context – Section 2 sets out relevant context for reviewing GB system operation arrangements and explains how this review aligns with and relates to wider decarbonisation policy and other large change projects.
- Net zero system changes – Section 3 reviews the system changes required to deliver net zero across the energy system.
- System operator roles for net zero – Section 4 sets out the current roles and functions of the SOs and examines how these could change to meet the system change requirements identified.
- Assessment of the current arrangements – Section 5 assesses the suitability of the current arrangements including governance and

ownership interests of the current SOs for enabling the SOs to perform the net zero roles identified.

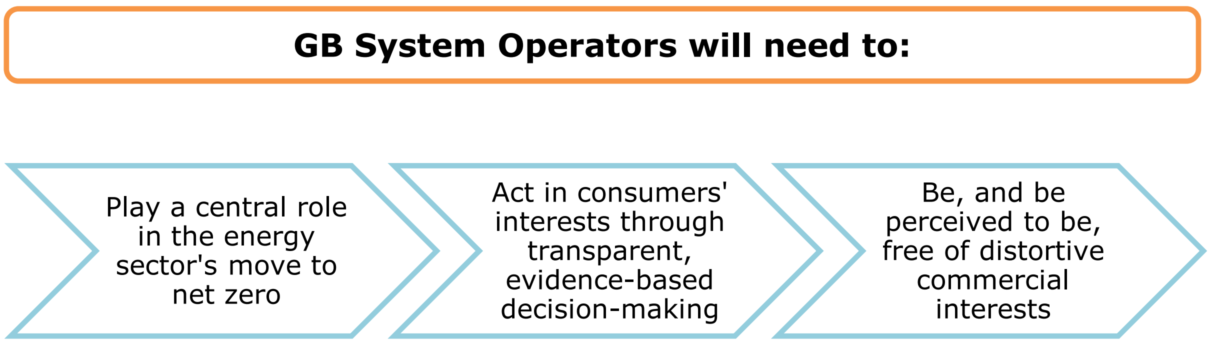
(1) Sections 6 and 7 provide an initial assessment of alternative SO models.

- SO remit and separation from National Grid plc – Section 6 identifies and qualitatively assess options for separating SO roles and functions from National Grid plc.
- High-level SO design – Based on the findings from Section 5 and 6, Section 7 identifies potential organisational design models and design parameters important for future system operation.

Approach

Principles for future system operation

1.13. The emergence of new energy system functions creates an opportunity for the SOs to take on a much more central role in facilitating net zero. We have identified the following three guiding principles for future GB system operation which we have used in assessing current arrangements and identifying viable alternatives:



The evidence base

1.14. We used the ESO Future Energy Scenarios and Committee on Climate Change emissions scenarios, and other reputable sources, to identify likely changes to the gas and electricity systems.

1.15. We gathered insight through over 30 interviews with industry experts and stakeholders[17] in GB on:

- the roles, performance and drivers behind the approach of the current SOs;
- how the roles and functions of GB SOs could change, in particular to facilitate net zero at lowest cost to consumers;
- whether changes to current governance arrangements are required to facilitate any changes to roles and functions; and
- the associated benefits, opportunities and risks of changes identified.

1.16. We used our experience of regulating the current SOs to review the effectiveness of the current arrangements, as well as the interviews, based on the expected nature of future SO roles and functions. We also commissioned FTI Consulting to assess the possible magnitude of potential conflicts of interest in the current SO arrangements in light of the system and network changes required to deliver net zero, and to assess options for alternative arrangements that could mitigate any potential conflicts identified.[18]

1.17. We identified alternative SO models through a review of international comparators and organisations in other relevant sectors within GB. We carried out over 10 interviews with representatives from a range of these organisations and their regulators to identify key design parameters and inform our assessment.

1.18. We tested our approach and key findings with Ofgem's Academic Panel, and commissioned papers from academics with specific expertise in energy system operation and governance to inform our review.

Your feedback

1.19. We believe that feedback is at the heart of good policy development. We are keen to receive your comments about this report. We'd also like to get your answers to these questions:

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[17] List of participating organisations and individuals at Appendix 1.
[18] FTI Consulting's report is published at Annex 1.
https://www.ofgem.gov.uk/publications-and-updates/review-gb-energy-system-operation

1. Do you have any comments about the overall process of this report?
2. Do you have any comments about its tone and content?
3. Was it easy to read and understand? Or could it have been better written?
4. Are its conclusions balanced?
5. Did it make reasoned recommendations for improvement?
6. Any further comments?

Please send any general feedback comments to SOreview@ofgem.gov.uk

2. Strategic context

Section summary

This section sets out relevant context for reviewing GB system operation arrangements and explains how this review aligns and relates to wider decarbonisation policy and other large change projects.

Changes to the SO framework

ESO separation

2.1. We committed to reviewing the effectiveness of the ESO's separation during the course of 2020/21. We assess the suitability of the current arrangements (including the current separation of the ESO) in light of its recent separation. However, our review is forward looking and considers whether the current arrangements are effective in the context of the future roles and functions the SOs could perform.

RIIO-2 price control

2.2. Since early 2011, we have developed incentives for the SOs, transmission owners ("TO") and distribution network operators ("DNO") in line with our RIIO (Revenue = Incentives + Innovation + Outputs) framework. On 8 December, we published our Final Determinations for the RIIO-2 price control following consultation.[19] For the ESO, we will keep the same broad structure for incentives as for the system operation aspects of the RIIO-1 incentives but with a number of planned improvements to encourage the ESO to be flexible and reactive to changing system priorities. As the gas SO roles are carried out by the Gas Transmission Owner ("GTO"), its outputs and funding are covered by National Grid Gas Transmission's[20] ("NGGT") price control. Where possible, we have taken the changes

[19] https://www.ofgem.gov.uk/publications-and-updates/riio-2-final-determinations-transmission-and-gas-distribution-network-companies-and-electricity-system-operator The RIIO-2 price control for the electricity and gas TOs and the Electricity System Operator ("ESO") will cover the five-year period from 1 April 2021 to 31 March 2026.

[20] National Grid Gas plc

proposed for RIIO-2 (as set out in our Final Determinations) into account in assessing the current arrangements and the status quo option for SO models.[21]

Recent events

9 August 2019 power outage

2.3. We committed to undertake a strategic review of GB system operation to consider whether further improvement is required to the ESO's structure and governance framework to meet the challenges of the energy transition, following our investigation into the 9 August 2019 power outage. This review meets that commitment and we have used lessons learned from our investigation into the outage to inform our assessment of current SO arrangements.

Spring and summer 2020 balancing costs

2.4. The GB electricity system has seen an increase in balancing costs in spring and summer 2020, coinciding with the onset of the COVID-19 pandemic. Lower demand (as a result of COVID-19 lockdown restrictions) during periods of high wind and solar generation could be representative of a future where an increasing level of power supply comes from intermittent, low inertia renewables.

2.5. In August, we set out our intention to review the high balancing costs and identify lessons. Given the timing and scope of that review, we have not considered the specific lessons from it in this report. However, the period under review provides evidence of the role of the ESO becoming increasingly challenging and underpins the need for a proactive ESO that can adapt to complex system changes.

[21] As noted in the Final Determinations, if this review (or any subsequent review) results in the government deciding to make changes to the current model for system operators, then we may need to reconsider the suitability and effectiveness of RIIO-2 price control arrangements for any affected companies, which could lead to key parameters of the settlement adapting.

Wider changes to energy system roles and functions

Net zero and Ofgem's Decarbonisation Action Plan

2.6. This review considers GB system operation within the context of the likely system requirements for decarbonising our energy, transport and heat systems by 2050. We have applied our Decarbonisation Action Plan's vision for the SOs to our consideration of how their roles and functions will need to evolve. The review provides initial advice to government to inform its forthcoming review of energy system governance.

BEIS - Ofgem consultation on reforming the energy industry codes

2.7. The joint BEIS and Ofgem work on reforming energy industry codes aims to ensure there is effective and agile governance of the technical and commercial rules underpinning the energy system. In July 2019, BEIS and Ofgem published a joint consultation proposing changes to the energy codes governance framework.[22] The consultation identified new functions under the codes and sought views on whether existing or new organisations are best suited to these new functions, including the System Operator. We have been considering responses[23] and plan to consult further jointly with BEIS on detailed proposals for reform this year.

The development of Distribution System Operation ("DSO") functions for RIIO-ED2

2.8. In our July Sector Methodology consultation, we proposed to introduce a suite of reforms to define and regulate how DNOs deliver DSO functions.[24] However, we are keeping the case for separation of DSO functions from DNO functions under review and maintaining an approach that keeps the opportunities for various separation pathways open. This includes identifying arrangements that may better unlock the benefits to the whole system from better coordination and planning.[25]

[22] https://www.gov.uk/Government/consultations/reforming-the-energy-industry-codes
[23] *https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/943756/reforming-energy-code-summary-responses-.pdf*
[24] https://www.ofgem.gov.uk/publications-and-updates/riio-ed2-sector-specific-methodology-consultation
[25] We have also proposed a reopener to allow for changes associated with any future reform decisions.

2.9. Any review of institutional arrangements for DSO functions may lead to changes to current ESO and DNOs' roles and responsibilities. This review does not make recommendations on future DSO roles and functions. However, it will be important to consider the adaptability of alternative SO models to any future DSO models, to identify arrangements that may better unlock the benefits to the whole system from better coordination and planning. As noted in Section 4, net zero system change requirements may lead to the SOs taking on new DSO-related market development functions and playing a greater role in the coordination of industry codes and standards.

BEIS Offshore Transmission Network Review

2.10. In July, the UK Government announced a review of the offshore transmission regime.[26] The review aims to ensure that connections for offshore wind are delivered in the most appropriate way, considering the increased ambition for offshore wind to achieve net zero.[27] The review brings together key stakeholders including Ofgem and the ESO. We are working to understand where we can make changes to the existing regime, and to advise government within the review on how to deliver a framework for greater coordination in the development of the offshore transmission system to ensure delivery of 40GW of offshore wind by 2030.

2.11. We have supported the ESO's study on the options analysis for a more coordinated offshore network. We have taken the expected timings of these outputs into account in considering potential future functions of the ESO.

Independent review of electrical engineering standards and the Energy Data Task Force

2.12. The Energy Data Task Force published recommendations on the use of energy system data in June 2019.[28] In July 2019, BEIS and Ofgem jointly commissioned an independent review of electrical engineering standards, which reported in December

[26] https://www.gov.uk/Government/publications/offshore-transmission-network-review
[27] In December 2019, the UK Government increased its target for installed offshore wind energy to 40GW for 2030, while the current approach to designing and building offshore transmission was developed when offshore wind was a nascent sector.
[28] https://es.catapult.org.uk/reports/energy-data-taskforce-report/

2020.[29] We take these recent reviews into account in considering the SOs' current and potential future roles.

[29] https://www.gov.uk/Government/publications/electrical-engineering-standards-independent-review

3. System changes required to deliver net zero

Section summary

This section identifies the key energy system changes required to achieve net zero across the energy system. It provides:

- an overview of the system changes required to deliver net zero as identified from a literature review;
- the key requirements for enabling the system changes identified; and
- two case studies of interlinked system changes and requirements relevant to future system operation.

Our key conclusions are:

- The transition to net zero will fundamentally reform the physical and digital structure of the whole energy system and will require a much more integrated energy system.
- This more complex and integrated energy system is also likely to feature local approaches to developing low carbon solutions.
- Current electricity and gas system functions will evolve as the energy system changes and becomes increasingly integrated. New functions will emerge and should be undertaken by those with complementary expertise and capabilities.
- Greater coordination of network planning across the system (eg across transmission and distribution, onshore and offshore and electricity and gas), competition and market facilitation across fuels are needed to make the most effective use of available technologies and resources.
- Key strategic decisions will need to be informed by whole-system insight and impartial, technical advice.

Introduction

3.1. Achieving the UK's net zero emissions target whilst keeping costs and disruption to a minimum will require an ambitious and innovative approach to decarbonisation. While significant transformation is required across all parts of the energy system, the pathway for achieving this is highly uncertain.

3.2. A wide range of organisations have published reports that assess scenarios for decarbonisation pathways and net zero outcomes. The reports largely call for widesweeping change across the power, heat and transport systems. The commonalities between the publications relate to what is needed to achieve net zero and anticipated system changes, as opposed to the potential decarbonisation pathways and net zero outcomes.

3.3. We have reviewed this literature to identify the system changes and system change requirements essential for delivering a net zero energy system. The reports referenced provide a range of views from a relevant cross-section of expertise on the energy system.

Box 3.1. The energy system, an energy vector and an integrated energy system

For this review, we adopt a broad definition of the **energy system:** a system of interconnecting components that enables energy (eg electricity, gases and fuels) to be produced and supplied to end-users in homes, businesses and industry. It includes production, conversion, trading, transport and delivery.

An **energy vector** is a medium for carrying and transferring energy – examples include electricity and fuels and gases such as natural gas, hydrogen and biomethane. Materials and structures for transporting and storing energy such as wires, pipes and batteries, as well as technologies for converting energies between vectors (eg electrolysers) are not vectors, even though they are essential in ensuring an efficient and reliable energy system.

In this report, references to an **integrated energy system** represent a future energy system that is connected across the electricity and gas systems, across vectors (eg between electricity and hydrogen) and to different areas such as transport and heat.

Existing links between the electricity and gas systems and interactions between the energy system and other areas such as heat and transport will increase as we make progress in decarbonising our economy. For example, electricity is increasingly being used as a substitute for powering vehicles. The gas system also provides storage and flexibility for the electricity system with this currently provided by combined cycle gas turbines ("CCGT") plants. In the future, other technologies such as electrolysers have the potential to create hydrogen gas from renewable electricity at-scale.

Net zero system changes

3.4. We have identified nine consistent themes across the literature in terms of the likely energy system changes and technologies associated with the transition to net zero. Figure 3.1 provides an overview of the themes across the literature. Additional information on the themes is provided in Appendix 2.

Figure 3.1.Net zero system changes and technologies

System change requirements

3.5. To deliver the energy system changes required for net zero at least cost, a number of key actions and mechanisms ("system change requirements") will be required to manage uncertainty and complexity throughout the transition. We have identified a number of recurring themes in the literature that represent non-exhaustive requirements for delivering the system changes set out in Figure 3.1. These change requirements are set out in Table 3.1.

Table 3.1. System change requirements

Change requirements	Definition
System adequacy and operability	The ability of a system to meet operability requirements through the availability (or "adequacy") of assets sufficient to cover peak demand accounting for uncertainty (eg loss of load events) for a given security of supply standard.
Increased flexibility	The modification of energy generation and/or consumption patterns in response to a signal (such as a change in price) to provide a service within the energy system.
Adaptive testing	The trialling of a number of small-scale solutions to specific problems and using stakeholder feedback to iterate and improve.
Consumer engagement	Seeking and integrating the views of end users to ensure that the energy transition meets their needs and facilitate required consumer behavioural changes.
Coordination and collaboration across an increasingly integrated energy system	Effective coordination and planning across an increasingly integrated energy system (see Box 3.1). This includes increased coordination between: • offshore and onshore transmission networks • national transmission and regional distribution networks and • vectors and systems via connecting technologies.
Access to open and transparent data	The need for entities (in particular companies) across the system to open up their data to enable others to offer services that reduce balancing costs and minimise the need for new investment in generation and network infrastructure.
Early policy decision-making and a supportive regulatory framework	The need for strategic leadership and government decision-making that is able to: • facilitate proactive system change and reduce uncertainty over the decarbonisation pathway • provide the right incentives and financial support through the regulatory framework (including taxes and subsidies) • provide strategic direction that encourages timely investment in and uptake of key solutions, • allows for synergies between decarbonisation issues • minimise the scope for stranded assets, and • continues to provide a resilient, reliable and cost effective energy system to service the needs of future consumers as we transition to net zero.

3.6. The two case studies below emphasise the importance of these system change requirements when considering the future of system operation. Appendix 2 provides additional detail on the system change requirements.

Case study 1: System adequacy and operability

3.7. Maintaining the reliable operation of the energy system will become an increasingly challenging and complex function as we transform our energy supply. The net zero literature consistently indicates the need for a sizeable increase in electricity generation capacity over time (see Figure 3.2). A high proportion of this capacity is expected to be intermittent wind and solar generation.

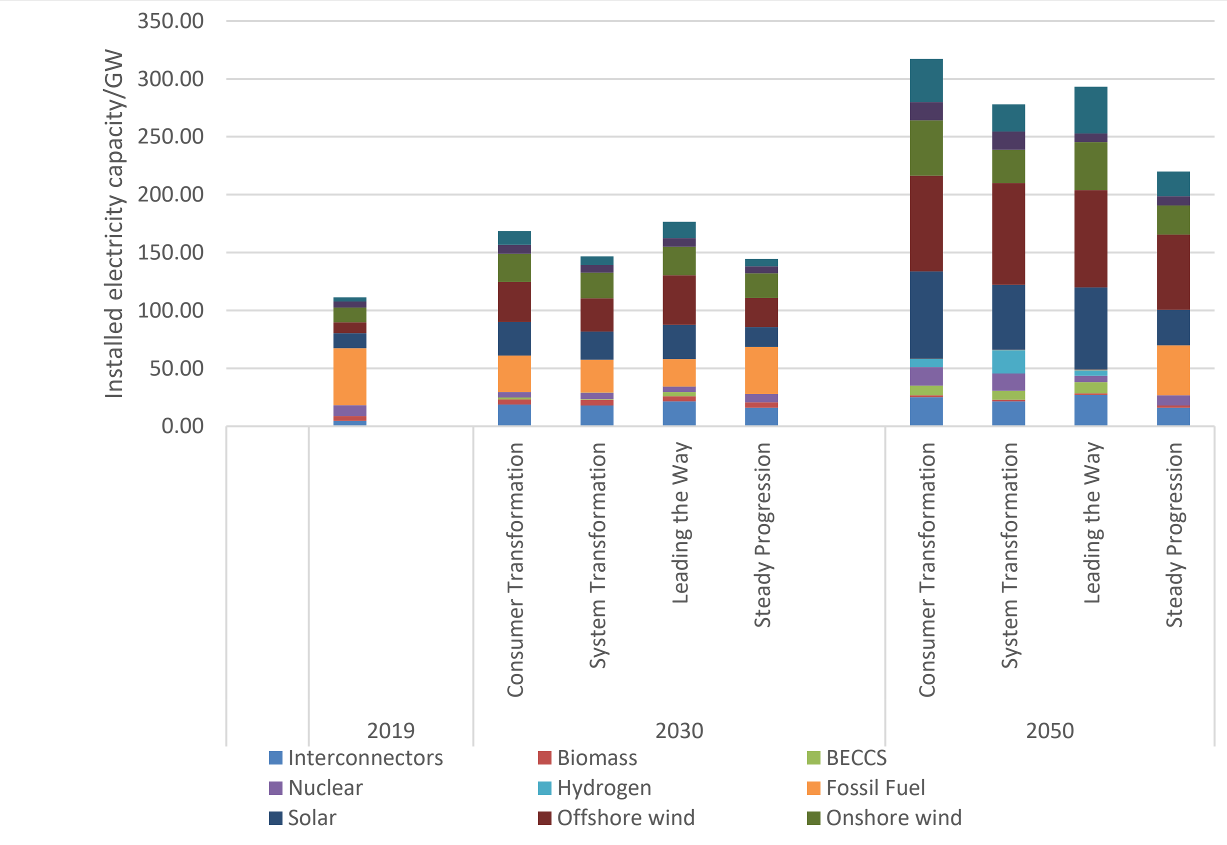
3.8. Balancing an electricity system with a high proportion of intermittent, renewable generation already presents a significant challenge, which has contributed to a significant increase in electricity system balancing costs between 2015 and 2020 (see Figure 3.3). Cost-effective management of an increasingly complex and renewable power system will play an important role in achieving net zero at least cost. Enhanced approaches to system operation that make use of new data and digitalisation opportunities to manage this complexity in a transparent way are expected to play a key role in transforming our energy supply at least cost.

3.9. Low carbon flexibility will be a key component of a net zero system. Existing market arrangements may need to evolve and innovate to enable a flexible but resilient resource mix and support efficient system balancing. Current flexibility is provided by a range of sources, with the largest being carbon intensive Combined Cycle Gas Turbines ("CCGT"). However, a large fleet of unabated CCGTs is not consistent with achieving a net zero power system. There could be significant consumer benefit in developing new long-term approaches to planning how the necessary increase in low carbon flexibility can be incentivised to enable more efficient energy balancing.

3.10. Many different solutions could be employed to provide low carbon flexibility such as: installing transmission network infrastructure, large scale electricity storage assets such as pumped hydro storage, or the generation of hydrogen via electrolysis, developing energy intensive industries such as steel that can utilise surplus renewable energy, or smaller scale technologies such as electric vehicles and demand side response.

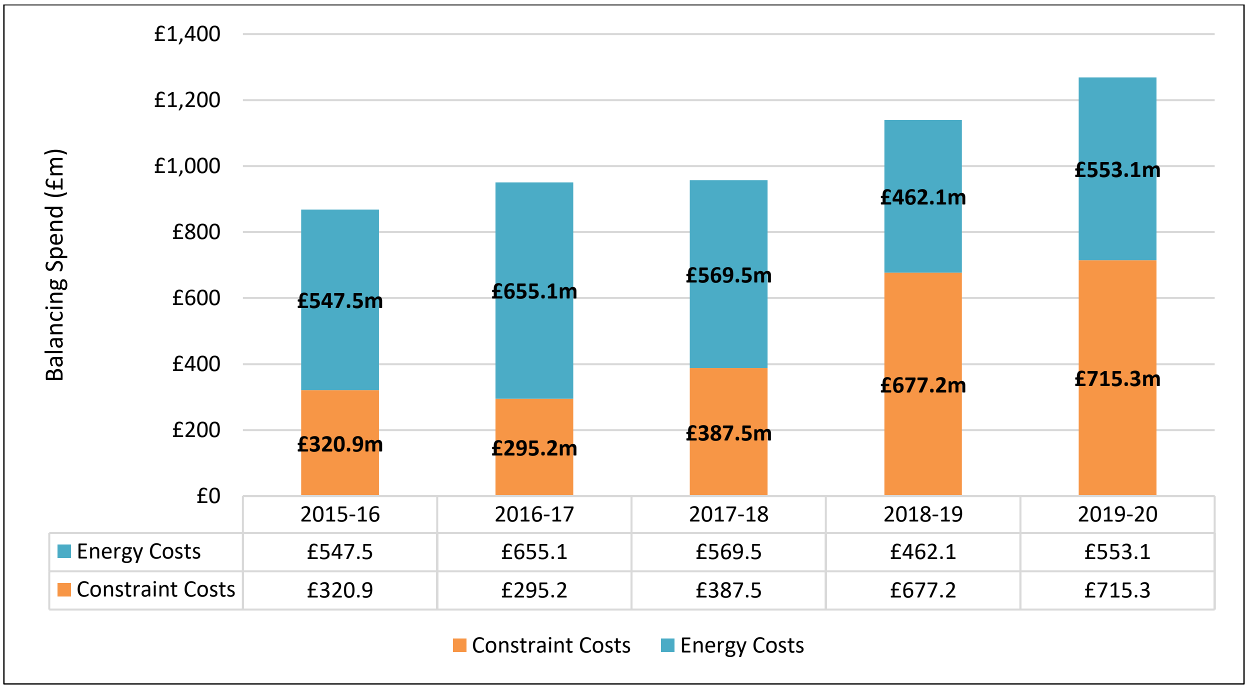
3.11. Evidence-based assessments, free of real or perceived conflicts of interest, will be needed to identify the most appropriate solutions (in different places and at different times) to reduce whole system costs. These assessments will require the development of whole system insight (see para 3.14) and greater coordination across traditional system boundaries to enable effective optimisation across the energy system. Decisions could then be brought forward through an appropriate balance of technology-neutral markets and more targeted interventions.

Figure 3.2 Future Energy Scenarios installed electricity capacity for 2019, 2030 and 2050



Source of capacity	2019	2030				2050			
		Consumer Transformation	System Transformation	Leading the Way	Steady Progression	Consumer Transformation	System Transformation	Leading the Way	Steady Progression
Storage	3.8	12.0	7.4	14.0	6.4	37.3	23.5	40.5	21.3
Other renewables	5.3	7.5	6.7	7.5	6.2	15.8	15.7	7.3	8.0
Onshore wind	12.6	24.5	22.3	24.6	21.2	47.7	28.8	41.5	25.3
Offshore wind	9.5	34.4	28.6	42.8	25.4	82.7	87.9	84.0	64.7
Solar	13.0	29.0	24.4	29.6	17.1	75.4	56.2	71.1	30.8
Fossil fuels	49.2	31.6	28.5	23.7	40.5	0.1	0.2	0.5	43.2
Hydrogen	0.0	0.0	0.3	0.2	0.0	7.1	20.3	4.8	0.0
Nuclear	9.3	4.6	5.2	4.6	7.1	15.9	14.7	5.5	8.8
BECCS	0.0	1.8	0.6	3.6	0.0	8.4	7.8	9.6	0.0
Biomass	4.2	4.5	5.1	4.6	4.9	1.7	1.5	1.3	2.1
Interconnector	4.8	18.7	17.9	21.5	15.9	25.1	21.5	27.2	15.9

Figure 3.3. Increasing system balancing spend between 2015/16 and 2019/20[30]



Case study 2: Coordination and collaboration across an increasingly integrated energy system

3.12. The physical structure of the energy networks in 2050 will look radically different from today. From 2030, the energy system will become increasingly integrated (see box 3.1). New technologies, such as electrolysis[31], are expected to create new, more dynamic interactions between the electricity and gas systems. The energy system is also expected to increasingly couple with heat, transport, hydrogen and carbon capture use and storage ("CCUS") (see Figure 3.4 below).

