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Review of Electricity Market Arrangements:
A Vision for Scotland

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NOVEMBER 2023

Acknowledgements:

The report has been prepared by Dr. Simon Gill, The Energy Landscape for Scottish Futures Trust. The work has been supported by Ellie Brundrett and Johnny Gowdy at Regen who provided comments and suggestions throughout the process.

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Foreword by Scottish Futures Trust

The Scottish Futures Trust (SFT) is an infrastructure agency of the Scottish Government. SFT commissioned The Energy Landscape (TEL) to undertake this report to provide some technical analysis and stakeholder views around what might be a positive outcome from the UK government's REMA process, given Scottish Government's draft Energy Strategy and Just Transition Plan (ESJTP).

Scottish Government's draft ESJTP sets out Scotland's ambition for a Just Transition to a net zero energy system. The vision sets out that by 2045, Scotland will have a flourishing, climate-friendly energy system that delivers affordable, resilient and clean energy supplies for Scotland's households, communities and businesses. This will deliver maximum benefit for Scotland, enabling the nation to achieve its wider climate and environmental ambitions, drive the development of a wellbeing economy and deliver a Just Transition for workers, business, communities and regions.

Working towards this vision, investment is crucial - not only into new renewable electricity deployment but also to grow the green hydrogen sector and invest in accelerating the transition from fossil fuels for the demand sectors. The Scottish Futures Trust believes that creating and maintaining a secure and stable investor market will be critical to attracting the tens of billions of investment required for this transition.

Scotland also has a significant contribution to make to UK government's target of a fully decarbonised GB electricity grid by 2035 and this report considers what a shared vision for the GB electricity system, and Scotland's role within it, could look like. This report draws upon stakeholder engagement in Scotland across generators, consumer groups, energy intensive users including the hydrogen sector and the public sector to draw conclusions about the REMA options. The TEL report makes a number of recommendations for next steps for key stakeholders to work towards this vision.

The work for this report was conducted during the first three months of 2023 and the project was finalised in June. Since then the report has been used to inform discussions with Scottish Government, public sector organisations, UK government and GB-wide REMA stakeholders. However, it is important to publish the report to add to the public debate in the run-up to the second consultation on REMA, expected from UK government in the near future.

Since the report was originally written, there have been a number of important developments in the national debate. Firstly Nick Winser, the UK government's Electricity Networks Commissioner, published a detailed **report** and set of recommendations focused on speeding up the delivery of new electricity network capacity. Responding to that report, in September 2023 **the Prime Minister committed** to the first ever spatial plan for energy infrastructure alongside provisions for developing strategic system planning through the new **UK Energy Act** which received Royal Assent last month. These developments show welcome movement at a UK level towards the coordinated vision and plan for Scotland's electricity system.

Scottish Government has also published its **Onshore Wind** sector deal with recommendations that echo those in this report, particularly commitments to work with NGESO, Ofgem and UK Government to ensure that Scotland's vision is integrated into plans for the wider GB energy system. Most recently, **Ofgem has published** a detailed assessment of Locational Wholesale pricing, concluding that improved locational signals can produce material benefits for consumers, a point SFT agrees with. Ofgem believe that these could be delivered through locational marginal pricing, but also note that it is working to develop a counterfactual option involving improving locational signals under current market arrangements, an approach that is one of the recommendations of this report. SFT hopes this report can feed into that development.

More generally The Scottish Futures Trust believes the recommendations and insight within the report can make a positive contribution to the REMA debate regarding what Scotland needs, and by extension what is needed to contribute to the wider GB electricity market decarbonisation. It is important to emphasise that neither the comments nor the contents of the report itself constitute Scottish Government policy.

Scottish Futures Trust

November 2023

Executive Summary

A vision for market reform to support Scotland

A vision for the future Scottish electricity system

Renewable power is the foundation of our net zero transition. It delivers benefits to energy consumers and citizens, supports a strong economy and delivers positive outcomes across society. Electricity markets need to ensure a fast transition to a net zero electricity system powered largely by renewables and delivering affordable energy and stable prices. Market frameworks must support the electrification of heat and transport.

Flexibility will ensure effective use of Scotland's renewable fleet and play a critical role in ensuring Scotland benefits from hosting renewables. Markets will support the development of pumped storage, batteries and other energy storage technologies as well as helping to develop hydrogen electrolysis, adding significant flexible consumption to the electricity system and forming a key component of Scotland's thriving hydrogen economy.

Consumers will benefit from affordable and stable prices, reflecting the low cost of net-zero technologies, particularly renewable generation, whilst retaining a secure supply. Electricity markets will support a Just Transition by recognising and encouraging the creation of a broad range of social benefits including jobs, strong local economies, and a contribution to communities' wealth.

Wholesale market reform will be delivered in coordination with wider energy system reforms including the development of more strategic ways to plan and deliver electricity networks and retail markets that deliver better outcomes for consumers. The result will be a market framework and a wider system that helps ensure both Scotland and GB benefit from successfully decarbonising our electricity system.

Three Scottish principles for REMA		
Coordination **between and within Scottish and UK government and institutions.** The right decisions on market reform will be critical to delivering Scotland's ambitions to decarbonise its energy system, deliver net zero by 2045 and ensure a strong and thriving renewable industry. Delivering these ambitions are also critical to meeting UK government's ambitions for a fully decarbonised electricity system and deliver the UK's sixth carbon budget. Without well-designed electricity markets Scotland can't succeed; without Scotland delivering the UK won't succeed.	**Commitment** **to deliver for people, businesses, communities and society across Scotland.** Reform of electricity markets can deliver a wide range of outcomes that are valued by consumers including low costs, stable costs, and fairness. It also supports the wider interests of people, businesses and society as a whole through the provision of jobs, economic growth and community value. Future market arrangements should ensure everyone can benefit and reflect the collective endeavour that goes into delivering energy infrastructure. It reflects the role of communities and local economies as well as developers and operators.	**Confidence** **for renewable and flexibility investors and consumers in Scotland.** Confident investors are critical because of the scale and pace of investment needed in all technologies and because ensuring a fast transition is the best way to deliver for consumers and for society. Confidence is particularly important for renewables because, although they have the lowest levelised cost of energy of any type of generation, their costs are much more weighted towards upfront investment. A lack of confidence could lead to an investment hiatus and / or increased cost of capital. Providing confidence to consumers, including industrial and commercial end-users, means giving certainty that costs are both affordable and stable.

What 'good' looks like for Scotland					
A shared vision and plan for the GB electricity system and Scotland's role within it.	An increasingly strong focus on transmission network investment.	A clear articulation of consumer values and outcomes and a set of consumer-focused principles for decision making.	Retain a GB-wide wholesale market and a pricing mechanism, such as an evolution of CfDs, linking long term costs to prices.	Targeted, forecastable, stable, locational investment signals for generation, demand and flexibility, e.g. through reform of TNUoS.	Operational locational price signals to reward flexibility for reducing network constraints e.g. a regional constraint management market.

This report presents a vision for how electricity market reform could support Scotland to achieve its net zero and Just Transition ambitions. It highlights the role Scotland will play in supporting key UK government commitments including the ambition to deliver 50 GW of offshore wind around the UK by 2030, full decarbonisation of the whole GB electricity system by 2035 and delivery of the sixth carbon budget.

The context for the report is the UK government's Review of Electricity Market Arrangements (REMA) which aims to identify the reforms needed to ensure electricity markets support delivery on net zero and ensure consumers benefit from the transition. REMA has implications for both the development of Scotland's existing electricity system, which supplies around a quarter of Scotland's overall energy demand, and for the process to electrify heat and transport demand, currently supplied by fossil fuels. Electricity markets will also be important in our growing hydrogen economy which, through electrolysis, is likely to become a significant consumer of electricity.

Renewables are expected to be the powerhouse of the energy transition, with Scotland aiming to deliver 20 GW of onshore wind by 2030 and build out the 28 GW of Scotwind leases awarded offshore. Markets need to support investment in those sources of energy and in the flexibility required to manage the system. They also need to deliver value to people, businesses, communities and wider society.

This report was prepared by Dr. Simon Gill of The Energy Landscape and presents the outcome of work commissioned by infrastructure specialists Scottish Futures Trust (SFT) in order to better understand the implications of market reform on the Scottish electricity sector and the wider Scottish economy. The vision represents The Energy Landscape's view on what is important for Scotland. This is informed by Dr. Gill's extensive experience in electricity markets and energy policy along with significant stakeholder engagement with 36 organisations representing a wide range of interests related to the electricity system. There was widespread support for the approach taken, based on meaningful engagement, but this does not imply all stakeholders agree with all the recommendations presented.

It is hoped the outcome of the work can inform Scottish government, UK government and other bodies working on electricity market reform. This report is not endorsed by Scottish government, nor does it represent Scottish government's policy position on electricity market reform or wider energy and Just Transition policy.

The principles

Coordination between Scottish and UK governments

The first principle reflects the importance of decisions made at GB level for delivery of Scottish ambition and targets. It also reflects the critical role Scotland will play in meeting wider UK targets.

Without well-designed electricity markets Scotland cannot succeed; without Scotland delivering the UK will not succeed.

Delivering success means Scottish and UK governments working closely together to ensure decisions taken within both jurisdictions support each other. This will include processes such as planning and consenting of new generation and network capacity, seabed leasing, transmission network planning and policies related to the electrification of new parts of the energy system. Coordination needs to go beyond governments to include devolved and reserved agencies, for example Ofgem and the Future System Operator.

The principle of coordination also applies *within* government at both UK and Scottish level. For example, ensuring affordability means aligning measures taken across a wide range of energy and social policy domains.

Commitment to deliver for people, businesses, communities and society

The second principle reflects the overarching role of the electricity system in delivering on the needs and values of electricity consumers and of wider society. It recognises, for individuals, households, and businesses within Scotland there is a diversity of interests and needs. This principle fits with Scotland's focus on delivering a Just Transition and extends the domain in which benefits delivered by the electricity system – from those related purely to electricity bills and emissions savings – to include the impact on the wider economy through supply chains, jobs, local and regional economic benefit, and community ownership.

Confidence for investors and developers

The need for confidence in investment follows directly from the first two principles. Neither the needs of consumers nor the ambitions set out by government can be met without ensuring the confidence of organisations to invest in and build the infrastructure needed for a net zero electricity system. The pace and scale of investment needed, across renewables, dispatchable low carbon generation, flexibility, and networks, is substantial. Realising that investment is only possible if confidence is maintained.

The principle of confidence is important for all parts of the electricity system, however it is particularly important for investors in renewable generation. Renewable generation is the foundation of a net zero energy system. Today renewables supply just 8% of GB's total energy demand (electricity, heat and transport), to achieve net zero it will need to reach at least 50%, likely significantly more[1].

1 Based on analysis of the Energy Flow Diagrams in the *2022 Future Energy Scenarios*: **https://www.nationalgrideso.com/future-energy/future-energy-scenarios**

Ensuring confidence and minimising uncertainty for investors means ensuring reform takes direct consideration of real-world practical delivery challenges. For example, in terms of location it means ensuring the market supports delivery of generation, flexibility and end-use infrastructure where it is possible and sensible to build. It means considering carefully the degree and type of risk project developers are exposed to. For Scotland that means realising the opportunities already identified as part of its pipeline of renewable and wider net zero energy projects.

Key outcomes for Scotland and proposals for action

A shared vision and plan for the electricity system and Scotland's role within it

There is significant value in a shared vision for the future of the GB electricity system which articulates how electricity supply, demand and flexibility may develop in different parts of the country. This could include a GB-wide plan which reflects the aims and ambitions of both UK and devolved governments and provides an indication of the likely scale and pace at which different technologies and enabling infrastructure – wind, solar, network capacity, flexibility etc. – could be deployed in different parts of GB. Such an approach would provide much needed clarity around the capacity of Scottish offshore wind to target in 2030, 2035 and 2040, and the degree to which pumped storage hydro, other energy storage technologies, and hydrogen production is expected to provide flexibility to the system. The plan could consider the needs of technical and commercial stakeholders and could be linked to the development of new local and regional system planning and governance frameworks[2].

Proposal:

1. A GB-wide vision and plan should be developed, including an appropriately detailed delivery plan, drawing together ambitions and targets in both jurisdictions. National Grid ESO should reflect the outcomes of that process in their Centralised Strategic Network Plan[3] (CSNP) ensuring the CSNP appropriately reflects Scottish ambitions and the role of Scottish projects in delivering wider UK targets.

An increasingly strong system-wide focus on transmission network investment

Building on Ofgem's Accelerating Strategic Transmission investment (ASTI) decision, market reform needs to be augmented with a renewed focus on getting transmission network investment right. Decisions on market reform need to assume Britain is successful in accelerating network development. ASTI has given the go ahead for significant investment in transmission capacity aimed at supporting delivery of the UK government's 2030 target for 50 GW of offshore wind. This includes major reinforcement of the transmission network within Scotland and between Scotland and England. However, the ASTI approach could be extended to cover other electricity system developments, supporting the development of onshore wind, solar, dispatchable generation and new sources of demand. In short, it could take a 'whole system' rather than a technology specific approach. The approach also could be extended beyond 2030 to ensure a clear focus on network investment taking us right through the next two decades.

2 **https://www.ofgem.gov.uk/publications/consultation-future-local-energy-institutions-and-governance**

3 **https://www.nationalgrideso.com/research-and-publications/electricity-ten-year-statement-etys/etys-and-our-future-network-planning**

Proposal:

2. Ofgem should extend the scope of the ASTI framework from offshore wind to a whole electricity system approach and the timescales over which ASTI could be extended to cover at least 20 years and be clearly linked to the shared vision and plan proposed under Recommendation 1.

An articulation of value: consumers, citizens and society

In order to deliver for consumers, citizens and wider society it is important to understand the different aspects of value the electricity system creates for people, businesses and the country as a whole. Outcomes that deliver value will include: affordable and stable prices, reduced emissions and increased sustainability, equality and fairness between different groups and different places, economy growth both nationally and locally, delivery of local benefits and the creation of high quality jobs.

Today there is no clear articulation of those outcomes and the weight that should be placed on each. Having such an expression of the value the electricity system can deliver, combined with thoughtful consideration of how to deal with tensions between different aspects of value and the views of different groups in society will be critical for getting the right decision on market structures.

It is important this is an articulation shared across Scotland, England, and Wales. The context for market reform, and the potential impact of different options on each part of GB, will vary. It is also important it considers the full range of stakeholders. It should pay particular attention to the interests of vulnerable groups and the implication for new end-users such as electric vehicle and heat pump owners. Where there are tensions between different groups or different elements of value, it is important to reflect how these should be balanced.

Without such an articulation there is a risk, seen in some of the analytical evidence developed for REMA so far, of defaulting to a relatively narrow concept of theoretical economic consumer value based primarily on low cost and largely ignoring other elements including cost certainty, equality, fairness and wider society and place-based value.

Proposal:

3. UK government should work with the devolved administrations including Scottish and Welsh governments and representatives of the English regions to develop a shared articulation of the different elements of value the electricity system provides to people, businesses, communities, and society across Britain. The result could play a central part in the next phase of REMA ensuring decisions consider the broadest possible set of social, economic, and environmental elements of value. It should also consider the balance between national and regional benefits.

Retain a GB-wide wholesale market with firm access rights

The most important factor in delivering for consumers is ensuring a fast transition to a largely renewable electricity system whilst retaining the high reliability of supply consumers are used to. This is at the heart of developing not just a strong renewable sector in Scotland, but a green hydrogen economy and successful decarbonisation of heat and transport. Achieving this goal means maintaining confidence in investment across the electricity sector, and particularly in the renewable sector.

Evidence from stakeholders highlights this is best achieved by maintaining the current GB-wide wholesale market rather than introducing a major revolutionary change to locational pricing. For Scotland in particular, a move to locational pricing or the removal of generators' firm right of access to the system appears likely to be hugely detrimental to the renewable sector based on the information currently available. Whilst there are reforms that could potentially mitigate some concerns around locational marginal pricing *in theory*, the uncertainty that would be introduced by trying to develop a brand new system would likely delay investment and / or increase the cost of capital. This is likely to increase costs for consumers and put our overall objectives at greater risk.

This point is also important for Scotland's contribution to GB-wide decarbonisation. The risk that a move to locational wholesale pricing would create for investment in Scottish renewable generation could put in jeopardy delivery of both Scotland's targets and the UK-wide ambitions including the sixth carbon budget and the GB-wide commitment to a fully decarbonised electricity system in 2035.

Proposal:

4. UK government and other organisations who are leading the discussion should rebalance the focus of the REMA debate away from locational wholesale pricing towards options which evolve the existing GB-wide wholesale market design. Options for providing locational signals within the current market design have not yet been explored in sufficient depth and more emphasis is needed to support good decision making.

Targeted, forecastable, stable, locational investment signals

There are already significant locational signals capable of influencing the siting of generation in the current system. Some of these are related to price and others come from factors such as availability of renewable resources, land, or seabed. In terms of price, Transmission Network Use of System (TNUoS) charges already introduce a difference of around £8 - £10 / MWh between renewable projects connecting in the north of Scotland and the south of England and under the current system this is forecast to rise to more than £25 / MWh by the early 2030s. However, there are significant challenges associated with the current TNUoS regime, due to a lack of stability and difficulties in understanding how charges will vary in the future.

There is also a lack of equivalently strong investment signals for end-users and for flexibility. Providing such signals will be important in supporting green hydrogen production in Scotland and could play an important part in other demand-side investment such as large-scale electrified heat networks.

TNUoS, if better designed, is a potential mechanism to deliver appropriate locational investment signals. It is important that the design of any price-based signal is given at the right time in the investment cycle and in a way that can genuinely influence decisions and reflect only those costs that are appropriate to place on individual market participants.

Proposal:

5. Scottish stakeholders should work with Ofgem and National Grid ESO (NGESO) to explore options to reform current arrangements for TNUoS that deliver appropriate locational investment signals, in a way that can support good decision making from all sides. Where market participants, including end-users and flexiblity providers, create system savings they should benefit from low transmission charges or income from transmission payments.

A framework for locational operational price signals alongside the GB-wholesale market

The existing system lacks an appropriate mechanism by which consumers and flexibility providers can adjust their demand or operation to support and benefit from the reduction of constraints. This is critical to ensure Scottish consumers and flexibility providers can benefit from otherwise curtailed renewable generation.

