

A vision for Scotland's electricity and gas networks



SUMMARY
2019 - 2030



Scottish Government
Riaghaltas na h-Alba
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MINISTERIAL FOREWORD



Scotland's Energy Strategy, published in December 2017, sets out ambitious targets for a low carbon future for Scotland's energy system and society. In concert with our Climate Change

Plan, it will help Scotland deliver against the Climate Change Scotland Act 2009 and play our part as a nation in tackling the damaging effects of climate change. The Strategy will boost Scotland's economy, while also tackling the problem of fuel poverty and creating a range of new models for developing local and community energy.

In 2017, Scotland's gas and electricity networks delivered around half of all the energy we used in Scotland; in that year £2.25 billion worth of Scottish electricity generation entered the networks, more than 50% of which came from renewables, and gas valued at more than £5 billion entered the gas transmission network at the St. Fergus Gas Terminal. These networks help deliver affordable, reliable and increasingly low carbon energy across Scotland. They will be critical to delivering the principles of the Energy Strategy, and achieving its outcomes.

Their critical importance will remain as we look at opportunities to accelerate progress to decarbonise both our heat and transport systems. We expect electric vehicles to create significant new demand for electricity and lead to new challenges for electricity distribution networks. In particular, new solutions will be needed at the edges of the grid where network capacity may currently be insufficient for unmanaged EV charging. We expect there to be a need for significant investment in these distribution networks, but it is important that capacity is used efficiently.

The ability to deliver low carbon gases, including hydrogen, through the gas networks represents one option for the future of low carbon heat provision, and for transport as a fuel for road, rail and shipping. Repurposing the gas network

in this way would allow us to continue using the flexibility and reach that the gas network provides. In the years ahead we propose to explore further opportunities for the generation of low carbon hydrogen, and the use of the gas networks for its distribution and storage.

Whatever their ultimate shape, it is certain that we are going to see huge changes to the ways in which networks are planned and operated. These changes have to be delivered quickly and carefully. We believe that they must be designed to meet the interests of both consumers and businesses, be consistent with our desire to reduce fuel poverty, and reflect the needs of vulnerable customers across mainland Scotland and our islands.

We must work to ensure that our networks continue to support a resilient energy system, throughout and beyond the low carbon transition. There needs to be a greater strategic focus on regional security of supply which considers not only the networks themselves but also the location and characteristics of the resources connected to them.

Our vision for the networks highlights the growing complexity, technical challenges, structural changes and new technologies that together have the potential to fundamentally alter the relationship between consumers and the networks. It also shows the unique opportunity that exists in Scotland to lead the development of networks that are fit for the 21st Century, enabling and sustaining a truly low carbon economy – for example, through Scottish Government's role in the planning and consenting of new energy infrastructure in Scotland.

For this to be effective, we need organisations to work in partnership and to deliver networks which support wider social and economic aims - including the economic aspiration of our remote rural areas and 93 inhabited islands.

We are already working closely with the UK Government and Ofgem to understand and support work on the future design of our networks. We remain determined to ensure

that, at all times, Scotland's priorities are properly understood and reflected in any decision making that impacts on the networks.

We will take a number of actions to help achieve our goals. These will include a Networks Summit, to be held in Scotland later this year, and the creation of a Scottish Energy Networks Group focussed on the issues set out in this document. We will also look at ways to support consumers and their representatives, communities, businesses and local authorities to engage in conversations about the future of our networks in the most effective way.

We will continue to work with our stakeholders on a range of hydrogen energy and transport initiatives, and publish an interactive mapping tool charting hydrogen activity on a region by region basis across Scotland.

This is a complex and technical area, as this document reflects, but it is critical to setting the framework within which the energy and wider low carbon transition will happen. We want to broaden participation in the debate and we will support this by every means possible.

This document lays out our perspective on the scale of the challenges which we face. It is our vision, and one that is true to the low carbon principles and ambitions laid out in our Energy Strategy. We are keen to enter a discussion with you on this vision.

I believe that the spirit of innovation and collaboration that we have developed around Scotland's Energy Strategy will play a major part in delivering our Networks Vision.

Paul Wheelhouse MSP,
Minister for Energy, Connectivity and the Islands

OUR ELECTRICITY AND GAS NETWORK VISION FOR 2030 - KEY POINTS

The electricity and gas networks place Scotland's consumers, economy and society at the heart of our energy systems, supporting:

- an inclusive transition to a decarbonised energy system
- a whole system approach across heat, transport and electricity, and
- smarter, local energy models.

The networks' transition over the coming decade takes place in a way which considers the impact on all consumers – especially those considered vulnerable – as well as businesses.