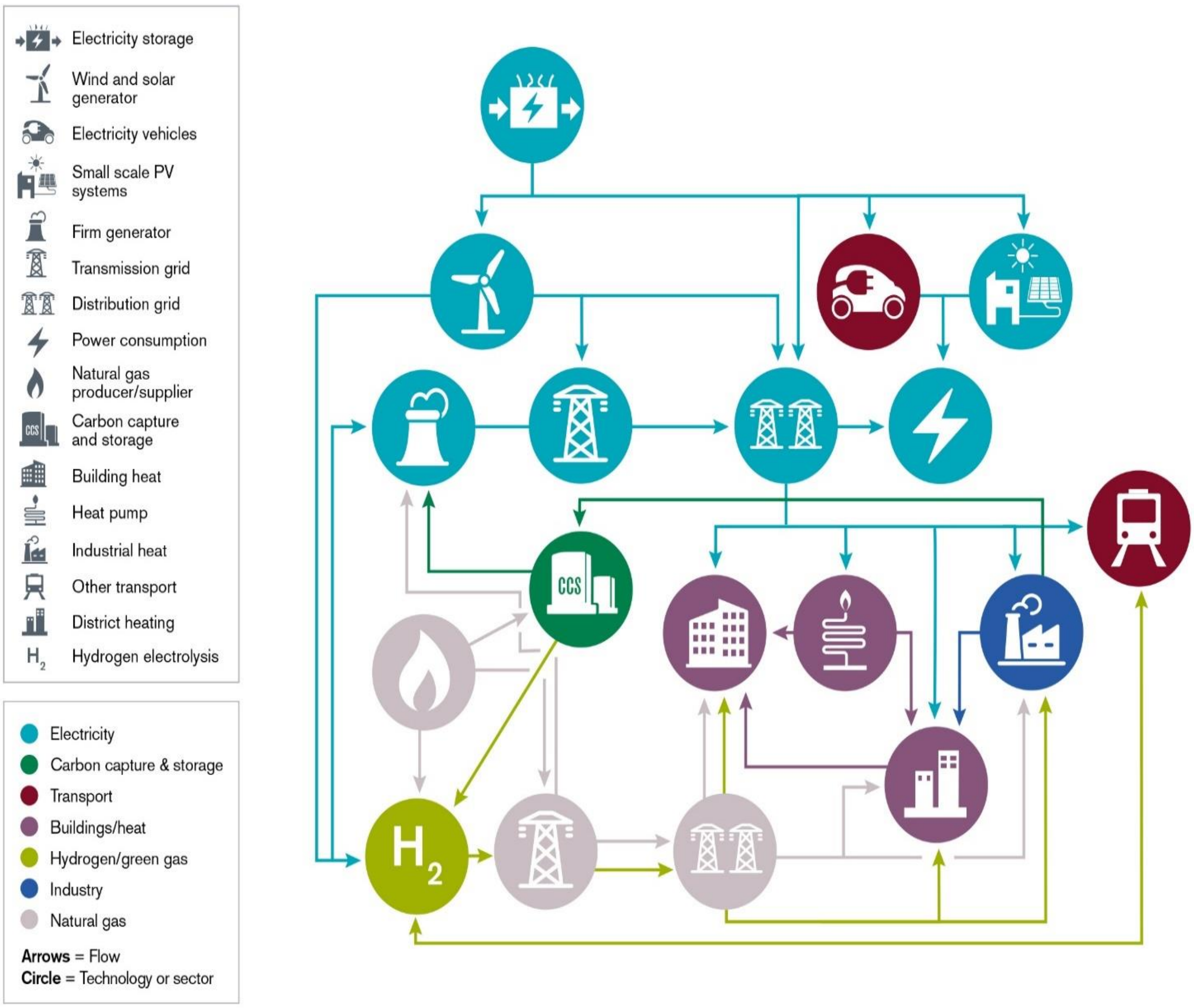
3.13. An integrated energy system will increase the complexity of operational and planning challenges. Greater coordination and long-term strategic planning across different networks, fuels and vectors can help address this and promote efficient consumer outcomes from systems integration.

3.14. Effective market development and network planning across an increasingly integrated and decentralised energy system will need to consider complex interactions and

[30] Energy costs relate to balancing supply and demand. Constraint costs refer to managing network flows.
[31] Electrolysis refers to the use of electricity to convert water into hydrogen for use as a form of storage.

solutions across networks (eg transmission and distribution and onshore and offshore), across the electricity and gas systems and across energy, heat and transport. The development and application of this 'whole system insight' will be vital for enabling effective optimisation across the energy system and achieving net zero at least cost.

Figure 3.4. A potential future integrated energy system



Box 3.2. Benefits of an integrated energy system

Progress towards decarbonisation has already created significant challenges for the energy system. The growth in renewable generation has increased the supply of green electricity but has created new challenges such as an increase in balancing costs as wind and solar generation are curtailed to balance electricity demand and supply and manage the system.

The impact of the COVID-19 lockdown on the electricity system provides insight into the challenges associated with managing a future electricity system dominated by low carbon electricity. Record low demand and abundant renewable generation during lockdown led to a significant increase in balancing costs as the ESO curtailed wind and solar generation to balance electricity demand and supply. The ESO has committed to being able to operate a zero carbon electricity system by 2025.

An integrated energy system could provide the SOs with a new range of tools and services to cost-effectively balance a more dynamic energy system. These approaches will be particularly helpful in a future energy system where demand may need to be scheduled to follow supply. For example:

- Wide-spread **electric vehicle uptake** and **smart charging infrastructure** is expected to provide new opportunities for the ESO to balance the electricity system. A smart charging system and two way flows of electricity between vehicles and the electricity networks (vehicle-to-grid or "V2G") can enable vehicles to charge at periods of high renewables output/low demand and supply electricity back to the grid at times of low generation/high demand. The ESO's 2020 Future Energy Scenarios suggests that by 2050 V2G could provide up to 38GW of flexibility from 5.5 million vehicles.

- As mentioned in Box 3.1, electrolysers could be used to create hydrogen gas from excess renewable electricity at-scale. This could avoid the costs associated with curtailing renewable generation and provide green gas for heating or transport purposes. Turning up or down on command future hydrogen or heat network could also lead to new options for efficiently balancing the electricity system. Green hydrogen could also improve the economics of offshore wind by acting as additional demand when wider demand is low, thereby increasing the wholesale electricity price.

3.15. Greater coordination of market development and network planning across national transmission and regional distribution networks will be crucial for delivering the net zero target efficiently. Several net zero scenarios identify local and regional decarbonisation solutions as an important feature of a net zero energy system. National Grid's Future Energy Scenario (2020) estimates that up to 42% of electricity generation capacity could be decentralised by 2050, ie connected to the distribution networks.

3.16. Distributed energy resources ("DER") – resources connected to the distribution networks - can be used to provide local peer-to-peer services; offer grid operational services to the Distribution Network Operators ("DNO") to defer or avoid network investment; offer grid operational and system balancing services to the ESO; and participate in wholesale markets.[32] At the same time, DER is an increasingly important resource and source of flexibility for the ESO in balancing the NETS (see Box 3.3). However, without sufficient coordination between the DNOs and ESO, there are risks the ESO could call on DER in a way that creates or exacerbates a distribution constraint or over-procure to compensate for some DER being behind distribution constraints.

3.17. Increased DER, the ability for households to provide flexible, demand-side response and emerging regional solutions for decarbonising heat and transport will all have implications for the electricity transmission networks and potentially the gas transmission network. As a result, the risk and complexity of ensuring the integrity of the whole electricity and gas systems will increase. Greater coordination across these networks will be vital in ensuring local decarbonisation solutions work in the interests of the whole system and enabling optimisation across these networks (see box 3.3).

Box 3.3. Enabling DER to participate in national markets and provide services to balance the NETS

This summer the ESO developed the Optional Downward Flexibility Management ("ODFM") service. This tool allowed the ESO to manage reduced demand for electricity during times of high renewables generation (eg solar and wind) by turning off or turning down small scale renewable generation connected to the distribution networks.

With DER expected to grow as the system becomes increasingly decentralised, it will be vital the ESO has greater visibility of these resources, can send signals to the generators and can procure services from them to manage the NETS.

The ESO's current lack of visibility and ability to communicate with distributed generation meant it had to procure ODFM products at day-ahead when there is less information on the actual real-time system needs. This can lead to excess procurement to ensure system stability. This spring and summer highlighted the need for the ESO to access local markets to manage the NETS and to access services closer to real-time to more efficiently manage NETS system needs, in coordination with DNOs to ensure there is also optimal management of distribution network constraints.

3.18. More effective planning and coordination across onshore and offshore electricity transmission networks will play a key role in delivering the UK Government's target for 40GW of offshore wind by 2030 and 80GW by 2050 at least cost. These targets will require

[32] The Power Potential project between the ESO and UK Power Networks ("UKPN") is exploring these arrangements in order to develop operational procedures for the future.

a substantial expansion of the offshore electricity networks. Greater coordination and planning of the offshore networks and their connection to the onshore transmission networks can facilitate additional network capacity and new connections at lower cost.

3.19. Multi-purpose interconnectors are already being considered to link offshore wind projects with cross-border interconnectors in a way that optimises associated network build costs. Beyond this, there are opportunities to link electricity and hydrogen generation/storage offshore to optimise capacity and repurpose stranded offshore oil and gas assets. As multi-purpose interconnectors are likely to be built by several entities/more than one TO, new functions to manage competition in network delivery will be required. Harnessing the power of competition should drive down costs in network build and provide further benefits to consumers.

3.20. Gas interconnectors can also work to ensure security of supply by enabling the transportation of gas from the continent to GB. As part of the energy system transition, there may be opportunities to repurpose offshore assets to facilitate the storage and transportation of gases associated with a net zero energy system. The importance of gas interconnectors is inherently linked to how much gas GB and connected European countries use in the future. These countries will need to consider each other’s policies and practices when implementing changes that decarbonise the gas system.

3.21. Greater strategic planning of infrastructure investment across the energy, heat and transport networks could also deliver significant consumer benefit. As investment in these networks is likely to represent a significant proportion of the overall costs of achieving net zero, exploiting links between infrastructure investment needs (eg by identifying links between otherwise siloed infrastructure projects) could promote more cost-effective network infrastructure delivery.

4. System operator roles for net zero

Section summary

This section sets out the current roles and functions performed by the electricity and gas SOs and considers how they may need to evolve to meet net zero. It also considers new functions that the SOs could be well-placed to perform.

Our key conclusions are:

- The electricity and gas SOs have a unique and vital role to play in facilitating net zero.
- Real-time system balancing experience is crucial for effective energy system planning.
- There is a strong case for enhancing the roles and functions of the SOs to harness their position and build upon their expertise. Enhanced roles could include greater responsibility for the coordination, planning and design of network and market developments to bring greater efficiency to the delivery of net zero.
- Combining system operability and enhanced planning and coordination functions in an SO would create a body best placed to: anticipate the operability impacts of new technologies; proactively consider opportunities and challenges across a range of energy markets and networks; and provide technical advice across a wide range of decarbonisation issues.
- The SOs will need to develop new approaches, tools and skills and evolve existing functions, including real-time system balancing, to efficiently manage an increasingly integrated, digital and dynamic energy system.

Introduction

4.1. Current electricity and gas system functions will evolve as new technologies and business models create new interactions between different systems. New functions are already emerging and will need to be undertaken by those with complementary expertise and capabilities. Consideration will need to be given to how new functions interact with current functions.

4.2. The SOs currently perform a wide variety of unique functions and in doing so interact with a large number of industry parties. Over time, the functions of the SOs have gradually expanded from historic core functions such as real-time system balancing. This has particularly been the case for the ESO in the past decade as decarbonisation efforts have driven significant increases in renewable electricity generation.[33]

4.3. This section considers how the roles and functions of the ESO and GSO[34] could develop across the following three broad categories:

1) control room operations
2) market development and transactions, including coordination of industry codes and standards and
3) whole system insight[35], network planning and coordination.

4.4. For each category, we identify potential enhancements to current roles and new functions the SOs could be well placed to perform. Taken together, enhanced and new roles and functions represent a potential range of 'net zero roles' for the SOs. In considering future SO functions, we have not taken into account any limitations created by the existing SO ownership and governance framework.

4.5. The development of ESO roles over the last decade and insight from the decarbonisation challenges currently facing the ESO have aided us in identifying potential net zero ESO roles. There is greater uncertainty over how the gas system will decarbonise which is reflected in the gas net zero system roles and functions identified in this section.

The potential role for the SOs in facilitating net zero

4.6. The full suite of roles and functions required to deliver net zero at least cost will involve a range of skills and capabilities. These functions will be performed by multiple organisations working together across the energy sector and wider economy. In many instances, it may be more appropriate for organisations other than the SOs to take on new functions identified below. For example, the SO is one of several organisations currently

[33] For example, the ESO took on a greater delivery role as part of the UK Government's Energy Market Reform ("EMR") and a greater network planning role following Ofgem's Integrated Transmission Planning and Regulation ("ITPR") project. https://www.ofgem.gov.uk/electricity/transmission-networks/integrated-transmission-planning-and-regulation
[34] The current gas system operator (GSO) functions described in this section refer to system operation activities carried out by the GSO part of NGGT.
[35] As discussed in section 3, we consider that whole system insight and a whole system mind-set will need to consider interactions and solutions across networks (distribution and transmission and onshore and offshore), across the electricity and gas systems, and across energy, heat and transport systems.

being considered to take on emerging functions related to code governance and data standards.

4.7. Roles directly related to real-time system operation (including market design functions related to balancing services) sit naturally with the SOs given their core function of operating and managing the national transmission systems securely and economically. Enhanced functions discussed below that aim to increase the coordination of network planning and facilitate a more integrated approach to market development could, however, be undertaken by another body. For example, a new stand-alone body such as a cross-government 'Energy Agency' could be established to perform system architect-like functions or the functions of the National Infrastructure Commission ("NIC") or Climate Change Committee ("CCC") could be consolidated and expanded.

4.8. While there is no single definition for an 'Energy Agency' or a 'system architect', such a body could undertake a range of roles and responsibilities related to energy, transport and heat networks design and planning, the development of energy markets, delivering onshore and offshore electricity network competition and providing trusted advice to Ministers. As part of this, this body could take on some of the market development and network planning functions currently performed by the SOs, TOs, DNOs and others.

4.9. Interviewees generally supported an expansion of the SOs' current roles to facilitate net zero (see box 4.1. below) rather than a separate Energy Agency or system architect.[36]

Box 4.1 Interviewee views on the future SO roles and functions

The majority of interviewees supported electricity and gas SO roles and functions developing further. Specific reference was made to the need for the SOs to:

- develop a genuine whole system approach to system planning and operation;
- increase coordination with the DNOs/DSOs/gas distribution networks ("GDNs") to enable whole system optimisation;
- have a greater role in coordinated network planning;
- drive forward competition in the delivery of network and non-network solutions;
- continually evolve short-term system operation to manage increasing complexity, maximise the potential of digitalisation and enable co-optimisation across energies; and
- enable greater data sharing, collaborative thinking and knowledge transfer.

[36] Views shared by interviewees that have been used in the main report may represent personal views or commercial interests.

4.10. We consider that the SOs would be better positioned than an Energy Agency to take on new and enhanced functions beyond real-time system operation given the importance of real-time system balancing experience for effective system planning.

4.11. Keeping the electricity and gas systems safe and secure as we transition to net zero will become more complex. Long-term system planning needs to be combined with technical expertise on the physical engineering challenges of real-time system operation in order to be effective and efficient. In addition, the SOs' position at the heart of their respective systems, their daily interactions with a range of industry actors across multiple interfaces and access to commercial data would allow them to develop whole system insight and use this to effectively optimise across the energy system.

4.12. Industry experts, including those with roles in relevant National Grid plc companies, highlighted the importance of synergies between the SOs' current control room operation, market development and network planning functions (see box 4.2 below). Specific reference was made to the importance of the feedback loop between these functions which enables the sharing of information, technical knowledge and expertise vital for performing these functions effectively. The importance of this feedback loop is expected to increase as the electricity and gas systems become increasingly integrated and innovative approaches, such as the use of smart grid technologies and other non-network reinforcement solutions, are trialled and rolled out.

4.13. Combining system operability and enhanced planning and coordination functions in an SO would create a body able to anticipate the operability impacts of new technologies and cross-system solutions and proactively consider opportunities and challenges across a range of energy markets and networks. This would position the SO to provide policy makers and wider stakeholders with technical advice across a range of decarbonisation issues (see box 4.3 below). The provision of clear, technical and strategic advice to government is required to enable early policy-decisions and support a least cost decarbonisation pathway.

4.14. Separating system balancing and system planning functions could also lead to security of supply risks over time by making it more challenging to give unequivocal clarity on responsibility for system security between the SOs and an Energy Agency. The SOs would retain responsibility for securely operating the system in the short-term but the Energy Agency would be responsible for creating and developing many of the tools the SOs would need to perform this function. The closest possible feedback loop is required between

Box 4.2 The feedback loop between system balancing and system planning

Electricity system operation

Industry experts, including those with key relevant experience, viewed the ESO's direct experience and responsibility in managing operational challenges in system balancing as instructive for designing and procuring market services.

This experience was viewed as vital for developing long-term system plans which align with the physical characteristics of the system and potential future operability challenges. For example, the ESO uses information from the Electricity National Control Centre ("ENCC") on common points of congestion to inform network reinforcement recommendations in the Networks Options Assessment ("NOA"), an annual exercise in which the ESO recommends which options the transmission networks should invest in and can indicate the optimum level of interconnection to other European electricity grids.

Synergies between these functions were viewed as particularly important given the dynamic and real-time nature of electricity system balancing:

- *"System operation is intrinsically linked to system planning. System planning must be informed by the tools, information and techniques of short-term operation, particularly given the current high rate of change in the system. Having these merged together, and having common objectives avoids a lack of understanding, duplication of work and prevents the two functions moving in different directions."*
- *"In real-time, the control room operates the system securely, economically and transparently using the tools and services that the market development team have developed. This involves re-optimising and re-planning to […] ensure the ESO haven't missed operational challenges or cost-saving opportunities for consumers. The control room fed into the Pathfinders projects development to ensure operational expertise were understood, same with the NOA."*
- *"You can't divorce the two. The boundaries between the SO short-term and long-term roles don't break down very easily".*

Gas system operation

The integration of gas transmission network planning and daily balancing functions can enable NGGT to make use of information synergies and use its direct oversight and experience in system operation to inform its roles related to market development and system planning. For example, NGGT uses its knowledge of common points of faults, constraints and congestion to inform network planning and network capability assessments.

Interviewees with key relevant did not consider the information feedback loop in gas system operation to currently be as important when compared to electricity system operation. This, in part, reflects physical characteristics of the gas system and the nature of gas system operation functions. However, some industry experts viewed this feedback loop as having potential significant value which could increase as the energy system decarbonises:

One independent industry expert noted: *"There's definitely a strong feedback loop from the [gas] system operation into [gas] network planning. If you were to create some kind of separation across a shallower delivery model, the interface between the two needs to be strong. It needs to be stronger now."*

those operating the system and those creating the tools for them to do so, with minimal barriers to the flow of information.

4.15. Any mismatch in approach or timing could create serious implications for the effective delivery of security of supply. We anticipate it would be difficult to fully guarantee alignment, as it would be challenging to fully define the responsibilities of both the Energy Agency and the SOs to a level which ensures robust accountability by each. A framework for ensuring the Energy Agency was accountable for security of supply in the medium term would need to be developed, with performance potentially difficult to benchmark and measure. Splitting responsibility for security of supply in this way would represent a significant change from the status quo and has very limited international precedent. As there are important differences between the electricity and gas systems and the operation of the systems, the impact and materiality of this is expected to differ between electricity and gas system operation.[37]

4.16. Lastly, the SOs have established expertise in real-time system operation and, to a certain extent, in market development and network planning. A new Energy Agency may have difficulty in attracting the required technical expertise to perform its system-architect functions as effectively. We think there is therefore a strong case for system planning and real-time balancing functions to be performed by one body and that the SO would be best placed to perform these functions. Below, we consider how the SO's current expertise, skills and functions could evolve to support this.

[37] Differences between electricity and gas system operation may mean separating system balancing and planning functions represents less of a risk for the gas system. This reflects the unique physical characteristics of the gas system, specific gas control centre functions and the tools used for ensuring system safety and the GSO's less expansive role in facilitating gas markets compared to the ESO. These features are considered in greater detail in sections 5 and 6.

Box 4.3 Key areas in which the SOs could provide trusted, impartial advice includes:

- evolving electricity generation choices and their implications for system costs and resilience to inform government support schemes and targets;
- the trialling of new technologies and approaches, including the viability of specific decarbonisation technologies and how they will interact with the energy network (eg renewable energy sources such as hydrogen, hydrogen blending and biogases to help target government funding, trials and final policy decisions);
- technical and strategic advice on the trade-offs between electrification and hydrogen/green gases to inform the decarbonisation pathways;
- the evolution of the wider markets frameworks and making recommendations on alternative arrangements and design changes; and
- strategic network infrastructure development, including whether hydrogen should utilise an adapted national gas transmission network to support the decarbonisation of heat and transport.

Control centre operations

Key current functions

4.17. Balancing the electricity and gas systems in a safe, reliable and efficient way is a core function for the ESO and GSO.[38] While there are key physical differences between the gas and electricity systems that influence SO activities[39], the Electricity National Control Centre ("ENCC") and the Gas National Control Centre ("GNCC") carry out the day-to-day, short-term operational activities for the respective transmission systems.[40] The ESO and GSO are also responsible for providing information to market participants to facilitate informed decision-making, and for ensuring efficient operation of the system.

[38] Other key control centre functions include: coordinating with network owners on operational decisions and outage changes and network planning out to one year; in gas, managing the daily transmission capacity obligations and facilitating network access for maintenance / alarm response; short-term energy forecasting and feeding into long-term forecasting; managing and sharing system data and information; and restoration and emergency response (eg to system instability events). See Appendix 3 for additional detail on key current functions.
[39] The physical characteristics of gas and the gas transmission network means there is an inherent safety risk of over-pressurisation. If pressure gets too high, this could result in the safe operating limits of the physical pipelines being exceeded and the risk of rupture. Such an event could lead to loss of supply in a large area of direct offtakes, including GDNs. In gas, the GNCC works to maintain safe operating pressures to enable all users to put gas on and take gas off the NTS. The GSO therefore operates under a safety case supervised by the HSE.
[40] In doing so, both the ENCC and GNCC interact with the distribution networks to ensure all demand is met.

Table 4.1. Key electricity and gas system balancing actions

Electricity system balancing	Gas system balancing
• The ENCC balances the whole electricity system in real-time. • The ENCC operates the Balancing Mechanism[41] and uses ancillary services to balance the system.[42] • The ENCC can also request TOs to adjust network assets.	• The GNCC utilises linepack[43] to balance the gas system throughout the day. • The GNCC performs day-to-day operation and network control functions by utilising NGGT's assets. • The GSO and GTO operate under a single safety case supervised by the Health and Safety Executive ("HSE"). • The GSO acts as residual balancer by entering the market and undertaking trades.

Net zero system role

Enhanced SO functions

4.18. Electricity and gas control centre operations are expected to become increasingly complicated, with the challenges associated with balancing a low carbon system efficiently requiring new approaches, skills, capabilities and systems.[44] Interviewees identified two primary ways in which the SOs' control centre capabilities will need to develop to manage this increasing complexity:

- effective use of data and digitalisation and
- development of a whole system mind-set.

[41] The Balancing Mechanism is a market used to balance supply and demand on a half-hourly basis and is one of the tools the ESO uses for system balancing. The ENCC instructs market participants to increase or decrease their planned supply or demand through this mechanism, based upon system requirements and the relative costs.
[42] The ENCC instructs the utilisation of flexibility services including mandatory and procured services to ensure that the system remains operable, such as frequency response or voltage control contracts. The Ancillary Services market in GB is made up of a number of commercial services that the ESO procures from energy market participants to help balance the network. These include, for example, Short Term Operating Reserve ("STOR"), used for energy balancing, and Frequency Response, one of many services used for system balancing.
[43] Linepack describes the total volume of gas contained within the system. The acceptable range over which the amount of gas in the network can vary and the ability to further compress and expand this gas is generally referred to as 'linepack flexibility'.
[44] Figure 3.3 in Section 3 shows that in electricity, system balancing actions have increased significantly since 2014/2015. In addition, in the context of the COVID-19 pandemic, the ESO's ancillary services costs (constraint management in particular) have increased significantly in 2020 compared to the previous two years. The effects of lower demand due to COVID-19 during periods of high renewables generation on electricity system operation reflect the challenges and potential costs associated with operating a net zero energy system. Interviewees often attributed increasing complexity to greater interdependencies between electricity and gas, a greater number of stakeholders and technologies and increasing volumes of intermittent renewable capacity.

Data and digitalisation

4.19. The electricity and gas SOs currently consume and produce a large volume of data and have access to other parties' commercial data. The demands and opportunities of this will increase with the digitalisation of the energy system. The SOs will have a key role in enabling data transfers between parties and ensuring data is collected and available in sufficient detail to enhance its value and promote efficiency.

4.20. Digitalisation across the system can enable more effective and efficient system operation in real-time. Enhancing the SOs' current engineering expertise with digital expertise can enable the identification and application of innovative, non-network solutions in addressing system change requirements. Several industry experts identified data digitalisation, machine learning and artificial intelligence as opportunities for improving control centre functions, as outlined in Box 4.4 below.

4.21. A core competence of a future system operator will be the effective development and running of world class digital infrastructure.[45] Key capabilities required to support this include: highly capable, modern IT systems; new skill-sets and tools to manage, manipulate and utilise data effectively and facilitate transparency; and enhanced cyber security and protection for critical infrastructure.

Box 4.4. Advances in the use of data and digitalisation can improve:

- short-term demand forecasting, including improving weather patterns, demand curves and network energy flow predictions at a granular level as supply becomes more weather-dependent;
- pre-empting asset failures to avoid post-failure maintenance work and minimise the likelihood of disruption, as well as optimising maintenance schedules;
- managing system constraints by helping to predict and solve constraints, particularly given declining investment in natural gas network assets which manage constraints in the natural gas system;
- increasing the transparency of balancing and system management actions;
- identifying investment opportunities in community-level microgrids; and
- providing real-time data for coordinating actions and real-time operational strategies with an increasing number of market participants, networks owners and potentially SOs (eg those performing DSO functions) when performing short-term operational activities.

[45] The ESO and NGGT have put forward proposals as part of the upcoming RIIO-2 price control to further develop their capabilities required to support digitalisation.

Whole system mind-set

4.22. An increasingly integrated energy system will increase the complexity of electricity control room operations and system planning and may have similar impacts in gas.[46] Establishing an effective whole system mind-set will be a key requirement for all SO roles and functions. Interviewees identified this as a key requirement for future control centre operations, as the SOs will need to manage the energy system's increased dependence on flexibility and make effective use of evolving flexibility sources across different vectors.

Figure 4.1 Hydrogen in a renewable energy system

Hydrogen can be produced from electricity and stored and deployed for a variety of uses (as indicted in the image to the right). Large-scale hydrogen production and use has the potential to impact the level and volatility of power prices, reduce peak demand and peak capacities.

Hydrogen also has the potential to help the SOs balance the electricity and gas systems. As the infrastructure and markets for hydrogen, electric heating, CCUS and power-to-gas develop, the SOs will need to adapt real-time operation to make use of potential new flexibility sources from these markets. To make effective trade-offs between different sources of flexibility, the SOs will need to liaise with TOs, developers, DNO/DSOs, generators, power-to-gas facilitators etc., who may differ in structure, ownership and size from the operators we know today.