The only mechanism which can facilitate this in today's market is the Balancing Mechanism operating during the last hour before delivery. This has increasingly been used to manage constraints. However, it has a number of limitations and was never designed for the bulk redispatch required today. An alternative approach is a regional constraint management market where generation, demand and flexibility participate to relieve forecast constraints on operational timescales. NGESO is currently introducing a simple 'local constraint management market' to manage congestion between Scotland and England[4]. This has the potential to evolve into a sophisticated mechanism that can support a sufficient system, deliver greater value to Scotland, and reduce costs for all GB consumers. However, the details of such a mechanism, including the risks and implementation challenges, need to be explored in significantly more detail.

Proposal:

6. Scottish stakeholders should work together with UK government, Ofgem and NGESO to explore in greater detail how a regional constraint management market could operate alongside a GB-wide wholesale market.

4 https://www.nationalgrideso.com/industry-information/balancing-services/local-constraint-market

1. Introduction

Over the next decade, Scotland's electricity supply needs to be fully decarbonised and substantial progress made towards economy-wide net zero. Scotland also has a critical role in delivering a commitment by UK government to ensure the electricity system across Great Britain is fully decarbonised by 2035. At the same time, electricity must become affordable, and remain that way. To do that electricity markets need to support low cost and low carbon electricity, deliver prices that fairly reflect the underlying cost base, and put in place mechanisms to support and reward flexibility and contributions to security of supply. Designing markets to deliver these outcomes will be particularly challenging given the characteristics, both physical and economic, of a decarbonised electricity system that will be very different from the fossil fuel based system that preceded it.

To get market reform right it is important the way our electricity market works is examined from the perspective of all stakeholders and in terms of the full range of the benefits our electricity system can provide to people, businesses, communities, and ultimately society as a whole.

For Scotland, the goals for the electricity system are clearly defined: support delivery of a net zero Scotland by 2045, contribute to a Just Transition, help deliver a strong and growing economy, and ensure a secure and resilient supply of energy.

Scotland is part of the wider GB system which is organised, regulated and operated for the benefit of GB as a whole[5]. The goals for the GB system are set by UK government and include supporting delivery of the sixth carbon budget and the UK's transition to a net zero economy by 2050. In the medium term there is a clear target of delivering a decarbonised electricity system by 2035.

1.1 Reviewing GB electricity markets

In 2022 UK government set up the Review of Electricity Market Arrangements (REMA)[6] as part of the British Energy Security Strategy[7]. Over the past 18 months this has acted as a focus for a wide ranging debate on how both electricity markets and the wider electricity system should evolve to better support a decarbonised power system and better deliver on consumers' interests. REMA's focus is on the wholesale elements of electricity trading arrangements and covers wholesale energy trading itself and the structures supporting low carbon generation, capacity adequacy, operability and flexibility.

In this report The Energy Landscape (TEL) explores the debate around REMA through the lens of Scotland and proposes a broad vision and a set of principles and outcomes along with recommendations to achieve those outcomes. A key theme of the report is that what looks good for Scotland is likely to be what looks good for GB as a whole. As such there is significant scope for common cause between Scottish and UK governments and institutions. Delivering a decarbonised electricity system and doing so in a way that works for people, businesses and society across GB is a challenge which will need all parties to collaborate and avoid pitching one group against another, whether generators against consumers, or one part of GB against another.

5 Scotland is part of an electricity system shared with England and Wales and referred to throughout this report as the GB electricity system. Northern Ireland is part of the Island of Ireland electricity system which it shares with the Republic of Ireland. The term UK will be used to refer to the UK Government and UK-wide targets, whilst the term GB will be used to refer to the electricity system and the regulatory and market framework operating across Scotland, England and Wales.

6 **https://www.gov.uk/government/consultations/review-of-electricity-market-arrangements**

7 **https://www.gov.uk/government/publications/british-energy-security-strategy/british-energy-security-strategy**

The report includes a vision which can guide discussions on market reform within Scotland and between Scotland and GB-wide stakeholders. The objective is to frame and support discussion rather than proposing an inflexible set of requirements. It could provide a useful framework to facilitate future engagement between governments and industry to support practical and useful change to the structure of our electricity markets for the benefit of all.

1.2 Stakeholder engagement

This work has involved a significant element of stakeholder engagement. The objective has been to engage widely, to draw together opinions from across Scotland's energy system, and to discuss our emerging findings with Scottish and GB/UK institutions including Scottish government, UK government, Ofgem and National Grid ESO.

The methodology for stakeholder engagement involved stakeholder mapping to identify the wide range of energy stakeholder could be affected by REMA and to ensure the project heard from a diversity of stakeholders. The project then engaged with 36 organisations through a combination of semi-structured bilateral discussions (27 organisations), a facilitated online workshop (17 organisations), and written feedback (6 organisations). This was over the period January – April 2023. Stakeholders included renewable developers, investors, public bodies, local authorities, consumer representatives, fuel poverty groups, hydrogen developers, flexibility providers, network owners and others involved in the running of the GB energy and electricity system.

Engagement with existing or potential market participants and with representatives of consumer, end-user, generator, flexibility, and investor interests focused on eliciting their views on what was important for market reform. Engagement with decision makers and those who would be responsible for implementation, including Ofgem, National Grid ESO, and UK government focused on sharing and discussing the evolving vision and was partly focused on building awareness of the work among these organisations and preparing them for its delivery. A similar approach was taken with Scottish government where engagement focused on keeping officials informed of the project.

Just engagement has informed and shaped the final principles, outcomes and recommendations.

There was widespread support for the approach taken, based on meaningful engagement. This does not imply all stakeholders agree with all the conclusions, however the vision, principles and outcomes do have significant support from across the spectrum of stakeholders engaged through the project. Many organisations agreed with the full range of principles and outcomes proposed. Some gave strong support for the high level principles but felt they did not have sufficient expertise or access to evidence to make a judgment on the more specific outcomes. Others noted the difficulty of coming to a reasoned conclusion on outcomes which have the potential to create a tension between different participants (such as generators and consumers) or different elements of the value (such as minimum overall cost and fair distribution of costs). An example of this was the view expressed by some stakeholders who felt they did not have a suitable framework for considering the possible trade off inherent in a move to locational wholesale market pricing.

The vision presented in this report must therefore remain flexible. It is also important the range of organisations meaningfully involved in the debate continues to expand, ensuring interests across the energy sector and wider society are reflected, and more organisations are given the support, knowledge and evidence needed to contribute in a well informed manner. (See Section 3 of the report for further details on the results from stakeholder engagement.)

1.3 The vision

The vision is a key output of the work and describes principles and outcomes that, if embodied in REMA, could support deliver of Scotland's wider energy system objectives as laid out in the draft Scottish Energy Strategy and Just Transition Plan. It is informed by three main inputs:

- The stakeholder engagement described in section 3;
- A review of existing literature and published contributions to the public debate. This includes the UK government's 2022 Review of Electricity Market Arrangements (REMA) consultation and many of the responses to that consultation which have been made public; and
- High level analysis carried out as part of the project.

The vision rests on several important arguments. Firstly, as mentioned previously, what is good for Scotland is also what is good for GB. Secondly a broad range of outcomes are considered across the economy: delivering low cost reliable energy is important, but so is ensuring investment in our economy, jobs and appropriate contributions to our communities and places is realised. Thirdly, renewable generation is at the heart of a Just Transition to net zero with wind, solar, hydro and marine energy serving as the major source of energy, not just for today's electricity system but across the whole energy system helping supply energy for heat, transport and industry as well as traditional electricity demand. Finally, in order to deliver a renewable energy system at pace, investors need to have confidence. That includes both confidence for investment in renewables themselves and confidence for investment in a wide range of other technologies across electricity networks, flexibility and end-use – most notably an emerging green hydrogen sector.

1.4 Structure of this report

This report was prepared by Dr. Simon Gill of The Energy Landscape and presents the outcome of work commissioned by infrastructure specialists the Scottish Futures Trust (SFT) in order to better understand the implications of market reform on the Scottish electricity sector and the wider Scottish economy. It is hoped the outcome of the work can inform Scottish government, UK government and other bodies working on electricity market reform. This report is not endorsed by Scottish government, nor does it does represent Scottish government's policy position on electricity market reform or wider energy and Just Transition policy.

Following this introduction, the report is split into three sections. Section 2 introduces both the Scottish and GB-wide context for change and articulates in more detail why REMA is important, Section 3 provides a brief overview of stakeholder engagement, and Section 4 sets out the vision and lays out the arguments which support the principles, outcomes and recommendations included. The report also makes recommendations focused on how Scottish and UK institutions could work together to help deliver the vision.

2. The implications of electricity market reform for Scotland

Electricity markets represent a critical element of the framework within which Scotland's energy and Just Transition targets will be delivered. The importance of electricity within the energy system is growing: today around a quarter of Scotland's energy demand is delivered through electricity[8], by 2045 this could be as high as 80%[9].

Many of the stepping stones which will lead us to net zero relate directly to the electricity system. These include targets and ambitions for renewable electricity generation, for decarbonisation of heat and transport which will require significant electrification, and development of a hydrogen economy with significant production capacity coming from hydrogen electrolysis.

The reforms under consideration in REMA could have far-reaching implications for Scotland. An effective wholesale electricity market, along with the wider frameworks for supporting low carbon generation, capacity adequacy, flexibility and operability, will be critical to Scotland's ability to deliver on its own statutory climate change targets, energy and Just Transition objectives, and wider social and economic policy ambitions. Electricity market arrangements set the rules within which many Scottish targets will need to be delivered.

Getting REMA right for Scotland means ensuring all elements of the electricity value chain are supported by the way our electricity markets are designed and operated. Electricity market reform must also be considered in the context of wider electricity system reform such as a more strategic approach to system planning, particularly for electricity transmission networks. It must fit with in a wider 'whole system' approach to energy across electricity, heat and transport.

It is not an overstatement to say electricity market reform has the potential to make or break Scotland's wider approach to net zero. This is highlighted by Table 1 which lists the full range of Scottish ambitions which could be impacted by decisions made through REMA. This section summarises some of the key sectorial implications of REMA, including the potential impact on a Just Transition, before proving a more detailed overview of what options are under consideration within REMA.

8 **https://scotland.shinyapps.io/sg-scottish-energy-statistics/**

9 See for example 'Leading the Way' scenarios in 2022 FES: **https://www.nationalgrideso.com/future-energy/future-energy-scenarios**

Table 1: Summary of key Scottish targets and ambitions which could be impacted by electricity market reform[10].

	Area of Interest	Target / Ambition	Why is electricity market reform important?
Overall climate targets	Climate Change targets	30% GHG reduction by 2030 + net zero by 2045.	Electricity could meet up to around 80% of Scotland's energy demand by 2045 (up from 16% today).
	Electricity sector	An emissions reduction pathway which requires a zero carbon electricity system by 2030.	In addition to generation, feasible 'flexibility' business cases are needed for energy storage (including batteries and pumped storage) and other forms of flexibility.
	CCS and negative emissions	3.8 MT CO2 of negative emissions by 2030 and 5.7 MT by 2032 under the Climate Change Plan Update (2020).	Direct air capture: requires significant energy input to operate (approx. 2 TWh per MT CO2). NETS via CCS (e.g. BECCS): likely to be most feasible in the electricity generation sector.
Electricity supply targets	Offshore wind ambition	8 – 11 GW capacity in Scottish waters by 2030.	Wholesale market structure sets the framework within which Scottish generators compete with those in the rest of GB. Locational pricing could reduce the price charged in Scotland in the short term under some models, but also introduces greater uncertainty over prices in the medium to long term. Most new renewable capacity is expected to require support mechanisms such as CfDs.
	Onshore wind ambition	20 GW capacity by 2030.	
	Renewable generation target	Renewable generation to meet the equivalent of 50% of Scottish energy demand by 2030.	
Energy demand targets	Heat decarbonisation	Decarbonise at least 1 million homes by 2030 and equivalent non-domestic decarbonisation.	Core option for decarbonisation of transport and heat (including heat network supply) is electricity. Wholesale market structure will impact the price paid by the electricity demand side. Locational market reforms could see electricity prices lower in Scotland than elsewhere. But there is significant uncertainty about the longer term impact and impact on ability to access zero carbon electricity.
	Heat network target	6 TWh of heat delivered through heat networks by 2032.	
	Transport – cars and vans	Remove the need for petrol and diesel cars and vans by 2030.	
	Transport – rail	Scotland's railways to reach net zero by 2035.	
Hydrogen economy	Hydrogen production	5 GW installed renewable and low-carbon production capacity by 2030 and 25 GW by 2045.	Green hydrogen production uses electricity and faces similar impacts as demand side sectors (above).
Just Transition ambitions and targets	Just Transition outcomes	Including: ensure people have access to affordable, clean energy; ensure Scotland is supportive for private investment, home to a multi-skilled energy workforce, and competitive in domestic and international markets.	The key '*transition to*' area for oil and gas jobs is the renewable electricity sector which therefore needs to be flourishing. Other areas including hydrogen production (green and blue), CCS etc. are also likely to depend heavily on the successful and fast decarbonisation of electricity.
	Oil and Gas sector	The fastest possible Just Transition for the oil and gas sector.	
	Fuel poverty	Remove fuel poverty, as far as is reasonably possible, by 2040.	Wholesale costs set around 29% of domestic electricity bills pre-energy price crisis and significantly more today. Wholesale market design and evolution of support mechanisms such as CfDs will impact on prices paid by consumers including new demand for heat and transport use.
	Community ownership	2 GW of community owned energy by 2030.	Market reform will influence the availability, length, and structure of PPAs for renewables – including those suitable for community ownership.

10 Targets and ambitions have been collated from recent Scottish Government publications including the **Draft Energy Strategy and Just Transition Plan**, **Heat in Building Strategy**, **Hydrogen action plan** and **Climate Change Plan Update**,

2.1 Sectoral implications

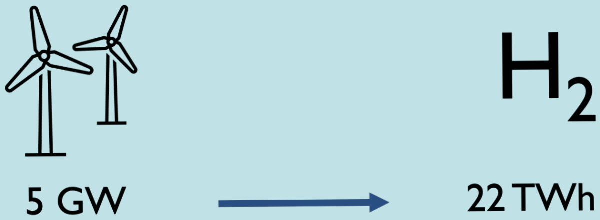
The importance of REMA for today's electricity sector is obvious. Changes to the way markets operate will have implications for generators, electricity consumers and providers of flexibility including assets such as Scotland's pumped storage fleet and emerging battery sector. However, as shown in Table 1 there are implications across other parts of the wider energy system. This is particular because significant parts of our energy system currently served by fossil fuels will be electrified– in particular transport and heat. Therefore it is important electricity market reform considers all relevant parts of the energy system:

- REMA has significant implications for Scotland's ambitions to **grow its renewable electricity generation sector.** The build out of ScotWind and development to meet the 2030 target of 20 GW of onshore wind depends on developers having confidence in revenues will come mainly from the combination of the wholesale electricity market itself and low carbon support mechanisms. Revenue from ancillary service and potential flexibility revenues may also play a part. Changes to arrangements in these are will impact on projects' revenue streams, risk exposure and investment appetite.
- Implications for the **electricity demand side** are in two broad groups. Firstly, consumers ultimately pay the costs of the electricity system, whilst the design of the market itself influences the opportunities for generators and flexibility providers to make profit. REMA will influence both the absolute costs which needs to be recovered through consumer bills and the frameworks which link cost and prices and set the incentive structure around profits and risks for all parties. The second group of impacts focuses on the opportunities provided directly to consumers. There will be an increasing need for electricity consumers to act flexibility, such as avoiding periods of peak demand (such as the Demand Flexibility Service introduced in Winter 2022/23[11]). Market reform will impact on the opportunities and revenues or lost savings available.
- In addition to the general points on the electricity demand side, REMA has the potential to make a significant impact on **the electrification of heat, transport and industrial energy demand**. These sectors will be supported to succeed in decarbonising if REMA reforms deliver a market where electricity is affordable, there is confidence in relative stability of prices, and importantly, the trajectory for decarbonising the electricity system remains on track.
- The **development of flexibility**, including pumped storage hydro and grid scale battery storage, is likely to be critical to integrating Scottish renewables into the electricity system. Flexibility business cases depend on a mixture of wholesale market trading (known as energy arbitrage), ancillary services and capacity market revenues. Ensuring markets incentivise useful operation from flexibility is an important outcome from REMA.
- In addition, **Scotland's security of electricity supply** depends on appropriate business cases for biomass power stations, gas with CCS, BECCS, and hydrogen power stations.
- These reforms will also set the framework within which power purchase agreements (PPAs) and other trading mechanisms will evolve, this is important for all generators, including the way in which **community owned generators** will engage with the market.
- The role of **hydrogen production and the development of a wider hydrogen system** and economy within Scotland and across GB is another important area for REMA to consider. Ambitions laid out in Scotland's hydrogen policy statement and hydrogen action plan include 5 GW of hydrogen production capacity by 2030 and 25 GW by 2045 alongside commitments to support the development of wider hydrogen infrastructure including transportation, pipelines, storage and end-use. Box 1 shines a light on the interaction between the electricity and hydrogen systems.
- Lastly, the ability to deliver **a Just Transition away from oil and gas** depends on developing a vigorous renewable industry and a clear conception of what constitutes fairness for consumers and citizens. Scotland's Just Transition ambitions include desire to maintain or increase employment in Scotland's energy industry, to maximise the development of a Scottish supply chain to support the transition, increase community ownership and eradicate fuel poverty by 2040.

11 https://www.nationalgrideso.com/electricity-explained/electricity-and-me/esos-demand-flexibility-service

Box 1: Hydrogen and electrolysis

Hydrogen is expected to play a significant part in Scotland's future energy system. Ambitions for 5 GW of hydrogen production capacity by 2030 and a continued trajectory of growth throughout the following decade could mean the use of electricity to produce hydrogen could represent similar levels of consumption to all of Scotland's current electricity demand by the middle of the next decade. However, the evolution of a hydrogen economy depends on many factors and the impact on the electricity system depends on the split between hydrogen produced by electrolysis, reformation from natural gas or gasification of biomass.



The use of 5 GW of wind capacity to power green hydrogen production could produce 22 TWh of hydrogen, equivalent to 67% of Scotland's current electricity demand.

Hydrogen electrolysis has the potential to act as a flexible electricity asset. One advantage electrolysis brings is that the production of hydrogen represents energy leaving the electricity system for use elsewhere in the energy system. Whilst some hydrogen may later be used in hydrogen power stations, particularly peaking plants, it main uses are likely to be in industrial demand, transport, some aspects of heat demand and for export. The operation of electrolysis can be adjusted to reflect prevailing electricity system conditions. For example, electrolysis could operate during periods of constraints to reduce curtailment of Scottish wind generation and electricity market arrangements can be designed to encourage this behaviour and to reward it when this happens.