NETWORK INFRASTRUCTURE

ELECTRICITY TRANSMISSION

- A secure and resilient transmission network for Scotland, engineered to reflect the changing dynamics of the electricity system, and with a System Operator able to access the technical services needed to maintain stability.
- New transmission infrastructure that ensures we can meet Scotland's renewable energy ambitions – including new links to meet the needs of Scotland's islands, stronger links within Scotland, and new links to the rest of Great Britain.
- New and stronger interconnections between Scotland and our European neighbours – supporting a wider market and more secure system.

ELECTRICITY DISTRIBUTION

- Distribution networks with sufficient capacity to meet the growing demand for distributed generation, and capable of carrying clean electricity to and from new demands including electric vehicles and a growing number of heat pumps.
- A Distribution System Operator (DSO) transition which engages and provides opportunities to reward **all** consumers, manages risk effectively and ensures safety, security, efficiency, openness and flexibility.
- Demand management, new platforms and technologies, including batteries, to help manage peaks in local demand and generation in ways that deliver greater value to local communities and support resilient

supplies – particularly in rural areas, including our island groups.

- Smart meter data and enhanced, real-time network monitoring works with traditional systems to keep the network safe, secure and efficient whilst respecting consumers' data privacy and security.
- Managed charging and successful innovations to help integrate a growing fleet of electric vehicles into our transport systems, and ensure that investment in new infrastructure can be focused where it is most needed and will deliver greatest added value.

GAS TRANSMISSION

- Continues to transport gas across Scotland and Great Britain from a range of sources, providing vital storage and flexibility to our energy system, and supporting our economy whilst adapting to changes in supply of natural gas from the North Sea.
- Develops the evidence base to show the feasibility and costs associated with adapting the network to support regional energy systems based on 100% hydrogen and supports strategic decision making over the future of low carbon heat across Scotland and Britain.
- Identifies and implements opportunities to support the continued and increasing decarbonisation of gas that flows through the network.

GAS DISTRIBUTION

- Continues to provide low cost energy to Scotland's households and businesses throughout the 2020s.

- Blends increasing quantities of low carbon gases with natural gas, including hydrogen, bio methane, bio SNG and hydrogen, while maintaining the safety of the system.
- Demonstration schemes have delivered 100% hydrogen to consumers through new and existing distribution networks. These have enabled an evidence based decision on the long term role for these networks in a close to zero carbon energy system.
- Assesses and makes investment decisions based on their carbon, economic and social benefits, including their potential to reduce fuel poverty and comparison with alternative options for low-carbon heat.
- Links low carbon sources of gas to consumers through local and community energy projects, leading to more efficient use of the network.
- Uses open, flexible and simple processes to connect many more small, decarbonised gas producers.
- Electricity and gas networks' plans are coordinated with each other, and with other forms of energy infrastructure such as heat networks.
- The networks enable major increases in renewable energy capacity and generation, ensuring that we meet our target of 50% of all energy from renewables in 2030.
- Electricity and gas networks use scenario planning to guide development and investment decisions and to forecast and manage risk effectively.

NETWORK FUNDING

- Network funding reflects the changing environment – producing fair decisions and outcomes which reflect the networks' role in delivering an 'essential service'.
- The principle of 'cost reflectivity' is balanced against the need to protect vulnerable customers, with government and the regulator working closely together to agree and implement appropriate principles.
- Network funding processes and decisions consider current and future consumer needs and the role of emerging technologies and, where identified, the opportunities to support inclusive growth.

COORDINATING THE CHALLENGE

REGULATION AND GOVERNANCE

- Consumers and their representatives are deeply involved and central to the processes of developing our networks, ensuring that decision-making starts from the impact of change on all consumers – especially those considered vulnerable – as well as businesses.
- Regulation and governance is more flexible and agile – able to respond quickly to changes and disruption while protecting and advancing consumers' interests.
- We have a much better understanding of how to balance the interests of today's consumers against those at different points in the future.
- There is an effective and constructive relationship between the energy regulator and government at all levels, with the regulator able to consider Scottish policies, programmes and priorities when making its decisions.