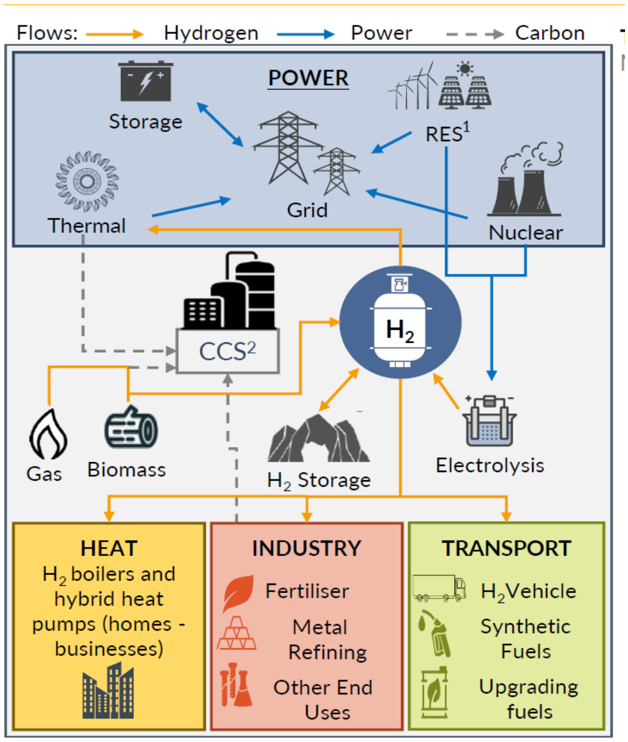


Image Source: Aurora Energy Research (September 2020)

4.23. The development of a genuine whole system mind-set that looks across different networks and markets will be crucial if the SOs are to play a central role in facilitating the energy transition. Several interviewees, including industry experts, identified the SOs'

[46] Hydrogen, in particular, is expected to bring the electricity and gas systems close together if it is used to decarbonise heat, industrial and transport sectors at scale (see Figure 4.1). Section 5 considers current legal restrictions on information sharing between the ESO and the GSO, which may act as a barrier to the SOs performing key roles and functions in an energy system with a high-level of integration between the electricity and gas systems. These barriers relate to sharing of Physical Notifications ("PN") data at day-ahead stage, sharing of information on the location and timing of specific network connections or ancillary service contracts etc.

expertise in control centre operations as an important input for testing dependencies between technologies (eg electrolysers and heat pumps), between vectors (eg electricity, biogas, hydrogen) and the real-time effects of moving to renewable gases.[47] The SOs are developing some of this understanding already, for example through testing electrified heat pumps with gas-boiler top-ups and through the GSO's coordination with distribution companies on hydrogen blending trials.[48]

4.24. The development of whole system insight and expertise will also be crucial if the SOs are to play a greater role in providing expert advice to government across a wide range of decarbonisation issues (see Box 4.1).

4.25. Overall, the tools, capabilities and approaches required to effectively perform system balancing functions will need to continually evolve to ensure an increasingly integrated and complex energy system remains operable as it transitions towards net zero. The continual development of electricity and gas control room operations and associated expertise will be particularly important given the critical role of the ENCC and GNCC in informing the SOs' wider market development and network planning functions.

Market development and transactions

4.26. A key feature of electricity and gas market arrangements is bilateral trading with incentives on market participants to balance their inputs and offtakes from the networks.[49] This supports the physical balance of each network. The SOs play a significant role in market development and facilitation at a national and international level, with this driven by their requirements to operate the system securely and efficiently and their longer-term roles in supporting efficient network development.

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[47] For example, the impact of blended gas on pressures and gas quality.
[48] Such as FutureGrid (https://www.nationalgrid.com/uk/gas-transmission/futuregrid), HyNTS, HyDeploy etc. under the ENA's Workstream 5 – Hydrogen Transformation https://www.energynetworks.org/gas/futures/gas-goes-green/ggg-workstreams/ws5-hydrogen-transformation.html As well as leading on the projects to develop understanding through trials and testing, it will become increasingly important that the SOs are in a position to effectively participate in and support projects led by others.
[49] The electricity and gas markets are fundamentally different with this influenced by different balancing requirements. Key differences include products commonly traded, durations for delivery and liquidity. For example, electricity trading can take place in the intraday market until the delivery period and market products can be hourly, whilst gas markets can operate with little variation in price for the whole day based on day-ahead and daily exchange traded contracts.

Key current functions

Table 4.2 Current ESO and GSO market development functions

Current ESO functions	Current GSO functions within NGGT
The ESO has six principal functions in this area: • balancing and ancillary service market design • balancing and ancillary service procurement and settlement • revenue collection, including management and development of the Transmission Network Use of System ("TNUoS") charging process • Electricity Market Reform ("EMR") Delivery Body[50] • policy advice and delivery of market framework changes, and • code administrator for the Connection and Use of System Code ("CUSC"), Grid Code and System Operator Transmission Owner Code ("STC").	The GSO has an important but currently less expansive role (when compared with the ESO) in facilitating gas markets. Its principal functions include: • having the capability to manage Network Gas Supply Emergencies and coordinate National Emergencies (eg gas Demand Side Response service) • providing articulation of network investment needs or non-investment (commercial) needs and providing information to enable investment and operational decisions, and • providing the platform for gas shippers to buy and trade capacity to flow gas on the NTS, running capacity auctions and operating the energy balancing cash-out arrangements.

See Appendix 3 for more detail.

Net zero system role

Enhanced SO functions

4.27. The current energy market frameworks will need to evolve as the system transitions to net zero.[51] The SOs' roles are inherently linked to the design of the market and incremental changes to wholesale market design could therefore affect the SOs' current functions in developing markets and transactions (and their control centre operations) that depend on those markets.

4.28. The electricity and gas SOs' approaches to facilitating and incentivising cost-effective solutions to balancing a low carbon system will need to evolve. It will become increasingly important for the SOs to take a strategic and proactive approach when facilitating markets

[50] More information can be found at: https://www.emrdeliverybody.com/SitePages/Home.aspx
[51] Several key market design questions will need to be considered and addressed, including the pricing of carbon, optimal settlement times for energy trading, opportunities associated with alternative dispatch models and balancing regimes.

for flexibility which accounts for long-term system needs and interactions across and within systems. For example:

- In electricity, the potential gains from greater flexibility are large, with the CCC reporting that the value of flexibility could rise to approximately £8bn per year by 2030 and to £16bn per year by 2050.[52] The ESO should enhance its existing market facilitation function and, as part of this, consider flexibility sources from across the energy system, including interactions between offshore and onshore transmission and distribution networks.
- In gas, the SO will need to consider new services and products for natural and green gas to enhance the availability of system flexibility capacity across the transmission and distribution systems.
- Both SOs will need to adopt a whole system mind set when assessing and enabling different technologies (including battery and hydrogen storage and demand-side response) and identifying opportunities for competitive balancing service markets to develop.

4.29. The ESO’s current functions mean it is well placed to understand interactions between markets (including the wholesale, balancing and capacity markets) and price signals in transmission charging. Given the potential for substantial energy market reform out to 2050, the SOs should use their insight and expertise to identify opportunities to promote greater competition and consumer benefit. This should include assessing and advising on the potential impacts of significant policy change and enabling continuous improvement to the market frameworks. As part of this, the SOs should take a more proactive and cross-system approach to this market development function, which will require enhanced commercial and economic expertise.[53]

Potential new SO functions

4.30. Net zero system change requirements may also lead to the SOs taking on new market development functions, as signalled by other, ongoing policy work-streams. For example, emerging new functions that the SOs could be well placed to take on include

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[52] https://www.theccc.org.uk/wp-content/uploads/2019/05/Net-Zero-Technical-report-CCC.pdf and Imperial College for the CCC (2015).
[53] This could include cost-benefit analysis capabilities and auction and pricing design.

enabling distributed providers to participate in national markets and playing a greater role in the coordination of industry codes and standards.

Enabling distributed providers to participate in national markets and balance the national electricity system

4.31. As set out in our RIIO-ED2 Methodology Consultation[54], DNOs have started to deliver some market facilitation functions (eg tendering for flexible alternatives to resolve network constraints) to access flexibility from DER. The DNOs and the ESO are starting to share operability data (eg about trades and network constraints) and collaborate to develop mechanisms for coordinated access to flexibility from DER.

4.32. Interviewees stressed the need for clarification and codification of roles between the ESO and DNOs.[55] At a minimum, the ESO has a responsibility to manage how these markets interact with the NETS and will require the ability to signal instructions, either directly or via a third party.

4.33. We are reviewing institutional arrangements for DSO functions. As part of this, we will consider whether alternative whole system coordination models are likely to lead to better outcomes. This could include a greater role for the ESO in procuring and dispatching DER for distribution grid operational services on behalf of the DNO. Alternatively, the ESO role could be more limited, with a greater role for a DNO or separate DSO in defining the mechanisms for procuring, coordinating and dispatching DER.

4.34. The future role and functions for the GSO in relation to gas distribution and local gas networks are at an early stage of thinking. Initial experience and learnings with renewable energy (at a large scale) are expected to occur at distribution more than transmission (eg biomethane and hydrogen fed in at the distribution level), with the first tests expected to be performed on industrial consumers. Some future scenarios for a decarbonised gas network could therefore be highly localised and dependent on opportunities, limitations and plans for the gas distribution networks.

[54] https://www.ofgem.gov.uk/publications-and-updates/riio-ed2-sector-specific-methodology-consultation
[55] The SO is also currently expected to ensure that the design of markets it leads is fully coordinated with the evolution of flexibility markets at the distribution level and to proactively provide system operation expertise into the development of new distribution-level operational frameworks.

4.35. Regardless of the role the electricity DNOs/DSOs and GDNs will play in facilitating local markets, the electricity and gas SOs' roles in collaborating and coordinating with the distribution networks will need to evolve to ensure effective optimisation of the whole system.

Governance of industry codes and standards

4.36. The electricity and gas SOs could potentially take on a greater role in the governance of the detailed technical rules of the system. Significant change will be required across industry frameworks to deliver net zero, including industry codes, engineering standards and data standards. These frameworks will need to be governed in an agile and coordinated way to enable innovation and new market entry.

4.37. The joint BEIS-Ofgem Energy Codes Review consultation[56] considered whether the ESO (among others) should take on proposed strategic functions for codes given it already is the code administrator for the National Electricity Transmission system Operator ("NETSO") related codes. Although we identified the ESO as one of a number of potential options, the consultation highlighted some concerns, as outlined in the table below.

Table 4.3 Strengths and concerns associated with the ESO taking on strategic codes functions

Strengths	Concerns
• The ESOs current roles mean it already possesses some of the skills and capabilities required to perform this strategic function, including an understanding of system requirements and system user capabilities. • The ESO's position at the centre of the energy system and its existing interfaces across a range of industry parties can enable it to take on a coordination function. • There are synergies with evolving SO functions such as facilitating markets for flexibility, coordinating with DNOs/DSOs and facilitating cross-system network planning. The ESO may be more able and	• Oversight and direction of all codes (including retail, generation, distribution and gas) goes beyond the current scope of electricity system operation and would require additional core expertise that goes beyond that required by other core SO roles. It would also require structural change to accommodate the gas codes. • The new strategic body function would need to be designed to mitigate potential conflicts of interest and would need a structure in place to ensure the correct accountability to consumers. • This option would require consideration of the separations put in place between National Grid plc and the ESO functions.

[56] https://assets.publishing.service.gov.uk/Government/uploads/system/uploads/attachment_data/file/828302/reforming-energy-industry-codes-consultation.pdf

Strengths	Concerns
more inclined to drive forward system-wide changes if it is also required to ensure consistency and provide direction across codes.	

4.38. This review of SO arrangements and BEIS's forthcoming review of energy system governance could result in changes to the SO governance framework that could address some of the concerns around potential conflicts of interest, once implemented. However, the wider questions around the scope and accountability of the emerging roles will require further detailed consideration as part of the Energy Codes Review, which will assess the various options for a future codes framework in order to identify which body is best placed to take on the strategic function for codes.

4.39. The Engineering Standards Review has recommended that a party is designated to be responsible for engineering standards coordination. This would include maintaining an overview of standards and coordinating their development, within GB and across relevant international standards development. Given technical and regulatory synergies between industry codes and engineering standards, there could be system-wide benefits from greater strategic coordination and alignment between industry codes and engineering standards.

4.40. We will take these additional factors into consideration as part of the ongoing review of energy codes governance. In doing so, we will consider the different roles that a future SO could fulfil in the shorter and longer term in the context of the other options available to us, as well as considering how an SO could interact with, for example, government, Ofgem and code managers under these various options.

4.41. The SO could also take on new data governance functions. The energy system will become increasingly data driven which will increase the need for the governance of data standards and protocols. As the industry codes currently provide some of the industry frameworks for collecting and sharing data, there is a link between code governance and data digitalisation and the associated standards. Any expansion of current SO roles regarding data would require a significant increase in the existing SOs' technical and operational expertise and capabilities.

Whole system insight, network planning and coordination

Key current functions

4.42. The ESO and GSO have an established central position within the respective electricity and gas systems. The electricity and gas systems are currently largely planned for separately, with the ESO and the GSO supporting the planning and coordination of electricity and gas network development to ensure anticipated demand and supply needs can be met (see Table 4.4 and Appendix 3 for more detail). The ESO and the GSO also provide advice to government and Ofgem.[57]

4.43. The electricity TOs perform the detailed planning required to deliver transmission investment including design, routing and consenting.[58] Gas network planning functions are undertaken by NGGT, with the GSO running the Network Capability Assessment process. Both system operators manage connections onto their respective networks, with the TOs responsible for designing and building the associate infrastructure.

Table 4.4 Current key SO network planning functions

Key current ESO functions	Key current GSO functions within NGGT
• Performs long-term forecasts for the development of the gas and electricity system and publishes as the Future Energy Scenarios • Identifies long-term electricity system needs in the Electricity Ten Year Statement ("ETYS") • Provides GB input into the development of the pan-European Ten Year Network Development Plan ("TYNDP")	• Conducts annual planning cycle which concludes with the publication of the Gas Ten Year Statement • Provides GB input into the development of the pan-European TYNDP • Runs the Network Capability Assessment process and options analysis[59] • Manages connections on to the transmission networks

[57] For example, interpreting current and unusual demand and supply patterns on the electricity and gas networks, advising of future system requirements and likely changes influencing the development of future networks such as increasing intermittency and asset replacement.
[58] Detailed planning of the onshore electricity transmission network is performed by NGET and the Scottish TOs. The TOs are decision-makers for transmission planning in their respective geographic areas and are not legally obligated to comply with the ESO's recommendations. The TOs develop investment plans which are submitted to and approved by Ofgem as part of the regulatory framework, RIIO. The ESO coordinates with the TOs to optimise short and long-term outage plans. In gas, by contrast, all network planning functions are performed within the same, integrated entity. The offshore wind developers have control of siting, routing, designing, consenting of the offshore networks.
[59] Options analysis includes consideration of commercial rules, operational tools and asset investments.

Key current ESO functions	Key current GSO functions within NGGT
• Carries out an annual Network Options Assessment ("NOA") process to assess and recommend boundary reinforcement options proposed by the TOs • Provides cost benefit assessments on major new investments in the onshore transmission networks proposed by TOs • Role in improving coordination of offshore network development through the wider network benefit investment ("WNBI") mechanism • Provides connections for interconnectors and an assessment of system operability impacts to inform interconnector needs cases • Manage connections on to the transmission networks	

Net zero system role

Enhanced and potential new SO functions

4.44. Changes in the physical structure of the energy networks will require a more complex, whole system approach to energy system planning. This may require the SOs, particularly in gas and hydrogen networks, to collaborate with several TOs, DNOs/GDNs and other network developers.

4.45. One way to manage an increasingly complex energy system, while bearing down on network infrastructure investment costs, is to enhance the electricity and gas SOs' current roles to include greater responsibility for strategically planning and coordinating the development of the electricity and gas networks (including onshore, offshore, interconnectors and distribution networks where relevant). This could also enable greater strategic alignment across electricity and gas network planning and between energy, heat and transport networks.

4.46. Network assets will increasingly become one of several solutions for meeting consumers' low-carbon energy needs. Network asset owners' vested commercial interests in how their assets are used and developed can reduce their incentive to encourage more economic alternatives to come to the market. The SOs can act as a counter-balance to this by having a clear role in enabling more independent, economic alternatives to traditional network-build solutions to come to the market and, more generally, integrating network development with market-based, flexible solutions.

4.47. Some of the potential new electricity and gas SO functions in transmission network planning and development could require the SOs to develop expertise that currently sits with the TOs. Careful consideration would need to be given to the transfer of responsibilities between organisations to ensure regulatory incentives that promote cost-efficient planning are not reduced.

Electricity network planning and development

4.48. In electricity, interviewees noted recent progress in the ESO's network planning and development function, including:

- the introduction of the ESO obligation to carry out a NOA process to assess options for network development which should consider system and market-based solutions as well as TO solutions to meet long-term system needs; and
- the ESO Pathfinders Project that has introduced more competition into network development by tendering for solutions to specific network needs such as voltage and system stability issues.

4.49. Several interviewees saw the potential for significant benefit from the ESO promoting a more strategic approach across several different aspects of network planning (see Box 4.6 below). This included:

- options development and assessments (including cost-benefit analysis) for solutions to long-term system needs that incorporates market-based and system engineering solutions for the whole system (including looking at distribution network solutions to address transmission network constraints);
- managing optimal connection arrangements for onshore, offshore and cross-border transmission assets to promote greater coordination and anticipate long-term transmission network reinforcement needs;
- tendering for different solutions to network needs and driving competition between alternatives where appropriate[60]; and

[60] Reasons given for why the ESO should have an enhanced network planning role included: synergies with the ESO's wider roles and functions and corresponding technical capacity to compare different solutions to system needs; the relevance of existing processes such as the ETYS, NOA and Pathfinder Project and an ability to consider how different options interact with system operability.

- delivering some aspects of network planning directly, eg for strategic network investment required to deliver 40GW of offshore wind by 2030.

Box 4.6 Potential enhanced and new ESO functions in network planning

Enhanced functions

- Enhanced role in **critically reviewing the TOs investment plans**, including needs cases for individual, large projects. The ESO could supplement or extend the NOA process by proposing its own solutions for onshore network development across the TOs plans and/or seek options from a wider range of parties – and doing so in a way that is not limited to boundary constraints. Some interviewees suggested that the NOA could be expanded to 132 kV (distribution level) in England and Wales.
- Provide a more **formal and structured assessment of the impacts of interconnectors on system operability** on a regular basis. This could either form a part of the NOA interconnector analysis or could take the form of a regular submission to inform Ofgem's assessment of the need for new interconnector projects.
- **Tender for different solutions to network needs and drive competition between alternatives where appropriate**. Appendix 3 sets out our latest position on the ESO's potential functions in facilitating early and late competition.
- Enhanced function to **plan a coordinated network offshore,** for example by making high-level design recommendations for offshore wind connections. Several interviewees expressed concern that the current process for building and connecting offshore wind may not produce the most efficient whole system outcomes. The ongoing Offshore Transmission Network Review will provide greater clarity on the form that a potential future regime could take, with the potential for this to include a greater or new role for the ESO in overseeing coordination, planning and competition in the offshore network.

Potential new functions

- The ESO could take on a new role that would require it to make **binding recommendations to TOs or developers on the strategic network investment needed for 40GW of offshore wind**. The ESO's role in transmission network planning and development could be expanded to take on some of the roles and responsibilities of the TOs and developers, eg to identify needs, propose options to Ofgem for major network projects and take on responsibility for delivering those options, at least until a certain stage of development, eg completion of preliminary works or construction. This would require the ESO to develop additional expertise.

Gas network planning and development

4.50. The future of the gas system and gas network development will be heavily influenced by strategic policy decisions principally on heat decarbonisation. In scenarios with an expansion of the gas system (eg upgrading the existing gas system and new-build green gas networks), a 'future GSO'[61] may have to take on new functions to manage and coordinate across multiple green and natural gas networks[62], which may be owned and operated by different parties and include different geographic boundaries and participants. In this scenario, independent strategic network planning and coordination across multiple parties will be required to enable competitive approaches to network development and ensure the efficient and effective development of the gas system.[63]

4.51. Future GSO functions will need to include forecasting, planning and developing the future gas networks in a way that enables the best-value technologies and solutions for substituting natural gas to come forward.[64] This will require impartial decisions and trade-offs between green gas technologies and electricity and gas system solutions offered by different transmission and distribution networks and market participants.

4.52. The future GSO could take on **new functions** with varying degrees of responsibility in network planning, development and design. This could include the future GSO taking on some of the network design functions currently performed by the gas TO (and other independent providers) to enable it to direct and coordinate network development. We have identified two potential options:

- **Establish a process similar to the NOA for the gas system**. The future GSO would continue to work with the ESO to identify long-term system needs as part of the FES and provide a framework in which multiple parties (eg multiple TOs[65], GDNs) and providers could participate and provide solutions to gas system needs, including network and non-network solutions. To be effective, the future GSO would need to be able to scrutinise TO investment plans, including new investment in hydrogen-proof pipelines, compressors etc., and recommend against asset replacement works proposed by the TOs for assets it believes are likely to be decommissioned or repurposed in the future.

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[61] In scenarios with a large expansion of the gas system, the potential scale of system change and range of gases being utilised (eg natural gas, blue and green hydrogen, and potentially other fuels such as biogas and syngas), mean a 'future GSO' would be a body with a much wider remit to the current GSO (ie potentially undertaking a range of market development and network planning functions),
[62] Natural gas will continue to be a key fuel in the 2020s and possibly beyond if used in conjunction with CCUS.
[63] These networks may be capable of separate operation, however the GSO would likely be responsible for strategic network planning functions which would include, for example, long-term forecasting and new investment planning.
[64] This could include blending biogas, biomethane and hydrogen.
[65] In certain future scenarios, there could be more than one transmission operator and owner of natural gas and green gas networks.

- A future decarbonised gas system is likely to depend on the supply of green or blue gases from multiple sources. In planning and designing this type of system, the future GSO would need to consider the existing distribution and transmission infrastructure (and associated options to repurpose existing infrastructure to accommodate increasing volumes of green gas and new technologies), alongside options for new-build, such as hydrogen-only infrastructure. A future gas network planning and design role could involve the future GSO identifying system needs, assessing a range of options to meet these requirements and then **mandating the TO(s) and other developers** to **build, decommission and upgrade the network** in line with its assessment. To do so, the future GSO would need to work in close collaboration with the TOs' planning teams or contain planning teams that have the expertise to deliver relevant TO responsibilities.

4.53. A future GSO taking on new or enhanced gas planning functions of this nature would need to be considered alongside those currently performed by existing bodies with responsibilities for the development of local and national approaches to gas decarbonisation, including the GNDs, the TO and NIC.

Facilitating whole system planning and assessment

4.54. Both the ESO and GSO will have to look beyond the electricity and gas systems and increasingly consider the energy system's interaction with wider heat, transport and potential future hydrogen networks. As part of this, the SOs could develop strategies that allow them to identify and consider cross-system opportunities that could provide them with new tools and approaches for system operation and planning. In building up to this, the SOs could provide technical expertise, data and support to cross-system trials to promote system-wide capability and expertise.

System-wide benefits from the SOs taking on enhanced and new functions

4.55. Effective performance of the net zero roles identified in this section have the potential to deliver significant system-wide and consumer benefit. By building upon the SOs' current excellent engineering and system operation capabilities and existing synergies between the SOs' roles, enhancing the roles and functions of the SOs could enable them to:

- make better, more coordinated decisions and improve their ability to optimise across technologies, networks and fuels by making best use of systems-thinking and operational expertise in market development and network planning functions;
- improve the long-term, strategic planning and coordination of future network development (including across onshore and offshore, transmission and distribution, and electricity and gas) and drive competition between solutions, where appropriate;
- provide strong, effective leadership and strategic direction across the industry and drive change across the whole system, including across vectors; and
- provide informed and trusted policy advice to government, Ofgem and industry across a range of decarbonisation issues, including the decarbonisation of heat and transport.

5. Assessment of current arrangements

Section summary

This section assesses whether the current arrangements for GB system operation in electricity and gas are suitable for enabling the SOs to perform the net zero roles and functions identified in Section 4 effectively.

We identify three features of the current arrangements which could act as barriers to the SOs taking on and performing the net zero system roles effectively:

I. Potential asset ownership conflicts of interest
II. Regulatory challenges aligning the commercial interests of the SOs' shareholders with consumer interests
III. Discrete electricity and gas system operation frameworks.

Our key conclusions are:

- All three of the features identified would appear to constrain the ability of the SOs to perform the net zero system roles and functions effectively.
- There is a strong case for considering changes to the ownership, governance and commercial model of the current SOs, and for considering combined responsibilities for electricity and gas net zero system roles.

Introduction

5.1. The SO roles of ensuring secure and safe operation of the electricity and gas systems have been performed effectively whilst private companies affiliated with National Grid plc have delivered them. Great Britain has one of the most reliable energy systems in the world with comparatively few supply disruption events affecting consumers. However, as set out in Section 4, providing secure real-time operation is becoming more challenging and the SOs could be well-placed to take on a range of enhanced and new functions across their roles in the transition to net zero. Our assessment of the suitability of the current SO arrangements is based on the expected nature of the functions the SOs could be required to perform to facilitate net zero at least cost.

5.2. Our assessment is informed by the SOs' performance in current roles; stakeholder views on the current arrangements; an assessment of the possible impact of potential conflicts of interest; and our experience of regulating the current SOs. Our assessment considers potential conflicts of interest that could arise if today's arrangements were not updated. We have not undertaken an in-depth assessment of whether the potential conflicts have impacted current roles, as the focus of this review is on the arrangements that will be required to achieve net zero at least cost.

Asset ownership conflicts of interest

The ownership and governance of the current SOs

5.3. National Grid plc is an investor-owned multi-national electricity and gas company that has ownership interests in the companies that carry out the current SO roles.[66] National Grid plc's other UK business interests include ownership of the electricity transmission network in England and Wales and the GB gas transmission network.[67] It also co-owns four of the six electricity interconnectors between the GB and European markets and owns a liquefied natural gas import terminal in the UK through different subsidiary companies.[68]

5.4. In electricity, the ESO has been a legally separate, licensed function within National Grid plc since April 2019. Its licence includes restrictions and obligations on the ESO's governance, which have facilitated separation from NGET and other National Grid plc companies.[69] In gas, the SO and Transmission Owner ("TO") functions are carried out by an integrated company, NGGT.[70] There are no limitations in the interactions between these parts of the business in order to mitigate potential conflicts of interest.