However, it is also important to remember the ability of electrolysis to operate flexibly in this way depends on the development of the hydrogen system itself. For example, hydrogen can only be produced in a flexible way if either the final demand for hydrogen is itself flexible, or if there is sufficient hydrogen transportation and storage infrastructure.

REMA identifies whole system considerations as a factor in making decisions on the future of electricity market design. The development and operation of future hydrogen systems represents an important whole system factor.

How will electrolysis interact with electricity markets?

Within the green hydrogen sector, there are a variety of business models which describe how renewable generation and electrolysis could interact. Hydrogen electrolysis could develop:

- as an electricity demand-side technology (when connected standalone to the electricity network);
- as part of a hybrid electricity-hydrogen business model (when connected behind a generator's electricity meter); or
- operationally independent of the electricity system (if built as part of a non-grid connected system).

In the first two cases the operational costs of the electrolyser will be affected by decisions made under REMA, either by directly setting the market framework within which electricity must be purchased to run the electrolyser, or, in the case of the second model, through the impact on the 'opportunity cost' of using electricity for hydrogen production instead of selling in the wholesale electricity market.

Even in the third case, the impact of electricity market arrangements will be felt at investment stage as developers compare technical designs and business models for standalone and grid-connected designs and choose which model to use.

2.2 Electricity market reform and Scotland's Just Transition

Scotland's focus on ensuring a Just Transition as part of its net zero journey means it is important to broaden the discussion of electricity system reform to include the delivery of a wide range of impacts, benefits and value stream that include but go significantly beyond the direct impact on bills. A useful way to analysis the potential impact of REMA on ambitions for a Just Transition are to consider the eight Just Transition Outcomes defined by Scottish government[12]. Table 2 lists the outcomes along with a brief discussion of why it is important to consider each outcome in the market reform debate.

Table 2: The importance of REMA for Scotland's Just Transition outcomes

Just Transition Outcome	Implication for REMA
Citizens, communities and place	REMA needs to focus not just on consumer value but also value to citizens and wider society. In particular REMA needs to ensure people, places and communities in Scotland benefit from the transition, benefits which may be delivered through wider impact as well as purely through bills. It should directly consider how market arrangements impact on opportunities for community ownership, wealth buildings and community benefit arrangements.
Jobs, skills and education	The electricity sector represents a significant opportunity for long term, high quality, well paid jobs. Aligning the long term process of skill acquisition and education with the needs of the future electricity system is challenging and needs significant foresight and long-term stability of vision. Decisions under REMA can support the development and delivering of such a long term approach to skills, education and workforce planning.
Fair distribution of costs and benefits	REMA will need to balance competing outcomes including high levels of cost reflectivity and equality between different groups using the electricity systems at different locations across Scotland and GB. It is important the relevant aspects of fairness, equality of opportunity and equality of outcome are articulated and considered. Of particular importance is the need to consider vulnerable groups and deliver Scotland's statutory target to eradicate fuel poverty, as far as is reasonably possible, by 2040.
Business and economy	To achieve net zero business, commerce and industry need to flourish whilst embracing net-zero. This means ensuring energy for these end users is decarbonised, affordable, and prices are stable. Given the expectation that significantly more energy demand will be electrified in the future, this means considering the long term impact on these sectors of electricity market arrangements. REMA needs to consider the impact on businesses moving to electrified heat, transport and industrial processes.
Adaptation and resilience	The electricity system itself must be robust against future climate change, including an increase in the number and severity of extreme weather events. REMA needs to ensure market frameworks appropriately value the resilience benefits that different market participants provide. In particular a key component of resilience is flexibility, and it is important to ensure markets reflect the role energy storage and demand-side flexibly can play in delivering a secure and reliable supply.
Environmental protection and restoration	Whilst putting downward pressure on overall cost is a critical component of an efficient electricity market, it is also important to ensure good quality, environmentally supportive outcomes. For example, protection of key habitats and consideration of impact on peatlands. Whilst these aspects of the electricity system lie outside the usual consideration of market design, it is important REMA is alive to the risks that might be created for environment protection.

12 **https://www.gov.scot/publications/transition-fairer-greener-scotland/**

Decarbonisation and efficiencies	Decisions under REMA need to ensure Scottish and GB targets for decarbonisation remain central. Market frameworks must be focused on delivery of net zero pathways for all parts of the economy and across the whole energy system. Where market frameworks create either material risks to timely decarbonisation, or particularly strong opportunities to accelerate it, this should be given a high weighting within REMA's decision making.
Further equality and human rights implementation and preventing new inequalities from arising	Any reform of market arrangements risks new inequalities arising either through design or unintended consequences. REMA needs to actively consider the potential for unintended consequences and ensure decisions are robustly tested from a range of perspectives. In particular it is important to consider possible inequalities between different parts of Scotland and between Scotland and the rest of GB, between different groups of electricity consumers, and inequalities between today's consumers and those in 5-, 10-, 20- and 50-years' time. For example, if the provision of flexibility is an important part of ensuring domestic bills are affordable there is a real risk those unable to participate in flexibility markets for whatever reason are left behind in the transition.

2.3 The role of renewables

Renewables generation technologies are the foundation for decarbonisation of the whole energy system. Ensuring a fast transition to a renewable based electricity system is likely to be the best way to deliver for Scotland's electricity consumers both in the medium and long term. It is also the foundation for how its citizens, businesses and communities will benefit.

In terms of costs: renewables are the cheapest form of electricity generation, according to analysis commissioned for UK government in 2020, renewables are between £28 / MWh and £41 / MWh cheaper than the nearest alternative (gas powered generation). Today, three years on from that study the gap is likely to be significantly higher given recent increases in gas prices[13]. Renewable costs are also likely to be significantly more stable over time compared with alternatives: estimates made in the same 2020 work suggest between 54% and 75% of the cost base is upfront-investment costs, if fixed operation and maintenance costs – those costs which don't depend on output – are added, the fraction is between 86% to 100%. By comparison for a gas power station, the initial investment costs is 9% of total, raising to 11% if fixed operation and maintenance costs are included[14]. The consequence of this is in addition to providing low prices, renewables can provide cost stability: the majority of cost are sunk at investment stage and largely involve recovering a fixed cost base rather than covering highly uncertain future fuel and carbon prices.

However, low costs are not enough if generators receive revenues through the wholesale market which are significantly in excess of their underlying costs. The low and stable costs associated with renewables need to be combined with an effective mechanism to tie prices more closely to the long term average costs of these technologies. The existing Contract for Difference (CfDs) mechanism provides a template for such an approach. Generators agree a strike price ahead of investment, once operational, when wholesale prices fall below the strike price they receive a top up form the wholesale price to the strike price. When wholesale prices are above the strike price they pay back the difference. Over the past year, whilst wholesale prices have skyrocketed, CfD generators have been paying back billions of pounds from their wholesale revenues. The reason this hasn't made a significant impact on bills during the current price crisis is the lack of scale: today CfD generators account for only 6% of electricity generation, however extending this approach means over time a significant quantity of our electricity supply can be delivered through what are effectively long-term fixed price contracts. (See section 4.4.2 and Box 5 for more information).

13 **https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/911817/electricity-generation-cost-report-2020.pdf**

14 Ibid. Investment costs involve those related to the plant itself and wider infrastructure costs (such as networks). Offshore wind has the lowest fraction of up-front investment costs due to the significant level of fixed operation and maintenance costs. Solar has the highest fraction of up-front investment.

Other elements of system cost are also important. Constraint costs have been highlighted as a particular driver for market reform and could potentially exceed £3 bn per year by the end of the decade, fall again during the early 2030s and return to similar levels in the middle of the next decade[15]. Much of the cost comes from constraints within Scotland and between Scotland and England. In terms of consumption, this equates to around £8 / MWh in 2030 reducing, due to expected demand growth, to around £5 / MWh in 2036. These are not insignificant costs, but they remain significantly smaller than the difference between the levelised cost of energy for renewables and the next cheapest technology. The conclusion is that ensuring there are signals to help reduce constraint costs is important, however in terms of consumer bill impact this importance is likely to be secondary to accelerating the move to renewable power and ensuring prices closely reflect long-term costs.

Input from Scottish stakeholders highlighted the importance of ensuring Scotland and Scotland's places benefit from the renewable transition, particularly where infrastructure is installed for the benefit of GB as a whole. There was a sense that Scottish consumers often receive a raw deal, for example due to higher prices caused by network charges in Scotland, and greater energy use due to cold weather and poor quality housing stock. Some of this 'Scottish value' can come directly through market routes and related frameworks, but REMA and the wider reform agenda need to recognise the other benefits: jobs, community benefit, and local and regional economic growth they support.

The foundational role for renewables in a net zero energy system means it is particularly important to focus on delivery of renewables, and doing so requires confidence. Almost all forms of energy infrastructure require investment is repaid over relatively long time periods. This will be even more true in a net zero system. Renewable generation, pumped hydro storage, electrolysis and heat networks powered by heat pumps are all examples of technologies where investments are paid back over decades rather than years.

One limitation of the current market reform debate is a lack of consensus as to the size of the risks to investors in renewables and the ability to mitigate those risks and hence the impact on the cost of capital and a possible investment hiatus. Developing a more detailed objective evidence base is an important part of good decision making in REMA. For example, in terms of a move to locational marginal pricing, estimates of the impact on cost-of-capital range from 0.5%[16] to 3%[17] with values at the upper end of this range likely to remove any potential gain from the transition (even assuming no slow down in investment).

To manage this uncertainty investors in renewables need both appropriate revenue sufficiency (enough *expected* revenue to pay back their investments and deliver a reasonable return) and revenue certainty (high confidence of the level of revenue) over periods of at least a decade, potentially more. REMA needs to ensure market frameworks deliver both and do so in the context of a growing and fully decarbonised electricity system.

Investors in flexibility and demand-side technologies also need confidence. This includes confidence the ambition of decarbonising electricity is successfully achieved and low carbon supply grows in line with increasing demand; It also includes confidence the electricity costs they will face will be affordable and stable over the investment lifetime of their projects. For these technologies, confidence builds on certainty renewables will be delivered and pricing and hedging frameworks such as an adapted CfD mechanism works in the context of a highly renewable electricity system.

15 Constraint cost figures are taken from NGESO modelling. However, this analysis only considered transmission network upgrades identified up to and including the 2022 Holistic Network Design (HND). This process has not looked at transmission needs post-2030. Additional transmission capacity, beyond the HND work would reduce constraint costs during the 2030s compared with the values analysed here. **https://www.nationalgrideso.com/document/266576/download**

16 Workshop Slides 20th October: **https://www.ofgem.gov.uk/publications/locational-pricing-assessment**

17 **https://www.frontier-economics.com/media/gzwnyljs/implications-of-cost-of-capital.pdf**

An important element of that context Is the need for significant new transmission capacity, a fact Ofgem recognise in their decision to introduce an Accelerated Strategic Transmission Investment (ASTI)[18] framework which has given the go ahead for the new network infrastructure needed to deliver UK government's 2030 ambitions, including the target of 50 GW of offshore wind. Market design needs to ensure market participants are not discouraged from investing in Scottish renewables due to the risk of delays associated with delivery of transmission capacity.

2.4 A successful Scotland is critical for UK government's ambitions

Ensuring Scotland can succeed in achieving its own ambitions needs to one of the factors considered in making decision through REMA. Another is ensuring Scotland can play the role needed in supporting the delivery of UK government's own targets. Key UK government targets for which Scotland is crucial include:

- **Delivering net zero by 2050** and **delivering the sixth carbon budget:** the CCC highlight UK climate change targets cannot be met without significant and early contribution from Scotland. In particular they emphasised Scotland's earlier 2045 net zero target date is an important component of the UK as a whole achieving its 2050 date[19].
- **Reaching 50 GW of operational offshore wind generation by 2030:** this is supported by Scotland's ambition to connect 11 GW of offshore wind by 2030 and the strong project pipeline developing around Scotwind.
- **Achieving a fully decarbonised GB-wide electricity system by 2035:** this is likely to require between 100 and 120 GW of wind generation and around 50 GW of solar capacity. Scotland has a planning regime is supportive of onshore wind, and an active and well-developed supply chain capable of delivering an operational wind fleet of 50 GW by the mid-2030s.
- **10 GW of installed hydrogen production capacity by 2035:** Scotland aims to develop 5 GW of operational hydrogen capacity by 2030, at least half of which is expected to be green hydrogen, and 25 GW by 2045.
- **600,000 heat pump installations a year by 2028:** Scotland's heat decarbonisation ambitions include decarbonising one million homes by 2030, a process that will rely largely on heat pump installations and heat networks.

The importance of Scotland in this UK context is backed up by modelling from NGESO's Future Energy Scenarios (FES). This recognises the importance of a thriving Scottish low carbon electricity sector. In modelling for its 2022 FES20, across the three scenarios which are broadly consistent with UK net zero, the quantity of wind in Scotland in 2035 ranges from 49 GW to 56 GW. This is beyond even Scotland's own targets and the capacity modelled in Scottish whole energy system scenarios[21].

18 https://www.ofgem.gov.uk/publications/decision-accelerating-onshore-electricity-transmission-investment
19 https://www.theccc.org.uk/publication/sixth-carbon-budget/
20 https://www.nationalgrideso.com/future-energy/future-energy-scenarios
21 https://www.climatexchange.org.uk/research/projects/scottish-whole-energy-system-scenarios/

2.4.1. Decarbonising electricity supply

Scotland has long been supportive of renewable generation as the critical component of a zero-carbon electricity supply. Scotland leads the UK in the installation of onshore wind and, through the recent ScotWind leasing round, is developing a significant offshore supply chain. These ambitions on renewable supply underpin a whole-system vision for the energy system including decarbonisation of heat and transport[22]. Achieving success means finding market mechanisms that work with all these elements of the future electricity system to deliver a holistic approach that supports generation, flexibility and demand.

The level of consensus between Scotland and UK/GB on the importance of Scottish renewable capacity is best illustrated by comparing modelling conducted at Scottish and GB level. The most detailed public modelling of the Scottish energy system is the Scottish Whole Energy System Scenarios (SWESS) report published in 2022 by ClimateXChange[23] whilst the most detailed GB-level scenarios are the FES published annually by NGESO.

Both Scottish and GB modelling show a fast increasing capacity of installed generation capacity in Scotland. Both FES and the SWESS 'TEC' scenario[24] show installed capacity rising from just under 20 GW today to around 50 GW in 2035 and between 67 and 80 GW in 2045 (See Figure 1(a)).

Decarbonising supply will mean using a wide range of low carbon technologies including renewables and low carbon dispatchable power stations. The UK government also includes the significant use of nuclear in its plan, whilst Scottish government has ruled out new nuclear power stations under existing technologies.

Wind generation is likely to play the largest role in decarbonising electricity supply. The 2022 FES modelling shows three potential pathways to deliver a net zero compliant energy system. These contain between 100 and 120 GW of wind capacity across GB by 2035 delivering around 70% of total domestic generation in all three scenarios (by contrast the 'falling short' scenario, which does not meet net zero, only has 70 GW).

In net zero compliant FES scenarios each have around 50% of GB's wind capacity is located in Scotland and Figure 1 shows both the total Scottish installed capacity throughout the transition in the FES and SWESS TEC scenarios, and the 2035 split in wind capacity between Scotland and E&W.

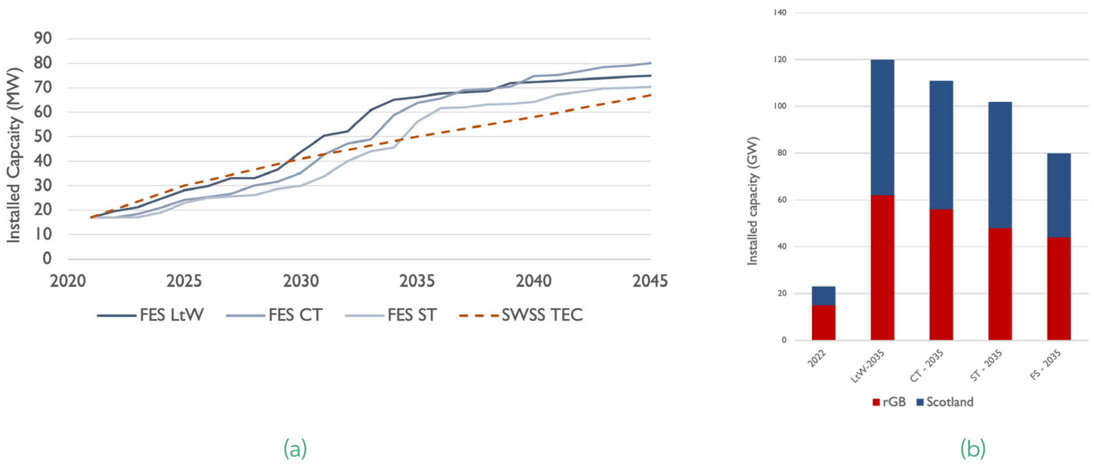


Figure 1: Wind generation in Scotland and GB: (a) shows the installed capacity in the FES net zero compliant scenarios along with the SWESS TEC scenario; and (b) shows the split in wind capacity between Scotland and the rest of GB (rGB) in the FES scenarios.

22 **https://www.gov.scot/publications/draft-energy-strategy-transition-plan/**

23 **https://www.climatexchange.org.uk/research/projects/scottish-whole-energy-system-scenarios/**

24 The SWSS produced three scenarios: a technology led scenario (TEC); a societal change-led scenario (SOC); and a balanced approach (BOP). In terms of infrastructure development TEC represents the most ambitious and is used in comparison with National Grid's FES modelling. SOC and BOP have slower and lower technology capacities.