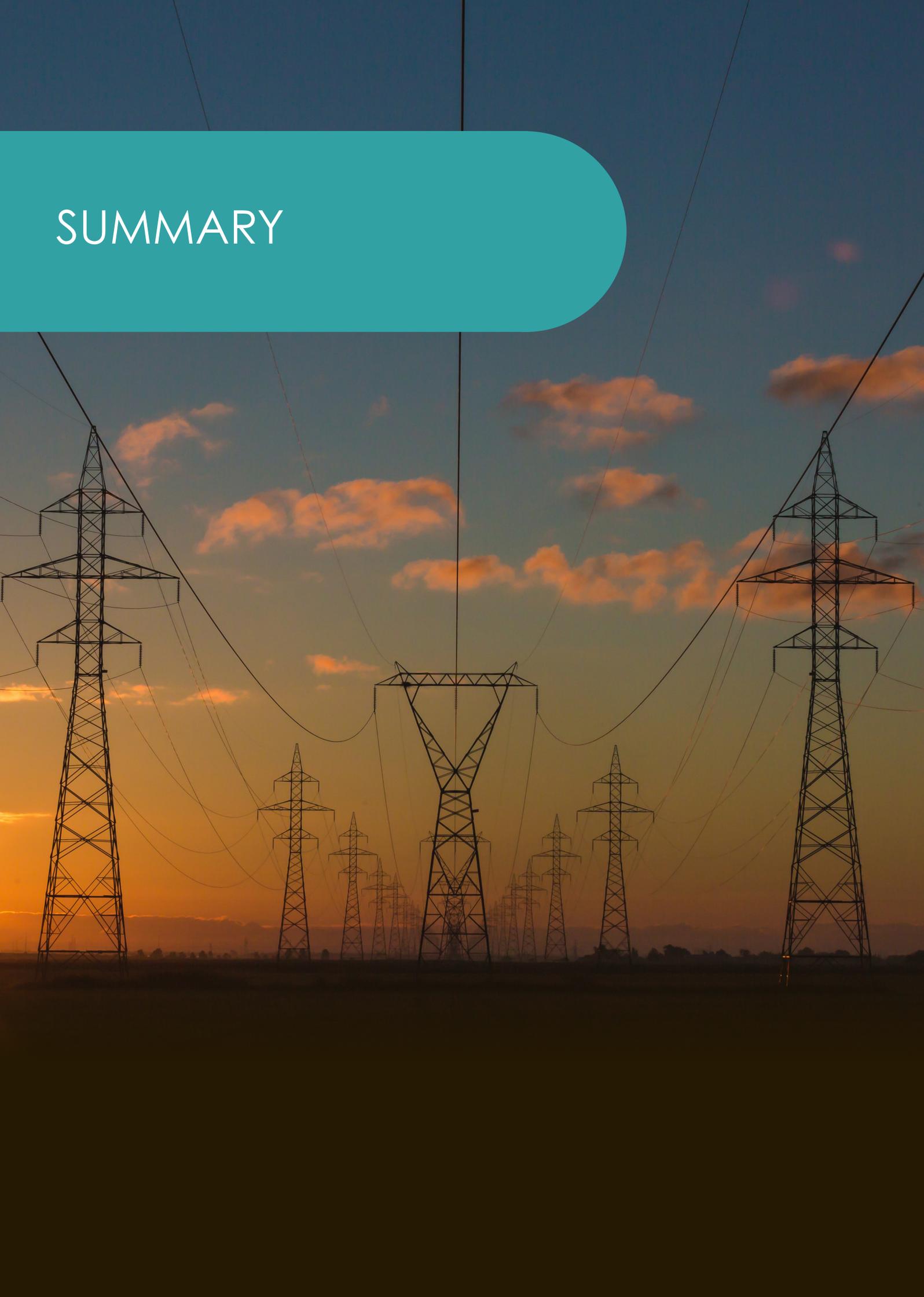
WHOLE SYSTEM PLANNING

- The energy system, at a national and local level, is designed strategically, taking economic and social priorities into account and supporting the principles and priorities laid out in the Scottish National Planning Framework and with a view to supporting sustainable energy solutions for Scotland's islands.

SCOTLAND LEADING THE WAY – INNOVATION AND SKILLS

- The culture of innovation in network companies fostered over the past decade continues to expand, with an increasing focus on delivering innovation as an ongoing aspect of daily business.
- There are greater opportunities for non-network companies to innovate in support of system and network outcomes, helping networks access flexibility from customers and deliver the services that people and businesses genuinely want.
- Our education system, skills and research institutions continue to provide the sector with skilled engineers and specialists, including experts in cyber-security, data-analytics, and consumer issues.

SUMMARY



SUMMARY

Our Vision: By 2030... Scotland's energy system will have changed dramatically in order to deliver Scotland's Energy Strategy targets for renewable energy and energy productivity. We will be close to delivering the targets we have set for 2032 for energy efficiency, low carbon heat and transport. Our electricity and gas networks will be fundamental to this progress across Scotland, and there will be new ways of designing, operating and regulating them to ensure that they are used efficiently.

Our electricity and gas networks deliver a secure supply of energy to domestic consumers and businesses across Scotland. In 2016, those networks delivered almost 50% of all the energy consumed in Scotland, including 86% of energy for domestic consumption. Ensuring that these networks are able to deliver affordable and increasingly decarbonised energy to everyone in Scotland over the next decade is essential to Scotland's Energy Strategy.

Re-engineering these networks to decarbonise the energy that flows through them is a major challenge – as is the coordination and integration of new and potentially 'disruptive technologies' that can contribute strongly to decarbonisation such as energy storage, electric vehicles, fuel cell vehicles and the use of hydrogen or biofuels for heating.

Although these changes are already underway, there is, as yet, no consensus on what Scotland's future electricity and gas networks will or should look like. The challenges are technical and solutions can often be complex; however, the proposals being discussed by the sector have the potential to fundamentally alter the relationship between consumers and the networks they use.