The potential conflicts of interest

5.5. The current ownership and governance structures of the companies carrying out the SO roles create potential conflicts of interest. These conflicts may result in real or perceived biases in the SOs' decision-making against outcomes that would negatively impact the

[66] National Grid also own the Electricity Market Reform ("EMR") Delivery Body, which is a functionally separate part of the ESO.
[67] The electricity transmission networks in Scotland are owned by companies that are not affiliated with National Grid plc.
[68] Appendix 4 provides further information on the ownership and corporate reporting structure of National Grid's key domestic energy businesses, which are relevant for this section.
[69] Restrictions, for example, apply to services that can be provided to the ESO across National Grid companies ('shared services') and movement of staff between the ESO and NGET is treated as 'sensitive'. Appendix 4 contains further details.
[70] National Grid Gas plc. In this section, the 'GSO' refers to the GSO part of NGGT.

significant value of the existing assets (ie interconnector and transmission network assets) or future assets in which National Grid plc may have a commercial interest.[71] At this time, we have no evidence of National Grid acting in a way that deliberately exploits any potential conflicts of interest.

5.6. Potential biases that could affect the SOs are:

- **Perception of lack of independent advice**: advice given by the SOs to government, the regulator, and other stakeholders may be, or perceived to be, in National Grid plc's interest rather than in the interests of consumers. For example, the SOs may have, or be perceived to have, inherent interests against market designs that reduce the need for transmission assets.

- **Possible bias in transmission network development**: the SOs may act, or be perceived to act, to increase the size of affiliated companies' transmission asset bases (thereby increasing the commercial return of those businesses). For example, the SOs may have inherent interests against challenging investment needs proposed by their affiliated companies to manage constraints.

- **Possible bias in facilitating competition**: the SOs may be, or be perceived to be, biased towards affiliated companies in the design, facilitation or operation of competitive markets or processes where affiliated companies can participate directly or where the markets provide investment signals for less transmission. For example, the ESO may have, or be perceived to have, inherent interests against fully integrating competition into planning for a wide range of network development needs.

5.7. In electricity, despite legal separation of the ESO, governance interactions with National Grid plc may limit the extent to which real or perceived biases in the ESO's decision-making towards outcomes that favour National Grid plc can be mitigated. Staff working for National Grid companies are also able and encouraged to gain experience in different areas of the businesses as part of their career development, which may subtly influence their decision-making in favour of the group's interests. In addition, the leadership of National Grid plc has not consistently distinguished between the ESO and

[71] Appendix 4 contains details of the asset values of relevant National Grid UK-based companies.

other National Grid companies in media engagements, and actions taken by the ESO influence public perceptions of National Grid plc and its share price.

5.8. The key areas where potential biases could manifest and the potential impacts on the SOs' ability to perform net zero system roles are explored further below.

Perception of lack of independent advice

5.9. The net zero system roles identified in Section 4 require the SOs to coordinate and collaborate effectively with a range of actors in the energy system across their functions. The enhanced and new functions identified should also enable them to provide better-informed and more holistic policy advice to government and other stakeholders to support net zero. This could include advice on the trade-offs between electrification and hydrogen/green gases for decarbonising heat and transport, whether hydrogen should utilise an adapted national gas transmission network, and market design changes. Any perceived lack of independence could materialise in general mistrust of advice or recommendations provided by the SOs and other companies being unwilling to collaborate fully with the SOs where they have potential competing commercial interests.

Box 5.1. Interviewee views on perceived independence of the SOs

One industry party suggested that legal separation of the ESO in particular had worked well to create perceived independence. However, several interviewees referred to issues of perceived lack of independence becoming more significant with an expansion of SO roles:

- An interviewee said "materiality of this perception issue is likely to increase as the role of the ESO increases […] independence will need to increase, particularly if [the ESO] strays into more policy decisions."
- An industry party pointed to National Grid plc's UK investments (in carbon capture and storage, hydrogen production and electricity interconnection) and its transmission network ownership and electric vehicle charging infrastructure interests as conflicts of interest for ESO and GSO roles in net zero delivery: "in terms of conflicts of interest, there will be a strong case going forward... […]...the SOs' role [in delivering net zero] is untenable as part of National Grid Group."
- Another industry party said: "…going forward as DSOs come up more […] and we see more flexibility tenders happening at DSO level and more of a bio-directional flow between the DNOs and TOs […] the ESO's independence is going to be more important in the medium term than it has been over the last couple of years."
- An industry expert we interviewed considered the net zero challenge to be a significant factor in the case for growing SO roles and increased independence in electricity and gas.

5.10. Box 5.1 above sets out some key themes in interviewees' perceptions of the SOs' lack of independence in relation to collaborating with other companies and influencing policy decisions as they take on additional roles.

5.11. Any unwillingness of other companies to collaborate fully and transparently with the SOs will hinder whole system optimisation and the effectiveness of the SOs in facilitating system changes. Any mistrust of the SOs' advice could delay or constrain policy decisions required to achieve net zero at lowest cost to consumers, given the SOs' access to key data, technical expertise and operational experience.

5.12. Box 5.2. below provides an illustrative example of a theoretical market design change which could be negatively affected by perceived bias in the SOs' advice.

Box 5.2. Illustrative example: locational marginal pricing

Locational signals are arguably more important in a decarbonising world. Locational marginal pricing is a way for wholesale energy prices to reflect the value of electric energy at different locations, accounting for the patterns of load, generation, and the physical limits of the transmission system. It can mitigate the potential negative impacts of uniform national pricing, such as:

- **Congestion rents** – additional revenue earned by parties that transfer energy over a constraint as a result of that constraint, being diverted away from consumers.
- **Inefficient investment signals to locate for supply sources and storage** - resulting in higher capital costs, for example, as more transmission network investments are required. The variable costs of electricity generation may also be higher (relative to a scenario with locational marginal pricing), as a result of poorly-located sources of supply.

The benefits of locational marginal pricing could be billions of pounds in net present value terms depending on factors such as congestion levels, the generation mix and network access arrangements in the region. For example, benefits arise from lower balancing costs and lower investment costs as investors take fewer but better located supply and storage investments and fewer transmission network investments are required through better use of the existing network infrastructure.

Ownership relationships with transmission network owners may create real or perceived bias in any views the SOs provide on the merits of such market design options because they can reduce the need for transmission network assets.

Possible bias in transmission network development

5.13. The TOs have a regulated asset value; their expenditure is subject to regulatory funding decisions, including the allowed return to investors. However, the TOs may have an incentive to expand or maintain their asset base unnecessarily, where they can carry out the work or finance the investment more cheaply than their funding allowance or have some discretion over making investments, since this can increase their return.

5.14. The corporate relationship of the companies that currently carry out the SO roles with those carrying out TO roles may lead to a real or perceived bias towards an inefficient level of transmission network investment. This potential bias could manifest through different aspects of the SOs' current whole-system insight, network planning and coordination role, such as the risk of:

- **inflated long-term forecasts** of the need for transmission network assets and an underestimation of their wider economic impacts;

- **limited or conflicted incentives to challenge affiliated TO's investment proposals** - for example, by challenging unclear needs cases or pressing for more timely or efficient development where the TOs' delivery or designs would lead to material constraint management costs for consumers:

    - **Lack of proactive consideration of alternative network development options** to those put forward by network companies or developers where this would also involve challenging TO interests.

    - Stakeholders may perceive the ESO's **options assessment in relation to interconnection to be biased towards any affiliated companies' interests**. This perception could exist if the ESO recommends a significant interconnector build-out with an affiliated company well-placed to deliver new projects or equally if it takes a more conservative view on optimal levels of interconnection that could protect revenues on existing affiliated company projects.

5.15. Box 5.3. below sets out some key themes in stakeholder views on potential SO bias in transmission network development.

Box 5.3. Stakeholder views on potential transmission network development bias

Two industry parties we interviewed commended the ESO's NOA process for coordinating network development, with one commenting on its transparency.

Other interviewees considered this potential bias problematic for the ESO's evolving functions:

- an industry party referring to the FES said "…**National Grid** [sic] **will never come up with a scenario with no nuclear in it** because the nuclear industry is England and Wales based and connects to their transmission network";
- another industry party said that the NOA analysis is **"driven by the mind-set of infrastructure assets… […] not aligned with what real time operation shows is happening on the system."** This interviewee also referred to **poor modelling** of the costs and benefits of interconnection and considered it could be part of a "strategic aim to protect the interconnector business";
- consultation respondents to our initial project assessment of three recent cap and floor interconnector projects also raised concerns regarding the ESO's potential **conflict of interest in promoting interconnector investments** (in its relationships with relevant TSOs); and
- a number of interviewees, including those with key relevant experience, referred to the perception of this bias creating issues for the ESO's credibility in potential growing network planning functions.

5.16. The SOs' affiliated companies have material commercial stakes in network development, particularly in the transition to net zero. Significant expansion will be required in the GB electricity transmission network to accommodate increased offshore wind generation and interconnection. Meanwhile, projections of reduced demand for natural gas transmission may require decommissioning of some existing gas assets. There is also potential for significant investment requirements to upgrade and expand the existing natural gas transmission network to enable hydrogen transmission and investment in distribution networks, which will require coordination.

5.17. The current SO roles in network development are advisory in nature. However, the SOs have a unique position and access to information on the electricity and gas systems, including information that is pertinent to security of supply analysis, and an ability to recommend an evolution of onshore, offshore and cross-border network development. As a result, Ofgem takes account of the SOs' modelling and recommendations in assessing TO and developers' proposals and it can be resource intensive to scrutinise and challenge their analysis effectively.

5.18. Transmission network development bias, whether real or perceived, can result in inefficiency from reduced stakeholder engagement and confidence in network development plans, legal challenge and delayed decision-making. Where there is a real bias, it can also result in over-investment on transmission network assets if alternative, more efficient network development options are not put forward by the SOs, given they are well placed to provide coordinated views across the system.

5.19. In section 4, we set out a range of potential enhanced and new SO network planning functions, which involve increasing strategic responsibilities. Real or perceived transmission network development bias when exercising these functions could have significant negative cost impacts for consumers and delay decarbonisation, and this is likely to constrain the SOs' ability to take on and perform new functions effectively.

Possible bias in facilitating competition

5.20. The SOs' facilitation of new competition frameworks across different roles could erode the financial return of affiliated companies. There is therefore a theoretical basis for bias in the SOs' approaches.

5.21. Real or perceived bias in facilitating competition may manifest in different aspects of the SOs' **market development and transactions role**, such as:

- **facilitating and delivering trading and operational market rule changes** which could impact connections to affiliated companies' transmission networks or (in electricity) the revenue streams including curtailment compensation for interconnectors. For example:
    - the ESO's actions in implementing cross-border balancing markets could be perceived as influenced by the cost impacts on affiliated companies;
    - any real or perceived bias in the ESO's function of facilitating trading and operational market rules changes would act as a barrier to it taking on a potential new function of setting the strategic direction for the rules underpinning market and commercial frameworks.
- **effective coordination with DNOs** to develop mechanisms for accessing flexibility from distributed energy resources in current ESO functions could be hampered by incentives to avoid any consequential displacement of transmission connections. The SOs' performance in potential net zero system

roles could be similarly limited as both the SOs will, at minimum, have to manage the interaction of regional markets with the national transmission system and collaborate with the DNOs/GDNs effectively to promote optimisation of the system.

5.22. Box 5.4. below sets out key themes in stakeholders' perceptions of potential bias in the ESO's current and potential net zero system functions in facilitating competition in wholesale, balancing and capacity markets.

Box 5.4. Stakeholder views on ESO bias in facilitating competitive markets

Facilitating and delivering trading and operational rule changes:

- One interviewee noted that the ESO has always been particularly careful about its interactions with National Grid Ventures. However, two industry parties suggested that the ESO's position on market rules favours interconnectors – an example given was its position on interconnector participation in the Capacity Market.
- Two interviewees referred to perceived ESO bias in its support for code modification proposals from market participants due to the commercial impacts on National Grid plc.
- An industry party suggested there was potential conflict in the ESO's management of the transmission charging process: **"[the] transmission charging model is out of date and because that has an impact on where people build, whether they build in England (ie in National Grid's patch) [...] this calls into question their independence.**"
- A few consultation respondents to the joint BEIS-Ofgem consultation on Energy Codes Reform noted that, in its current form, the **ESO may have a conflict of interest and would not be appropriate to take on the role of a strategic body for codes**. This view was also expressed by some of the industry parties we interviewed.

5.23. In its **whole system insight, network planning and coordination role**, the ESO, in particular, could be perceived as biased in its facilitation of competition in transmission network investment and development. This could affect:

- the ESO's **development of tenders or assessment of proposals for solutions to specific network needs** that should be equally open to DNO, TO and third-party-led non-network solutions may be perceived as favouring transmission solutions. A more likely risk is that the ESO's work in this area is perceived to be limited in scope or delayed in delivery due to a lack of strategic interest across the wider commercial group in developing the ESO's roles in network planning.

- any **enhanced/new ESO functions** in identifying long-term system needs that are suitable for competition, designing competitions for a wider range of needs that are open to both network and non-network ideas and delivering preliminary design and preparatory work (such as obtaining planning consents) before competitions for transmission network projects would be subject to the same risks.

5.24. Box 5.5. below sets out key themes in stakeholder views on perceptions of potential ESO bias in facilitating competition in network development.

Box 5.5. Stakeholder views on potential ESO bias in facilitating competition in network development

Several interviewees, including those with key relevant expertise, considered perceptions of bias created by the ESO's ownership structure as a potential barrier to growth of its role of facilitating competition in transmission network development:

- "**it's not right for an independent SO to be owned by a TO who it** [...] or developers **may be competing against**…[..] it is a perception that, at an organisational level, **will generate conflicts of interest at the higher levels**";
- "**if the SO is deciding those things** [competition for solutions or competition for delivery of transmission] **with the TOs competing, you can see the obvious conflict**";
- "it is **becoming an increasing problem**…. [..] consider that **one bit of the Grid are thinking about whether another part of the Grid should invest or whether it go a third-party** to buy a service rather than build a piece of network"

Several respondents to the RIIO2 sector methodology consultation raised concerns about conflicts of interest should the ESO be required to run network competitions in absence of full independence from the National Grid Plc.

5.25. Several stakeholders referred to the importance of trust in the SOs' neutral facilitation of competition across its market development and network planning roles for enabling participation. Perceptions of bias can deter potential market participants regardless of whether it exists, which could dilute the consumer benefits expected from market efficiency.

The need for refreshed thinking in system operation

- A common theme from our interviews with stakeholders was respect for the unrivalled expertise of the SOs' staff, and an impression that working level staff are motivated by consumer interest. It is clear the ESO has committed to delivering an ambitious RIIO-2 business plan. However, we have also identified some approaches taken by the SOs that suggest a broader and more innovative mind-set and culture would be beneficial when taking on net zero roles. We consider this mind-set is likely to be driven by the strategic direction and vision of the SOs, which is partly influenced by their current ownership structure. This could also be influenced by potential bias towards transmission asset-based solutions that make the SOs' short-term system operation role easier to manage[72], which would exist whether or not there was full separation of the TO and SO businesses.

5.26. Areas where the SOs will need to develop new capabilities include:

- Expanding the focus from traditional engineering methods and skill-sets to include other alternatives, such as digital technology and market development; and,

- Increasing the level of whole system thinking across all roles, with more focus on emerging real-time balancing and longer-term risks.

5.27. Our interviews and wider engagement suggest that the origins of the current SO organisations as networks businesses and employee transfers could subtly influence a transmission network mind-set.

The potential magnitude of asset ownership conflicts of interest

5.28. FTI Consulting undertook theoretical analysis to estimate the potential net consumer benefits of separating SOs (on the assumption that they are exploiting conflicts of interest) from the TOs. The analysis quantitatively assessed the potential magnitude of two possible

[72] For example, favouring more reliable or predictable solutions for network reinforcement over novel technologies.

impacts from conflicts of interest in the electricity and gas SO functions, and the potential net benefits to consumers of removing the conflicts. The assessment models potential future costs if the SOs perform additional roles on top of their current roles on network planning and competition. Given the inherent complexity the quantification assessment, the modelling is only one element of our overall assessment.

5.29. FTI's assessment assumes that removing the potential quantifiable conflicts of interest requires full unbundling of the SOs from National Grid plc[73], and that the maximum net benefits that can be obtained are equal to the potential costs to consumers arising from possible conflicts in the current arrangements. The assessment period is 2022- 2050.

5.30. The quantifiable benefits to consumers of fully unbundling the SOs are comprised of:

- prevention of a potential over-investment on the electricity and gas transmission networks through the SOs' recommendations on the evolution of NGET and NGGT's transmission networks; and
- cost savings that would otherwise not be achieved through the ESO facilitating competitive procurement of new electricity transmission network assets due to the perception of potential competitors that there is an 'incumbency advantage' for NGET.

5.31. The costs to consumers of full unbundling of the SOs are comprised of:

- any loss in operational synergies between the GSO and the GTO following full unbundling; and
- any direct upfront or ongoing costs associated with unbundling.[74]

[73] In this document, 'unbundling' is used to refer to transfer of SO functions away from the corporate structure in which National Grid plc is the parent company rather than the unbundling of a vertically integrated undertaking in the context of EU law.
[74] The approach taken to assessing each of these components, and the detailed methodology used are set out in chapter 3 and the appendices of FTI Consulting's report, which is published at Annex 1.

5.32. Box 5.6. below provides an overview of operational synergies between the GSO and GTO.

Box 5.6. Operational synergies in gas system operation

There are important differences between electricity and gas system operation. For example, unlike electricity, gas flows slowly through the network and can be stored with relative ease. This means the GSO does not need to balance demand and supply on a second-by-second basis. The GSO does, however, constantly monitor and manage the system and intervenes on a daily basis to ensure system safety.

Operational synergies between the GSO and GTO functions are a key feature of gas system operation. Compared to electricity, the gas system is managed almost exclusively though the operation of physical transmission network assets and, less frequently, through market trading (see Appendix 3 for additional information). This is due to the GSO and GTO functions being integrated within the same company and physical characteristics of the gas system.

Ensuring system safety

The gas NTS operates under a Safety Case supervised by the Health and Safety Executive ("HSE") as over or under-pressurisation of the network can result in fires and explosions. The GNCC actively manages pressure on the network to maintain safe pressure by flexing transmission assets, eg operating compressors and values to avoid over pressurisation.

Constraint management

Integration of GTO and GSO functions enables the GSO to optimise and coordinate between its commercial control room actions and the short-term operational actions the GTO can take to balance the network:

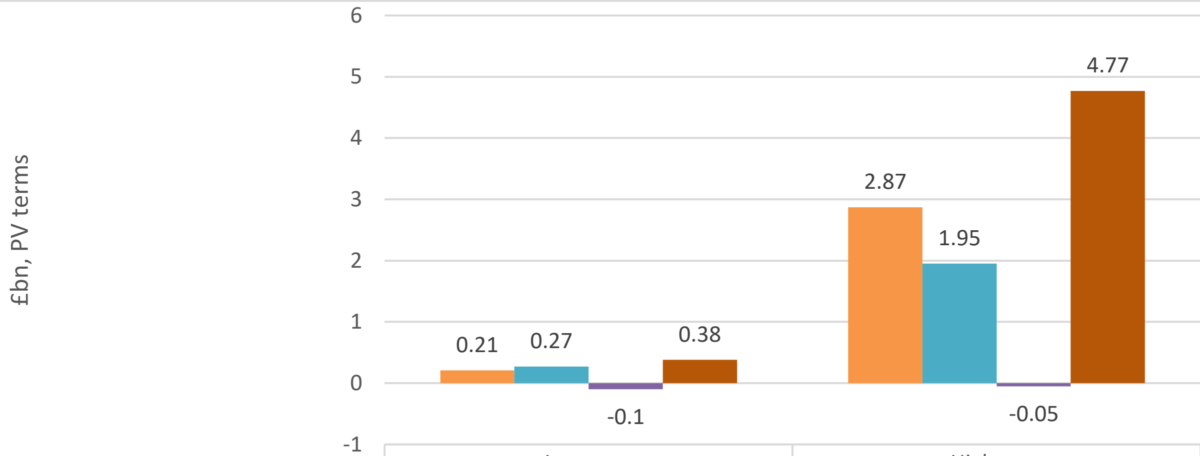
- Commercial actions taken by the GSO include locational trades and capacity buybacks from gas shippers.
- Short-term operational actions undertaken by the TO can include delaying planned maintenance or a compressor to reduce the likelihood of a constraint, with the TO bearing the cost of operational actions.

A combined GTO-GSO entity can be incentivised to choose the action with the lowest cost to consumers. This means the GTO is more willing to incur the cost from short-term actions and the GSO is able to choose the most efficient action. If the GSO functions were unbundled from the GTO functions, other arrangements such as contractual arrangements would need to be developed to enable efficient GTO balancing actions. This may create some additional frictions as use of the GTO assets would have financial and safety implications and the processes between the GSO and GTO which underpin it would need to be seamless.

The loss of similar operational synergies in electricity system operation from integrated ESO and electricity TO functions has already occurred in England and Wales due to legal separation of the ESO and is not applicable in Scotland, as set out further in Section 6 (Box 6.2).

5.33. The assessment suggests that the net benefit to consumers of removing the two **potential conflicts quantified in electricity ranges between £0.4 billion and £4.8 billion in present value terms** over the assessment period.[75] The significant benefits from removing the quantified conflicts in electricity are driven by the assumed continued need for additional electricity transmission assets as the UK moves towards net zero and an expected increase in demand for electricity; and the scope for potential competitive procurement of new assets.[76] The costs relate to direct implementation costs of full unbundling of the ESO.

Figure 5.1 estimated impacts of removing asset ownership conflicts in electricity system operation arrangements



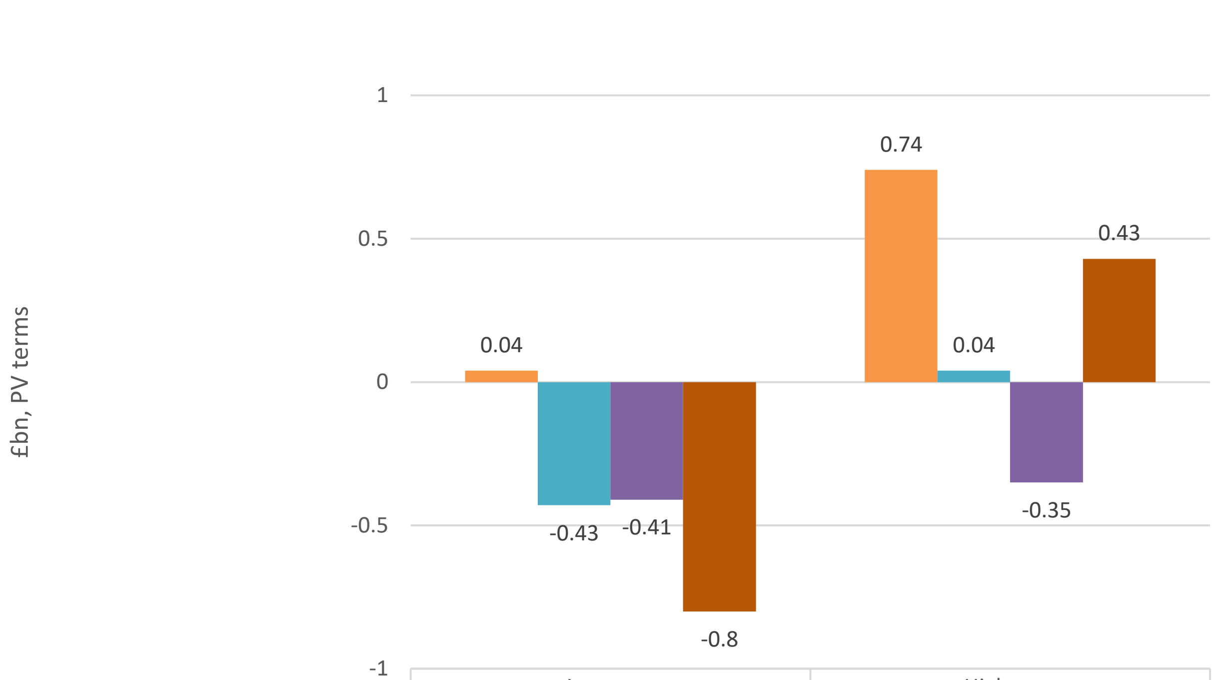
	Low case	High case
Avoided over-investment in the transmission network	0.21	2.87
More effective competition in delivery of transmission network assets	0.27	1.95
Implementation costs	-0.1	-0.05
Net	0.38	4.77

5.34. The assessment suggests that the net impact of removing the asset ownership bias in **gas ranges between a £0.8 billion cost and a £0.4 billion benefit**. These results are primarily driven by the assumed reduction in expenditure on the gas network due to

[75] The results of the assessment are set out in detail in chapter 4 of FTI Consulting's report.
[76] The range of benefits from avoided overspend on the transmission network is based a range of assumed growth in total expenditure on electricity transmission per annum until 2050 (1%-3.5%), and a range of "overspend" caused by asset ownership bias (1% -10%). The range of benefits from removing potential bias in competitive procurement is based on a range of assumed projects for competitive procurement (worth £9.7b-£19.5b), cost savings achievable through competition (11%-20% of the asset's initial estimated cost), and reduced cost savings from perceptions of 'incumbency advantage' and related dilution of competitive pressure (25%-50%).

lower demand for natural gas[77] (which lowers the estimated benefits of unbundling), the impact of removing some of the operational synergies between the GSO and GTO functions, and the implementation costs of unbundling (which are higher than in electricity given the current fully integrated GTO-GSO model). Figure 2 below illustrates the component parts of the net impacts estimated.

Figure 5.2 - estimated impacts of removing asset ownership conflicts in gas system operation arrangements



	Low case	High case
Avoided over-investment in the gas transmission network	0.04	0.74
Removal of operational synergies	-0.43	0.04
Implementation costs	-0.41	-0.35
Net	-0.8	0.43

5.35. FTI assume that with an unbundled GSO, commercial balancing actions could increase to substitute for a decrease in short-term asset optimisation actions taken by the GTO. This is due to assumed frictions in the contracting between the two fully independent entities. Depending on the cost scenarios used, the costs of the increased commercial actions can outweigh savings estimated from reduced asset optimisation actions and

[77] This ranges from a 1% per annum reduction to a £300m per annum investment level to cover replacement and operational expenditure only.

savings assumed from removing a regulatory incentive for the combined GTO-GSO entity to balance efficiently.

5.36. FTI assume that as the demand for gas falls, maintaining gas balance will become an increasingly challenging and more costly task based on the current GB gas market design. However, we consider there to be limited evidence to prove that the magnitude and the cost of constraint management actions will indeed increase going forward.[78]

5.37. Potential scenarios involving hydrogen or green gas alternatives to natural gas are excluded from FTI's core analysis because of the uncertainties associated with the role of hydrogen and complexities in its potential impact on the gas network. However, most of the FES 2020 scenarios assume that the vast majority of natural gas is replaced with lower carbon alternatives by 2050. This could require further investment in NGGT's current assets as well as significant investment from local gas distribution network owners, which the GSO could influence and coordinate through its role in considering impacts on national transmission. The benefits to consumers from removing potential asset ownership conflicts of interest from the current GSO functions in network planning could therefore be greater than estimated.