There are several reasons for the size of Scotland's expected contribution to GB wind power:

- **Wind resources in Scotland are high:** average wind speed in Scotland both onshore and offshore are higher than the equivalent values in England and Wales, meaning that wind farms will have higher capacity factors, higher outputs and lower cost-of-energy.
- **Planning and consenting frameworks in Scotland, both on- and off-shore, are highly supportive of wind development.** For onshore development, this is in stark contrast to the position in England where almost no onshore wind development is permitted. The current National Planning Policy Framework for England[25] includes a special requirement on onshore wind which creates an assumption against onshore development. By contrast Scotland's National Planning Framework 4, adopted in 2023, includes a policy intent to "encourage, promote and facilitate all forms of renewable energy development onshore and offshore."[26]
- **There is a strong project pipeline in Scotland:** around 23 GW of wind capacity in Scotland has either received planning consent or has applied. This compares with around 22 GW across E&W which is largely offshore wind. The number for Scotland includes some capacity which has won seabed leasing rights through Scotwind, with further Scotwind capacity expected to apply for consent over the coming months and years. Scottish government estimates the total pipeline, including that which has not yet applied for planning or consent, is 40 GW[27]. Figure 2 shows the pipeline capacity listed in the Renewable Energy Planning Database as of January 2023[28].

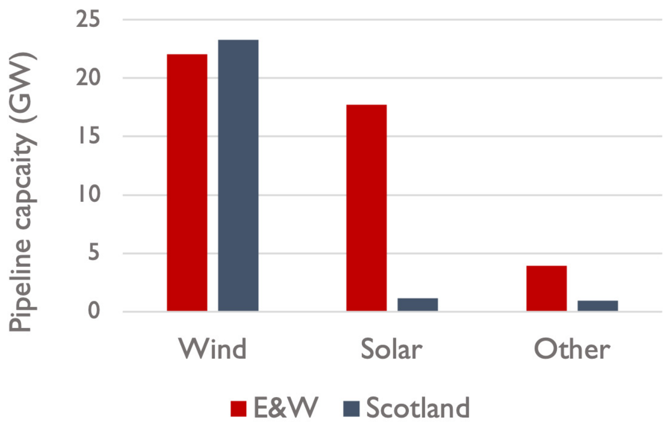


Figure 2: Pipeline capacity for renewable generation split between Scotland and E&W. This includes all capacity in construction, awaiting construction or in planning (planning application submitted or appeal submitted). Source: Renewable Energy Planning Database.

2.4.2. Decarbonising demand and the wider energy system

Accelerating decarbonisation of the electricity system underpins decarbonising the wider energy system as an increasing fraction of energy demand is met through electricity. Today, although renewables make a significant contribution to electricity supply across GB, they represented just 8% of total energy demand (not just electricity) in 2020. To achieve net zero this will need to reach at least 50% and likely significantly more[29]. A recent report by the Climate Change Committee reinforces both the importance of fully decarbonising the GB electricity system by the mid 2030s achieving this ambition, and the need for swift

25 https://www.gov.uk/government/publications/national-planning-policy-framework--2
26 https://www.gov.scot/publications/national-planning-framework-4/
27 https://www.gov.scot/publications/draft-energy-strategy-transition-plan/
28 https://www.gov.uk/government/publications/renewable-energy-planning-database-monthly-extract
29 Based on analysis of the Energy Flow Diagrams in the 2022 Future Energy Scenarios: https://www.nationalgrideso.com/future-energy/future-energy-scenarios

action to be taken to ensure this can happen[30].

NGESO's FES modelling suggests electricity demand could grow by between 9% and 27% by 2035 and between 95% and 125% by 2050 across GB. However, Scottish ambitions for decarbonising energy demand imply a faster rate of increase in electricity demand over the coming decade compared with GB assumptions. In particular, electrification of heat and the development of a hydrogen economy could run faster in Scotland in comparison with England and Wales.

Scottish government aims to decarbonise heating in at least one million homes by 2030 and an equivalent quantity of non-domestic heat demand, a process which will rely predominantly on electrification[31]. This can play an important part in delivering the emissions reductions from the heat and building sector that are needed across the UK in order to meet the sixth carbon budget.

On hydrogen the development of 5 GW of production capacity by 2030 and 25 GW by 2045 will account for a significant quantity of additional electricity consumption. Scottish government expects at least half of the 2030 hydrogen production capacity to be in the form of electrolysis and evidence from stakeholder engagement suggests this could ramp up quickly during the first half of the 2030s. Stakeholders suggested 5 – 10 GW of electrolyser based hydrogen production in 2035 could be feasible, subject to the appropriate development of the wider hydrogen system. This is significantly faster than implied by the FES modelling where the net zero compliant scenarios contain between 0.7 GW and 5 GW of electrolysis in Scotland by 2035 out of a total of 4 GW and 12 GW across GB.

2.5 An overview of REMA

REMA is the UK government's process for identifying the shortcomings of existing wholesale electricity market arrangements and agreeing on the future frameworks. It kicked off with a wide ranging consultation in summer 2023 and has continued throughout 2023 with ongoing debate with the electricity sector. This has included two forums chaired by the Department of Energy Security and Net Zero: a Market Participants Forum consisting of generators, flexibility providers and supply companies, a an End User Forum representing consumers in various form (with the exception of the very largest users, electricity consumers participate only in retail electricity markets with supply companies, aggregators and other third party service provider interfacing to the wholesale markets on their behalf). It is expected a further consultation will be issued by UK government by the end of 2023, although it is not clear over what timescale final decisions will be made.

This section provides a summary of the REMA process including its scope and other aspects of reform with which REMA interacts.

2.5.1. The case for change

The case for change away from the existing set of arrangements rests on the changing characteristics of the electricity system associated with the move toward a decarbonised system and the argument that existing arrangements are not suitable for the new circumstances. These changes include the growth of renewables, primarily wind and solar generation, whose output and availability are inherently variable and uncertain, and the associated decentralisation of supply from a small number of large power stations to a large number of smaller generators. Renewable generators also tend to be located in different parts of the GB system in comparison with fossil fuel power stations.

30 **https://www.theccc.org.uk/publication/delivering-a-reliable-decarbonised-power-system/**

31 **https://www.gov.scot/publications/heat-buildings-strategy-achieving-net-zero-emissions-scotlands-buildings/**

In the context of this report, there is a significant and growing contribution from on- and offshore wind generation located in Scotland. The implications of the changes in the generation mix is the electricity system, including its infrastructure and markets, need to deal with more variable, less predictable generation with a distinctly different geographical spread than the one the system has been built for over the past half a century or more. Physically this will require more flexibility, more transmission network, more 'curtailment' of renewable generation, and an increased focus on 'adequacy' (the ability to meet peak demand even when the wind isn't blowing and the sun isn't shining).

In the REMA consultation UK government lists four key challenges market reform needs to overcome[32]:

- the need to increase the pace and breadth of investment in generation capacity;
- the importance of increasing system flexibility;
- providing efficient locational signals to minimise system costs; and
- ensuring the system remains operable.

The UK government's case for change is informed in part by NGESO's market reform work which has led the sector in identifying the need for market reform and exploring some of the options. This has highlighted four problems the current market arrangements create for the delivery of net zero:

- constraint costs are rising at a dramatic rate;
- balancing the network is becoming more challenging and requires increasing levels of inefficient redispatch;
- national pricing can sometimes send perverse incentives to flexible assets that worsen constraints; and
- current market design does not unlock the full potential of flexibility from both supply and demand.

NGESO concludes that: "Our assessment found that real time, dynamic locational signals are needed to inform how both supply and demand assets dispatch in operational timescales. Neither national nor zonal pricing can deliver efficient locational signals as GB transitions to a net zero energy system" [33].

In 2022 Ofgem reviewed the challenges the GB system faces in order to achieving net zero. They highlight three groups of challenges[34]:

- the need for coordination which highlights the scale of the investment needed and the importance of combining strategic planning with market-driven outcomes and particularly the challenge of finding the right balance between network capacity and flexibility;
- optimisation of the energy system which focuses on the need to deal with the marginal price challenge (even a small quantity of gas sets the price for much of the time in today's system) and the lack of locational and sufficiently granular time-varying market signals; and
- challenges facing consumers highlighting unaffordable bills and the potential value to consumers of being flexible.

32 **https://www.gov.uk/government/consultations/review-of-electricity-market-arrangements**

33 **https://www.nationalgrideso.com/document/221776/download**

34 **https://www.ofgem.gov.uk/publications/net-zero-britain-developing-energy-system-fit-future**

There is widespread acceptance by the electricity sector of several areas of the case for change. In particular, there is recognition of the scale of infrastructure investment needed, including the importance of investment in all forms of low carbon generation, networks and flexibility to deliver on net zero. There is also widespread acceptance of the need to change the way the costs of electricity production feed through to prices paid. However, other elements of the case for change need more careful consideration. For example, whilst there is agreement locational price signals on both investment and operational timescales can play an important part in delivering an efficient electricity system, it is not clear what strength of signal that should take or what the trade offs might be between strong locational signals and the wider end goals of electricity and energy market and system design.

2.5.2. The scope of REMA

UK government has instigated a major Review of Electricity Market Arrangements (REMA) covering the wholesale electricity market and the structures that sit alongside[35]. The review covers:

1. The design of the wholesale market for electrical energy
2. Support for low carbon generation
3. How flexibility is incentivised
4. Mechanisms to ensure capacity adequacy
5. System operability.

Combined, these elements define the framework within which the wholesale side of the electricity system operates. They set the revenue streams and opportunities available to all types of wholesale participants along with the costs and risks those participants face. As such, their design, and the coordination between each element plays a significant role in how market participants will behave. The principle underlying REMA is that the design of these markets should incentivise electricity generators, flexibility providers, suppliers and other wholesale market participants to act in ways that help us deliver on our energy ambitions. The REMA consultation articulates these as facilitating the full decarbonisation of the electricity system by 2035 subject to security of supply and cost effectiveness for consumers.

Within the five areas under review, Figure 3 shows the options being considered. The first area, the wholesale market for electrical energy, is broken down into five sub-divisions highlighting the complexity of the different options available. It also shows options that were included in the initial consultation but have since been discounted either entirely (red) or as standalone options (orange)[36]. Box 2 describes the arrangements currently in place for each area.

35 **https://www.gov.uk/government/consultations/review-of-electricity-market-arrangements**

36 See UK Government summary of responses to the REMA consultation, **https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/1140189/review_of_electricity_market_arrangements_summary_of_responses.pdf**

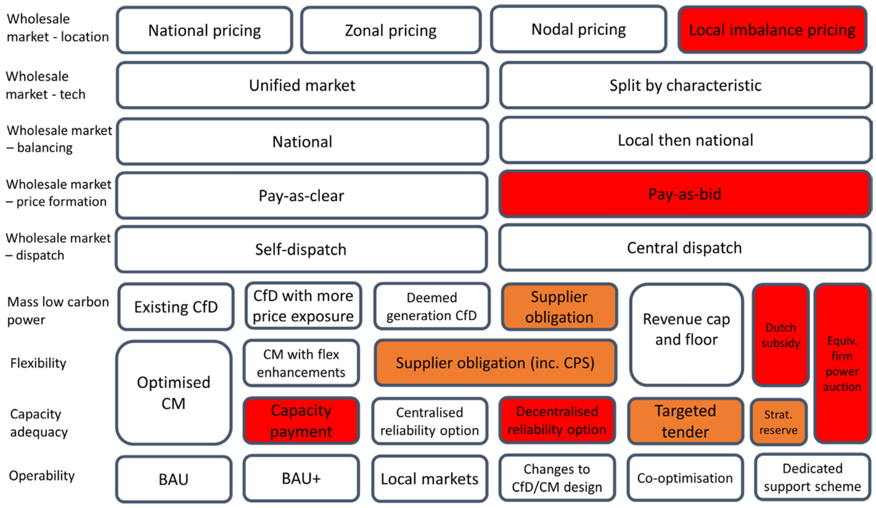


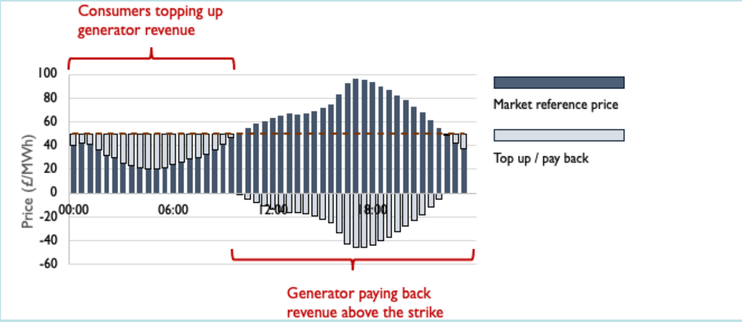
Figure 3: Aspects of electricity trading arrangements included in REMA and options under consideration. Options highlighted in red were consulted on during the Summer 2022 consultation and those in orange are no longer in consideration as standalone options.

Box 2: Today's market arrangements

Wholesale energy market

Today's wholesale electrical market is best described as:

- **Bilateral:** trades can be made between two market participants entirely on their own terms. The only requirements are final quantities traded must be reported to the system operator by 1 hour before delivery. Options exist for market participants to trade standardised forward products or participate on day-ahead or intra-day spot markets.
- **Self-dispatch:** owners of generation can choose which power stations to dispatch and, as with bilateral trading, the only requirement is they inform NGESO of the final level of output expected from each generator.
- **GB-wide:** All generators, suppliers and other market participants can trade together without the need to consider the location of supply and demand.
- **Pay-as-contracted:** although the existence of a competitive market tends to lead to convergence of market prices, prices are set bilaterally through private contracts. This means there will always be a range of prices over different time-horizons and representing different approaches to managing risk, uncertainty and variation. Whilst the current system is often portrayed as 'pay as clear' (for example see Figure 4) this is at best an approximation reflecting some elements of the current system such as the tendency of much of the market to follow gas prices, but ignores others such as the a range of hedging techniques used by market participants to lock in prices over different timescales.
- **Balancing Mechanism (BM):** following gate closure, one hour before delivery, NGESO takes over balancing the system and uses the BM to support three outcomes: (a) ensuring a precise balance in the supply and demand for electricity across the whole system, (b) resolving constraints by re-dispatching some generation or flexibility to keep the system within critical limits network limits, and (c) providing a mechanism to dispatch some ancillary services.

Mass low carbon power	• **Contracts for Difference (CfDs):** the current approach to support low carbon generators is to use CfDs where generators are effectively guaranteed a fixed 'strike price' for their generation through a combination of wholesale market revenues and top-up / pay-back mechanisms. The framework assumes generators receive the 'reference price' through their wholesale market trading, typically through Power Purchase Agreements, and the CfD pays a top up when the reference price is less than the strike price or claws back additional revenue when the reference price is greater than the strike price. Consumers ultimately cover the cost of the CfD mechanism or receive the benefit of payback. This is seen by investors as largely insulating generation from market volatility and hence providing a relatively low risk income stream once assets are built. Hence the introduction of CfDs has resulted in a significant fall in required equity returns. CfDs should no longer be considered as a 'subsidy' from consumers (£1.3 bn will be paid back by CfD generators between Q4 2021 and Q1 2023[37]) but rather a support scheme stabilises income and hence returns.  **Figure 4:** Illustration of CfD revenue flows. • **Renewable Obligation Certificates and Feed in Tariffs (ROCs and FiTs):** legacy arrangements for renewable generators which provide a revenue uplift largely independent of the wholesale market price. Investors have tended to view this support mechanism as leaving them with significant 'merchant risk' – i.e., they are exposed to market volatility.
Capacity adequacy	• **Capacity Market (CM):** The CM aims to procure sufficient capacity to meet the system-wide expected peak demand. Capacity providers are paid an annual fee, set by an auction, in return for being available to generate or to reduce demand during a period where there could be a shortage. Consumers cover the costs of the CM through their bills.
Operability and flexibility	• Flexibility business models tend to rely on multiple revenue streams derived from wholesale and ancillary service markets and 'behind-the-meter' arrangements, for their business case. • Operability is delivered through a combination of ancillary service markets run by NGESO (e.g., Dynamic Containment Reserve) and regulatory requirements on market participants (e.g., Mandatory reactive power requirements set in the Grid Code).

37 https://eciu.net/media/press-releases/2022/new-analysis-wind-power-bonus-could-cut-bills-by-25-this-winter-and-45-next-winter

2.5.3. Wider reforms

Whilst a well designed wholesale electricity market is critical to delivery of our future electricity system it is important to place REMA in a wider context. There are important areas of reform outside the scope of REMA which will play an important role in delivering societal objectives and wholesale market reform needs to coordinate with developments in those areas. The following are of particular importance:

- **Development of electricity networks:** networks are the basis on which markets are built, and the capacity of those networks sets strict limits on the operation of the electricity markets themselves. Therefore, a well designed and appropriately sized network is a prerequisite for any market framework to operate effectively. Over the past ten years there has been a significant lack of investment in electricity transmission networks, particularly between Scotland and England and Wales (E&W) leading to growing constraints. Whilst some level of constraints should be expected in a well designed electricity system, it is not inevitable that *excessive* constraints will be a continuing element of our electricity system. There have been positive moves in this area over the past year. In December 2022 Ofgem announced a new framework for regulating transmission investment needed to deliver the UK government's target of 50 GW of offshore wind by 2030. The Accelerating Strategic Electricity Transmission Investment (ASTI) framework has greenlighted significant network investments which will increase the network's capacity to securely export power from Scotland to England and Wales from around 6 GW today to 16 GW by the early 2030s[38]. At the same time, work by the UK's electricity network commissioner aims, by the mid 2020s, to half the time it takes to build transmission infrastructure[39]. Whilst these are welcomed there is the need to go further, for example extending the philosophy underpinning ASTI to other technologies beyond offshore wind and ultimately a 'whole system' approach.
- **Retail market reform:** REMA specifically excludes retail market reforms, meaning the relationship between suppliers and electricity consumers is not covered. Many of the options being considered under REMA have implications for consumers, but how those implications will manifest will depend on the structure and regulations which define the retail market. Examples include the range of tariffs suppliers are allowed to provide, whether there are limits on the temporal or locational variation in prices that can be offered to end users, and the way in which costs and benefits associated with all five areas within REMA's scope are passed through to consumers. Retail market reform will be significant in defining the future role of suppliers and the degree to which signals from the wholesale market are passed through to final consumers. There is also a risk some elements slip through the cracks between wholesale and retail reform. UKG have acknowledged the interdependencies between retail and wholesale reform and the importance of coordination between these two areas and in summer 2023 published a vision for the energy retail market[40].