Consumers, businesses and their representatives need to be aware of the significant changes that are coming, and they also need to be supported so that they are able to take part in the debate. Consumers need to be at the heart of the transition to a low carbon energy system, and the way in which our networks evolve must reflect that.

Our vision for Scotland's networks is built upon the principles and priorities of the Energy Strategy, which lays out how we want the future energy system in Scotland to develop. It highlights the implications for our gas and electricity networks, and sets out the context within which decisions about the future of these networks will be made.

The vision focuses on our gas and electricity networks between today and 2030. How they develop beyond that will depend on important strategic decisions that we must make during 2020s such as the future role of the gas network in a fully decarbonised energy system.

Networks are long-term investments. Pylons and pipelines built today will be expected to operate until well beyond 2050, so we need to make sure decisions taken over the next few years consider our longer term ambitions.

Our Climate Change Bill, introduced in May 2018, proposes a 90% reduction in all greenhouse gas emissions by 2050. This will mean achieving net-zero emissions of carbon dioxide by the same date. In other words, Scotland will be carbon-neutral.

The Bill also requires that the earliest credible date for a net-zero target for all greenhouse gases is kept under review. As soon as a target date can be credibly and responsibly put in legislation, that will be done. It is important that Scotland's networks evolve in a way that helps us deliver these long term ambitions.

There are significant challenges to face and opportunities that can be fulfilled. Our vision considers the investments which we need to see in the physical networks themselves and in the institutions which govern how they are planned, regulated and funded.

Although gas and electricity policy is reserved to the UK Parliament, there is a high degree of relevance to devolved responsibilities, including our plans to decarbonise both heat and transport – and the importance of getting the right network investment to fulfil our wider social and economic development and climate change objectives. This means that the Scottish Government has an important role to play and that we intend to do everything possible to influence and support optimal thinking and decision making for Scotland's distinct needs. This vision will inform and support our continuing engagement with the UK Government and Ofgem.

The Scottish Government's devolved powers over planning and consent for new energy generation and transmission infrastructure, and decarbonising heat and transport, will also play a key part in delivering the goals set out within this vision. We are also committed to delivering local and community energy projects and development of our islands' economies, with this now underpinned in statute, through the Islands Act, 2018.

Table 1: Gas and Electricity networks' role in delivering the Principles and Priorities of the Scottish Energy Strategy.

PRINCIPLES	<p>A whole system view</p> 	<p>Electricity and gas networks should support an efficient and effective process of decarbonisation across the whole energy system and should support broad societal and economic ambitions. Long-term investments must take account of local and regional aspirations for the whole energy system – including transport, heat, energy efficiency and support to the local economy.</p>
	<p>An inclusive energy transition</p> 	<p>Access to affordable and reliable energy underpins our society and economy. The networks are instrumental in providing that access. Decarbonisation will create new opportunities, and new relationships between consumers and networks.</p>
	<p>A smarter local energy model</p> <p><i>Innovative local energy systems</i></p> 	<p>The networks already support GB-wide national markets for energy. We want to see the structures and regulations develop to support innovative local energy models, and to help those models develop and reward communities for managing their energy in ways that support efficient and cost reflective networks.</p>
	<p>Consumer engagement and protection</p> 	<p>Consumers must be at the heart of decisions made about networks; we need to find new and effective ways to bring consumers and their representatives into what are challenging and technical conversations. This has to extend to those who have perhaps been traditionally considered unable or unwilling to think about or benefit from the changes that are going to take place.</p>
	<p>Energy efficiency</p> 	<p>The networks have an important role to play in delivering Scotland's energy efficiency ambitions. They have long term relationships with consumers, and continue to serve the same properties throughout their lives. Energy efficiency can also lead to direct savings to network companies where reduced demand reduces the need to increase capacity.</p>
	<p>System security and flexibility</p> 	<p>Our electricity and gas networks link together a diverse range of energy sources, and this will continue to be one of the most important roles that they play – especially as we move still further towards a decentralised energy system, and the greater demand for sources of flexibility that we expect that to create.</p>
PRIORITIES	<p>Renewable and low carbon solutions</p> 	<p>Electricity networks, especially at the distribution level, will need to continue to connect renewable generation, with regulation and investment decisions designed to enable this. We will also need changes to enable the gas networks to transport more low carbon alternatives. These changes will be vital to decarbonising heat and transport in particular.</p>
	<p>Oil and gas industry strengths</p> 	<p>We will need the gas networks to continue to support the most appropriate use of our remaining gas resources during the coming decades. The oil and gas sector's innovation and engineering expertise can help us understand how the existing network infrastructure can support decarbonisation – for example, its role in transporting hydrogen and carbon.</p>

TABLE 2: KEY TECHNICAL CHALLENGES

ELECTRICITY

- The ability to continue connecting new renewable generation capacity to the electricity networks in Scotland throughout the 2020s and using those networks efficiently to deliver renewable electricity to consumers across Scotland and beyond.
- Integrating electric vehicles and heat pumps into existing electricity distribution networks designed on increasingly outdated assumptions.
- Ensuring the physical limits of networks are protected as new and smarter ways emerge for consumers, sources of generation and energy storage to engage in national as well as local markets.
- Maintaining a secure and stable electricity system, including greatly reduced capacity from large, 'dispatchable' and 'synchronous' generation and increasing contributions from intermittent renewables and interconnection.