Conclusions on asset ownership conflicts of interest

5.38. Our overall assessment of the potential asset ownership conflicts of interest demonstrates the significant scope for real or perceived bias to manifest in different aspects of the SOs' roles, and to undermine the advice to policy-makers that should be a key output of all future roles. Perceptions of bias are damaging regardless of whether there is any explicit evidence.

5.39. Our interview evidence suggests that, although legal separation of the ESO has gone some way to mitigate perceptions of conflicts of interest, it has not yet created sufficient confidence to enable it to take on and perform potential net zero system roles effectively. The fully integrated nature of the TO and SO in gas means the current arrangements may constrain the GSO's ability to drive forward net zero even further.

[78] Our RIIO-GT2 Draft Determinations set out our views on the magnitude and costs of constraint management actions forecast by NGGT for the RIIO-2 period (which also relate to FTI's forecasts).

5.40. The governance of the organisations that currently carry out the SO roles can influence the SOs' approach to innovation and adaptation to rapid system changes, and aligning the vision and strategic direction of the SOs with the changes needed for net zero would be beneficial. This may require fundamental change to the ownership structure.

5.41. The possible magnitude of net benefits to consumers from removing two aspects of current conflicts of interest also appears significant in the case of electricity. Based on our assessment, we consider there to be a strong case for considering fundamental changes to the governance and ownership of the ESO to address these conflicts.

5.42. In gas, the case is less certain particularly due to: (i) uncertainties in the future of the gas network and scale of required investment and (ii) the potential loss of operational synergies from integrated GTO-GSO functions in daily gas system operation. However, there are likely to be significant benefits to removing conflicts of interest that would otherwise constrain the development of the future GSO's network planning functions, including enabling independent advice to government on new technologies and the decarbonisation of gas and timely decommissioning of any redundant gas network assets. There are also likely to be significant efficiency benefits in removing real or perceived conflicts of interest from the GSO's potential market design functions. We therefore consider there to be a case for considering fundamental changes to the governance and ownership of NGGT with respect to its GSO functions.

Regulatory challenges aligning the commercial interests of the SOs' shareholders with consumer interests

Regulatory incentive arrangements

Electricity:

5.43. The most material impacts related to system operation activities are the external costs of contracting with balancing service providers or the wider system impacts on market participants. We have developed regulatory incentives as part of the funding allowances we set for the ESO to promote broader consumer value in their activities as well as internal cost efficiency.

5.44. Throughout the RIIO-T1 period (ie until April 2021), although the ESO has been funded through its own price control, certain aspects remain the same across NGET and the

ESO. Its funding model includes cost recovery, performance incentive and innovation funding mechanisms.

5.45. In 2018, we adopted a holistic performance incentives scheme for the ESO.[79] This scheme applies an evaluative scorecard approach to the ESO's performance including its development of future strategies and short-term plans and delivery against them, maximisation of consumer benefits and quality of stakeholder engagement. This approach reflects the broadening of the ESO's roles (for example, in facilitating efficient network investment across the system) and its associated influence over longer-term system-wide costs.[80]

5.46. The ESO's current internal cost recovery mechanisms include:

- An allowance for its approved forecast capital and operating expenditure.
- A TOTEX Incentive Mechanism ("TIM") which incentivises the ESO to minimise its internal costs against the allowance (whilst delivering against its obligations) by enabling it to retain approximately 50% of any outturn cost savings.

5.47. From 2021, the ESO will be subject to a separate price control arrangement under the RIIO-2 framework and will no longer be subject to the TIM.[81] The incentives framework will remain broadly similar to the current framework. It will have some refined or additional features designed to further promote proactive delivery of consumer benefits and strategic actions within the price control period that create longer-term efficiencies.[82]

Gas:

5.48. As the GSO is fully integrated with the GTO, system operation activities are funded through NGGT's price control. As part of the RIIO-GT1 price control (from 2013-2021), NGGT has an incentives scheme which incentivises the operational efficiency and delivery of consumer value beyond "business as usual" levels when operating the NTS. Some of the

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[79] Appendix 4 contains information on prior approaches to incentivising the ESO.
[80] The approach requires the ESO to develop forward work plans with stakeholders; publish regular performance metrics and performance reports; gather and submit stakeholder feedback and wider evidence on its performance to a Performance Panel appointed by Ofgem. Under the incentives scheme, the ESO is able to earn or required to pay a maximum of £30m per year.
[81] The ESO's performance in internal cost efficiency will be assessed against a cost benchmark as one of the performance metrics in its overall incentives scheme.
[82] Appendix 4 contains further information on the key changes.

system operation incentives bear resemblance to the historic approach used to incentivise ESO efficiency. For example, the residual balancing incentive rewards NGGT for minimising the impact of balancing actions it takes on market prices; and the quality of demand forecasting incentive rewards NGGT for improving the accuracy of its gas demand forecasts.

5.49. Under RIIO-GT2, the incentives package for system operation activities will be smaller, given the different natural gas landscape compared to the start of the current RIIO-GT1 price control. Although RIIO-2 will change the size and structure of the incentives, the financial incentives will continue to be based on the same activities and on quantifiable metrics.

Key outcomes under current regulatory incentive arrangements

5.50. In this section, we focus on the ESO. This is because its roles have expanded in recent years to encompass more market-based functions and strategic coordination functions in line with the direction of travel we have presented in Section 4 (SO roles for net zero), and its regulatory regime has developed accordingly.

5.51. The GSO functions and regulatory regime have not evolved in the same way to date and fundamentally shifting the model would be constrained by the current combined nature of the GSO and GTO. There is significant scope for a future GSO to take on new functions and the natural gas landscape is likely to undergo significant change due to decarbonisation. Overall, we consider the outcomes achieved under the current incentives framework for gas system operation to be less relevant for potential future GSO roles and environment.

5.52. Under the current regulatory framework, we have seen some successes relative to previous frameworks in terms of the approaches taken by the ESO and early outcomes. The ESO is now considering its performance on a much broader spectrum of activity and has a clearer longer-term vision and aims. There is also, generally, greater transparency of the ESO's activities. Some of our interviewees expressed support for the approach we have taken since 2018 as driving more responsiveness to change from the ESO. Other interviewees welcomed the increased transparency that the ESO's published forward work plans provide.

5.53. However, the ESO is meeting expectations whilst we need operational excellence in order to meet the challenges of the energy transition. The key future challenges for the

ESO's performance relate to providing **proactive leadership in complex areas with multiple partners**, **strategic planning** for securing and optimising the system including whole systems thinking.

5.54. We have identified some key examples where changes to the ownership and governance structure of the ESO could enable it to better develop these capabilities and to play a central role in facilitating net zero at least cost:

- **Operability risks related to distributed generation**: An increasing integrated and decentralised electricity system will require the ESO to adopt a whole system perspective in operating the transmission network. Our investigation into the 9 August 2019 power outage[83] identified a number of areas, such as issues with distributed generation and the impacts on system security, where new and improved systems and processes will be needed to tackle future system challenges. We recognise the challenges for the ESO in having sufficient visibility of generation not connected to the NETS given the current arrangements. We consider that changes to the current ownership structure could improve the ability of the ESO to coordinate with a much larger and more diverse set of generation owners and DNOs.

- **Rising balancing costs and market development:** Electricity system balancing costs have become increasingly difficult to manage as more intermittent renewable generation has been integrated into the electricity system. The development of a long-term framework for managing the system's increasing need for flexibility will be crucial for facilitating and incentivising cost-effective solutions for balancing a low carbon system. We, along with some of our interviewees, identified the need for the ESO to progress rapidly the development of transparent and tangible markets for new products to address on-going and foreseeable system stability challenges. With balancing costs likely to increase on the path towards net zero, it is important that the SO is fully empowered to develop and implement new and innovative approaches to reduce balancing costs.

- **NOA:** Since the launch of the NOA in 2014, the ESO has delivered several improvements that have aimed to deliver additional value to consumers. We have

[83] https://www.ofgem.gov.uk/publications-and-updates/investigation-9-august-2019-power-outage

challenged the ESO to be more ambitious and increase the speed of these changes and translating learnings from trials into tangible frameworks.

5.55. We recognise that, particularly since legal separation, the ESO has made increased efforts to be innovative. However, the challenge of net zero requires an even greater level of ambition to push the boundaries of innovative thinking.

Inherent regulatory challenges aligning the SOs' commercial interests with consumer interests

5.56. The overall package of financial incentives the SOs face through the regulatory framework will continue to be refined in order to promote consumer interests. For example, the removal of the TIM from the ESO's RIIO-2 price control will remove its previously sharp incentives to minimise internal costs. This should mitigate some of the risks of untimely delivery of plans and reductions in quality of service in its business-as-usual functions due to under-resourcing. In addition, the RIIO-2 allowance for the ESO will be based on a business plan solely focused on ESO outcomes and over a shorter-time period of two years. This should help to ensure funding is reflective of ESO specific activities and changing needs.

5.57. However, we expect that ensuring performance and appropriate incentivisation will become even more important given the challenges of net zero and the likely evolution of ESO and GSO roles. There are inherent challenges in incentivising a private profit-distributing company through the regulatory framework:

- **Limited appetite for risk-taking may prevent proactive leadership in complex areas.** Proactive leadership and whole system coordination will likely require the SO to challenge stakeholders in order to drive forward change. This can create risks, including reputational and litigation risks, that the SOs may often be perceived to be unwilling to take due to the potential negative impacts on projected shareholder value and the share price.
  - The consumer benefit from the SOs taking risk-taking actions may not align with the associated financial costs or rewards that are relevant to shareholders.
  - This is because the whole system benefits that the SOs can influence can be inherently difficult to quantify, attribute to the SOs' actions, and scale down precisely to the appropriate reward for the much smaller financial size of the SOs. In addition, whilst these risks are likely to be assessed in-

the round, there may be a weak relationship between risks occurring or being taken and the consumer benefits of specific actions (for example, providing particular advice to stakeholders).

- The current model therefore relies on a commitment to acting in consumers' interests regardless of the financial rewards or penalties but it is not reasonable to assume that this commitment will always be present in a commercial company – particularly if shareholder value is negatively impacted by its acting in this way.

- **Annual corporate reporting and shareholder reporting cycles can drive a short-term focus on within-year performance.** This goes against the requirement for strategic planning to create consumer benefits, which will be realised over a longer period of time.[84]

- **The SOs hold significant asymmetric information, which they can use to support their performance and funding claims,** given the lack of relevant comparators. This means it is inherently difficult to define the correct counterfactual against which to measure the SOs' performance. There is also significant risk that transparent dialogue with the SOs on the key challenges they face and how they could act more effectively and efficiently could be hampered by the negative impact that this could have on the companies' financial position. As a result, we are increasingly required to provide more detail of what the SOs should deliver whilst the SOs are clearly best placed to set their own plans.

- **Information asymmetry is expected to become more problematic as SO functions expand**. The SOs will acquire additional, unique information and expertise and it will not be possible to benchmark their performance (ie create a counterfactual) in any new functions against historic performance. This issue is likely to be particularly prevalent in gas where there is further scope for the GSO functions to expand relative to current functions.

[84] The ESO has said it does not agree that its financial reward or penalty should be determined every two years to align with the period over which Ofgem sets expectations, costs and outputs: https://www.nationalgrideso.com/document/176041/download

5.58. The difficulties associated with aligning the commercial interests of shareholders and consumer interest are very difficult to overcome through the regulatory framework. The potential for distortive commercial interests will in turn reduce the level of trust that industry and policy-makers placed in the SOs' information, choices and advice, preventing the SOs from taking on and performing net zero system roles effectively.

5.59. Box 5.7 below sets out some of the key themes in interviewees' views.

Box 5.7. Interviewees' views on aligning the SOs' commercial interests with consumer interests

Some interviewees questioned the appropriateness of the SO distributing profit to private shareholders, suggesting:

- the influence of shareholders' interests in profit and dividends (whether real or perceived) creates a **lack of trust** in the SOs' impartiality across the energy industry;
- it would be harder for the SO to be a profit-distributing organisation if it moves into the territory of **quasi-policy decisions**; and
- the ESO staff have an ethos of carrying out a **public service** and some question the appropriateness of profit-making based on their activities.

Other interviewees considered profit essential for incentivising high performance. Some suggested that adaptations to the regulatory framework could improve the SOs' performance:

- Some industry parties suggested a full cost-pass through mechanism would avoid risk-aversion in SO spending but also recognised this would require further trust.
- Another industry party suggested reforming **distribution network incentives** and aligning them with SO incentives would help to achieve whole systems outcomes.
- Others, including those with key relevant experience, considered the subjectivity of the **ESO performance assessment process** and uncertainty over whether it can earn additional revenue a barrier to its investments in improving its capabilities

However, several industry parties referred to inherent challenges in adapting SO regulatory incentives to drive net zero forward based on factors including:

- **complexity and uncertainty** of the actions that could be required;
- significant **information asymmetries** relative to the regulator; and
- **lack of any direct commercial incentives** for any party to minimise balancing costs.

The need for refreshed thinking in system operation

5.60. We also consider the influence of shareholders' commercial interests on the SOs' governance to drive approaches in the SO organisations which would benefit from a refreshed consumer-focus. These approaches include a tendency to consider other commercial companies in the industry as business partners and to prioritise open relationships with them rather than proactively monitoring and challenging their compliance with regulatory obligations where the SOs have the best information available to do so. This can lead to outcomes that are not in the consumer interest.

Conclusions on the regulatory challenges aligning the commercial interests of the SOs' shareholders with consumer interests

5.61. We consider the distortions in the SOs' incentives caused by the commercial interest of the shareholders to create significant challenges to the SOs taking on and performing net zero system roles effectively. Achieving the performance required is dependent on the design of different aspects of the future SO governance arrangements. However, if distortive commercial interests were removed, a model might be found where SO interests were better aligned with consumer interests. We therefore conclude that there is a case for considering alternative models to the profit-distributing private limited company model of the current SOs.

Discrete electricity and gas system operator frameworks

Legal and operational arrangements

5.62. The electricity and gas sectors are distinct legally, as reflected in the separate legislative, licensing and regulatory arrangements. The development of the electricity and gas systems under the current arrangements has typically been considered discretely in the context of these separate frameworks.

5.63. Section 105 of the Utilities Act 2000 prohibits disclosure of information relating to the affairs of a business. It contains a series of exemptions including where a licence holder due to a condition of their licence makes disclosure or where it is made by one licence holder to another and is required by that other licence holder for specific purposes. There are no licence conditions requiring the ESO or NGGT as the GSO to provide information to each other, which could provide specific exemptions for information sharing.

5.64. In addition, since the ESO was legally separated from NGET in 2019, staff are only able to work across GSO and ESO activities by exception. This restriction aimed to limit the influence of National Grid Plc on the ESO through NGGT due to conflicts of interest. The two SOs have recently completely separated themselves operationally. Our interviews and engagement with the SOs suggest that this separation was enacted to enable separation of the ESO to work better practically and that any losses were limited compared to those previously envisaged.

The issues

5.65. In section 4, we set out how the SOs will need to evolve towards operating in an increasingly integrated energy system in the future. Box 5.8. below sets out some key themes in interviewees' views on issues with coordination between the current SOs.

Box 5.8. Interviewee views on coordination between the current SOs

- An industry expert considered the **lack of people, skills and expertise** that work across gas and electricity and an "**electricity focus**" in National Grid Plc as a barrier for cross-systems thinking.
- A few interviewees referred to actual or perceived **legal barriers to information-sharing** between the ESO and GSO in advance of any wider sharing (for example, on the location and timing of specific network connections or ancillary service contracts) as a barrier to further coordination.
- Other interviewees including those with key relevant experience thought that improved coordination could be achieved through sharing **publically available information** and developing **a common language** across fuels – this was considered a lesson learned from the "Beast from the East" event in 2018.

5.66. Introducing licence conditions which enable information-sharing between the entities performing SO roles could address potential barriers to seamless coordination which could otherwise prevent the SOs from making informed whole system assessments in some of the net zero system roles. However, aside from this, the current arrangements do not appear to facilitate a step-change towards a cross-fuel approach to system operation. The SOs' potential new and enhanced functions are likely to require this kind of approach to ensure they can keep pace with and enable the net zero system change requirements identified in Section 3. The current arrangements appear to be particularly restrictive because the SOs have discrete legal frameworks setting out their obligations and incentives, and there are currently restrictions on dual fuel staff. Aligning the regulatory and legal frameworks and enabling cross-team working may be achieved and maintained most efficiently by integrating the ESO and GSO roles.

Conclusions on discrete electricity and gas system operators

5.67. We consider the current arrangements to present potential barriers to seamless coordination and the development of the joint electricity and gas thinking and expertise required by the net zero system roles. Without addressing these issues, the lowest cost and most effective solutions for achieving net zero may not be identified and developed. We consider there to be a case for considering combined responsibilities for performing electricity and gas net zero system roles.

6. Options assessment: SO remit and separation from National Grid plc

Section summary

Following our conclusion that there is a case for considering alternative options to current SO arrangements, we have identified and qualitatively assessed a range of alternative SO models. This section focuses on models that separate SO roles and functions from National Grid plc. Section 7 considers high-level organisational design.

Our key conclusions are:

- There are several alternatives that would allow for greater independence from transmission network operation and ownership (and National Grid plc).
- In electricity, full independence from the Transmission Owner ("TO") and the wider National Grid plc corporate structure would address an asset-ownership barrier and potentially bring significant consumer benefit.
- A similar case can be made for the gas SO but there is added complexity in untangling the current fully integrated SO-TO model due to certain physical characteristics of the gas system.
- Based on work done to date, we think there is a good case for separating key gas network planning functions from the TO.
- We will work with government on its forthcoming review of energy system governance to consider the appropriate roles, functions and responsibilities for a future SO, including whether it should include gas daily system operation functions.

Introduction

6.1. We commissioned FTI Consulting ("FTI") to assess a range of alternative SO models against criteria (see Tables 6.1 and 6.2). The alternative models vary according to the degree of separation from National Grid plc and remit (SO roles and functions). FTI's assessment did not conclude with a recommended option as they did not make a judgment on the relative importance of different assessment criteria. FTI considered policy-makers would likely have to make such judgments to decide on a suitable option.

6.2. This section provides an overview of our assessment of each option including a view on whether the option meets our principles for future system operation as set out in

Section 1. Appendix 5 provides additional detail on the considerations underpinning our assessment which draws upon FTI's assessment at Annex 1.

6.3. Following changes to the ESO's governance arrangements and changes set out in our RIIO-2 Draft and Final Determinations[85], we consider that the 'enhanced legal separation' option considered by FTI more accurately represents the status quo for the ESO during the RIIO-2 period and therefore use it as the status quo option for electricity. We continue to consider the status quo option, as set out in Table 6.1, for gas.

Table 6.1. Options assessed by FTI

Option	Key characteristics	
Description	**Degree of additional separation of unbundling**	**Fuel/vector**
Status quo: represents current SO arrangements.	**None**. Reflects the current legal separation arrangements for the ESO and the fully integrated nature of NGGT.	Electricity, gas
Enhanced legal separation: represents additional obligations on the ESO that aim to further mitigate any conflicts of interest.[86]	**Limited.** Enhanced separation of the ESO without unbundling any functions.	Electricity only
Strategic planning body: this model unbundles[87] a range of current and net zero system roles from National Grid plc with control centre operation functions performed by NGET or NGGT.	**Considerable.** Current and future net zero system roles related to market development and transactions and whole system insight, network planning and coordination[88] would be unbundled from National Grid plc and transferred to a strategic planning body. Electricity control room operations would be performed by NGET. Gas control room operations would be performed by NGGT.[89]	Electricity, gas

[85] Notable changes since FTI's assessment include: as of 01 August 2020, the ESO Board has a majority share of Independent Non-Executive Directors; changes to the membership of the ESO Committee to reflect its separation from National Grid; and removal of staff positions that overlapped the ESO and GSO. In addition, in our RIIO-2 Final Determinations we set out our continued concern regarding the ESO's current shared IT model and that we see a strong case for full ESO IT autonomy, delivered to an appropriate timetable. Given the relative complexity of the issue and the wider context, we decided to consider these arrangements outside of the RIIO-2 process.
[86] This includes: stronger restrictions on ESO's use of shared services provided through National Grid plc; stronger restrictions on day-to-day governance interactions with National Grid plc and its affiliated companies; changes to the ESO board's role and structure to increase the role of the independent directors' and removal of any scope for 'dual fuel' employees to exist.
[87] The term 'unbundles' is used to refer to the transfer of SO functions away from the corporate structure in which National Grid plc is the parent company rather than the unbundling of a vertically integrated undertaking as in the context of EU law.
[88] In gas, these functions would include, but not be exclusive to, long-term forecasting, long-term network planning and leading on the network capability assessment process.
[89] As discussed in section 4, the GSO currently has an important but less expansive role, when compared with

Option	Key characteristics	
Independent System Operation ("ISO"): SO companies are no longer a part of National Grid plc – Box 6.1.	**Full.** Unbundling of all current and future net zero system roles from National Grid plc.	Electricity, gas, electricity and gas combined.

Table 6.2. Assessment criteria used by FTI

Criteria	Description
Efficiency	• Extent to which a set of arrangements promote outcomes that reflect those in competitive markets and whether the system, as a whole, is likely to incur costs efficiently on an ongoing basis. • Includes ability to facilitate secure and efficient day-to-day system operation, promote outcomes that deliver net zero at lowest cost to consumers. Also includes efficiencies/cost-savings associated with eliminating any asset-ownership bias in the current SO arrangements.
Simplicity	• Ease at which market participants can engage with SO arrangements. Simpler arrangements likely to: 1) reduce regulatory burden on regulators and stakeholders and 2) be easier to monitor and increase the predictability of behaviour and decision-making.
Transparency and credibility	• Ability (real and perceived) of providing useful and unbiased information to market participants and other key stakeholders. Includes provision of impartial, strategic advice to government, Ofgem and industry on a range of issues, including decarbonisation. • Considers extent to which the SO is perceived to be credible in its role by market participants.
Co-ordination and adaptability	• Ability to act as a strategic co-ordinator across stakeholders in the energy system and remain relevant and effective in response to changing energy system needs. • Includes ability to future-proof the energy system, by providing robust assessments of energy system infrastructure needs and facilitating effective system planning and network development.
Ease of implementation	• Likely complexity and cost associated with transitioning to the arrangements from the status quo.

electricity, in facilitating gas markets. There is less certainty over future gas market development and transaction functions as the way in which heat and heavy industry, for example, will decarbonise, depends on forthcoming policy decisions. Depending on how these roles and functions develop over time, it could be more appropriate for them to remain with NGGT.

Box 6.1. The ISO model

The ISO model is well-established and used around the world, including in Australia, Canada, the USA, Chile and Peru.

While the term 'ISO' has different connotations across jurisdictions, they are independent from ownership of electricity transmission wires or gas transmission pipes and typically government-regulated entities that coordinate regional transmission to ensure non-discriminatory access to the grid and a reliable electricity system.

The ISO model has previously been considered for GB system operation:

- This was first suggested in Pollitt (2012), 'The role of policy in energy transitions: Lessons from the energy liberalisation era' in *Energy Policy* and in Strbac et al (2014), 'Electricity transmission arrangements in Great Britain: Time for change?' in *Energy Policy*.

- In 2016, the Energy and Climate Change Select Committee recommended the ISO model, with the ISO to be a non-profit distributing entity, completely separate from NGET and with no other transmission interests.

- In August 2017, motivated by the objective to deliver decarbonisation and energy security (the "twin objectives") in the most cost-effective way, BEIS launched an independent review led by Professor Dieter Helm CBE. The institutional structures proposed by Professor Helm to support the twin objectives are an independent national system operator ("NSO") and regional system operators ("RSO"), who would do the following:

a) take on some of the obligations in the relevant licences from regulation transmission and distribution companies;
b) open up the various functions and enhancements to the networks to competitive auctions; and
c) at the local level, invite bids for network enhancements, generation and storage, and demand-side response from energy service companies.

- The Helm Review proposes placing public duties on the NSO/RSOs, who would take on some of the obligations currently shared between the network companies, Ofgem and government.

Assessment of electricity options

Status quo / enhanced legal separation

6.4. We expect further separation of the ESO's governance from National Grid plc and changes to its use of shared services to improve outcomes for consumers. However, this option will not fundamentally change the corporate ownership link of the ESO to National Grid plc and governance interactions will remain. As a result, we do not expect this option to fully resolve potential real or perceived conflicts of interest. These conflicts will increase in materiality if the ESO were to take on key net zero roles. This will limit the ESO's ability to play a central role in the energy sector's move to net zero and its ability to act in consumers' interests. In light of anticipated energy system changes and net zero SO roles and functions, this option does not meet our principles for net zero system operation as set out in Section 1.

Electricity strategic planning body

6.5. Under the strategic planning body option, control centre operations would be carried out by NGET, while all other roles and functions (see Table 6.1.) would be transferred from National Grid plc to a new strategic planning body.

6.6. The key benefits of the strategic planning body option include:

- May **mitigate some of the potential for real or perceived asset-ownership bias** to impact the strategic planning body's performance of key current and net zero system roles and functions.

- Separating responsibility for the control centre operations role from the market development and network planning roles could create **better incentives to apply longer-term thinking** to those latter roles. This could reduce conservatism and distortive short-term thinking as the strategic planning body would not be directly occupied by the real-time requirements associated with 'keeping the lights on'.

- The strategic planning body option would enable the **return of operational synergies between the control centre operations and NGET's asset operation** (see Box 6.2.).

6.7. There are several potential limitations with this option including:

- **Less effective and efficient system planning and balancing**. A new interface between electricity control centre operation functions and the market development and network planning functions (see Box 4.2 and Box 6.2) could introduce inefficiencies across these roles. For example, the strategic planning body's lack of direct experience and potential technical expertise on real-time system operation could undermine its ability to understand the operational impacts of new technologies. This could create system risks and operability challenges that would need to be retroactively addressed, eg through changes to market arrangements.

- **Potential security of supply risks from separating system balancing and system planning functions**, as highlighted in Section 4.

- NGET (as control room operator and real-time system balancer) would play a critical role in providing the strategic planning body with information and operational advice that will be pertinent across the strategic planning body's roles and functions. An **information asymmetry between the strategic planning body and NGET** could undermine the strategic planning body's ability to perform its functions effectively. The loss of information synergies across system planning and balancing functions (see box 4.2) would be compounded by the potential for asset ownership bias within NGET to constrain the flow of information from the control centre to the strategic planning body.

    - Any limitations in the information from NGET could **create inefficiencies and undermine the strategic planning body's ability to perform its functions** effectively and efficiently.