38 **https://www.ofgem.gov.uk/publications/decision-accelerating-onshore-electricity-transmission-investment**

39 **https://www.gov.uk/government/news/new-electricity-networks-commissioner-appointed-to-help-ensure-home-grown-energy-for-britain**

40 **https://www.gov.uk/government/publications/delivering-a-better-energy-retail-market/delivering-a-better-energy-retail-market-a-vision-for-the-future-and-package-of-targeted-reforms-html**

- **The need for strategic system planning:** current arrangements place a strong emphasis on the role of markets in deciding on the type, location and design of electricity generation, flexibility providers, and consumption. However the very long lead times involved in the development of some forms of generation (such as nuclear and offshore wind projects) and major transmission networks, and two way dependency between each, means there may be a need for some degree of high-level strategic planning of the system beyond simply network capacity. The set up of the Future System Operator, and the proposal for National Grid ESO to develop a Centralised Strategic Network Plan which, in future could involve "co-optimis[ing] the electricity transmission network design with the location of new demand and generation"[41]. The need for strategic planning is one of the main recommendations of the UK's Electricity Networks Commissioner[42].
- **First-of-a-kind support mechanisms:** REMA's focus is on business as usual trading arrangements but excludes the bespoke agreements often used to support specific emerging technologies. An example is the Dispatchable Power Agreement being developed for use with carbon capture power stations[43].
- **Carbon trading:** the evolution of the UK Emissions Trading Scheme (ETS)[44] will have a significant impact on the electricity market, adding significant costs to the operation of the unabated fossil fuel power stations to which it applies whilst making other sources of generation relatively cheaper. REMA's scope does not include the design or development of the ETS.

The vision presented in section 4 of this report includes elements of these wider aspects, particularly related to network planning and strategic system planning. This reflects the fact that whilst it is important REMA has a clear scope, it is not happening in isolation, and must propose frameworks that work with these elements of wider electricity system reform.

2.5.4. Principles and tensions

The debate around several elements of REMA have become particularly polarised, for example the discussion about whether to implement locational wholesale pricing, and the discussion about how much risk different market participants should face. The different positions put forward often reflect different underlying perspectives on how change should be managed, how risk should be shared, and which outcomes are most important. As with many complex topics, there is unlikely to be a perfect set of choices, and any decisions that REMA makes will need to balance different outcomes, different groups and different uncertainties. The following list highlights a few of the key areas of why these are particularly important for Scotland:

- **Revolutionary versus evolutionary reform:** some of the options under consideration require complete reform of the wholesale market with a new system introduced across-the-board at a single point in time. Examples of this type of reform include a move towards a centrally dispatched locational market, or a move to a formally 'split' wholesale market with significantly different arrangements for different types of generators. By contrast, other options allow for a more incremental approach with a step by step delivery of overall reform. One of the considerations which needs to inform these decisions is the degree to which choosing an option which requires complete transformation will introduce significant additional risk to achieving societal objectives such as delivery of fast approaching decarbonisation targets.

41 **https://www.nationalgrideso.com/research-and-publications/electricity-ten-year-statement-etys/etys-and-our-future-network-planning**

42 **https://www.gov.uk/government/publications/accelerating-electricity-transmission-network-deployment-electricity-network-commissioners-recommendations**

43 **https://www.gov.uk/government/consultations/carbon-capture-usage-and-storage-ccus-dispatchable-power-agreement-business-model**

44 **https://www.gov.uk/government/publications/participating-in-the-uk-ets/participating-in-the-uk-ets**

This point is important for Scotland because of the pace and scale of investment needed in the short to medium term in order to deliver on key targets such as ambitions for on- and off-shore wind capacity in 2030 and the desire for new largescale electricity demand to come forward in the form of hydrogen electrolysis, and heat electrification.

- **The degree of risk faced by market participants:** the market structure today shares risks between generators and consumers in a particular way. For example, generators generally have firm financial rights of access to the system meaning they are shielded from the risk the network is unable to physically transfer their power to consumers. Another example is the CfD mechanism which shields some generators from the risk of low prices in the future through what amounts to a 15 year indexed linked fixed price contract backed by UK government[45]. In return CfD generators give up the right to additional revenue if the wholesale market price rises above the strike price and require a relatively low financial return by attracting significant bank debt over the life of the CfD.

  This principle is important for Scotland because, under some reforms being considered, market participants in Scotland could face a greater change to their risk exposure compared with market participants in England and Wales. For example, a loss of firm access rights or the introduction of stronger or more volatile locational price signals will have a larger effect on Scottish market participants than on those elsewhere in GB.

- **The value of locational price signals in investment and operational timescales:** The REMA case for change highlights efficient locational signals as an important aspect of an efficient market. However, there is disagreement between groups as to the strength and form such signals should take, and the ability of them to deliver value in practice as well as in theory.

  This principle is important for Scotland because locational price signals, particularly embedded in the wholesale price, are likely to lead to significant change in Scottish prices both relative to the current system and to England and Wales under a locational market. This could mean prices in Scotland fall significantly on implementation, but it could also mean greater volatility in Scottish prices, and more uncertainty on how prices will vary over the medium to long term. This is why a significant increase in the cost of capital for projects in Scotland (relative to the rest of the GB market) could be expected under LMP.

45 Subject to conditions such as those set out in negative pricing rules in more recent contracts which mean CfD uplift payments are not made when the day-ahead wholesale market turns negative.

3. Stakeholder Engagement

Stakeholder engagement has been an important part of the work undertaken for this report. The project has engaged with 36 organisations to elicit views and test thinking. The engagement has been wide ranging and has aimed to involve organisations from across the electricity and wider energy sector. It has primarily focused on Scottish-based stakeholders but has also included key GB decision makers and organisations. The process has sought to ensure this report reflects key views articulated by stakeholders, and the vision laid out in the report reflects and responds to those views.

However, there is no implication that all the stakeholders agree with the vision presented here, and the summary below highlights where there are areas of divergence between stakeholders.

Table 3 shows a breakdown of types of stakeholders consulted during the development of this report and a full list is provided in Box 3.

Table 3: Summary of Stakeholder engagement (Note some organisations fit into multiple categories)

Organisation type	Number	Examples
Generation developers and investors	8	Scottish Power
Network companies / system operator	3	SSEN
Professional Services	2	Addleshaw Goddard
Consumer representatives and end-users	7	Consumer Scotland
Flexibility providers	5	Flexitricity
Public sector / government and its agencies	8	Crown Estate Scotland,
Hydrogen sector	4	Scottish Hydrogen Fuel Cell Association
Consultancies and Think Tanks	3	Offshore Renewable Energy Catapult
Scottish based or focused	20	
UK / GB wide	16	
Total	**36**	

Engagement consisted of bilateral discussions and an online workshop, and had two key objectives: firstly, to understand a range of points of view and secondly to test emerging thinking from the overall vision.

The following summarises the key points which emerged from stakeholder engagement.

- **Although REMA has the potential for significant impact across the energy system many stakeholders are not engaged in the debate in a meaningful way.** There was a clear divide between those stakeholders fully engaged in REMA and those who are not. There is a perception the debate around market reform is complex and difficult to understand and those stakeholders without existing expertise and significant resource find it difficult to contribute. Our discussions suggest those able to engage in the details of the debate are primarily either organisations who are directly involved in wholesale trading (renewable generators, suppliers and flexibility providers) or representative organisations such as trade associations. One category that is not fully engaged is investors, which is particularly concerning given the potential impact of REMA on this group.

- **The development of Scottish Energy and Just Transition policy is predicated on the continued growth of a vibrant renewable sector.** All Scottish stakeholder groups agreed continuing to develop the Scottish renewable sector is at the heart of Scotland's net zero pathway. This view was expressed by end-user representatives, flexibility providers and public sector organisations. Stakeholders made a number of suggestions as to how Scotland and its communities should benefit from hosting renewable capacity (see below).
- **Stakeholders agreed there is significant value in a more joined-up approach between Scottish and UK governments and institutions.** Another area that received universal support from stakeholders was the importance of coordination. When presented with a comparison of modelling between Scotland and GB, such as that shown above, there was surprise from some stakeholders around the degree of alignment between Scotland and UK scenarios. Many organisations highlighted the importance of Scotland working cooperatively with UK government, Ofgem and NGESO on both a joined-up approach and a shared vision or plan. This reflected the importance many organisations placed on the growing importance of strategic planning of the electricity system and in particular transmission networks.

  A related point made by several stakeholders was coordination within Scottish and UK governments is equally important.
- **There is a perceived tension between reform options good for consumers and those good for generators** particularly in terms of locational wholesale pricing. Whilst a majority of stakeholders expressed agreement that locational marginal pricing would likely be detrimental to Scotland (and to GB), some stakeholders, particularly those involved in supporting both consumers and generators, felt there is a tension between options that may be supportive of consumers but detrimental to generators. These organisations felt they wanted to explore the trade-offs in more detail and understand the degree to which theoretical benefits for consumers may or may not be delivered in practice. An outcome of these discussions was an awareness of the need to avoid presenting options as supportive of one group over another and to consider consensus solutions that can be supported by all stakeholders.
- **It is important Scotland, its regions, communities and people benefit from hosting renewables.** There was a perception across end-users, regional development agencies, and consumer representatives that Scottish consumers and communities do not benefit sufficiently from hosting renewable capacity. This perception is partly informed by the fact Scottish consumers face some of the highest energy bills in the UK, although there was less understanding of the processes which drive this. Several conversations explored how this results from higher distribution network charges and higher energy usage rather than higher wholesale prices. Other stakeholders focused on the fact there is a lack of operational incentives and rewards for consumers and flexibility providers associated with reducing constraints and using otherwise curtailed generation.

  Some of these discussions explored non-price related benefits and value streams for Scotland and the potential for future market and system arrangements to deliver benefit to local areas and regions through these wider value streams as well as directly through bills and revenues. The concept of either a shared 'social contract' or a 'collective endeavour' between generators, flexibility providers and the communities and regions within which they are situated emerged, and several stakeholders highlighted new infrastructure, if developed in conjunction with a local region, can positively support the local economy, provide skills and jobs, and support the area through a wide range of Just Transition outcomes that, together, ensure the local area benefits.

- **Of all the Scottish-based stakeholders who expressed a view, none actively supported the introduction of Locational Marginal Pricing** however a significant minority either did not have a formal position or felt they did not have enough information to form a formal position. Several organisations representing consumer-side and local development interests felt there was a tension between potential value for consumers through lower prices and potential risks to the development of generation. Those organisations that did not support locational pricing cited several reasons: LMP is likely to reduce generator revenues therefore making generation investment in Scotland less viable; LMP raises uncertainty and volatility of prices; and implementation would be a challenging, protracted process. A small number of GB based stakeholders did express support for locational pricing.

3.1 Reflecting stakeholder views in the vision

The vision presented in the next section of this report has been informed by the views expressed by stakeholders, without implying that it reflects all views. There was near universal support for the high level *principles* and for several of the 'what good looks like' outcomes. On the *outcomes*, there was near universal support for a coordinated vision and plan between Scottish and UK Governments and institutions, an articulation of consumer and societal value, and an enhanced focus on transmission investment. The outcomes which focus on the role of locational signals received majority but not universal support, as noted above several organisations identified that they felt there was a tension between the potential impact of reform on different stakeholders, particularly between impact on generation investment and on Scottish consumers. Several of those stakeholders didn't feel they either they didn't have sufficient knowledge or understanding to take a view on the last three outcomes, or there wasn't sufficient evidence. These outcomes are included in our vision on that basis, together with an acknowledgement of the need to help a wider range of organisations to understand and engage with the REMA process.

In the area of capacity adequacy reform and the design of low carbon flexibility, although there was agreement around the importance of these areas, there was limited consensus on solutions that would be good for Scotland. This was partly because many organisations did not have sufficient understanding of both the challenges facing current arrangements and the options for change to allow them to take a position. For this reason, no direct outcomes have been included in the vision for these areas. However, an important recommendation is that the Scottish renewables sector work to develop consensus and to socialise understanding to other organisations involved in the energy system.

Box 3: List of organisations covered by Stakeholder engagement

Addleshaw Goddard	Highlands and Islands Enterprise	Scottish Renewables
Argyll and Bute Council	Hutchisons Associates	SG Fuel Poverty Advisory Panel
British Hydro Association	MUFG	Siemens Energy
Carbon Trust	National Grid ESO	SPEN
Citizens Advice	Ocean Winds	South of Scotland Enterprise
Community Energy Scotland	Octopus	SP Renewables
Consumer Scotland	Ofgem	SSE Networks (SSEN)
Crown Estate Scotland	Offshore Renewable Energy Catapult	SSE – Renewables
EDF	Orkney Isles Council	Star Renewables
Energy Action Scotland	Scottish Fuel Cell Association	Sustainability First
Flexitricity	The Scottish Government	UK government – Department of Energy Security and Net Zero
Greencoat	Scottish Power – Hydrogen	Vattenfall

4. The Vision

4.1 A vision, principles, and outcomes that work for Scotland

The vision presented here consists of a high level vision statement, three overriding principles for decision making, and six outcomes which represent 'what looks good for Scotland' in relation to electricity market reform. In addition, a number of recommendations are made throughout which would help deliver the outcomes and vision.

The vision represents the main outcome of the work commissioned by SFT. Its objective is to set out a vision for market reform to further the ongoing debate, informed by broad stakeholder input as to what needs to happen to enable both Scotland to succeed and Scotland to support the UK in succeeding in reaching net zero. Given the centrality of renewables as the main source of energy expected to power a net zero energy system (not just the electricity component of the system) there is a focus on ensuring investment in renewables comes forward, but also on ensuring the enabling technologies including demand-side flexibility and energy storage are developed, and ensuring market frameworks deliver the low and stable costs bases associated with these technologies.

The vision has been informed by the following key elements:

- Bilateral and combined engagement with the stakeholders listed in the previous section
- Review of existing literature and published contributions to the public debate. This includes the UK government's 2022 consultation and many of the responses which have been made public.
- The Energy Landscape's existing knowledge and experience, derived from previous work in the area including a detailed review of Locational Marginal Pricing[46] and a response to the original REMA consultation[47].

The overall vision is shown in Figure 5 and the following section provides detail on each of the elements included.

46 **https://strathprints.strath.ac.uk/83869/**

47 **https://www.regen.co.uk/publications/regens-rema-consultation-response/**

A vision for the future Scottish electricity system

Renewable power is the foundation of our net zero transition. It delivers benefits to energy consumers and citizens, supports a strong economy and delivers positive outcomes across society. Electricity markets need to ensure a fast transition to a net zero electricity system powered largely by renewables and delivering affordable energy and stable prices. Market frameworks must support the electrification of heat and transport.

Flexibility will ensure effective use of Scotland's renewable fleet and play a critical role in ensuring Scotland benefits from hosting renewables. Markets will support the development of pumped storage, batteries and other energy storage technologies as well as helping to develop hydrogen electrolysis, adding significant flexible consumption to the electricity system and forming a key component of Scotland's thriving hydrogen economy.

Consumers will benefit from affordable and stable prices, reflecting the low cost of net-zero technologies, particularly renewable generation, whilst retaining a secure supply. Electricity markets will support a Just Transition by recognising and encouraging the creation of a broad range of social benefits including jobs, strong local economies, and a contribution to communities' wealth.

Wholesale market reform will be delivered in coordination with wider energy system reforms including the development of more strategic ways to plan and deliver electricity networks and retail markets that deliver better outcomes for consumers. The result will be a market framework and a wider system that helps ensure both Scotland and GB benefit from successfully decarbonising our electricity system.

<table>
<tr>
<th>Three Scottish principles for REMA</th>
<td colspan="2">Coordination
between and within Scottish and UK government and institutions.
The right decisions on market reform will be critical to delivering Scotland's ambitions to decarbonise its energy system, deliver net zero by 2045 and ensure a strong and thriving renewable industry. Delivering these ambitions are also critical to meeting UK government's ambitions for a fully decarbonised electricity system and deliver the UK's sixth carbon budget.
Without well-designed electricity markets Scotland can't succeed; without Scotland delivering the UK won't succeed.</td>
<td colspan="2">Commitment
to deliver for people, businesses, communities and society across Scotland.
Reform of electricity markets can deliver a wide range of outcomes that are valued by consumers including low costs, stable costs, and fairness. It also supports the wider interests of people, businesses and society as a whole through the provision of jobs, economic growth and community value.
Future market arrangements should ensure everyone can benefit and reflect the collective endeavour that goes into delivering energy infrastructure. It reflects the role of communities and local economies as well as developers and operators.</td>
<td colspan="2">Confidence
for renewable and flexibility investors and consumers in Scotland.
Confident investors are critical because of the scale and pace of investment needed in all technologies and because ensuring a fast transition is the best way to deliver for consumers and for society.
Confidence is particularly important for renewables because, although they have the lowest levelised cost of energy of any type of generation, their costs are much more weighted towards upfront investment. A lack of confidence could lead to an investment hiatus and / or increased cost of capital.
Providing confidence to consumers, including industrial and commercial end-users, means giving certainty that costs are both affordable and stable.</td>
</tr>
<tr>
<th>What 'good' looks like for Scotland</th>
<td>A shared vision and plan for the GB electricity system and Scotland's role within it.</td>
<td>An increasingly strong focus on transmission network investment.</td>
<td>A clear articulation of consumer values and outcomes and a set of consumer-focused principles for decision making.</td>
<td>Retain a GB-wide wholesale market and a pricing mechanism, such as an evolution of CfDs, linking long term costs to prices.</td>
<td>Targeted, forecastable, stable, locational investment signals for generation, demand and flexibility, e.g. through reform of TNUoS.</td>
<td>Operational locational price signals to reward flexibility for reducing network constraints e.g. a regional constraint management market.</td>
</tr>
</table>

Figure 5: A vision for electricity market reform that supports Scotland.

4.2 Vision statement: What is the aim of market reform?

A vision for the future Scottish electricity system

Renewable power is the foundation of our net zero transition. It delivers benefits to energy consumers and citizens, supports a strong economy and delivers positive outcomes across society. Electricity markets need to ensure a fast transition to a net zero electricity system powered largely by renewables and delivering affordable energy and stable prices. Market frameworks must support the electrification of heat and transport.

Flexibility will ensure effective use of Scotland's renewable fleet and play a critical role in ensuring Scotland benefits from hosting renewables. Markets will support the development of pumped storage, batteries and other energy storage technologies as well as helping to develop hydrogen electrolysis, adding significant flexible consumption to the electricity system and forming a key component of Scotland's thriving hydrogen economy.

Consumers will benefit from affordable and stable prices, reflecting the low cost of net-zero technologies, particularly renewable generation, whilst retaining a secure supply. Electricity markets will support a Just Transition by recognising and encouraging the creation of a broad range of social benefits including jobs, strong local economies, and a contribution to communities' wealth.