GAS

- Valuing the flexibility that Scotland's gas networks provide to the wider energy system through their significant energy storage capabilities.
- Finding ways to safely and incrementally decarbonise the gas that flows through the networks during the 2020s by blending biomethane and low carbon hydrogen.
- Clearly identifying the options for using the gas networks to link with new, low carbon technologies including Steam Methane Reforming to produce Hydrogen, Carbon Capture Utilisation and Storage, and 'power-to-gas'.
- Using these options to understand the feasibility and costs of converting parts of the gas networks to deliver 100% hydrogen in the future, and the role those networks should play in a fully decarbonised energy system, alongside the potential for use of hydrogen in transport decarbonisation.

ELECTRICITY NETWORKS

Our Vision: By 2030... there will have been the necessary substantial investment in new capacity for our electricity networks, including transmission links to our island groups and new undersea cables between Scotland, England and Wales. There will be a strategic focus on security of supply and resilience when designing these networks and the systems that they connect. New distribution network investment will be balanced against the use of smart grid systems which create opportunities for flexibility and thriving local markets for both the generation and use of electricity.

The electricity system is changing quickly. One example is the demand from new renewable generation for connections to the (lower voltage) distribution networks; today many of those networks are at full capacity. New network capacity is therefore needed, in some cases urgently, to meet this demand. However, we also need to use existing capacity far more efficiently through expanding opportunities to balance supply and demand at a local level within the constraints of the network.

The growth and integration of electric vehicles (EVs) will be another factor which changes the underlying assumptions on which electricity networks will need to be designed and operated. Owning and charging an EV can double the electrical demand of a typical house, and more than double that household's impact upon the peak demand placed on a local electricity network. We expect EV numbers to grow in response to our ambition to phase out the need for petrol and diesel cars and vans by 2032. We will need to think carefully about how they are integrated and develop pragmatic, technically deliverable solutions for coordinating and managing domestic EV charging. We need to ensure in doing so that Scotland's networks can continue to operate reliably, and that new investment is targeted efficiently and economically.

Coordinating these changes is a challenge that the industry has picked up through the proposed 'Distribution System Operator' (DSO) transition. This aims to build smart, local markets for energy, rewarding both people and businesses for being flexible in their use of the networks. However, rather than implementing a transition that is imposed on consumers, this must be one in which consumers and their representatives are at the heart of decision making. We must protect those who can't respond flexibly, or who struggle to engage in these markets, to help reduce economic exclusion, and instead promote inclusive growth.

We will also need significant investment in new electricity transmission infrastructure. This will provide the essential connectivity to our island groups and ensure that investors in new Scottish renewable energy developments can invest with confidence due to the ability to access to markets across both the British Isles and other parts of Europe.

Transmission network investment needs to consider carefully the technical challenges posed by the move from large, synchronous power stations to distributed intermittent generation. If the architecture of the electricity system, including network investment, doesn't adequately reflect the needs of the new, distributed energy model, then that would have potentially significant implications for security of supply, the stability of the network and resilience of electricity supplies in Scotland.

The ability to operate the electricity system as a whole is becoming more challenging. The closures of large, thermal power stations across Britain, including those in Scotland, means that while discussions about infrastructure often focus on the capacity of networks to move power, a stable electricity system needs other services such as the ability to support voltage, detect faults, and remain resilient to unexpected events.

We think, based upon our own analysis, informed by the work of the Scottish Energy Advisory Board, that there needs to be a greater strategic focus on regional security of supply. This means considering not only the networks, but also the location and characteristics of resources connected to them.

The supporting infrastructure, such as telecommunications and IT, and the systems used to control the network and the resources connected to it, will also need to evolve. As we rely more on the ability to adjust and adapt systems in real time, being able to see and respond quickly to what is happening becomes ever more critical.

GAS NETWORKS

Our vision: By 2030... gas networks remain a vital and flexible component of Scotland's national infrastructure, delivering affordable energy for heating our homes and businesses. The energy resource carried by the networks will be lower carbon than it is today. The policy, regulatory and technical developments will have been put in place to allow natural and low carbon gas to be blended in the networks, including a contribution from hydrogen. We will also understand clearly the feasibility and costs of repurposing the gas networks to carry 100% hydrogen, and will have made strategic decisions about the long term role of the networks and the wider decarbonisation of heat.