    - Given these potential conflicts, this may necessitate **duplication of resource and expertise** within the strategic planning body.

    - Stakeholders may also have **concerns over the transparency and credibility** of that information, with this negatively affecting the strategic planning body's ability to coordinate system-wide change and take on additional roles and functions.

6.8. This option would create implementation costs which have not been quantified. These costs would likely be lower than the full ISO model and take less time to implement as the strategic planning body would have a more limited range of functions and this option may not require legislation. However, these costs would be non-trivial and include:

- Up-front costs associated with establishing a strategic planning body (eg establishing a new entity with appropriate premises and governance arrangements); licence, code and any further legal changes required to transfer functions from the ESO and establish the body's obligations; and on-going costs related to duplicated functions between the strategic planning body and

NGET which are currently provided through National Grid plc, eg back-office and some corporate functions.

- Returning control centre operations to NGET which would require changes to NGET's licence conditions and industry codes.

Box 6.2. Operational and information synergies in electricity system operation

Information synergies

As discussed in detail in box 4.2, industry experts, including those with key relevant experience, stressed the importance of the feedback loop between system planning and balancing:

"If you take out the System Operator [functions] into an independent body and the control room remains within NG, there would be a big danger you lose the connection between commercial people and engineers. Therefore, the commercial people won't actually understand how market development should align with system needs." (Industry expert).

Operational synergies

The ENCC carries out real-time system balancing by contracting and trading with energy market participants (eg generators, storage providers and third-party providers of aggregated flexibility). This is done via the Balancing Mechanism and the use of ancillary services.

The ENCC can also request the TOs to make physical changes to network configurations using network assets to help balance the system (eg flexing voltage tolerances, amending specific circuit ratings or delaying planned outages and maintenance). The TOs have final decision on how the ESO's system operation needs can be met.

Operational synergies between the ESO and TOs are an important part of electricity system operation and are valuable given the highly constrained nature of the electricity system and high cost of system balancing. However, the current and future use of operational synergies is constrained by several factors:

- opportunities for operational synergies are limited in Scotland where the TOs are not National Grid plc entities;
- operational synergies between the ESO and NGET have reduced following legal separation, with the benefits from legal separation deemed to greatly exceed any loss of synergy[1]; and
- ESO and TO operational synergies in England and Wales are likely to reduce over time as new transmission network projects may be built and owned by third parties.

[1] https://www.ofgem.gov.uk/system/files/docs/2017/08/future_arrangements_for_the_electricity_system_operator_-_response_to_consultation_on_so_separation.pdf

6.9. We have considered a variant on the strategic planning body option considered by FTI based on the arrangements in Brazil, where an ISO is responsible for control centre operations, including real-time grid management and connections. The Brazilian Energy Research Company, a separate public sector body that reports to the Brazilian Energy Ministry, is responsible for long-term system planning (with a 10-year remit), advising the Ministry on the evolution of the energy market and facilitating competitive tendering in transmission asset delivery.

6.10. The key difference between the Brazilian model and the FTI strategic planning body variant is that the Brazilian model has control centre operations independent from the TO. This could **reduce potential real or perceived conflicts of interest in the control centre and flows of information from it,** meaning the strategic planning body would not be undermined by potential distortive commercial interests. This could enable the strategic planning body to perform its roles more effectively and efficiently than under the FTI variant.[90]

6.11. On balance, we do not think the strategic planning body option meets our principles for net zero system operation as set out in Section 1. While this option would restore operational synergies between the ENCC and NGET, the strategic planning body could be constrained in its ability to perform its functions effectively due to a lack of operational expertise and susceptibility to distortive commercial interests. Given the importance of the feedback loop between system planning and balancing, if a range of current and net zero system roles and functions were allocated to a strategic planning body (eg a non-SO entity), we believe it would be important for electricity control centre operations to be free of potentially distortive commercial interest and network ownership.

Electricity ISO

6.12. By fully unbundling all current and future net zero system roles from National Grid plc, this option **fully removes the potential for real or perceived asset-ownership**

[90] The Brazilian model does however create an additional interface between control centre (the ISO) and the TO, as well as between the ISO and the Strategic Planning body. This may introduce additional inefficiencies and complexities in the coordination of multiple parties with different core functions and incentives.

bias. Removing this potential bias would enable the electricity ISO to perform a wide range of current and future net zero functions effectively and increase the SO's incentive and ability to coordinate system-wide changes compared to the status quo. It would have better incentives to act in consumers' interests and would not be viewed as subject to potentially distortive commercial interests related to asset ownership bias. On this basis, it meets our principles for future system operation as set out in Section 1.

6.13. As set out in Section 4, there are potentially significant consumer benefits associated with the SO performing future net zero system roles effectively. FTI estimated net transmission network investment benefits of between £0.4-£4.8bn from moving to an electricity ISO.[91] This model does not increase operational synergies but it does retain the existing feedback loop between control centre operations and market development and whole system insight and network planning functions. As noted in Section 4, we regard real-time system balancing experience as crucial for effective electricity system planning and anticipated that it will become increasingly important in the future.

6.14. The electricity ISO option creates implementation costs and risks. These costs are lower than would be the case if NGET had retained its SO functions.[92] Implementation costs are broadly associated with:

- Up-front and on-going costs associated with full separation from National Grid plc (eg creating separate currently shared back-office and corporate functions and operational IT systems).

- Potentially significant changes to the legislative, licensing and industry codes (see box 6.3 below) which have not been quantified.

6.15. Implementation costs and transition risks will be closely tied to decisions related to the future structure and design of an ISO (see box 6.3 below) and require a full cost-benefit analysis. However, we consider that the significant potential benefits of an electricity ISO have the potential to outweigh the associated risks and costs, particularly as

[91] FTI's assessment models the value to the UK economy of the change. Therefore, they do not include transfer payments such as the costs associated with the divestment of the assets.
[92] See Appendix 4 for information on legal separation obligations and restrictions.

effective transition arrangements can mitigate against some of the risks and minimise potential costs.

Box 6.3. Legislative and regulatory changes

We assume that creating and implementing an ISO model will require significant change to the current legislative and regulatory regime. The scope and extent on this change would depend upon a range of government policy and regulatory decisions including:

- the ISO's scope (ie the remit of its activities and whether it would include both electricity and gas functions);
- the ISO's ownership/commercial model (see Section 7); and
- whether the ISO would be a licenced and regulated entity (also considered as part of section 7).

We assume primary legislation would be required to introduce an ISO with a bespoke remit, in particular one that performed both electricity and gas functions. The scope and intent of the legislation would also depend upon several factors including the ISO's ownership and commercial model. For example, if the ISO was to be a licensed and regulated entity, primary legislation would need to set out the conditions for granting a licence to the ISO, grant modification powers and (potentially) create initial licence conditions to reflect new responsibilities across ISO roles.

An ISO licence would depend upon the organisation's scope and roles which could, in turn, require modifications to relevant transmission licences. In addition, we assume code changes would be required, eg where responsibilities have transferred to the ISO via licence conditions.

Assessment of gas options

6.16. Our assessment of gas SO models differs in three key ways from our assessment of electricity SO models:

- **Differences in the status quos**: The current fully integrated gas TO/SO model would result in higher implementation costs if moving to the ISO model. For example, if you were to unbundle control room operations from NGGT, this would be expected to produce significant costs, some of which have already been incurred in electricity through legal separation.
- **Physical characteristics of the gas system that mean the loss of operational efficiencies may be significant and materially impact the gas Safety Case**: The GNCC currently uses NGGT's assets to operate the system on

a daily basis (see Box 5.6 and Appendix 3). Separating TO and SO functions would result in the loss of operational synergies which impact safety. Mitigations (such as GTO-GSO service level agreements and licence conditions) could be used, however, an interface between the GTO and GSO is anticipated to create some friction and be less cost-efficient and more likely to impact safety than the status quo.

- **Greater uncertainty over the future of the gas system and network investment needs:** Uncertainty over the role of the gas system in decarbonising heat and transport means future GSO roles and functions and gas network investment are highly uncertain. This makes it more difficult to estimate the gas transmission network investment savings associated with addressing the potential asset ownership bias.

Status quo/counterfactual

6.17. The fully integrated TO/SO model creates significant potential for real or perceived asset ownership conflicts of interests. In light of anticipated energy system changes and net zero SO roles and functions, this option does not meet our principles for net zero system operation as set out in section 1.

6.18. These conflicts would increase in materiality if the GSO was to take on net zero roles and constrain its ability to provide impartial, technical advice on the future of the gas system and the decarbonisation of heat. The status quo will, therefore, limit the GSO's ability to take on enhanced functions, play a central role in the energy sector's move to net zero and constrain its ability to act in consumers' interests.

6.19. As the gas status quo is not subject to the mitigations present in the electricity status quo, the gas status quo has the potential to bear greater risk and cost in terms of credibility, coordination and adaptability.

Gas strategic planning body

6.20. Under this gas strategic planning body option, control centre operations would continue to be performed by NGGT. Key long-term strategic planning functions would be separated from the TO. These functions would include, but not be exclusive to, long-term forecasting, long-term network planning and leading on the network capability assessment process.

6.21. This model has the potential to meet our principles for net zero system operation. As discussed in our assessment of the electricity strategic planning body option, there are several drawbacks to this model. However, this option could help accommodate the following practical considerations of gas system operation:

- The gas strategic planning body option would retain important operational efficiencies between gas control room operations and the TO. The integration of certain SO and TO functions is important for gas system safety and security, with the SO (within NGGT) using transmission network assets to operate and control the network on a daily basis to manage constraints and ensure system safety.

- This option would avoid potentially significant costs associated with removing the control room from NGGT.

- As shown in Section 4 (see Box 4.2), interviewees with roles in relevant National Grid plc companies did not consider the feedback loop between the gas control room and NGGT's market development and network planning functions to currently be as important when compared to electricity system operation. On this basis, any remaining bias within control room operations may have less impact on the gas strategic planning body's ability to perform its functions effectively. However, we note that some gas experts indicated that the information feedback loop should be stronger and the importance of this may increase in the future.

6.22. Several interviewees and an industry expert, highlighted the importance of independent gas system planning for achieving net zero. This option has the potential to reduce the scope for potential real or perceived bias across a range of current and future net zero roles and functions, including network planning and design.

6.23. There is currently very little network connection and expansion activities associated with the NTS. Therefore, the benefits from independent network planning may be limited in the short to medium term. However, gas and whole system network development that is independent and not biased towards the existing networks is likely to be required in the future (eg to facilitate a move to hydrogen). A gas strategic planning body would have better incentives than the status quo to perform a coordination and delivery role for heat policy solutions and to act in consumers' interests. It could also play a key role in evaluating innovative projects and emerging gas decarbonisation options.

6.24. This option would create material implementation costs, which have not been quantified. As with the equivalent electricity option, this would include the up-front and on-going costs associated with establishing a new strategic planning body and duplicating certain functions across this body and NGGT, and changes to licences and industry codes. There would also be additional duplication of roles between NGGT and the strategic body given the status quo is a fully integrated model without any legal separation of current GSO functions. There would be additional legal and technical work to identify the relevant functions and obligations that would be transferred and to mitigate any consequences from decoupling SO functions from the TO function. Implementation costs and timescales are, however, assumed to be less than the full gas ISO model given the more limited functions being transferred.

Gas ISO

6.25. By fully unbundling all current and future net zero system roles from National Grid plc, this option **fully removes the potential for real or perceived asset-ownership bias**. Removing this potential bias would enable a future GSO to perform a wide range of current and net zero functions effectively and increase the SO's incentive and ability to coordinate system-wide change compared to the status quo. It would have better incentives to act in consumers' interests and would not be viewed as subject to potentially distortive commercial interests related to asset ownership bias. On this basis, it meets our principles for future system operation as set out in Section 1.

6.26. This model retains the existing feedback loop that facilitates information synergies between the control room operations and market development and network planning functions. However, compared to the status quo and gas strategic planning body options, a gas ISO requires the removal of control room operation from NGGT. This is anticipated to create additional risks related to the loss of operational efficiencies and Safety Case implications.

6.27. As set out in Section 5, FTI estimated the impact of removing operational synergies to range from a £0.8bn cost to a £0.4bn benefit from 2022-2050 in present value terms. While mitigations could be put in place to reduce the associated cost, for example GTO-GSO service level agreements, the outcome is expected to be less efficient than the status quo. However, the magnitude of this inefficiency is – at present - difficult to quantify, in particular due to uncertainty over future decarbonisation pathways.

6.28. Unbundling control room operation from NGGT would constitute a significant enough change to require a Safety Case to be submitted to the Health and Safety Executive ("HSE"). This may incur some additional one-off implementation and ongoing costs, which we were unable to estimate in our analysis.

6.29. Securing approval for a new Safety Case would need very careful consideration. The case would need to demonstrate that the new arrangements are at least as safe as current arrangements. This would involve demonstrating that all safety related operational processes within NGGT are as seamless and fluid between the gas ISO and NGGT, and that the ability of NGGT to invest in the safety and security of the physical network is in no way compromised. Additional costs would be incurred in resourcing this interface and new systems required to make this operational (eg a Network Operation centre within NGGT controlling physical assets like valves and compressors, seamlessly interfaced with the gas ISO control centre).

6.30. Compared to an electricity ISO, the implementation costs associated with the gas ISO model would be greater and changes would take longer to implement. Implementation costs include:

- Upfront and ongoing costs associated with full separation of gas SO functions from NGGT including establishing a new entity with appropriate premises, governance arrangements and the ongoing costs of duplicated corporate functions between the ISO and TO, which FTI estimate could range from £346 million to £408 million from 2022 to 2050 in present value terms.
- Potentially significant changes to the legislative, licensing and industry codes which have not been quantified. In addition to the code changes highlighted in Box 6.3, the creation of a gas ISO may also require the establishment of a new code to manage the high-level relationship between the gas ISO and NGGT.
- As mentioned above, further regulatory costs may arise from the need to submit a new Safety Case to the HSE and implement approved changes.

Assessment of a combined option

6.31. FTI assessed a fully combined electricity and gas ISO option. FTI concluded there may be additional benefits from a combined electricity and gas ISO relative to having fully unbundled but separate electricity and gas ISOs.

6.32. The additional benefits of a combined electricity and gas ISO included the potential for:

- enhanced coordination, adaptability and management of risk and synergies that generates efficiencies across the two systems;
- greater co-optimisation of network planning across the electricity and gas systems;
- improved coordination during times of system stress; and
- better understanding and provision of advice on cross-system technologies, with potential benefits for the adoption of new technologies such as hydrogen and heat pumps.

6.33. FTI note that a fully combined ISO is the option least easy to implement as:

- it would combine the costs of establishing ISOs in both electricity and gas, and
- any delay in unbundling the GSO from NGGT due to the current fully integrated gas SO model could delay the realisation of benefits from unbundling electricity functions.

6.34. As the nature of short-term electricity and gas system operation are very different, there may be limited synergies from combining real-time operations in one body. However, energy system changes and net zero SO roles indicate there could be potentially significant benefits from enhanced coordination across electricity and gas network planning. In general, there could be additional benefits associated with the creation of a new, overarching strategic energy ISO that is able to make better, more coordinated decisions and enable effective optimisation across the electricity and gas systems. A combined ISO would in turn be able to use its whole system insight to provide trusted, impartial advice across a broad range of decarbonisation issues.

Box 6.4 Interview views on a combined electricity and gas model

There were a range of views from interviewees on the merits of a combined electricity and gas system operator.

- An industry party said: "I think the benefits arise because it's an integrated role. Its skills and activities are very similar. Its procurement and balancing services. There's control room activities. Its coordinating between the system operation of the gas and electricity markets in perhaps a more coherent way than they do at the moment. I know it's not permitted at the moment, but clearly there are interaction between those two markets. That's where the synergies arise."

- An industry party said: "The ESO's role should grow in areas that bring efficiencies or greater coordination to deliver net zero. It is logical for the GSO to be part of this body."

- An industry expert said: "That is the bit that is missing, some optimisation, so that you can both leverage gas and put gas and electricity together […] the discipline was largely there because of the two licence constructs. But I think it also stifled some movement of staff."

However, some interviewees argued that electricity and gas system operation did not need to be in one entity to facilitate a whole system approach to energy system operational and planning.

- "You could set up a combined, unified ESO and GSO, but I don't know if that is going to achieve the objective of achieving net zero."

Key findings

- **Refining the current arrangements can improve consumer outcomes but will limit the ability of the SOs to play a full role in decarbonisation**

6.35. The enhanced electricity legal separation and gas status quo options do not respectively change the corporate ownership link of the ESO to National Grid plc or the fully integrated nature of gas TO-SO functions. Therefore, they do not correct for potential real or perceived asset ownership conflicts of interest. The materiality of these constraints are expected to increase as the ESO and NGGT (as GSO) take on new and enhanced roles needed to achieve net zero efficiently and effectively.

6.36. The status quo is likely to limit the ability of the ESO and GSO to play a central role in the energy system's move to net zero and act in consumers' interests. This reflects the potential for:

- perceived partiality by stakeholders and concerns over transparency and credibility which could limit the SOs' role in coordinating change and providing industry leadership;
- inefficiencies in functions related to network planning and facilitating competition; and
- commercial interests, particularly in gas, that may dampen the SOs' incentives to cooperate with and facilitate whole system coordination and collaboration.

6.37. As the gas status quo is not subject to the mitigations present in the electricity status quo, this has the potential to bear greater risk and cost in terms of credibility, coordination and adaptability.

➢ **The ISO model can enable and facilitate an integrated, flexible system and deliver significant consumer benefits**

6.38. We consider that full independence from the TO and the wider National Grid plc corporate structure will be required to address concerns related to potential real or perceived asset-ownership bias. Addressing this constraint would enable the SOs to take on and effectively perform a wide range of net zero functions and deliver system-wide benefits.

6.39. By addressing the asset ownership constraint, this option has the potential to:

- increase the transparency, credibility and adaptability of GB system operation with the ISO free, and perceived to be free, of distortive commercial interests related to asset ownership;
- deliver greater efficiencies in network planning, with scenario modelling estimating a net benefit of between £0.4-£4.8bn in electricity transmission network savings alone; and
- create system-wide benefits from the SO taking on greater leadership in whole system coordination and collaboration, with the SO having better incentives to drive forward change that is in consumers' interests.

6.40. The ISO model will create implementation costs and risks that will be influenced by government decisions on the ISO's role, remit and structure. Our initial view is that the significant potential benefits of an electricity ISO with enhanced roles and functions has the potential to outweigh associated risks and costs, particularly as effective transition arrangements can mitigate against some of the risks and minimise potential costs. This would need to be fully validated once relevant policy decisions were taken.

- **A similar case can be made for gas system operation but added complexity in untangling the current fully integrated SO-TO model and current uncertainty over the natural gas decarbonisation pathway means the benefits are less certain and need further analysis.**

6.41. Based on work to date, we think there is a good case for separating key gas network planning functions from the TO and combining in a new energy ISO to ensure this body has a substantial gas network planning team. We will work with government on its forthcoming review of energy system governance to consider the appropriate roles, functions and responsibilities for a future SO, including in relation to gas.

7. Options Assessment: high-level design

Section summary

This section uses an initial review of international SO models and relevant GB sectors to identify potential models for an ISO. It also identifies key design parameters that will be important for an ISO to perform roles and functions effectively and meet our principles for future system operation as set out in section 1.

Our key conclusions are:

- There are a range of alternative models that could address constraints associated with the current profit-distributing private limited company model of the GB SOs.
- Any government decision would need to consider complex trade-offs in developing an optimal model.
- We will work with government on its forthcoming review of energy system governance to consider the potential models and design parameters further.

Introduction

7.1. Ownership structure, governance arrangements and wider organisational design will be key determinants of whether an ISO, or any future SO model, will be able to perform net zero roles and functions effectively and meet our principles for future system operation.

7.2. Decisions on the future structure and design of GB system operation are for government. This section provides insight into the range of potential organisational design models appropriate for GB system operation and key design parameters important for future system operation. At this stage, we have not considered the full implementation costs or risks of the different models which could have important implications for timing and transitional costs. We will work with government to consider this and the full range of trade-offs between the various models in further detail.

International system operator comparators

7.3. While the ISO model is well established and used in several jurisdictions around the world, there is no single dominant model. A review of international SOs indicates that organisations are typically a function of their historical context and market development. All models have their challenges and limitations. Table 7.1 provides a high-level overview of SOs in different jurisdictions.

Table 7.1 High-level overview of international SOs

Organisation	Vector	Legal structure	Regulated	Profit status	Board appointment	Degree of separation from asset owning entities
AEMO (Australia)	Gas & Elec	Company limited by guarantee (60% government, 40% industry membership)	Not subject to economic regulation (except in Western Australia). Statutory duties described in National Electricity Law and Rules	Non-profit – operates on a cost recovery basis	Council of Australian Governments by prior approval by members	ISO – except some control room operations.
AESO (Alberta)	Elec	Statutory corporation - statutory duties described in Alberta Electric and Utilities Act	Yes – by the Alberta Utilities Commission (some functions)	Non-profit	Alberta Energy Minster and industry board	Full - ISO
California ISO	Elec	Public benefit corporation	Yes – by the Federal Energy Regulatory Commission ("FERC)"	Non-profit	By State Governor	Full - ISO
Eirgrid (Ireland)	Elec.	State-owned public limited company	Yes – licensed by Commission for Regulation of Utilities	For-profit (dividend paid to Irish exchequer)	By Ministers	Limited separation
Elering (Estonia)	Gas & Elec	State-owned company	Regulated by Electricity Market Act and Natural Gas Act	For-profit (dividend extracted for Estonian state)	By Minister	Limited – ITSO
Energinet	Elec	State-owned	Yes - by the Danish Utility Regulator	Not-for-profit	Largely by Ministers	Limited - ITSO
Fluxys	Gas	Public limited company – with government golden share	Yes – by the commission for Electricity and Gas Regulation.	For-profit	By parent company board	Limited – ITSO
Gasunie (Dutch/ German)	Gas	State owned – Dutch State is sole shareholder	Yes – by Dutch Authority for Consumers and Markets	For-profit (dividend paid to the state)	By Ministers	Limited – ITSO
National Grid ESO (GB)	Elec	Privately company limited by shares	Yes – licensed by Ofgem	For -profit (dividend paid to private shareholders)	By parent company board	Limited separation
New York ISO	Elec	Public corporation	Yes – by the FERC	Non-profit	Board with recommendation from stakeholder sub-committee	Full - ISO
PJM (US)	Elec	Privately held, limited liability	Yes – by the FERC.	Non-profit / operates as profit neutral	Via vote by member committee	Full - ISO

Organisation	Vector	Legal structure	Regulated	Profit status	Board appointment	Degree of separation from asset owning entities
		corporation (owned by industry members)				
Transpower (New Zealand)	Elec	Statutory corporation	Yes – by the Electricity Authority	Non-profit	By Ministers	No - ITSO
SONI (System Operator for Northern Ireland)	Elec	Public limited company – wholly owned subsidiary of Eirgrid	Yes – by the Utility Regulator	For-profit – dividend paid to the shareholder	By parent company	Full – ISO

7.4. Table 7.1 illustrates that while there is a wide range of SO ownership and governance structures, ISOs and ITSOs are typically not private, profit-distributing entities[93] and either state-owned (eg in Ireland and mainland Europe) or mutualised companies[94] such as public benefit corporations (eg typical of the US ISOs).[95]

7.5. We have identified only one private, for-profit ISO – the System Operator for Northern Ireland ("SONI"), which is part of the EirGrid Group, the Irish state-owned company. We note two failed attempts to establish a fully private, for profit ISO in the Providence of Alberta and the Alliance ISO in the USA.[96] The private, for-profit model is therefore rare.

Relevant GB comparators

7.6. In addition to reviewing international comparators, we have also considered potential comparators used in other GB sectors. We have identified four potential

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[93] The 12 international ISOs and Regional Transmission Organisations ("RTOs") studied as part of Anaya and Pollitt's 2017 review of ISOs are all categorised as not-for-profit organisations. Anaya and Pollitt note that the group of ISOs and RTOs existed in similar jurisdictions to GB in terms of the structure of the electricity industry (vertically disintegrated, privately owned and market based) and in terms of policy ambition towards decarbonisation and the promotion of renewable electricity. https://www.ofgem.gov.uk/system/files/docs/2017/12/eprg_report_on_international_system_operator_regulation.pdf

[94] The term "mutual" is not itself a legal form. Rather it is used as an umbrella term for several different ownership models. In the UK, they are most-commonly structured as community interest companies that are limited by guarantee.

[95] For further discussion, see: Michael G. Pollitt (2011), '*Lessons from the History of Independent System Operators*', *Energy Policy.*

[96] Pollitt (2011) provides context on the failures. A management contract was tendered for a for-profit ISO in the Providence of Alberta to run the system operation for 5 years. However, the contract was not deemed flexible enough, the power pool was being operated independently of system operation and the for-profit arrangement was too costly. An attempt to form the Alliance ISO was not completed after the FERC deemed that the proposed for-profit institution would be too costly and encouraged proposing members to join other membership SOs. Based upon a review of international experiences in electricity system operation, Pollitt (2011) concluded that an ISO should be not-for profit.

alternative models relevant to GB currently used in other regulatory contexts (see Table 7.2). Again, our review indicates that organisations are typically a function of their historical context and market development.

Table 7.2. Key features of the models considered

Model	Key characteristics
Model 1: Private company limited by shares, profit distributing	• Private company limited by shares. • Similar to the status quo but would be independent from the TOs and wider National Grid plc corporate structure and not part of any corporate group that owns other assets in the energy sector. • Profits extracted and distributed to private shareholders. • Licenced entity subject to price control and regulated by Ofgem. • Limited government involvement or accountability beyond licensing arrangements. • Independent board. • Would have to abide by the Companies Act and relevant corporate governance codes.
Model 2: Private company limited by shares with government golden share, profit distributing (eg National Air Traffic Services)	• Private company limited by shares but with government golden share. • Similar to the status quo but would be independent from the TOs and wider National Grid plc corporate structure and not part of any corporate group that owns other assets in the energy sector. • Profits extracted and distributed to private and government shareholders. • Licenced entity subject to price control regulation by Ofgem. • Option for greater government involvement, eg government board appointments. • Would have to abide by the Companies Act and relevant corporate governance codes.
Model 3: Private company limited by guarantee, non-profit distributing (eg Welsh Water, Mutual Energy)	• Company limited by guarantee. • Owners independent of government, the TOs and National Grid plc and not part of any corporate group that owns other assets in the energy sector. • Profits/surplus from over-performance either paid directly to staff, reinvested or returned to consumers. • Licenced entity subject to price control and regulated by Ofgem. • Independent board – with option for government appointments and/or an advisory membership drawing from industry stakeholders, consumer groups and government. • Would have to abide by the Companies Act and relevant corporate governance codes.