Wholesale market reform will be delivered in coordination with wider energy system reforms including the development of more strategic ways to plan and deliver electricity networks and retail markets that deliver better outcomes for consumers. The result will be a market framework and a wider system that helps ensure both Scotland and GB benefit from successfully decarbonising our electricity system.

The vision statement highlights the importance of renewable electricity generation in delivering outcomes across the energy system, the economy and society. It highlights the fact Scotland's climate change and Just Transition ambitions are founded on a fast transition to renewables. Whilst UK government's focus also includes consideration of nuclear as a component of a zero-carbon supply, the Scottish focus on renewables is both consistent with and required by UK government ambitions.

Despite starting from the need for renewable generation, the vision represents a whole-system view of what is required. This view takes the electricity system as the foundation for a low carbon energy system. The implications, captured in the vision, are that:

- Renewables will represent the single largest source of energy (not just electricity) in a decarbonised economy. By 2030 Scotland aims to derive at least 50% of its energy across electricity, heat and transport from renewable sources.
- Renewables are the lowest cost form of electricity generation and can support low electricity prices. As their costs are largely upfront, they can also help grow the stability of prices over many years.
- Investment in renewables has the potential to transform the Scottish economy and represents the bedrock of a Just Transition.
- Scottish renewable capacity represents the best way to support UK-wide net zero by ensuring the wider electricity system has access to Scotland's renewable resources with both Scotland and the rest of the UK benefiting in the process.

In hosting significant renewable capacity, the vision acknowledges the importance of ensuring Scotland benefits. As discussed in the section on Principle 2, this benefit can come through a range of pathways including electricity market mechanisms, wider impacts on the economy and other non-market routes such as community wealth building.

Finally, market arrangements need to support electrification of heat and transport, encouraging new demand to come forward in a way that is flexible. They also need to consider the needs of a growing hydrogen economy.

4.3 Principle 1: Coordination between Scotland and the UK

Coordination between and within Scottish and UK government and institutions.

The right decisions on market reform will be critical to delivering Scotland's ambitions to decarbonise its energy system, deliver net zero by 2045 and ensure a strong and thriving renewable industry. Delivering these ambitions are also critical to meeting UK government's ambitions for a fully decarbonised electricity system and deliver the UK's sixth carbon budget.

Without well-designed electricity markets Scotland can't succeed; without Scotland delivering the UK won't succeed.

The co-dependence between decisions made in Scotland and those made by UK government and organisations responsible for the GB electricity system, points to the need for detailed, genuine and meaningful cooperation and collaboration.

This coordination could be based on looking for synergies and alignments between policies and ambitions within both jurisdictions. This is most likely to be achieved if there is a shared understanding of the role of Scotland in achieving UK objectives. For some aspects of the energy system this shared understanding already exists. For example, as discussed in Section 1 there is consensus on the need for significant wind capacity in Scotland by 2035 in order to deliver against the ambition of a fully decarbonised electricity system. In other aspects there may be a need for greater joint exploration of what is possible and desirable. For example, given the likely operational challenges 50 GW of Scottish wind capacity will create, it is important the value of additional Scottish pumped storage hydro power, flexibility from a growing hydrogen sector, and the most valuable characteristics for energy storage locating in Scotland, are explored. Alignment on these issues can ensure a joined-up approach covering areas such as developing strategies for these sectors, innovation support, and planning and consenting approaches. There may also be an opportunity to align expectations around the fraction of the UK's 10 GW of hydrogen production capacity, in the form of electrolysis, that may be located in Scotland.

The value of coordination goes beyond pure market design and has the potential to support other aspects of electricity and energy system development. In particular, the obligation placed on NGESO last year to develop a Centralised Strategic Network Plan (CSNP)[48] provides an opportunity to ensure scenarios used in the development of that plan are aligned with both Scottish and UK Government institutions, and can help drive timely investment in the electricity networks needed to deliver shared ambitions. The need for the CSNP reflects the importance of considering the development of the transmission network alongside elements of the electricity system have traditionally been left to the market to deliver. As NGESO articulate through their objectives for the development of the planning system, the 'co-optimisation of the electricity transmission network design with the location of new demand and generation'[49] will be an important part of a future approach to system planning.

In addition to coordination *between* governments and institutions, several stakeholders highlighted the importance of coordination *within* government. This is becoming increasingly important due to the growth of systems approaches and the impact the energy system has on an increasingly wide range of policy areas. Scotland's draft Energy Strategy and Just Transition Plan represent an important part of the process of aligning activity across Scottish government. Similarly, the British Energy Security and Net Zero Strategies illustrate the role Number Ten can play in coordinating activity across the whole range of UK government departments.

48 **https://www.ofgem.gov.uk/publications/decision-initial-findings-our-electricity-transmission-network-planning-review**

49 **https://www.nationalgrideso.com/research-and-publications/electricity-ten-year-statement-etys/etys-and-our-future-network-planning**

4.3.1. What looks good for Scotland

A shared vision and plan for the GB electricity system and Scotland's role within it.

An increasingly strong focus on transmission network investment.

There are two clear outcomes that spring from a cooperative approach between Scottish and UK government and which could support good decision making through REMA. These are a shared vision and plan and an increasingly strong focus on transmission network investment.

The discussion above highlights the importance of a shared vision however it is important cooperation, coordination and collaboration go beyond high level qualitative statements and work towards agreements on quantitative elements including shared regional ambitions.

A shared vision

As such a shared vision must include a plan which builds on existing Scottish and GB-wide goals such as the target for 50 GW of offshore wind in GB and Scotland's 20 GW onshore wind target, giving an indication of how that would be split between each region of the system. This will provide clarity and confidence, important in choreographing the stages of renewable development from seabed leasing or land purchase through to development of both transmission and distribution networks and also siting of flexibility. It will also provide confidence to end-users of generation, to flexibility providers and to wider society. As an example, a shared ambition for 50 GW of wind in Scotland by 2030, would not just provide confidence to renewable developers but would also to hydrogen electrolysis developers. Through a coordinated approach to system planning involving NGESO, it could create the condition for more clarity around the scale of flexibility provided, such as from hydrogen electrolysis, and this in turn would allow planning of the wider supply chain needed to develop a hydrogen economy.

There is growing support for this type of strategic planning. For example, the recent report from the UK government offshore wind champion recommends that UK and devolved government should: set out clear ambitions for offshore wind deployment beyond 2030; take a whole energy systems approach; and needs to recognise the pan-UK nature of the energy system and ensure their respective contributions to stewardship are aligned and complementary[50]. It is also one of the main recommendations of Nick Windsor's report on accelerating electricity transmission network deployment. This detailed report recommends that that a future system operator should be established quickly with a mandate to produce Strategic Spatial Energy Plans[51]. More recently the Prime Minister has committed to delivering that recommendation[52].

Figure 6 and Figure 7 illustrate the level and form a shared plan might take. They illustrate a potential pathway to 2035 which is consistent with Scottish government's declared ambitions, modelling for the Scottish Whole Energy System Scenario project and National Grid's 2022 FES.

50 https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/1148888/independent-report-of-the-offshore-wind-champion.pdf

51 https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/1175649/electricity-networks-commissioner-letter-to-desnz-secretary.pdf

52 https://www.gov.uk/government/news/pm-recommits-uk-to-net-zero-by-2050-and-pledges-a-fairer-path-to-achieving-target-to-ease-the-financial-burden-on-british-families

A plan would need to be pitched at the appropriate level, for example ambitions should be pitched at high level strategic outcomes but given a spatial basis whilst the details of delivery are left to the appropriate organisations. The level of certainty involved will likely vary as the time horizon increases. For example, capacities and outputs or demand for elements of the energy system in 2030 and 2035 may might be presented as specific values within each region of GB, whilst those for 2040 and 2050 may best be presented as ranges, reflecting the lower certainty over what might be possible or desirable.

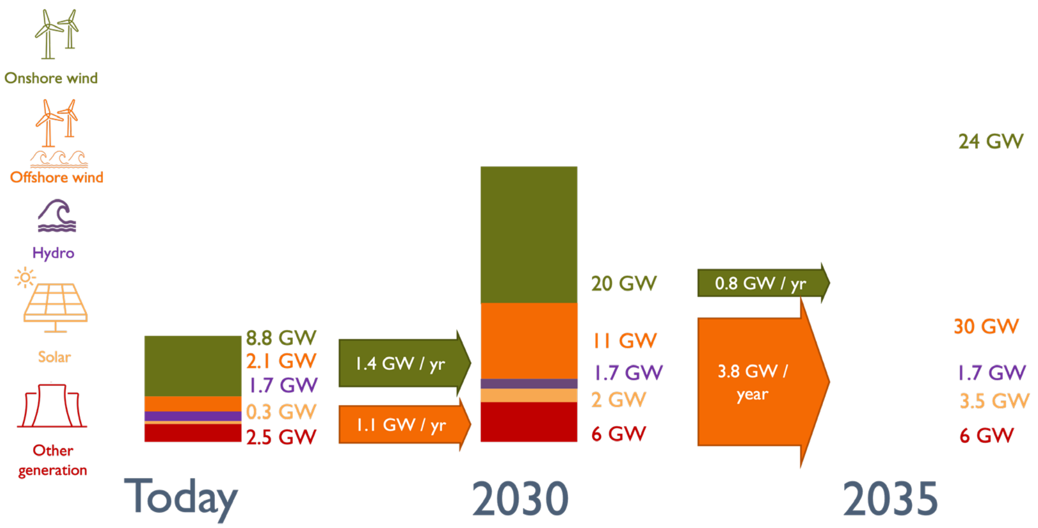


Figure 6: Illustrative pathway for Scottish generation capacity out to 2035 consistent with Scotland's declared ambitions in 2030, NGESO's net zero FES scenarios for 2035, and the Scottish whole energy system scenarios. It also highlights the annual build rates required for onshore and offshore wind to deliver this outcome.

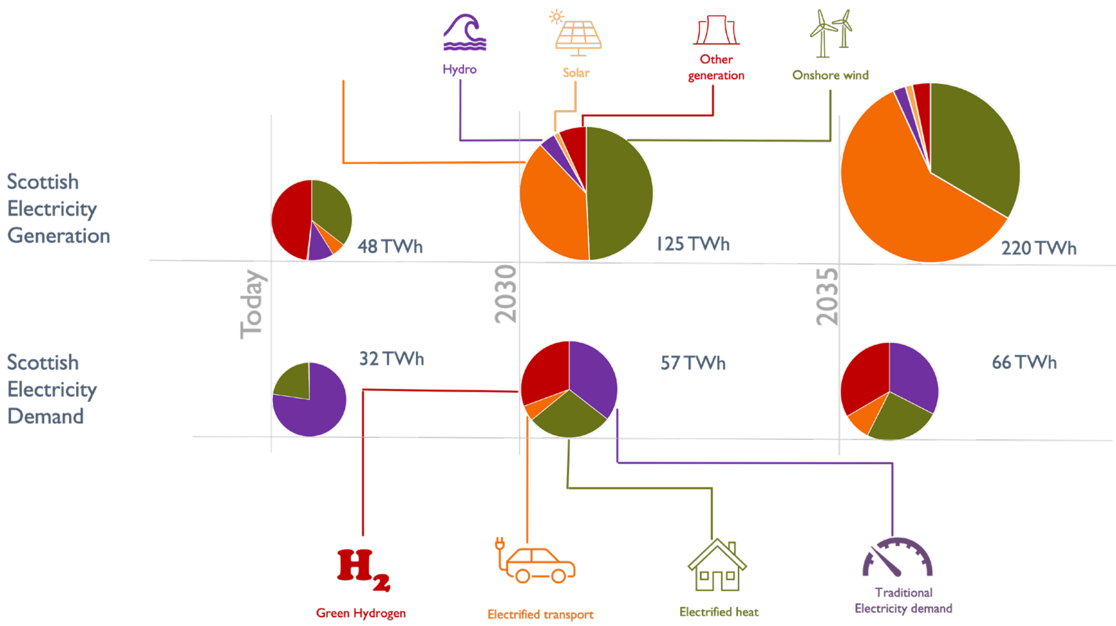


Figure 7: Illustration of annual electricity generation and demand in Scotland out to 2035. Values for today are based on current statistics, 2030 values are consistent with Scotland's declared ambitions (e.g. for the level of heat decarbonisation) and 2035 is broadly consistent with FES 2022 and the Scottish whole energy system scenarios.

The process of developing such a high-level plan will help grow our joint understanding of how the wider energy system might operate. For example, Figure 8 shows how the output of a 54 GW 2035 Scottish wind fleet might be used within the Scottish and GB electricity system. In this example, 19% of wind output meets Scottish underlying electricity demand, including electrified transport and energy, 48% is available to export to E&W subject to need, 17% could be used by a 10 GW electrolysis fleet and 10% could be curtailed.

Recommendation:

1. A GB-wide vision and plan should be developed, including an appropriately detailed delivery plan, drawing together ambitions and targets in both jurisdictions. National Grid ESO should reflect the outcomes of that process in their Centralised Strategic Network Plan53 (CSNP) ensuring the CSNP appropriately reflects Scottish ambitions and the role of Scottish projects in delivering wider UK targets.

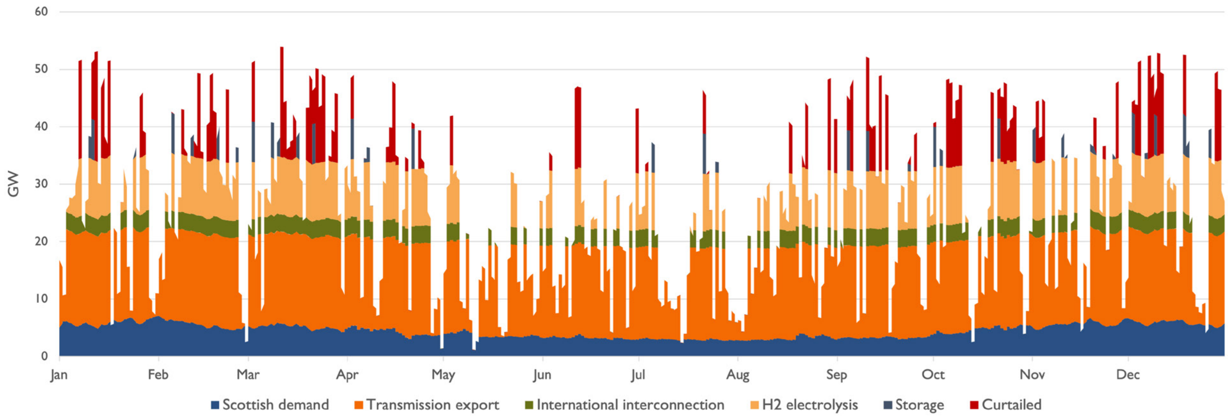


Figure 8: Visualisation of the potential utilisation of output of a 2035 wind fleet. Analysis: The Energy Landscape[54].

An increasingly strong focus on transmission investment

Electricity networks are the physical basis on which market frameworks operate. Ensuring there is sufficient network capacity delivered in a timely way is a critical part of system planning and coordination. However, given the long lead times for transmission network development, typically 11 – 13 years, waiting until all the required network capacity is in place before connecting generation can lead to significant delays.

A similar situation developed in Scotland in the late 2000s with a growing queue of wind projects unable to get connected under the prevailing 'invest and connect' model of transmission development, where generators had to wait until reinforcement of the network had been completed. In 2009 and 2010 this argument was made and accepted, leading to GB moving to the 'connect and manage' (C&M) regime where connection was allowed ahead of network reinforcement. (See Box 4 for a description of the connect and manage model.)

A connect and manage model requires the institutions developing the wider system – the system planner (NGESO), the regulator, and the transmission owners – ensure that once the renewable development has been allowed and has been given the confidence of firm access rights, the investment in transmission network is prioritised in order to ensure consumers gain the benefit from the newly connected generation.

C&M has been an important instrument in avoiding a hiatus in the development of renewables generation in Scotland. It is arguable that during the 2010s it has not delivered the transmission investment Scotland and GB needed. This failure has led to the situation we face today where there are significant and growing levels of renewable curtailment, driven by lack of network capacity.

53 **https://www.nationalgrideso.com/research-and-publications/electricity-ten-year-statement-etys/etys-and-our-future-network-planning**

Box 4: Connect and Manage

In 2009 and 2010 the UK government decided to move from an 'invest and connect' (I&C) regime for connecting generators to the electricity system to a 'connect and manage' regime. Under I&C generators had to wait until the transmission network was fully built out before connecting. Due to the long lead times required for transmission projects, this caused significant delays in bringing renewable generators online and began to put the then prevailing 2020 renewable targets at significant risk.

The UK government's objective in changing the connection regime included providing sustained, commercially viable connection opportunities consistent with project development timescales for generators and ensuring the delivery of renewable energy targets in 2020[55]. Under connect and manage, generators can connect before wider works are completed, it in effect allows generation to connect ahead of transmission build out.

The success of the UK, and in particular Scotland, in delivering the current fleet of more than 40 GW of renewables in GB (14 GW in Scotland) was in large part enabled by the change from invest and connect to connect and manage. Without that change renewable investors would have been unwilling to reach a final investment decision until there was high confidence sufficient transmission network capacity would be available and final connection to the network was possible as soon as the wind farm was built.

In short: without connect and manage GB and Scotland would not have delivered the scale and pace of decarbonation of the electricity system achieved throughout the 2010s.

However, the flip side of connect and manage was the importance of ensuring transmission investment continued in order to achieve the right balance between network costs and curtailment. The UK government response to the 2010 Connect and Manage consultation also highlighted "[t]he ultimate solution to the problem of network constraints and connecting new generation is investment in the transmission network, and we are working closely with Ofgem to ensure that this is delivered in a timely and efficient manner."[56]

Over the past decade, transmission capacity has been slow coming forward. Much of this can be put down to the regulatory framework employed which had tended to consider projects on an individual basis and with a relatively high regulatory bar. Ofgem recently acknowledged this in its decision on accelerating onshore electricity transmission investment in which it says the current regulatory system "offer[s] heightened regulatory scrutiny and consequential consumer protection on a project-by-project basis" but "assessing large transmission projects under this framework is unlikely to afford the necessary pace to deliver the government's 2030 ambitions, and limits the scope for the required investment to be considered and delivered in a programmatic fashion."[57]

The need to accelerate transmission network investment is now being acknowledged. Ofgem has introduced the Accelerating Strategic Transmission investment (ASTI) framework with the objective of accelerating the development of transmission infrastructure needed specifically to deliver the UK government's 50 GW offshore win target[58]. The decision to introduce the framework came with a green light for 26 major transmission projects at an estimated cost of £19.8bn and pre-construction funding for a further eight. A large number of these are either in Scotland, such as the 1.8 GW link to the Western Isles, or between Scotland and England, such as four east coast offshore links.