Our vision for the gas networks has three parts. Firstly, there is a recognition and improved understanding of the value that the gas network currently provides to the economy, consumers, and the wider energy system. Gas networks currently connect around 80% of households in Scotland and deliver comparatively low cost and reliable energy. The gas network also represents a highly flexible resource – it gives access to capacities of energy storage several hundred times greater than that which we could connect to our electricity networks. This flexibility supports the wider energy system by absorbing large swings in daily demand for energy for heating domestic and non-domestic premises.

Secondly, we want the gas that flows through Scotland's gas networks to become increasingly decarbonised during the 2020s. The connection of 15 biomethane production sites to the gas distribution networks in Scotland shows that this process has already begun. There is also the opportunity to produce low carbon hydrogen through power-to-gas projects, blending some hydrogen with natural gas where this can be done safely and with no impact on consumers. Transporting low carbon gases through the network will, however, require policy and legislative changes to gas quality regulations – and we support the industry in its efforts to secure these.

Thirdly, we want network companies to develop the evidence base needed to understand the technical feasibility and cost effectiveness of converting the gas networks to supply 100% hydrogen after 2030. Scotland's Energy Strategy highlighted a hydrogen future as one possible pathway to a near fully decarbonised energy system in 2030, including decarbonisation of both heat and transport systems.

Such a future will require networks capable of supporting the infrastructure to produce hydrogen, and, if steam methane reforming is utilised in its production, to transport the gases associated with carbon capture utilisation and storage, and to deliver the hydrogen to end consumers. By the middle of the 2020s, we will need to have the evidence required to make strategic decisions on the future of decarbonised heat, and the longer-term role of the gas network will be an important part of that decision.

COORDINATING THE TRANSITION

Our vision: By 2030... network regulation and governance will be more flexible and agile, based on deeper relationships with consumers. Scottish policies and priorities, as well as those of local authorities, will be taken fully into account ensuring that networks help deliver regional and local aspirations for energy. A coordinated, “whole system” approach to infrastructure planning will exist, with strong and effective discussion between the electricity and gas network companies and everyone in the wider energy system. The way networks are funded ensures that the essential service they provide – access to affordable, reliable, and low carbon energy – is available to all citizens and businesses in an efficient and cost effective way.

We will need clear and strong leadership to ensure that the network transition is well coordinated. There is an important role here for government and regulators to set the objectives and ensure that change is focused on delivering what is right for society.

There is exciting scope for new thinking, new business models, and new approaches to planning and regulating networks. This could consider the planning of networks in other areas – such as digital connectivity or transport, as well as the integration of heat networks as a new regulated sector, and ensure joined up development across Scotland.

The Smart Systems and Flexibility Plan¹ produced by the UK Government and Ofgem highlights many important issues and opportunities, describing their significance and proposing some good, practical changes. Ofgem's latest Forward Work Programme² also considers what the potential for radical changes across the energy market means for its role as regulator, and for the consumers whose interests it exists to serve.

Scotland's Energy Strategy also provides important leadership in this area. It highlights the need to focus on whole system issues, on an inclusive transition, and the importance of smarter local energy systems. It also focuses on the unique challenges and opportunities that Scotland has, stemming from its geography, its energy resources, its people and businesses.

The Energy Strategy is consistent with our most recent National Planning Framework. This includes Scotland's high voltage transmission network as a “national development”, along with infrastructure investment for pumped hydro storage, and carbon capture and storage.

Our goal remains, where possible, to collaborate constructively and openly with the UK Government, Ofgem and all relevant stakeholders to ensure that Scotland's differing circumstances, needs and priorities are clearly acknowledged and understood.

Scottish Ministers will meet annually with the Gas and Electricity Market Authority (GEMA) board to specifically discuss gas and electricity network issues – building on the strong engagement that already exists between Scottish Government and Ofgem.

¹ https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/633442/upgrading-our-energy-system-july-2017.pdf

² https://www.ofgem.gov.uk/system/files/docs/2018/03/forward_work_programme_2018-19_0.pdf

Scottish energy policy teams will meet with UK Government colleagues in the near future to discuss the issues set out in this document, and how our joint ambitions can contribute towards UK wide decarbonisation and industrial strategy. This will be in addition to continuing meetings between Scottish and UK Government Ministers, which cover a range of energy policy matters.

We recognise there is also a need to engage local government in this area. We have already started bringing local authorities and network companies together in a more strategic way, designed to give the former a more central role in planning the energy system in their area. As we help local authorities to develop Local Heat and Energy Efficiency Strategies, we will create opportunities – for example, through an annual workshop – to ensure that network companies can take the development of local plans into account.

Starting from the consumer

Consumers and their representatives need to be central in deciding how our networks develop. The work of consumer organisations like Citizens Advice, Citizens Advice Scotland and Home Energy Scotland will be vital – we need innovative approaches to ensure that consumer interests are represented in an area of growing complexity.