Model	Key characteristics
Model 4: Public-owned model, including public corporation or an arm's length body. (eg Scottish Water, Civil Aviation Authority, Network Rail)	• Viable options could include a statutory body (set up by statute), a government company (ie private limited company or public sector company where government is sole shareholder) or a non-departmental public body. • Set up and organised to participate in the market with substantial day-to-day operational independence from government. • Independent board – with option for government appointments and/or an advisory membership drawing from industry stakeholders, consumer groups and government. • Profits/surplus from over-performance either paid directly to staff, reinvested or returned to consumers. • Licenced entity subject to price control and regulated by Ofgem.

Key design parameters

7.7. Based upon our review of international SO and GB comparators, net zero roles, our principles for net zero system operation and assessment of current arrangements, we consider the following design parameters will be important in assessing the potential alternative models for a GB ISO.

<u>Accountable</u>

7.8. An ISO will need to be accountable to current and future consumers as its actions and performance will have significant consumer impact. The net zero roles will require the ISO to take on greater coordination, planning and strategic decision-making responsibilities. In doing so, the ISO will need to make complex judgements about short and longer-term public interest to deliver efficient outcomes for consumers. Net zero roles and functions may, therefore, require greater accountability than the status quo to government and/or Parliament.

7.9. There is an inherent link between accountability and ownership of an ISO. This is evident in private entities limited by shares where private shareholder interests play a central role in guiding the company's purpose and actions. Under such a model ('Model 1' in Table 7.2), it may be challenging to ensure an ISO is accountable to consumers as private owners/shareholders will provide a separate and direct line of accountability that may not align with consumer interests.

7.10. A key feature to enable accountability is ensuring the ISO has clarity of roles and functions and clearly defined responsibilities in relation to government, Ofgem and other industry parties including the TOs, DNOs/DSOs and GDNs. This could be achieved through legislation and the existing regulatory framework. An ISO would also require clarity of roles and functions in relation to bodies such as the CCC and the NIC, which already have distinct roles in facilitating net zero and in infrastructure development.

7.11. International SO and GB comparators work to create accountability through various means:

- the majority of organisations (regardless of ownership model) are licenced and subject to independent economic regulation with performance frameworks publically accessible and roles and relationships defined in the regulatory framework;

- several governments have taken on shareholder responsibilities (ie holding the board to account) through full or partial ownership with certain GB organisations in other sectors directly accountable to Ministers and Parliament; and

- the use of membership-based arrangements and/or advisory committees comprised of industry representatives and consumer groups to challenge and hold the board to account.[97]

Financeable

7.12. An ISO will need a reliable funding stream to perform its roles and functions effectively. It will need to be able to raise capital to manage short-term cashflow issues and finance capital expenditure.[98] If the ISO retained the ESO's current function of handling substantial 'external revenues' (eg BSUoS and TNUoS) then, as an asset-light company, it

[97] Effective accountability in membership-based models requires a membership with sufficient expertise, impartiality and the ability to achieve consensus and hold board to account. Discussions with relevant organisations indicated a mixed experience in the use of membership-based models.
[98] Under current arrangements, the ESO incurs expenditure of around £200-300m on its direct expenditure (staff and IT) and significant expenditure on balancing the system (~£1.0bn pa and increasing). It also has a critical role in collecting transmission charges revenue on behalf of the TOs (~ £3bn pa). Its annual revenue, around £4bn, is very high compared to its RAV, around £300m.

will also need to access a large working capital facility relative to its RAV which may be more difficult under certain models. The scale of this would depend on the exact arrangements for collecting and passing through charges.

7.13. An ISO could be funded via network charges and consumers' bills (ie how the ESO is currently funded[99]) or through general taxation. International SOs and GB comparators are typically funded via cost-pass through mechanisms (ie charges on industry and consumers) with these approved by a regulator. Several organisations commented that approval of tariffs by an independent regulator, as opposed to government, is important to protect funding from non-energy related macroeconomic swings and public sector spending priorities and limit cost recovery to those who benefit from the ISO's services.

7.14. In considering ISO design models, we assume ISO funding would remain relatively unchanged, ie that it would be funded on a cost-pass through basis with external balancing costs and internal costs funded through BSUoS.[100] Funding via bills/network charges implies the ISO would be subject to price control regulation.

7.15. A benefit of the status quo is the SOs' ability to access shareholder investment and equity from capital markets. This means the current SOs are not constrained by public sector borrowing or spending restrictions. While this is a benefit of the status quo when compared to some alternative models, the materiality of this may be limited by the relatively small capital funding needs of a stand-alone ISO compared to other businesses, such as nuclear power stations or network companies.

7.16. Some models may also encounter challenges and pose risks related to initial financing. For example, a mutual/no-dividend distribution company model may not be able to raise sufficient capital, as banks may be unwilling to lend the full amount required

[99] The ESO is presently funded primarily through a combination of a regulated return on its asset base (using a weighted average cost of capital), balancing charges, connection charges and a performance incentive payment, in a manner regulated by Ofgem. From April 2021, the ESO will also be funded via an additional fixed annual value to finance revenue collection activities and remunerate risk that is not appropriately remunerated by a return on the ESO's asset base.

[100] One of the key recommendations of the second Balancing Services Charges Task Force is that BSUoS should be set in advance, with a combined length of fix and notice period of 14/15 months. This would give greater certainty to consumers and other market participants but would expose the ESO to more cashflow/revenue risk. This could, in turn, have implications for the financiability of alternative ISO models. Solutions to deliver the Task Force's recommendations will now be developed through the code modification process. To support our evaluation of these proposals, Ofgem will undertake further work to quantify the net benefits of the solutions under consideration. This will include consideration of the ability of the ESO to take on this risk and any alternative options for which party bears this risk. See http://www.chargingfutures.com/media/1348/balancing-services-charges-task-force-final-report.pdf and https://www.ofgem.gov.uk/system/files/docs/2020/12/response_to_the_second_bsuos_task_force_report.pdf

without some form of equity buffer or accumulated reserves. Public owned models could also expose the government to financial risks associated with the timing of transactions such as a financial loss associated with buying the SO from National Gird plc and then selling at a lower price.

Operational capability

7.17. Operational excellence in the ISO's roles and functions is required to meet the challenges of the energy system transition. To realise the benefits of net zero, an ISO will need to increasingly maximise value for consumers across a widening variety of activities.

7.18. To achieve operational excellence and maximise value for consumers, an ISO will need the right organisational incentives. This is important given the significant impact its performance and actions will have on the energy system and consumers. Assessing the ISO's performance in a transparent manner will be an important feature of future arrangements.

7.19. All SO models may be subject to over-conservatism and a lack of countervailing incentives to combat this could influence the costs they incur and the system costs they influence. International experience indicates that ISOs' costs can inflate as their roles and functions expand.[101]

7.20. Discussions with international SOs and GB comparators indicate that accountability (discussed above) and incentive frameworks that link to efficiency are important in driving high performance and keeping costs down. Economic regulation was viewed as a key tool in achieving this across all jurisdictions and sectors, with the independence of the regulator and transparency and public availability of the performance framework viewed as important features.

7.21. A common assumption is that private, profit distributing companies are more efficient than public and/or non-profit distributing models. This reflects the assumed influence of competition and private shareholder interests (eg the desire to maximise financial returns through efficiency gains). Our experience as the economic regulator in the

[101] Greenfield and Kwola (2012) highlighted issues with cost inflation amongst the US Regional Transmission Organisations: http://www.iaee.org/en/publications/ejarticle.aspx?id=2440

energy sector is that this assumption has potentially limited application to GB system operation as the GB SOs are natural monopolies and unique entities.[102]

7.22. The regulatory framework exposes natural monopolies like the SOs and network companies to proxy-competition. This is a key tool for driving efficiencies in network businesses as there is some ability to benchmark between companies. Unlike regions such as North America, where some parties can move between jurisdictions in response to high ISO costs or poor performance, the GB SOs have no competitors or comparators against which they can be benchmarked. Challenges in effectively bench-marking performance are also influence by information asymmetries and, given the substantially changing role of the SO, historical benchmarks are also of very limited value. This is likely to become more challenging as the SOs take on new functions.

7.23. Wider benefits associated with the status quo, such as the ability for government to transfer the risk of poor performance or energy system incidents to private shareholders, is also likely to be limited by the nature of the ISOs roles and the impact of its performance on consumers.[103]

7.24. There are several different mechanisms for incentivising performance. Under the current private, for-profit distributing model, financial incentives such as company-wide financial incentives (eg financial rewards or penalties based upon performance against roles) can be used. The constraints identified in aligning private shareholder interests with consumer interests (eg difficulties scaling rewards/penalties to risks and short-term rewards vs long-term benefits) do, however, limit the effectiveness of company-wide financial incentives. These constraints are expected to increase in materiality with the net zero roles.[104]

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[102] There is also limited empirical evidence to support this assumption across a wide range of sectors. Several studies have examined the empirical evidence on the comparative technical efficiency of different ownership models across a range of sectors and forms of privatisation. These typically conclude that there is no conclusive evidence that one model of ownership (ie public, private or mixed) is intrinsically more efficient than the others, irrespective of how efficiency is defined. See: https://www.epsu.org/sites/default/files/article/files/Public%20and%20Private%20Sector%20efficiency%20EN%20fin.pdf and Rao, S. (2015). *Is the private sector more efficient? A cautionary tale* (Discussion paper 10). Singapore: UNDP Global Centre for Public Service Excellence.

[103] For example, certain risks such as security of supply failures are likely to always contain an element of political risk and, as the ISO would be 'too important to fail', we assume government would put in place a Special Administrative Regime in the event of failure, thereby further reducing the transfer of risks to private shareholders.

[104] Internal costs are easily observable and financial incentives for controlling internal costs are relatively easy to design but would still be subject to information asymmetries. The more material impact on consumers is from the

7.25. As international ISOs and ITSOs are typically not private, for-profit distributing entities, there is less scope to subject them to certain financial risks through the regulatory framework, in particular company-wide financial penalties. Regulatory models used internationally and in comparable GB sectors use a range of alternative financial and non-monetary incentives. This includes broad performance frameworks similar to GB that allow the organisations to earn a surplus from over-performance against targets with this surplus either paid directly to staff through managerial incentives (US ISOs), reinvested back into the company (Scottish Water) or returned to consumers (Welsh Water).

7.26. As international SOs and some relevant GB models do not distribute profit to shareholders, this removes some of the counter incentives for them not to act in the public interest. This can create greater trust that the entities are working to maximise consumer value.

7.27. In addition, an ISO will need to be able to attract and retain world-class technical expertise and specialist knowledge and have highly capable modern IT systems to perform its roles and functions effectively. This has implications for remuneration and managerial incentives.

Independently minded

7.28. The ISO will require sufficient operational independence from government, Ofgem and industry to provide impartial advice and challenge to the decarbonisation debate. The current private shareholder model provides a significant level of independence, which can promote stability across key energy system functions and encourage investment. The strategic nature of the net zero roles may, however, require government to have a greater role in guiding the ISO.

7.29. Several comparable GB sectors use mechanisms that enable government to provide strategic direction in a transparent manner, for example:

ISO's performance in roles that impact external and system-wide costs. Over time, Ofgem has moved away from the use of mechanistic, ex ante financial incentives for these costs to an evaluative, ex post performance assessment process.

- several organisations are governed by an independent board with a rigorous and transparent recruitment process but with the option for select government appointments (as the government has for Ofgem) and removals, and

- the use of specific legislative provisions or 'Strategy and Policy Statement' vehicles to provide government with tools to transparently steer bodies.

Resilient

7.30. The ISO will need to be resilient in times of system stress and in proactively responding to new challenges. This has implications for attracting and retaining key personnel, the ISO's relationship to other industry parties and organisational incentives.

7.31. The ISO will need to adapt and respond quickly to changes as the energy system evolves and provide leadership and strategic coordination on difficult issues that affect multiple parties. To achieve this, it will need to operate at pace and have a clear understanding of the way in which industry operates. The ISO will also need to operate within an adaptive framework that can enable timely changes to its roles, relationships with other parties and capabilities.

Key findings

7.32. Establishing a new body with a new sense of purpose and enhanced role in leading the energy system transition presents an opportunity to deliver a GB model of system operation uniquely designed to meet the challenges of net zero. Our initial review of international SO models and relevant GB sectors indicates that there are several viable models that would be better suited than the status quo to deliver net zero at least cost for consumers. However, any government decision would need to understand complex trade-offs in developing an optimal model. We will work with government on its forthcoming review of energy system operation to develop appropriate design parameters against which to assess potential models.

Appendices

Index

Appendix 1: Introduction

External contributors to the review

1. Below is a list of organisations and individuals that participated in interviews.[105]

Industry parties:

- EDF (UK)
- Eel Power
- Electron
- Elexon
- ENGIE
- Flextricity
- Habitat Energy
- Limejump
- RWE Supply and Trading
- Shell Energy
- SSEN Transmission
- Statkraft UK
- Transmission Investment
- Uniper UK
- Wales and West Utilities

Industry experts, including:

- Angus Paxton (Principal, AFRY Management Consulting)
- Goran Strbac (Professor, Department of Electrical and Electronic Engineering, Imperial College London)
- Keith Bell (Professor, Department of Electronic and Electrical Engineering, University of Strathclyde)
- Lisa Waters (Director of Waters Wye Associates)
- Nick Winser (Chairman of the Energy Systems Catapult, former Executive Director of National Grid plc)

[105] Views shared by interviewees that have been used in the main report may represent personal views or commercial interests.

- 11 senior leaders and non-Executive Directors from National Grid plc companies including the GSO part of NGGT and the legally separate Electricity System Operator ("ESO").

International system operators and other sector bodies:

- Australian Energy Market Operator
- Alberta Market Surveillance Administrator
- California Independent System Operator
- Commission for Regulation of Utilities (economic regulator for EirGrid)
- Energinet
- New York Independent System Operator
- Ofwat
- PJM
- Scottish Government
- Scottish Water
- Water Industry Commission for Scotland

2. Professor Jonathan Stern (Distinguished Fellow of the Natural Gas Research Programme at the Oxford Institute for Energy Studies) and Bob Hull (Managing Director of Riverswan Energy Advisory and former senior leader at Ofgem and strategy manager at National Grid plc) both contributed papers which have informed this review.

Appendix 2: System operator changes required to deliver net zero

Background and net zero literature

1. Below is the list of reports used to inform the net zero system changes and system change requirements in our review:

- Aurora: Hydrogen for a Net Zero GB
- BNEF: Sector Coupling report
- Committee on Climate Change: Net Zero report
- Energy Networks Association: Net Zero Pathways
- Energy System Catapult: Energy Data Taskforce report
- Energy System Catapult: Future Power System Architecture
- Energy System Catapult: Innovating to Net Zero
- Energy System Catapult: Multi-energy vector integration innovation opportunities
- IEA: Global EV outlook
- National Grid: Future Energy Scenarios 2020
- National Grid: Gas Future Operability Planning
- National Grid: System Operability Framework
- National Infrastructure Commission Net Zero: Opportunities for the power sector
- Ofgem: Decarbonisation Action Plan
- Ofgem: Consumer role in achieving decarbonisation
- Oil & Gas Authority: Offshore Energy Integration
- Timera Energy: Flex to Decarbonise
- UK FIRES: Absolute Zero report
- Wind Europe: Our Energy Our Future

2. The reports contain some significant differences which most often relate to absolute net zero outcomes. This is often influenced by:

   - underlying dependencies and assumptions within the analyses[106];

[106] For example, there is significant variability across the reports in the range of values used for the overall power generation capacity needed for a net zero energy system. Conservative reports indicate that 120 GW of capacity will be sufficient in 2050 while the other end of this range sees as much as 325GW of capacity as necessary.

- highly sensitive assumptions where small changes result in large differences in outcomes;
- the specific interests and expertise of stakeholders represented in the production of the report;
- the level of net zero related ambition applied in creating these reports; and
- the timing of the reports production in relation to the net zero legislation.

Net zero system change requirements

3. This section provides additional information on the system changes requirements identified from the net zero reports but not discussed in detail in Section 3 of the main report.

Adaptive testing

4. Several reports identified adaptive testing or "learning-by-doing" as an efficient method for arriving at evidence-based decisions. Adaptive testing can be used to address certain unknowns and the process of continuous improvement can be used to identify optimal solutions. Repeated, iterated testing can contribute towards an evidence base for policy-making. It can enable early awareness of fundamental barriers to the progression of certain technologies or solutions, thereby providing testers with the opportunity to stop projects early and efficiently.

5. The reports identify several actions that can promote adaptive testing including:

   - cross-system advocacy for user testing and stakeholder engagement as a key mechanism for problem solving and, where relevant, the use of iterative approaches to addressing issues with a focus on delivering a minimum viable product and
   - financial support and funding to manage the risk associated with the likelihood of operational success, in particular for small-scale projects.

Consumer engagement

6. The reports consistently identified consumer engagement as an important mechanism for delivering net zero. Consumer engagement on decarbonisation is viewed as vital for two key reasons:

- The scale of investment and disruption associated with transforming the energy sector means the public will need to be kept well-informed on the changes required, progress made and the costs and benefits of economy-wide decarbonisation. This will be important for building and retaining public support.

- Engagement and accessible information and services will be important for enabling the consumer behaviour changes required for net zero. This includes changes to the way we heat our homes and power our vehicles. The literature highlights several key areas in which consumer engagement can play an important role in delivering net zero including:

  - encouraging energy efficiency and the use of products and services that shift consumption to reduce peak demand and seasonal variations;
  - encouraging the uptake of electric vehicles and low carbon home heating; and
  - promoting an understanding of the need for significant network infrastructure development (both physical and digital) and new national and local infrastructure projects to support system changes such as increased electric vehicle uptake, onshore and offshore renewable generation and potentially new green gas systems.

Access to open and transparent data

7. Access to open and transparent data will make it easier for consumers to make informed choices and/or delegate decisions about their energy needs to trusted third-parties. Access to open and transparent data will also facilitate several other system change requirements including highlighting investment signals, facilitating coordination and demonstrating results from adaptive testing.

8. The availability and use of energy system data in the UK has historically been poor, owing to a landscape of unique datasets that do not use the same protocols or formats on legacy systems, as well as industry-wide risk adverse behaviour on sharing data. To begin to address this issue, the Energy Data Taskforce ("EDTF") was commissioned by the UK Government, Ofgem and Innovate UK to develop recommendations for an integrated data and digital strategy to help unlock the opportunities of a modern, decarbonised and decentralised energy system for the benefit of consumers.

9. Energy System Catapult published a list of recommendations that serve as actions which can support this system change requirement. This list contains a series of recommendations that include the adoption of two key principles:

    - Digitalisation of the Energy System[107] and
    - Energy System Data should be Presumed Open.[108]

10. Net zero will require these principles to be progressed alongside the alignment of data standards and increased digitalisation of the energy system.

Early policy-making and an adaptive regulatory framework

11. The reports overwhelmingly identify early policy-making as important for meeting the net zero target, as well as the effective sequencing of policy reform. Strategic leadership and direction setting can provide clarity on the decarbonisation pathway. An effective example is the legislation of the net zero target.

12. There are a range of challenges that can prohibit early-policy making including: uncertainty over future system changes, change requirements and challenges; technological barriers that create prohibitive costs and limit the ability to scale technologies; competing and conflicting evidence and interests; and a lack of expertise and/or impartial advice from sources of expertise.

13. A supportive regulatory framework will be important for achieving net zero and enabling innovation and investment while protecting consumers. This can ensure key organisations have the right incentives to facilitate net zero effectively and efficiently. Government sets the overall framework and policies for meeting its targets. In doing so, it makes key decisions on how the costs of the transition will be met and how to balance different objectives. Within that framework, Ofgem has a crucial role to play in helping the GB energy sector and wider economy decarbonise and in protecting current and future consumers.

14. Assessing the trade-offs between different technologies and solutions will remain a fundamental part of the decision-making process. Transparency and the ability to

[107] https://www.etip-snet.eu/wp-content/uploads/2018/11/ETIP-SNET-Position-Paper-on-Digitalisation-short-for-web.pdf
[108] https://es.catapult.org.uk/wp-content/uploads/2019/06/EDTF-Report-Appendix-7-Glossary.pdf

collaborate effectively will be important features for organisations with strategic roles and responsibilities in facilitating the system changes associated with net zero. There is therefore an important link between this system change requirement and 'access to open and transparent data'. Similarly, 'adaptive testing' and 'whole system coordination & collaboration' have implications for 'early policy making and a supportive regulatory framework'. This has been acknowledged in Ofgem's Decarbonisation Action Plan where we have pledged to become a more adaptive regulator and have taken on the recommendation to create a Net Zero Advisory Group of key sector stakeholders.[109]

[109] https://www.ofgem.gov.uk/publications-and-updates/net-zero-advisory-group-terms-reference

Appendix 3: System operator roles for net zero

Control room operations

1. Alongside the core functions identified in section 4, the ENCC and GNCC perform the following functions:

   - coordinating with network operators on operational decisions, outage changes and network planning out to one-year;
   - the GNCC manages the daily transmission capacity obligations and facilitates network access for maintenance and alarm response;
   - short-term energy forecasting, with the gas control room feeding into long-term forecasting carried out by other teams within NGGT;
   - considering the evolution of the electricity and gas systems when undertaking any balancing actions in the present and taking account of the impact of balancing actions on the market (including any changes to rules, balancing tools and operational strategies necessary to meet a particular capability need in the medium to long-term);
   - managing and sharing system data and information; and
   - restoration and emergency response (to system instability events).

Additional information on gas system balancing

2. The GNCC performs day-to-day system operation, network control and safety functions by utilising NGGT's assets, ie turning its own compressors on and/or off. It also operates in complimentary commercial markets and uses mechanisms for trading commodity and capacity rights. In particular, the GNCC takes the following actions on a daily basis:

   - operating compressors, valves and offtakes;
   - controlling entry/offtake flow rates and outages;
   - constraint management actions including (re)compressions and (de)compressions and commercial actions such as entry/exit capacity buy-backs and scale-backs;
   - pressure management; and

- maintaining linepack targets and end-of-day balancing.[110]

3. Shippers are responsible for being in balance or they face financial penalties. However, the GSO acts to resolve any gas (energy) imbalances. It does this by entering the on-the-day commodity market and buying or selling gas to change the price of gas in GB and send a price signal to shippers.

4. The GSO provides other services to maintain system pressures including: Demand Side Response ("DSR"), Operating Margins, safety monitors and meter validation and investigates reasons behind the unaccounted for gas (ie gas that has been lost in day-to-day operation). The GSO helps Xoserve host Gemini, the platform that runs daily nominations, capacity bookings and buybacks. It also procures own use gas and electricity to operate the system on a daily basis (eg to run compressors).

Market development and transactions

Current ESO functions

5. Alongside the key functions set out in the main report, the ESO participates in working groups and forums at an international level to influence the design of cross-border market arrangements. The commercial value of these markets has increased significantly as the ESO's short-term balancing actions have changed from correcting net energy imbalances to managing network constraints and system quality issues.

6. As well as providing policy advice on market reform, the ESO is expected to drive forward competition wherever efficient through proposing and supporting pro-competitive modifications to industry codes. The ESO is the code administrator for the main codes related to the electricity transmission system.[111]

[110] Primary role in balancing lies with the market/shippers. The GNCC is able to utilise linepack when performing day-to-day system operation actions.
[111] ELEXON, a subsidiary of the ESO is the code administrator for the Balancing and Settlement Code (BSC). The ESO is a panel member for 3 additional codes (DCUSA, Distribution Code and BSC).

Current GSO functions

7. Alongside the key functions set out in the main report, the GSO is responsible for setting transmission charging methodologies and charges to cover allowed revenue[112]; developing and maintaining Gas Market Rules, both nationally and on at a European level; reviewing consistency across transmission and distribution charging methodologies, i.e. ensuring pricing signals are consistent; defining and managing shrinkage strategy; procuring gas and electricity for utilisation within the networks (procuring services like operating margin, shrinkage, managing the calorific value regime) and managing the EU emissions trading position; and providing policy advice on market framework changes.

8. The GSO (within NGGT) also provides customer connection services on entry and exit, manages its relationships with its directly connected customers and facilitates competition in generation by managing the connection process, including unconventional connections (eg through project 'CLoCC').

9. The GSO has started exploring themes of change in its forums and bilaterally with the government and industry, and is taking a more active role in discussing decarbonisation challenges with the industry, as well as driving change in wholesale and balancing market arrangements.[113]

10. For gas codes, a number of entities take responsibility for code administration including: the Joint Office of Gas Transporters for the Uniform Network Code ("UNC")[114] which sets out the common transportation arrangements for GB's gas industry; Gemserv for the Independent Gas Transporter Network Codes ("IGT"); and Electralink for the Supply Point Administration Agreement ("SPAA"). The GSO oversees the implementation of changes to different aspects of the UNC and manages key industry

112 Xoserve performs invoicing and administers collection of charges.

113 This includes: Gas Future Operability Planning (GFOP): GFOP aims to shape the debate on how the changing energy landscape could impact the operability of the gas transmission system; Gas Markets action Plan (GMaP): National Grid Gas Transmission, in collaboration with industry, decision-makers, and stakeholders has launched the Gas Markets Plan (GMaP) outlining the most likely changes in the next 2-10 years; FOG Forum: In FOG Forums, NGGT brings forward discussions on decarbonisation/ green gases; the increasing flexible use of gas-fired power stations; changes required to balancing and capacity allocation mechanisms, and other changes and reforms that might be needed in transitioning to net zero; discussions at industry meetings eg Gas Transmission WG, Gas Distribution Workgroup etc.; the ENA-led Gas Goes Green (GGG) initiative; and NGGT participation in the preparation of FES and the Gas Ten Year Statement.

114 The Joint Office of Gas Transporters, which administers the UNC, is jointly operated by all gas transporters, which includes NGGT (ie the GSO). The Joint Office's role is to administer the governance of the processes for modifying the UNC.

contracts/relationships with Xoserve and Prisma. The GSO voluntarily leads on significant reviews of the UNC, such as gas charging review, access review etc. which require strong industry engagement.

11. For gas engineering standards, the guidelines adopted by NGGT as GTSO are maintained and developed by the Institute of Gas Engineers and Managers, which is a recognised authority on technical standards relating to the natural gas industry.[115]

Whole-system insight, network planning and coordination

Current ESO functions

12. In electricity, the ESO directs the flow of electricity over the National Electricity Transmission System ("NETS") including flows from offshore transmission, distributed energy resources and cross-border flows. The ESO performs long-term forecasting for the development of the gas and electricity systems, published as the Future Energy Scenarios ("FES"). It also identifies long-term electricity system needs in the Electricity Ten Year Statement ("ETYS") under the different energy scenarios. The ESO also provides GB input, based on the FES, into the development of the pan-European Ten Year Network Development Plan ("TYNDP").