55 **https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/42979/251-govt-response-grid-access.pdf**

56 ibid, pg 7

57 **https://www.ofgem.gov.uk/publications/decision-accelerating-onshore-electricity-transmission-investment** Pg 10

58 ibid

The result of the additional investment will be significantly enhanced transmission capacity. For example, the ability of the system to transport power from Scotland to England is expected to grow from around 6 GW today to 16 GW by the early 2030s, as shown in Figure 9.

Figure 9: Illustration of planned transmission capability between Scotland and England (red line) and the distribution of required transfers under the Leading the Way scenario. Based on transmission projects which have currently been given the go ahead by Ofgem, transfer capability is expected to grow to around 16 GW by the mid 2030s[59].

Ofgem are have also consulted more broadly on the way in which electricity network investment is regulated[60]. This consultation proposes "the future of the grid should be based on a modern version of 'invest and connect', where programmatic grid expansion occurs in line with top-down system plans prepared by the Future System Operator (FSO), in anticipation of generation and demand[61].

This new openness to coordinated and strategic investment in the network is welcome, however the approach needs to be taken further. Two enhancements of the ASTI framework could be particularly helpful to Scotland:

- ASTI's relatively narrow existing focus on the UK government's 2030 offshore wind targets could be expanded to allow the framework to make strategic network investments aimed at delivering other targets. These could include ambitions for other generation technologies such as Scotland's ambition to reach 20 GW of connected onshore wind capacity in 2030, and whole-system targets such as delivery of the sixth carbon budget or decarbonisation of the whole electricity system.
- The time horizon over which the framework allows strategic investment to be made in the network could be increased beyond 2030. This can build on the eight transmission projects provided with pre-construction funding through ASTI. This would develop projects for which there is reasonable confidence they will be needed, including the consenting of those projects, so they are 'shovel ready' when the time comes to commitment to full-scale investment. Any move to nodal or zonal pricing is likely to make such preparations and commitment to long term new transmission particularly critical to the approval of new investment in large scale renewable generation.

The expansion of the ASTI frameworks, or other approaches to moving network development towards a strategic and programmatic approach, will benefit from cooperation between Scottish and UK governments and could form an integral part of the planning approach.

59 NGESO, Electricity Ten Year Statement, Published August 2023, **https://www.nationalgrideso.com/document/286591/download**

60 **https://www.ofgem.gov.uk/publications/consultation-frameworks-future-systems-and-network-regulation-enabling-energy-system-future**

61 Note, that since the text of this report was finalized Ofgem have published their response to the consultation on future network regulation: **https://www.ofgem.gov.uk/sites/default/files/2023-10/FSNR%20Overview%20Document%20Final.pdf**

Recommendation:

2. Ofgem should extend the scope of the ASTI framework from offshore wind to a whole electricity system approach and the timescales over which ASTI could be extended to cover at least 20 years and be clearly linked to the shared vision and plan proposed under Recommendation 1.

4.4 Principle 2: Commitment to deliver for people, business, communities and society

Commitment to deliver for people, businesses, communities and society across Scotland.

Reform of electricity markets can deliver a wide range of outcomes that are valued by consumers including low costs, stable costs, and fairness. It also supports the wider interests of people, businesses and society as a whole through the provision of jobs, economic growth and community value.

Future market arrangements should ensure everyone can benefit and reflect the collective endeavour that goes into delivering energy infrastructure. It reflects the role of communities and local economies as well as developers and operators.

The overall objective of the electricity system is to deliver energy in the interests of consumers and society. Citizens Advice characterise what consumers want as 'good quality, value for money services that meet their needs'[62].

The different aspects of 'value' are often described in terms of the trilemma: low cost, security of supply and sustainability. But these aren't the only considerations: good management of risk, fairness, wider economic impact, support for local communities and jobs represent just some of the additional aspects of value which need to be considered.

An important element of value that is often left out of discussions is the degree to which consumers are exposed to price risk. During the 2010s consumers enjoyed (relatively) low prices during, but their exposure to risk went largely unnoticed until the current price crisis highlighted how prevailing market mechanisms did little to hedge the risk for consumers associated with high prices.

Although the most pressing concern for consumers in the short term is for prices to be reduced to affordable levels, they are also likely to value medium- to long-term price certainty, better management of risk in the electricity system on their behalf, and confidence a repeat of the current price crisis can be avoided in the future.

The importance of explicitly considering risk and of understanding how it is manifest is shown by the collapse of many small retailers in the years leading up to the current price crisis. Whilst some consumers benefited for a while from increased competition, the subsequent failure of these companies and the need to socialise the cost of those failures through Ofgem's Supplier of Last Resort mechanism shows what can happen if risk is not appropriately managed when designing market arrangements. The cost of failure of these suppliers has been estimated at £2.7 billion equating to around an additional £94 per customer per year[63].

62 https://www.citizensadvice.org.uk/Global/CitizensAdvice/Energy/Rough%20trade_%20 Balancing%20 the%20winners%20and%20losers%20in%20energy%20policy.pdf

63 https://www.nao.org.uk/wp-content/uploads/2022/03/The-energy-supplier-market.pdf

The concept of fairness and equality also plays a role in what consumers value. This has been explored in other contexts, for example by Sustainability First in the context of network charging[64] and by the Centre for Sustainable Energy in the context of 'smart'[65]. In terms of market design there are a range of trade-offs that different solutions may take and there are differing views on what might constitute the 'fairest' balance.

Citizen's Advice highlights nine areas of trade-off including between engaged and disengaged consumers ('the loyalty penalty'), between different locations, between those who consume during different parts of the day, and between current and future generations[66].

Related to fairness is the treatment of vulnerable customers. This includes a range of vulnerabilities covering low income, those with health concerns and the challenges of rural living. The importance of supporting these groups sits at the core of energy legislation. For example, Ofgem are directly required by primary UK legislation to consider the interests of particular groups of vulnerable customers, and Ofgem requires suppliers to treat all customers, including vulnerable consumers, fairly. Wholesale market arrangements can have particular implications for vulnerable customers, particularly where they incentivise and reward flexibility from end users whilst certain vulnerable groups may not be in a position to behave in a flexible way.

It is also important to consider not just domestic consumers, but the full range of non-domestic users of electricity. In Scotland in 2020, 43% of electricity use was outside the domestic sector[67]. The needs of SMEs, energy intensive industries, and other commercial, industrial and public sector organisations are likely to differ from domestic consumers. There will be crossover: for example, the importance of affordability and support for decarbonisation is likely to be common across both groups. But there will also be differences, such as in the degree of regulatory protection afforded to each group, and the ability to identify and manage risks.

The points above focus on what might be described as a broad concept of value for *consumers*. However, the electricity system plays a broader role delivering wider benefits to Scotland, its regions, communities and people. Aspects of value within this category include contributions to employment, the development of local supply chains and the delivery of community value. It reflects the point made by a number of stakeholders that energy infrastructure is a shared endeavour between developers and the community and Scotland as a whole and the localities hosting infrastructure need to benefit.

The discussion above is not a full exploration of the aspects of value the electricity system can deliver. Nor does it deal with the challenge of identifying how to create synergies or manage tensions between different elements of value. It is often said the decisions about electricity system reform need to place the consumer at the heart, this can be extended to include not just the consumer but the wider benefit of society (to which all consumers contribute to through their wider roles as citizens, businesses, public sector organisations etc). Turning that into a reality means fully articulating those outcomes.

64 **https://www.sustainabilityfirst.org.uk/images/publications/other/Sustainability_First_Future_Energy_Market_Discussion _Paper_September_2019.pdf**

65 **https://www.cse.org.uk/resource/smart-fair/**

66 **https://www.citizensadvice.org.uk/Global/CitizensAdvice/Energy/Rough%20trade_%20Balancing %20the%20winners%20and%20losers%20in%20energy%20policy.pdf**

67 **https://scotland.shinyapps.io/sg-scottish-energy-statistics/?Section=WholeSystem&Chart=EnBalance**

4.4.1. Ensuring a fast transition to renewables: a review of value

The vision for market reform starts from the need for fast transition to renewables as part of a whole-system and whole-society approach to energy. This reflects the fact renewables can help deliver against many of the individual elements of value discussed above. The following gives an indication of how renewables might support the delivery of some aspects of this broad concept of value to consumers. Firstly, on costs:

Renewables are low cost: Onshore wind, offshore wind and solar are widely accepted as being the cheapest forms of electricity generation. BEIS' 2020 Electricity generation cost report estimated that for projects commissioning in 2025, the levelised cost of energy (LCoE) for a gas power station would be £85/MWh, by contrast onshore wind, offshore wind and solar are £46/MWh, £57/MWh and £44/MWh respectively[68]. The difference is even starker if the gas price assumptions are increased. This is shown in Figure 10 (a).

Renewables can deliver cost stability: In addition to having the lowest overall costs, the vast majority of the costs of renewables are fixed giving much greater cost certainty to consumers. These estimates suggest around 86% of the LCoE is fixed for onshore wind, 94% for offshore wind and close to 100% for solar. By comparison, even at 2020 gas prices, only 11% of a gas power station's LCoE is fixed, leaving the rest of the cost exposed to changing market conditions throughout the power station's lifetime. The split of LCoE by cost-type is shown in Figure 10 (b).

Renewables can deliver significant additional value to Scotland and communities: beyond their impact on the electricity market itself renewable developments can provide value to Scotland and its communities in a wide range of ways, many of which relate directly to the Just Transition Outcomes lay out by Scottish government (See **Table 2: The importance of REMA for Scotland's Just Transition outcomes**, above). These include:

- **Economic activity:** investment in the electricity system delivers benefit to the economy. Research from the Fraser of Allender Institute suggests renewable activity in Scotland delivered £2.5 bn of Gross Value Added (GVA) per year[69] in 2020.
- **Supply chain support:** one aspect of the economic activity created is the development of Scottish supply chains. Plans submitted by the 17 projects initially successful through Scotwind show the potential for £25.5 bn in spending within the Scottish economy[70].
- **Jobs:** renewable energy activity in Scotland supports a significant number of jobs. Direct employment within the renewable sector in 2020 was estimated at 9,000 jobs[71] and when indirect jobs are included this rises to 27,000 full-time employees.
- **Community Value:** Scotland's Good Practice Principles[72] for community benefit from onshore renewable development encourage renewable developers to ensure at least £5,000 per MW per

68 Values used are for a CCGT H class turbine, onshore and offshore wind and large-scale solar all deployed in 2025. Although there are small differences in the split of costs for capacity delivered in later years, these do not significantly reflect the overall conclusions. **https://www.gov.uk/government/publications/beis-electricity-generation-costs-2020**

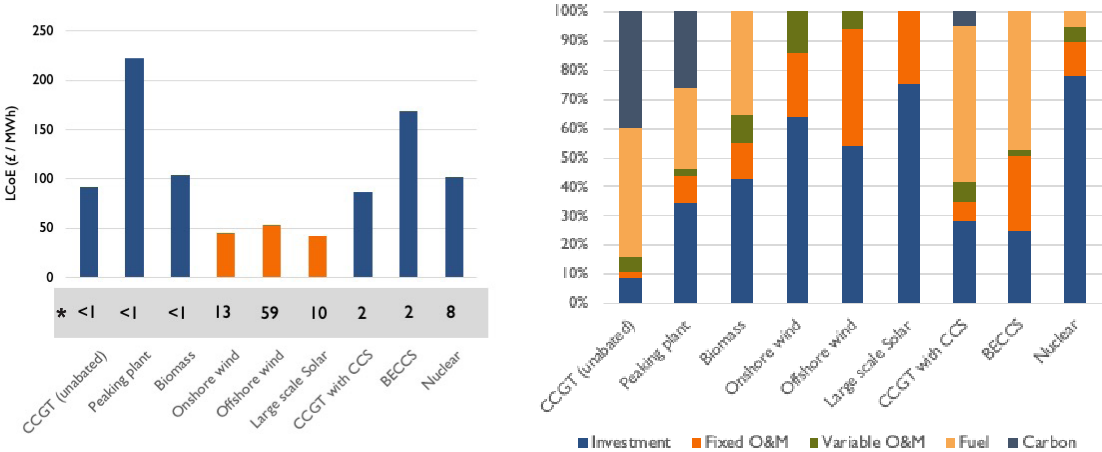
69 **https://www.scottishrenewables.com/assets/000/002/627/FAI_The_Economic_Impact_of_Scotland_s_Renewable_Energy_Sector_original.pdf?1664809336**

70 **https://www.crownestatescotland.com/news/scotwind-developers-set-out-multi-billion-pound-supply-chain-commitments**

71 **https://scotland.shinyapps.io/sg-scottish-energy-statistics/?Section=RenLowCarbon&Subsection=LowCarbonEconomy&Chart=LowCarbonEconomy**

72 **https://www.gov.scot/publications/scottish-government-good-practice-principles-community-benefits-onshore-renewable-energy-developments/**

year is passed back to local groups, whilst the ambition for at least 2 GW of community owned energy by 2030 supports those communities to have an ownership stake in local infrastructure.



(a) *% contribution to generation in 2035, under leading the way

(b)

Figure 10: LCoE estimates for key technologies based on the BEIS 2020 Generation Cost Report[73]: (a) the absolute LCoE along with the contribution of each technology to GB's generation mix in 2030 under the 'Leading the Way' scenario and (b) the breakdown for each technology by cost category. Investment and Fixed O&M costs represent costs that are fixed and independent of output; variable O&M, fuel and carbon costs are those that impact the 'short run marginal cost'.

Although renewables can deliver a low and stable cost base for energy generation capacity, that needs to be combined with appropriate market mechanisms in order to ensure two things: firstly, low and stable costs are passed onto consumers through low and stable prices, and also wider system costs such as curtailment are considered appropriately.

4.4.2. The role of markets in managing consumer risk

Although renewable generation has lower costs that are largely fixed at investment stage, the current crisis highlights there is a significant difference between cost and prices. Low cost generation technologies will only deliver value to consumers if appropriate mechanisms are in place to ensure prices remain closely linked to costs. The tendency of wholesale market prices in the current system to move towards the short run marginal cost of the most expensive generator on the system, gas power stations in the current context, needs to change.

A feature of the financing of renewable generation that can be used to the advantage of consumers, is the need for projects to recoup their investment costs over long periods of time. This means developers value mechanisms which provide price certainty and protect them from *lower* than expected prices. Similarly, consumers value price certainty, and in particular protection against *higher* than expected prices. This complementarity means generators and consumers are natural hedging partners.

The CfD mechanism currently employed to support renewable generators represents an example of such a hedge, with mutual benefits for consumers and generators. A CfD represents renewable generators making a deal with consumers: in return for revenue certainty generators agree to forgo the opportunity of making excessive returns. On their side consumers get price certainty: a guarantee the price they pay to that generator won't rise to excessive levels, in return for giving up the possibility of exceptionally low prices (see Box 5 for further discussion).

73 **https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/1140189/review_of_electricity_market_arrangements_summary_of_responses.pdf**

Since late 2021, renewable generation with CfDs have been paying back revenue from wholesale prices above their strike price. The Energy & Climate Intelligence Unit have estimated £1.3 bn will be paid back by CfD generators between Q4 2021 and Q1 2023[74]. In 2023 CfD generation represents only a small fraction of current generation, although this is set to rise quickly as new projects come onstream. So, today, whilst consumers benefit from these agreements for around 6% of the power sold, the remaining 94% continues to be influenced by the price of gas. These fractions are expected to change significantly and quickly as generators that have already won CfD auctions continue to come online and as further auctions, starting with 'Auction Round 5' in Spring 2023 award more contracts. By the end of the decade consumers should be benefiting from a substantial hedge against the type of price crisis experienced over the past two years.

There is significant appetite from renewable investors for agreements like CfDs. They naturally share risk and reward between consumers and generators in a way which supports the weighting of costs towards 'upfront' investment involved in renewable development. In addition to making renewable investment more feasible CfDs deliver an additional benefit: a lower overall cost of capital[75], which consumers directly benefit from.

This argument highlights the importance of ensuring market reform continues to support the accelerated delivery of a net zero power system supplied largely by renewables. And that it does this, not to deliver benefits to investors and energy companies, but because it can deliver benefits to consumers.

74 **https://eciu.net/media/press-releases/2022/new-analysis-wind-power-bonus-could-cut-bills-by-25-this-winter-and-45-next-winter**

75 See for example work by NERA in 2013 to inform the implementation of CfDs: **https://www.gov.uk/government/publications/nera-economic-consulting-report-changes-in-hurdle-rates-for-low-carbon-generation-technologies**

Box 5: Consumers and generators – natural hedging partners

CfDs and other mechanisms which fix prices over several years lead to benefits for both generators and consumers as they are natural partners in the hedge it provides. This is because they have opposing interests (in the narrow economic sense). Consumers have interests in the price remaining low and see high prices as a risk. Generators have interests in prices rising and see low prices as a risk.

On both sides however there is also value in having confidence over future prices. Figure 15 below shows a simplistic illustration of how both generators and consumers can benefit from a hedge. The solid black line represents the best guess forecast for future prices whilst the two grey dashed lines indicate upper and lower bounds on those price forecasts. The green dashed line shows a possible fixed price hedge. Under this arrangement, were prices to follow the forecast trajectory, consumers would pay more until year 8 under the fixed price hedge. However, from year 4 onwards they are also protected against the possibility prices are near the upper bound of the forecast range.

Similarly, although generators will receive lower prices from year 8 onwards than they would if wholesale prices follow the forecast, they are also protected from the risk prices actually outturn towards the bottom of the forecast range right up until year 14.

The fixed price hedge is beneficial for the generator, particularly one where the majority of its project costs are sunk at the start of the project, because it provides confidence on revenue and their ability to repay loans. If the CfD mechanism becomes prevalent across the market, for example through the expected expansion in CfD backed generation, it could significantly reduce the risk to consumers of facing a repeat of the current price crisis.