Business customers also need to develop a better understanding of how and where they are able to support the networks. Industrial decarbonisation is a critical part of our Energy Strategy; our upcoming Discussion Paper will highlight a range of options for Scottish energy intensive industries to improve their energy productivity, with a view to mitigating the risk of carbon leakage, and benefit from flexible networks that are better able to deliver low carbon energy.

Ofgem has recently asked all network companies to set up Customer and User Groups to challenge their spending and investments plans. We think this is a welcome step, and we will support these groups to ensure that they understand the challenges and opportunities that networks provide to Scottish energy consumers.

We will do this by working with consumer groups, business representatives and local authorities to identify and explore the challenges they will face in representing consumers in increasingly complex and technical debates. We will look closely at ways to enhance and improve the ability of these organisations to take part in those debates.

SCOTLAND LEADING THE WAY - INNOVATION AND SKILLS

Our vision: By 2030... the culture of innovation in the sector will continue to grow. For electricity networks this means a focus on coordinating and integrating new technologies, particularly electric vehicles, heat pumps and new generation. Meanwhile, for gas, it means a focus on innovation to support hydrogen and low carbon gases. With the development of new technologies, innovative approaches to bring together previously disparate parts of the energy system can ensure that we make the most of local opportunities in a 'whole-system' way. Delivering the skills that a changing sector needs, including in new specialisms such as cyber security and data science, will be a key priority for us our businesses and our education sector.

Scotland has been leading the way in developing smart electricity grids and more efficient ways to use our electricity networks. Orkney pioneered the world's first ever smart grid³, while the Mull ACCESS project⁴ has shown the benefits of a community-led approach to managing the electricity network. This trend is continuing with the largest smart grid project in the UK currently in development in Dumfries and Galloway. This will increase access to the electricity networks for new renewable generators and make efficient use of both the transmission and distribution networks. The Power Networks Demonstration Centre in Cumbernauld is also a location for significant research and development activity and demonstration of smart grid and storage technologies.

We are setting a similar example when it comes to gas. The Oban gas network has helped demonstrate over the past two years that a wider range of gases, including lower carbon gases, can be transported safely, while the H100 project plans to demonstrate a 100% hydrogen gas network in Scotland in the next few years.

The area around the St. Fergus terminal, the most northerly point of the gas transmission network, is an ideal location to begin demonstrating and learning about the potential for linking hydrogen, Carbon Capture Utilisation and Storage, and gas network infrastructure. The ACORN project based at St. Fergus aims to deliver a demonstrator combining the three technologies early in the next decade. The Scottish Government provided funding for feasibility studies into this project, and this is an example of how we will continue to support the development of a hydrogen economy. There is the opportunity to develop this as a hub, testing ways to blend hydrogen into the networks and potentially to reuse network infrastructure to transport the gases from Carbon Capture.

This document reinforces the key role that hydrogen could play in connecting and helping decarbonise our heat, industrial and transport systems. Hydrogen also has the potential to transform our urban, rural and island economies, and support the expansion of renewable energy.

³ <https://www.ssen.co.uk/OrkneySmartGrid/>

⁴ <http://www.communityenergyscotland.org.uk/access.asp>

The Scottish Government plans to build on our recent support for hydrogen. We are working to publish an interactive mapping tool which charts current hydrogen activity in Scotland and plots specific hydrogen opportunities and hydrogen production potential on a region by region basis.

We will also continue to work with our stakeholders to advance a bold range of hydrogen energy and transport initiatives, with accompanying clear analysis and policy statements on the role of hydrogen in Scotland's economy. We will capitalise on Scotland's unique strengths, skills and capabilities to maximise the role and contribution of hydrogen to Scotland's economy and energy future. More detail on these aspects will be included within our Annual Energy Statement published later this year.

The world leading projects described in this section build on other strengths at our disposal. Scotland's universities host world class research centres on networks and renewable energy, while institutions such as the Offshore Renewable Energy Catapult and the aforementioned Power Networks Demonstrations Centre bring industry, academia and government together to focus on how networks can be used to integrate the technologies we need.

We believe that Scotland's experience makes us well placed to lead on the networks' role in the energy transition. To build on that opportunity we will host a Networks Summit in 2019, bringing together everybody who has a stake in how our electricity and gas networks develop in Scotland, to discuss and debate the matters addressed in this vision. We will also convene a Scottish Energy Networks Group with senior representatives from industry, Government and consumer groups to help deliver this vision.

Getting into the detail

The transition that our electricity and gas networks need to go through is technically complex, but potentially revolutionary. There will be substantial implications for everyone who uses those networks depending on how this transition takes place.

We believe there needs to be a well-informed and meaningful debate across society, including the business community and the whole energy sector within it, about the priorities and effects of that transition. For example, consumer groups need support and resources to help them identify and understand the impacts on the consumers they represent, making it easier to act on their behalf. Energy producers – including renewable generators and producers of low carbon gas – need to understand the forms of flexibility and services that network operators might ask of them in future.