13. The ESO carries out an annual Network Options Assessment ("NOA") process which makes non-binding recommendations to the transmission owners ("TOs") and developers across GB on investment options and timelines to meet the network requirements defined in the ETYS. The NOA also includes an analysis of optimal interconnector capacity growth across the FES scenarios, which provides an assessment of the countries, capacities and timeframes that are likely to be economically beneficial for GB. This acts as a strong market signal to interconnector developers.

14. The ESO carries out cost benefit assessments on major new investments in the onshore transmission networks proposed by TOs, which informs Ofgem decision-making on their funding. The ESO has also provided an assessment of system operability impacts to inform Ofgem decision-making on interconnector needs cases.[116]

[115] https://www.nationalgrid.com/sites/default/files/documents/35829-TPC%20v4.0.pdf
[116] Ofgem regulates new interconnector investment through our cap and floor regulatory framework.

15. Within the current Offshore Transmission Owner ("OFTO") regime[117], the ESO has role in improving the coordination and development of the strategic network infrastructure investment needed to deliver 40GW offshore wind by 2030 through the wider network benefit investment ("WNBI") mechanism. This gives the ESO the power to request developers to build their transmission assets to deliver additional functions, beyond those required by the developer, at the ESO's request, with additional costs recouped as part of the OFTO assets. WNBI requests are informed by consideration of future network developments, directed by the EYTS and NOA. The ESO also provides connections for interconnectors, which are currently assessed through the Connection and Infrastructure Options Note ("CION") process on a case-by-case basis, taking into account the technical requirements and geographical location of the interconnector.

16. The ESO also supports the development and implementation of competition for the design and delivery of new onshore and offshore networks. As part of that work, the ESO is producing a detailed plan for how to introduce competition at the early stages of onshore network planning. It also has a function of developing whole system processes for efficient network investment and coordinated assessments of operability across network boundaries.

17. Detailed planning and development of the onshore electricity transmission network is performed by NGET and the Scottish TOs. The TOs are decision-makers for transmission planning in their respective geographic areas and are not legally obligated to comply with the ESO's recommendations. The TOs develop investment plans which are submitted to and approved by Ofgem as part of the regulatory framework, RIIO. The ESO coordinates short and long-term outage plans to accommodate the TOs' network development plans.

<u>Enhanced ESO network planning functions</u>

18. Several interviewees identified the ESO as well placed to enhance its functions and tended for different solutions to network needs and for driving competition between alternatives where appropriate. The reasons provided largely corresponding to

[117] Under the OFTO regime, the owners and operators of transmission links to wind farms are selected and licensed through a competitive tender process run by Ofgem. To date, all OFTOs have been built by the offshore wind developers and have been of radial design, meaning that each wind farm has its own dedicated transmission link.

stakeholder responses to our December 2018 consultation question on which entity was best place to run early and late competitions in RIIO-2.[118]

19. As part of our RIIO-2 Sector Specific Methodology Decision, in May 2019 we decided to investigate a broader role for the ESO in facilitating early competition. Early Competition can be described as competition run prior to the project design process to reveal the best idea to meet a system need, and could reveal non-network (and flexibility) solutions.[119] At Ofgem's request, the ESO has committed to develop an Early Competition Plan ("ECP") by February 2021.[120] The ESO published its initial consultation on the ECP in July 2020 and its Phase 3 consultation in December 2020. We will carefully consider the ESO's final proposals next year.

20. In 2016, as part of work to introduce competitive tendering to onshore electricity transmission, we noted that for RIIO-2 the SO may be a more appropriate party to take on preliminary works and preparatory activities for projects subject to Late Competition[121] ahead of a tender for that project.[122] This was because the incumbent TOs may either have an interest in participating in future tenders (and not be considered sufficiently impartial with regards the information made available about those projects) or would have incentives to avoid competition for projects (for example by designing projects so they did not meet the criteria for competition). We considered that incumbent TOs should undertake this role for RIIO-T1 as the TOs had already initiated these works and received funding for preliminary works under the Strategic Wider Works regime. We will consider the roles and functions for the ESO and TOs with regards Late Competition once there is clarity on enabling legislation.

[118] This included: synergies with the SOs' wider roles and functions and corresponding technical capacity to compare different solutions to system needs and identify the potential for non-build solutions including market or operational solutions; the relevance of existing processes such as the ETYS, NOA and Pathfinder Project and an ability to consider how different options interact with system operability.
[119] In our December consultation, we identified two high level approaches to early competition, the first is where the competition for ideas and delivery are separated into two stages; the second is where one competition process is run for both idea and delivery.
[120] https://www.ofgem.gov.uk/system/files/docs/2019/09/electricity_system_operators_early_competition_plan_letter_0.pdf
[121] Late competition refers to a competition run after the main planning consents have been secured, to identify a party to build and operate a project
[122] https://www.ofgem.gov.uk/ofgem-publications/100744

Current GSO functions

21. In gas, all network planning functions are performed by teams within the same, integrated entity, with NGGT conducting an annual planning cycle. At the start of the cycle, NGGT undertakes an analysis of network capability (with extensive external engagement), using information from the FES, gas distribution network owners ("GDNs") and shippers. This determines the ability of the national transmission system ("NTS"), in its current state, to accommodate expected supply and demand patterns. NGGT then reconsiders the planned projects from the previous investment plan, to verify whether they are still required, given the network capability analysis.

22. NGGT then considers if new investments, in addition to those already identified, are necessary to ensure network capability. The planning cycle concludes with the publication of the Gas Ten Year Statement ("GTYS"). NGGT relies on FES and GTYS when planning new investment and submitting its plans to Ofgem for approval.

23. The GSO (within NGGT and together with the TO) performs other network planning functions and services to optimise operation of the NTS, including:

- outage coordination (including construction and maintenance scheduling);
- planning for network access to accommodate maintenance, connections, and/or decommissioning;
- managing the contractual processes for new sites connecting to the NTS, modifications to assets or contracts, disconnection of assets, diversions of NTS assets, the contractual relationship with the distribution networks and shipper lifecycle processes;
- long-term forecasting to enable innovation based upon signals to industry on anticipatory investment;
- utilising system data, customer information and the FES to assess the future operability of the network;
- undertaking long-term market analysis to produce the Gas Market Plan ("GMaP"); and

- development of Need Cases[123], as well as economic evaluations of potential investments versus commercial solutions.

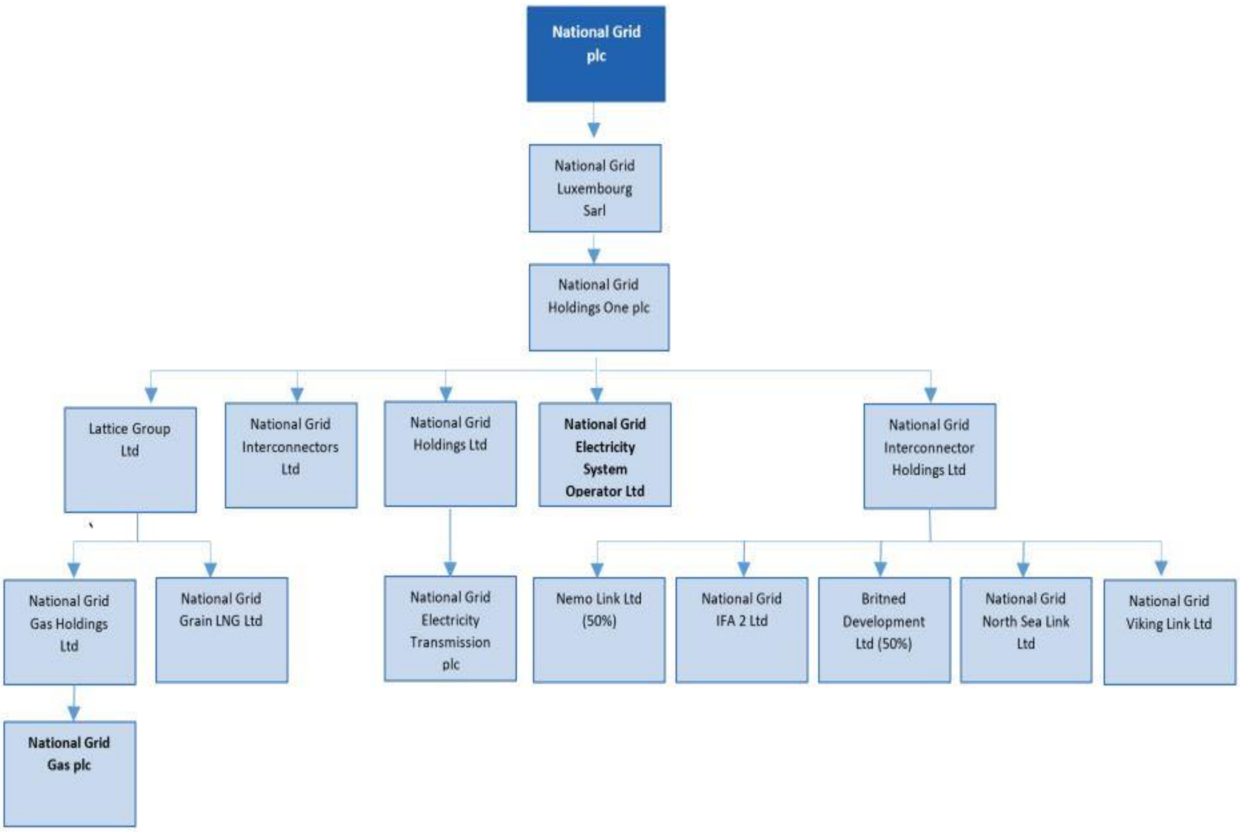
[123] This includes, in the long-term, identification on capability gaps by the GSO to drive options analysis, and, in the short-term, the GSO working together with the TO on optimisation of the TO outage planning processes to deliver asset projects and maintenance works.

Appendix 4: Assessment of current arrangements

Ownership structure of National Grid plc's relevant UK businesses

24. Figure A4.1 below sets out the corporate ownership structure of National Grid plc's UK operating companies and certain other shareholdings, which are most relevant to this report. The companies responsible for system operation are highlighted in bold.

Figure A4.1. Ownership structure of National Grid plc's relevant UK businesses



Key features of the ESO's legal separation licence obligations

25. Governance obligations and other restrictions in the ESO's licence include:

- **Governance** – a separate ESO board of directors consisting of at least 3 sufficiently independent non-executive directors, with a compliance sub-committee chaired by one of the independent directors. The ESO directors are not able to sit on the boards of National Grid plc or other National Grid electricity companies.

- **Employee separation, incentives and transfer** – all ESO staff will be employed by the ESO and managers and executives will be incentivised on ESO metrics.[124] All moves between ESO and NGET must be treated as "sensitive moves" and reviewed by the Compliance Officer.
- **Physical separation** – the ESO will be physically separated from other parts of National Grid's business.
- **Shared services** – transactional services (HR, procurement, Tax & Treasury, Investor Relations and Audit) will be shared on the same basis as they are provided to all National Grid Group entities whilst strategic services (Finance, Corporate Affairs) will be shared under a business partner arrangement. There will be a separate ESO regulatory capability.
- **Culture and branding** –a distinct and explicit visual identity must exist for the ESO

Asset values of National Grid plc's UK businesses

26. Table A4.1 below sets out the asset values for the year ended 31 March 2020 for National Grid plc's UK businesses.

Table A4.1 - asset values

Entity	Regulated Asset Value or other business assets' value as of 31 March 2020 (£m, nominal)
Regulated assets[125]	
NGET (transmission only)	14,224
NGESO	213
NGGT (excluding GSO)	6,173
GSO (within NGGT)	154
UK regulated total	20,764
Other business assets[126]	

[124] The licence conditions make exceptions for staff that work across the ESO and GSO but these dual fuel employee arrangements have been unwound by the SOs.
[125] https://www.ofgem.gov.uk/publications-and-updates/statutory-consultation-riio-2-transmission-gas-distribution-and-electricity-system-operator-licences
[126] https://investors.nationalgrid.com/~/media/Files/N/National-Grid-IR-V2/results-centre/2020/results-statement-fy2019-20.pdf

NGV and other activities[127]	4,105

ESO incentives

27. Prior to 2018, the ESO (as part of NGET) had financial performance incentives focused on its real-time electricity system balancing activities. These were part of the Balancing Service Incentives Scheme ("BSIS"), which:

- incentivised short-term or within-year reductions in external balancing costs and
- consisted of quantitative targets for balancing costs and a small number of other related activities.
  - The targets were set using ex-ante using forecasting models and adjusted using ex-post information.

28. The key changes to the ESO incentives framework for the RIIO-2 period, relative to the RIIO-1 framework are:

- the ESO's performance in internal cost efficiency will be assessed against a cost benchmark as one of the performance metrics in its overall incentives scheme, and the TOTEX Incentive Mechanism will be removed;
- the ESO will be required to set out how progress against its longer-term vision will be achieved within the new, five-year price control period through a medium term strategy;
- it will also be required to set two-year business plans to enable timely re-setting of its activities and funding in response to changing needs;
- we also propose to align the incentive schemes with the two-year business planning cycle to create consistent incentives to achieve exceptional quality of service;
- we propose an upside value of £30m over two years (i.e. £15m per year, paid at the end of 2 years) and we propose the downside penalty to reduce to £12m over the period of the scheme to ensure the ESO is not prevented from recovering its cost of debt through incentives decisions; and
- we propose to integrate the EMR Delivery Body framework into the ESO's framework to improve the effectiveness of the EMR Delivery Body incentives and streamline the regulatory arrangements.

[127] 'NGV' refers to commercial operations in energy metering, electricity interconnectors, renewables development and the storage of liquefied natural gas in the UK, also referred to as 'National Grid Ventures'.

Appendix 5: Options assessment for SO remit and separation from National Grid plc

Overview

29. This section provides additional information on the key considerations underpinning our qualitative assessment of the SO models. It includes a high level overview of FTI's assessment of the options, available in full at Annex 1.

Figure 5.1. Key for FTI's assessment

Table A5.1 Electricity status quo/ enhanced legal separation

Criteria	High-level FTI assessment	Key considerations in our assessment
Efficiency	 May dilute conflicts but unlikely to be as effective as full separation	• Can partly mitigate any real or perceived bias and associated cost inefficiencies. • Does not fundamentally address the corporate relationship between the ESO and National Grid plc and potential for conflicts of interest. ○ Potential for remaining inefficiencies and higher consumer costs, eg through less effective facilitation of competitive markets (including markets for the delivery of network investment projects), inflated long-term forecasts or analysis supporting the need for transmission network assets. • Existing feedback loop between control room operations and market development. and network planning functions maintained. • Does not reinstate operational synergies between the ENCC and NGET.
Simplicity	 Further legal separation unlikely to be materially	• Unlikely to increase the complexity of ESO arrangements materially as it refines established arrangements.

Criteria	High-level FTI assessment	Key considerations in our assessment
	different to the status quo	
Transparency and credibility	Conflicts (or perception of conflicts) may be somewhat weakened	• Can partly mitigate but is unlikely to remove perceptions of bias. This could potentially damage the ESO's credibility, eg when providing advice to Government and other stakeholders on changes to market and wider system design. ○ Potential to delay or constrain policy decisions that are crucial for net zero delivery and limit stakeholders' willingness to collaborate effectively with the ESO. • May have less of an incentive to provide transparent information which goes against National Grid plc's wider interests.

Co-ordination and adaptability	Unlikely to significantly impact adaptability	• Can partly mitigate but is unlikely to remove any real or perceived conflicts that could affect the ESO's ability to coordinate system-wide change. This could be influenced by:
		  ○ A dampened incentive to coordinate and drive-forward changes that go against National Grid plc's wider interests.
		  ○ Remaining stakeholder perceptions of partiality could undermine the ESO's ability to work with stakeholders and coordinate system-wide change.
		• The above could undermined the ESO's ability to perform a range of roles effectively thereby limiting its adaptability to system changes and its ability to take on new functions important for net zero including: new functions related to working with DNOs/DSOs and distributed energy providers and coordinating and planning onshore and offshore and cross-border network developments.

Ease of implementation	Likely to involve relatively minor costs	• Unlikely to impose material costs as modifies existing SO arrangements. • Further changes can be implemented via licence modifications as opposed to legislative change.

Table A5.2 Electricity Strategic Body (FTI variant only)

Criteria	High-level FTI assessment	Key considerations in our assessment

Efficiency	Conflict removed but separation of balancing from planning decisions may be inefficient	• Reduced scope for asset-ownership bias but strategic planning body's performance may be undermined by:
		  ○ Loss of feedback loop between control room operations and market development and whole-system insight and network planning roles.
		  ○ Lack of direct operational experience and technical engineering expertise
		  ○ Information asymmetry between the strategic planning body and NGET and remaining potential for asset-ownership conflicts within NGET to create inefficiencies in information provided.
		• Potential for asset ownership bias within NGET may require duplication of resources, expertise and functions within the strategic planning body.
		• Reinstates operational synergies between control room functions and NGET.

Simplicity	Separation of traditional SO roles may create complexity	• Separation of SO planning and balancing roles could bring additional complexity.
Transparency and credibility	Separation of planning and balancing roles could lead to less clarify in information provided	• Improves credibility and transparency compared to the status quo but stakeholders may have concerns over the transparency and credibility of key operational information provided by NGET and, in turn, the strategic planning body's advice and recommendations. • Better incentive than status quo to provide transparent information but its ability to do so many be undermined by remaining potential asset ownership conflicts in NGET and information asymmetry. • Absence of operational and day-to-day system operation experience could undermine the credibility of the strategic planning body in performing its roles, including network planning and integrating new technologies.

Criteria	High-level FTI assessment	Key considerations in our assessment
Co-ordination and adaptability	ISO willing and able to coordinate and adapt but cannot do so across planning and balancing roles	• Coordination benefit from operational synergies between NGET and control room functions • Better incentives than status quo to adapt to system change and coordinate across an increasingly decentralised and integrated energy system. • Remaining stakeholder perceptions of impartiality within NGET could undermine the strategic planning body's ability to coordinate system-wide change and effectively perform key functions. • Separating control room functions from market development and whole-system insight and network planning functions could create better incentives to apply longer-term thinking to latter roles but at the potential expense of operability.
Ease of implementation	Some costs required to set up new entity, but may be relatively easy to return balancing role to NGET	• Unbundling strategic planning functions from National Grid plc is likely to incur material costs and require licence changes.

Table A5.3 Electricity ISO

Criteria	High-level FTI assessment	Key considerations in our assessment
Efficiency	Conflict removed	• Fully addresses potential real or perceived asset-ownership conflict and removes any actual or perceived bias for the ISO to act in ways that place National Grid's wider interests over the interests of consumers. • Existing feedback loop between control room operations and market development and network planning functions maintained. • Does not reinstate operational synergies between the SO and NGET
Simplicity	Single unambiguous ISO entity – more familiar to participants than	• May be perceived to be relatively simple, as stakeholder interactions on any given issue are likely to be with a single ISO entity. • Significant change from current arrangements which may lead to uncertainty

Criteria	High-level FTI assessment	Key considerations in our assessment
	planning/strategy ISO	in how stakeholders will adapt and engage with the ISO
Transparency and credibility	Model most likely to eliminate potential conflicts (both actual and perceived)	• Likely to maximise the perception of the ISO's independence and credibility across its roles • ISO would have better incentives than the status quo to provide transparent and impartial information to other stakeholders.
Co-ordination and adaptability	ISO willing and able to coordinate and adapt across its functions but less coordination with TO	• Better incentives and ability than the status quo to coordinate system-wide change. • Full independence /removal of potential asset-ownership conflicts can enable the ISO to perform a range of future net zero roles making it adaptable to energy system changes and change requirements. • Potential for some reduction in the ISO's ability to coordinate with NGET.
Ease of implementation	Cost of setting up entirely new ISO may be significant	• Setting up a new ISO that is fully unbundled from National Grid plc is likely to incur material costs and require legislation and licence changes.

Table A5.4 Gas status quo

Criteria	High-level FTI assessment	Key considerations in our assessment
Efficiency	Status Quo has strong operational synergies across SO and TO roles	• Does not address potential real or perceived asset ownership bias as the GSO remains bundled with the GTO. Potential for resulting inefficiencies and higher consumer costs, eg through limited/conflicted incentive to challenge transmission owner's proposals and asset-based solutions to solving network constraints, inflated long-term forecasts and less effective facilitation of trade-offs between green gas technologies and system solutions offered by different network and market developers. • Retains both operational and informational synergies across SO and TO roles. This is particularly relevant for the control room operation functions, with the GNCC able to continue to achieve operational efficiencies in using NGGT's assets. NGGT's has full visibility and knowledge of operational risks and can

Criteria	High-level FTI assessment	Key considerations in our assessment
		use these to inform market development and transactions, as well as whole-system insight, network planning and coordination functions.
Simplicity	Known and understood by stakeholders with no separation requirements	• Current GSO arrangements have been in place in 1986 and are well understood by stakeholders.
Transparency and credibility	Conflicts (real or perceived) due to ownership link with National Grid	• Unlikely to change perceptions related to the independence and partiality of the current GSO, with perception of conflicts damaging to credibility. This is likely to undermine the GSO's ability to provide technical, expert advice on the future of the gas system and heat decarbonisation and to effectively perform roles related to market development and transactions and planning and coordination of the gas system. • GSO may have less of an incentive to provide advice on changes that go against the commercial interest of the transmission owner or wider National Grid plc interests, but may be in consumers' interest.
Co-ordination and adaptability	Strong ability to coordinate due to integration with NGGT but may be less willing to due to conflicts	• Remaining real or perceived conflicts could affect the GSO's ability to coordinate system-wide change. This includes: ○ The GSO's incentive to coordinate and drive forward changes that go against the transmission owner's and National Grid Plc's interests. ○ Remaining stakeholder perceptions of impartiality could undermine the GSO's performance in coordinating system-wide change. • The above could undermine the GSO's ability to perform a range of roles effectively. This could act as a barrier to the GSO's adaptability in taking on new roles and functions important for net zero including those related to coordinating market changes, with GDNs and localised gas systems, and facilitating cross-vector solutions.
Ease of implementation	Existing model	• Existing model so no change required.

Table A5.5 Gas Strategic Planning Body

Criteria	High-level FTI assessment	Key considerations in our assessment
Efficiency	Lower efficiency gains from removing conflicts due to less spending and no competition in gas transmission	• Reduced scope for asset-ownership biases in the strategic planning body's functions but performance (and resulting inefficiencies) may be undermined by: ○ Loss of feedback loop between control room operations and market development and network planning roles. ○ Lack of direct operational experience and technical engineering expertise ○ Information asymmetry between the strategic planning body and NGGT and potential for biases within NGGT to create inefficiencies in information provided.
Simplicity	Separation of SO roles may create complexity	• Separation of SO network planning and control room operation functions could bring additional complexity
Transparency and credibility	Separation of planning and balancing roles could lead to less clarity in information provided	• Reduced real or perceived asset-ownership biases in strategic planning body's roles and functions would improve its credibility and transparency compared to the status quo but stakeholders may have concerns over the transparency and credibility of key operational information provided by NGGT and, in turn, the strategic planning body's advice and recommendations. • Strategic planning body would have a stronger incentive to provide transparent information but ability to do so may be undermined by remaining potential real or perceived asset ownership conflict in NGGT and information flows from the control room. • General absence of operational and day-to-day system operation experience could undermine the credibility of the strategic planning body in performing its roles, including network planning and the impact of new technologies. • Introduces new information asymmetry between the strategic planning body and NGGT.
	Strategic planning body willing and	• Retains coordination benefits from operational synergies between TO and control room operations. • Strategic planning body would have better incentives than the status quo to adapt to

Criteria	High-level FTI assessment	Key considerations in our assessment
Co-ordination and adaptability	able to coordinate and adapt but limited ability to do so across system planning and balancing roles	system change and coordinate across an increasingly decentralised and integrated energy system, for example in coordinating with GDNs and localised gas systems and facilitate cross-system solutions. • Remaining stakeholder perceptions of impartiality within NGGT could undermine the strategic planning body's ability to coordinate system-wide change and effectively perform key functions (see examples above). • Separating control room functions from market development and whole-system insight and network planning functions could create better incentives to apply longer-term thinking to latter roles but at the potential expense of operability.
Ease of implementation	 Some costs required to set up new entity, but may be relatively easy to split out planning functions	• Unbundling gas strategic planning functions from National Grid plc is likely to incur material costs and require licence changes. • May require changes to gas Safety Case.

Table A5.6 Gas ISO

Criteria	High-level FTI assessment	Key considerations in our assessment
Efficiency	 Lower efficiency gains from removing conflicts due to lower spending, smaller conflicts, no competition in gas transmission and loss of operational synergies a significant cost	• Fully addresses potential real or perceived asset-ownership bias and removes any actual or perceived bias for the ISO to act in ways that place National Grid plc's wider interests over the interests of consumers. This could result in efficiency benefits and consumer savings from the ISO performing a wide range of current and future net zero system roles more effectively and efficiently, including those related to functions such as gas network planning and development (for new investment, as well as decommissioning, asset replacement and refurbishment) and market development and transactions (eg collaborating with the distribution networks and facilitating local markets • Existing feedback loop between control room operations and market development and network planning functions maintained.

Criteria	High-level FTI assessment	Key considerations in our assessment
		• Loss of operational efficiencies between control room functions and NGGT.
Simplicity	 Single unambiguous ISO entity – more familiar to participants than planning strategy body	• May be perceived as relatively simple, as stakeholder interactions on any given issue are likely to be with a single ISO entity. • Significant change from current arrangements (more so than in electricity) which may lead to uncertainty in how stakeholders will adapt and engage with the ISO
Transparency and credibility	 Model most likely to eliminate potential conflicts (real and perceived)	• Likely to maximise the perception of the ISO's independence and credibility across its roles • ISO would have better incentives to provide transparent and impartial information to other stakeholders. • Introduces new information asymmetry between the ISO and TO
Co-ordination and adaptability	 Loss of coordination between commercial actions and operational actions to balance the network	• Better incentives and ability to coordinate investment and change • Full independence /removal of potential asset-ownership bias could enable the ISO to undertake a range of net zero system roles more effectively, making it more adaptable to an increasingly integrated and decentralised energy system. This could include functions related to: coordinating with GDNs and localised gas systems, facilitating cross-system solutions when operating the system in real time, forecasting for future system needs, developing green-gas-related services for local markets and network planning and development functions. • Reduction in the ISO's ability to coordinate with NGGT on TO issues.
Ease of implementation	 Cost of setting up new ISO entity may be significant (and likely to be greater than in electricity)	• Setting up a new gas ISO fully unbundled from National Grid plc is likely to incur material costs. These will be significantly higher than change in electricity given the gas Status Quo. • The implementation of this option will likely depend on the outcome of the Safety Case application to the Health and Safety Executive.