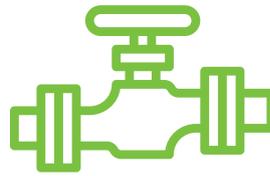
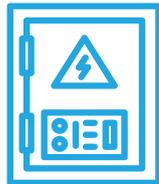
To support this, we have produced a more detailed view of our *Vision for Scotland's Gas and Electricity Networks to 2030*. This detailed vision underlines our commitment to ensuring that as many as possible can understand both the magnitude and implications of the transition, and begin to engage.

THE ELECTRICITY AND GAS NETWORKS TODAY



There are **71,000 miles OF ELECTRICITY CABLE** in Scotland

There are **98,000 ELECTRICITY TRANSFORMERS** in Scotland



There are **17,000 miles OF GAS PIPELINE** in Scotland

NATURAL GAS has an estimated **CARBON INTENSITY** of **184 g CO₂ per kWh**



There are **15 low carbon gas producers** connected to the gas network in Scotland with a **CAPABILITY OF 183 GW** and the potential to **INJECT UP TO 1,600 GWh of LOW CARBON GAS** per year.



Approximately **£1.0 Billion** is spent on **RUNNING AND INVESTING** in the electricity networks and **£200 million** on the gas networks **EACH YEAR** in Scotland.



There is **13.5 GW** of generation connected to the electricity networks in Scotland **OF WHICH 10.3 GW ARE RENEWABLE**. In 2017 this generated **25,200 GWh**.



GAS SYSTEM OPERATOR

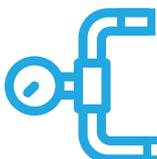
The gas system operator is responsible for ensuring that the British gas system is balanced across each day, and that the system is secure and can continue operating in the event of a fault in any part of the system. **National Grid** is the Gas System Operator for the whole of Britain.

GAS NATIONAL TRANSMISSION NETWORK (NTS)

The high pressure gas network that transfers gas across Britain from offshore pipelines, LNG terminals, and storage facilities. This includes gas injected from the North Sea at St Fergus in north east Scotland. **National Grid** are the Transmission Owners for the NTS.

GAS DISTRIBUTION NETWORKS

The lower pressure gas pipes that bring gas to our homes and the majority of our business are owned by Gas Distribution Network (GDN) owners. In Scotland there is one GDN: **SGN**. There are 7 GDN areas covering England and Wales.



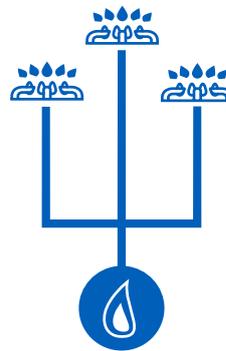
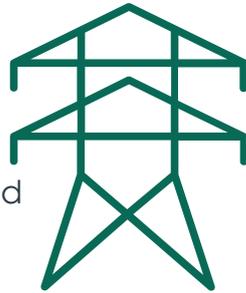


ELECTRICITY GENERATED IN SCOTLAND in 2016 had an estimated **carbon intensity of 54 g CO₂ per kWh**

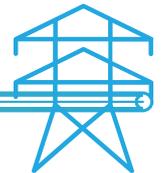
Gas and electricity network charges represent **25%** of the average domestic customers **ENERGY BILL** equivalent to **£284 PER YEAR.**



The **ELECTRICITY NETWORKS** deliver **31,000 GWh per year** to consumers, and meet a peak demand of approximately **5.5 GW**



The gas networks delivered **58,000 GWh** in 2017 to consumers and are able to meet a Scottish peak demand of approximately **22 GW**



ELECTRICITY SYSTEM OPERATOR

The Electricity System Operator (ESO) is responsible for the day-to-day security of the electricity System across Britain. It adjusts which power stations are operating, and ensures there is sufficient back up in the right parts of Britain to cover important contingencies. The ESO is also responsible for recommending which major network investment projects should go ahead. **National Grid ESO** carries out this role across the whole of GB; a role which is being legally separated from its role as the transmission owner in England and Wales.

ELECTRICITY TRANSMISSION NETWORK

The high voltage networks – 132,000 volts and above in Scotland – that act as the bulk transporter of electricity across the country. They are owned by Transmission Owners (TO's). **SSE Networks** in the north of Scotland and **SP Energy Networks** in the south of Scotland. **National Grid TO** are the owner of the transmission grid in England and Wales.

ELECTRICITY DISTRIBUTION NETWORKS

The low voltage networks that bring electricity to our houses and the majority of our businesses. They are owned by a Distribution Network Owner (DNO) – **SSE Networks** in the North of Scotland and **SP Energy Networks** in the South of Scotland. There are also 12 DNO regions covering England and Wales.





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