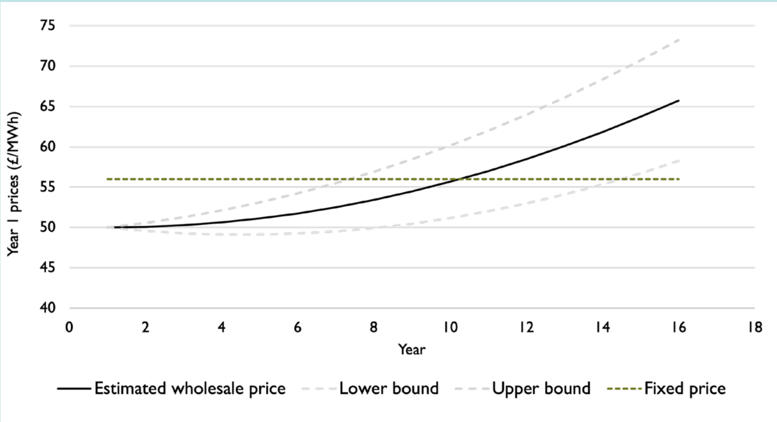


Figure 11: Illustration of the role of generation and demand as natural hedging partners.

4.4.3. Balancing the interests of different parts of GB

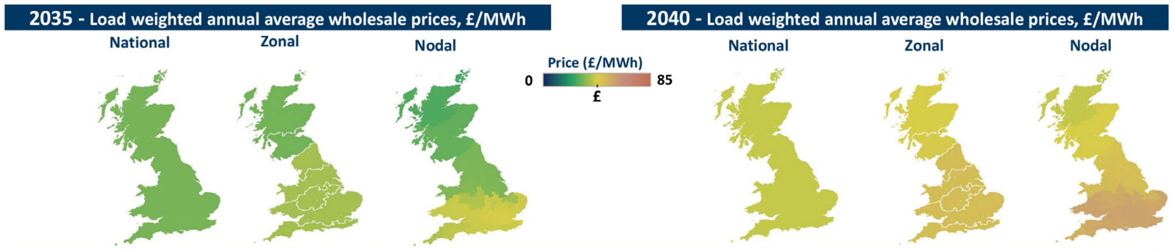
Some reform options could result in benefits for Scottish consumers at the expense of consumers in England and Wales, whilst other options could deliver benefit to Scottish consumers without detriment to consumers elsewhere. Where options with locational implications are considered, it is important both the upsides and the downsides are thought through, and the different groups to which these will accrue are identified.

An example of a reform option which could benefit Scottish consumers (at least in the short term) at the expense of others is locational wholesale pricing, applied to the demand side. This could lead to lower electricity prices for consumers in Scotland but would also lead to higher prices for other areas of GB.

For example, modelling by FTI for Ofgem suggests if national pricing is maintained the average national wholesale price may fall to £ 34.10 / MWh in 2035 whilst nodal pricing would lead to a range of average annual prices of between £ 25.70 / MWh and £ £42.30 / MWh. Results for 2040 show national pricing delivering an average of £50.90 / MWh whilst nodal delivers a range from £ 37.50 / MWh to £ 56.40 / MWh[76]. These results are shown in Figure 12.

Whilst locational pricing is argued to be more economically efficient, there are significant questions about whether efficiency can be delivered in practice and whether in delivering theoretical efficiency the result could simply be a reduction in investment in renewables in Scotland[77]. There are also questions about whether the different prices such a system would deliver for consumers in different places across GB are appropriate in terms of fairness and equality. There are options to insulate the demand side from locational variations, but it is not clear the degree to which this would reduce the benefit of locational pricing overall.

Gaining agreement on an answer to this question requires the type of articulation of consumer values and decision-making principles discussed above.



2035	National	Zonal	Nodal
LtW (NOA7)	£34.10	£31.80 - £37.80	£24.90 - £43.10
LtW (HND)	£34.10	£31.10 – £37.00	£25.70 - £42.30
SysTr (NOA7)	£29.90	£25.80 - £31.40	£22.80 - £35.00

2040	National	Zonal	Nodal
LtW (NOA7)	£50.90	£45.40 - £50.90	£37.0 - £58.70
LtW (HND)	£50.90	£43.00 - £48.90	£37.50 - £56.40
SysTr (NOA7)	£30.20	£27.60 - £32.20	£21.20 - £38.40

Figure 12: Results from FTI modelling showing average wholesale prices under national, zonal and nodal market designs. Source: FTI's report for Ofgem[78].)

4.4.4. Locational Costs

Renewable generation therefore can underpin a Scottish and GB energy system with low and stable costs, and low carbon support mechanisms can be designed that are mutually beneficial for both consumers and generators. However, the system still needs to be planned and delivered in an efficient way. For example, constraints and other system costs can add to the baseline generation costs, and significant investment is needed in the electricity networks and in flexibility in order to ensure generators can connect and the system remains operable. There will be value in appropriate locational signals, both price and non-price signals.

Constraint costs are particularly important in the context of Scotland. Their scale is significant and the need to manage them represents an important part of the argument for radical market reform. NGESO's modelling suggests constraint costs could rise from around £1 bn a year today to £3 bn a year by the end of the decade[79], although they would then likely fall again as new network development is commissioned around the end of the decade. Whilst this is a large cost, it is important to put it in the context of the significantly lower overall cost of electricity generation from renewables.

76 Results presented are for FTI's 'Leading the Way with Holistic Network Design scenario – LtW (HND). See Figure 13 for reference

77 See for example Gill, MacIver and Bell, *Exploring Market Change in the GB Electricity System : the Potential Impact of Locational Marginal Pricing*, 2023, **https://strathprints.strath.ac.uk/83869/**

78 **https://www.ofgem.gov.uk/publications/assessment-locational-wholesale-pricing-great-britain**

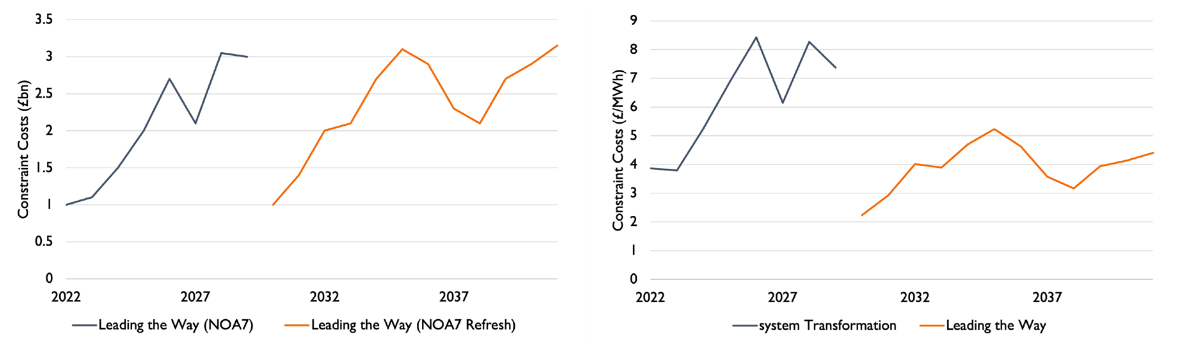
79 **https://www.nationalgrideso.com/document/266576/download**

Figure 13 illustrates the potential trajectory of constraint costs using FES Leading the Way scenario. Figure 13 (a) presents these as total costs as modelled by NGESO in 2022. The line between 2022 and 2029 is based on the development of the transmission network expected prior to the completion and acceptance of the Holistic Network Design (HND). That is, it uses conservative assumptions about the rate at which the capacity of the transmission network increases. In late 2022 Ofgem accepted the need for significant additional network investment to be delivered by 2030 in order to support the UK government's target of 50 GW of offshore wind (see discussion of the ASTI framework above). The line from 2030 onwards models constraints based on the completion of additional capacity.

In addition to considering these costs in totality, it is useful to present them in terms of the cost per unit of electricity delivered across GB. Figure 13 (b) shows the overall cost divided by the total GB electricity demand in each year in the Leading the Way scenario. This shows costs peaking in the late 2020s at around £8 - £9 MWh before falling to nearly £5 - £6 / MWh during the 2030s, reflecting the fact the total constraint costs are split across a growing demand for electricity. These numbers are clearly not negligible – they represent between 0.5p and 1p per unit of electricity – and therefore for a typical dual fuel electricity consumer, would represent between £15 - £30 per year. However, the potential reduction in costs and prices associated with moving to renewable generation, particularly in comparison to the prices faced by consumers over the past year, these values are relatively small.

More information on the context of Scottish constraint costs is given in Box 6 below.

The conclusion is that ensuring there are signals which incentivise market participants to act to reduce constraint costs is important, however in terms of consumers this importance is likely to be secondary to the importance of accelerating the move to renewable power and ensuring prices closely reflect long-term cost. Options for providing appropriate locational price signals in light of constraint costs are discussed further under Principle 3.



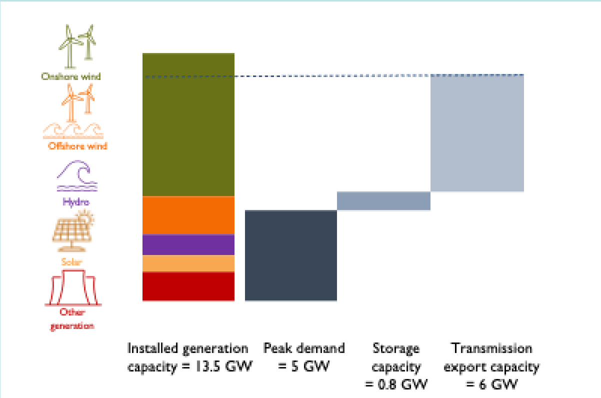
(a) (b)

Figure 13: (a) Constraint costs for the Leading the Way scenario modelled by NGESO against the 2022 Future Energy Scenarios. Results up to 2030 are based on the 2022 Network Options Assessment whilst results from 2030 onwards include additional network capacity included in the NOA refresh. (b) Conversely presents the overall constraint costs in terms of an average cost per MWh of electricity consumed using the total GB electricity demand modelled in each year. Source: NGESO and analysis by TEL[80]

80 Graph 17 (a) taken from: **nationalgrideso.com/document/266576/download** Graph 17 (b) derived by dividing total constraint costs by electricity supplied under LtW scenario in each year.

Box 6: Constraint costs and Scotland

Growing constraint costs have been identified by UKG as an important driver of REMA. Constraint costs occur when there is an excess of generation in one region of the electricity system which cannot be used either to meet local demand or exported. Scotland is regularly in such a constrained situation.



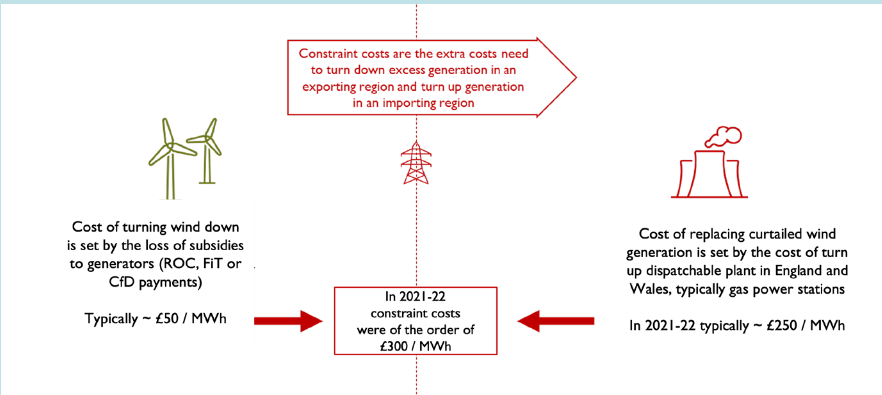
Today Scotland's installed generation is around 13.5 GW of which the majority is onshore wind. Winter peak demand is around 5 GW and when all parts of the transmission system are in service, the ability to export power from Scotland to England and Wales is around 6 GW.

This means there is a significant fraction of the year when available generation exceeds either the ability to use generation within Scotland or to export it to England and Wales. The exact quantity of available renewable generation that has to be curtailed depends on many factors: the wind resource across Scotland, the availability and economics of other types of Scottish generation, the level of demand in Scotland and the state of the transmission network. For example, for large parts of the year maintenance and upgrade of the transmission network reduces the transfer capacity and demand is well below its peak.

However, it is often not windy across all of Scotland's wind farms at the same time, and the variable nature of the wind resource means even uncurtailed wind farms only achieve a capacity factor of between 25% and 55%.

There is also a trade-off between network capacity and curtailment: where additional transmission is expensive to build and the reduction in curtailment is relatively small the most efficient solution will be for some curtailment to remain.

However, it is not just the need to turn down generation that contributes to the cost of a constraint. It is also the fact replacement generation needs to be brought online on the other side of the constraint to replace the output.



There are a number of ways to reduce constraint costs[81]:

- Increase the capacity of the transmission network to transfer power;
- Develop alternatives to turning down renewable generation in exporting areas, for example the development of flexible demand or charging energy storage;
- Develop cheaper alternative to turning up gas fired power stations in importing regions, for example demand turn down services or discharging energy storage;
- Remove the right of generators to be reimbursed for having their output constrained.

81 For a more detailed discussion of options to reduce constraint costs see: **https://www.regen.co.uk/wp-content/uploads/Regen-Insight-Managing-Constraint-Costs.pdf**

4.4.5. What looks good for Scotland

A clear articulation of consumer values and outcomes and a set of consumer-focused principles for decision making.

The key outcome is to ensure decisions made on the basis of REMA represent a commitment to deliver for people, businesses, communities and society. A full articulation is required of the consumer and broader societal value the electricity system can deliver, and the principles by which these could be used within decision making.

Without such an articulation there is a risk, seen in much of the evidence developed so far, of defaulting to a relatively narrow concept of theoretical economic consumer value based primarily on low cost and largely ignoring cost certainty, equality, fairness and wider society and place-based value.

An important point made by stakeholders is there is need for a structure the debate which, as much as possible, avoids pitching one group of GB consumers against another – whether that is different types of consumers or consumers in different locations. Good solutions are ones that support good outcomes in all parts of GB as well as in Scotland, and for all groups of consumers. Solutions need to recognise existing inequalities and vulnerabilities, and endeavour to tackle them within an overall fairer, faster net zero transition.

Recommendation:

3. UK government should work with the devolved administrations including Scottish and Welsh governments and representatives of the English regions to develop a shared articulation of the different elements of value the electricity system provides to people, businesses, communities, and society across Britain. The result could play a central part in the next phase of REMA ensuring decisions consider the broadest possible set of social, economic, and environmental elements of value. It should also consider the balance between national and regional benefits.

4.5 Principle 3: Confidence for investors

Confidence for renewable and flexibility investors and consumers in Scotland.

Confident investors are critical because of the scale and pace of investment needed in all technologies and because ensuring a fast transition is the best way to deliver for consumers and for society.

Confidence is particularly important for renewables because, although they have the lowest levelised cost of energy of any type of generation, their costs are much more weighted towards upfront investment. A lack of confidence could lead to an investment hiatus and / or increased cost of capital.

Providing confidence to consumers, including industrial and commercial end-users, means giving certainty that costs are both affordable and stable.

The previous sections have made the case for accelerated delivery of renewables: delivering Scottish renewable capacity is central to delivering good outcomes across the whole energy system, and is necessary for GB ambition as well as Scottish targets.

This section argues this requires four aspects of confidence:

- Confidence for investors in renewable generation;
- Confidence for the wider electricity sector that sufficient transmission network capacity will be built within Scotland and between Scotland and England and Wales; an
- Confidence for investors in the flexibility and end-use infrastructure needed;
- Confidence for investors in dispatchable low-carbon generation in order to ensure security of electricity supply.

Providing confidence across these four domains – renewables, networks, flexibility and low-carbon dispatchable capacity – will mitigate the real risk of an investment hiatus, something that would both represent a major barrier to achieving our goals and can ensure there is not a spike in the cost of capital.

4.5.1. Providing confidence for Scottish Renewable investors

In common with any investment in capital intensive assets, investment in renewable generation requires two characteristics from its revenue streams. Firstly, an expectation of *revenue sufficiency* so that revenue is expected to pay back investment, service the cost of debt and equity, and deliver a reasonable return to investors. Secondly, *revenue stability* so that if market and system conditions turn out differently from those forecast at the time of a project's final investment decision the project can still cover its costs (this is particularly important for senior lenders).

Support mechanisms for renewables began life as a way of helping deliver revenue sufficiency. For example, the Renewable Obligation scheme acted as a revenue top-up because returns from the wholesale market were expected to be insufficient to cover the cost of new technologies. Over time, and through the transition to CfDs, support mechanisms have moved away from providing revenue sufficiency towards providing revenue stability.

Today, as argued in the previous section, the national wholesale market provided revenue sufficiency whilst the CfD mechanism primarily helps deliver and revenue stability for generators whilst benefiting customers through the hedging it provides for the demand side.

However, the context within which generators operate is changing. As the electricity system continues to transition to one based largely on renewables the context within which wind farms operate will change. There will be increasing periods of time during which renewables will exceed demand across GB.

The first response to this will be to support the development of flexibility. When there is an excess of renewables nationally, storage can charge, flexibility demand should turn up, and interconnectors should make energy available to neighbouring countries.

But it also means it will be increasingly important to acknowledging that not all the potential generation from a wind farm can be used in the system. This means Scottish investors may benefit from low-carbon support mechanisms which decouple revenue from output.

In addition to maintaining investor confidence throughout the move to a highly renewables-based system, such mechanisms could incentivise renewables to make more effective use of their capacity, for example using it to provide ancillary services rather than energy.

These points are even more true within a constrained area of the transmission network such as Scotland, where there will be additional generation that cannot be used within network constraints. The first response to this issue is, of course, to accelerate investment in transmission capacity (see discussion under Principle 2). However even with a commitment from all parties – NGESO through its network planning frameworks, Ofgem through its role in allowing investment, and the Transmission Owners who build and operate the infrastructure – there remains significant risk around the timing and availability of that network. If generators are exposed to the consequences of delays to delivery of that network capacity, it would work against the principle of confidence.

The implications for decision making in REMA are that, in order to provide sufficient confidence to Scottish renewable investors, frameworks need to ensure revenue sufficiency as well as revenue certainty. And these frameworks need to be largely decoupled from the delivery of new network capacity. .

Set against this is the need to ensure there are investment and operational signals that help align the location and operation of generation, flexibility and demand with the networks connecting them. Setting up these signals can introduce uncertainty and risks for market participants. They can also be delivered through market mechanisms such as network charges or locational prices, or they can be delivered through non-market mechanisms associated with strategic planning frameworks or operational limitations.

There is therefore an important balance to be struck between on one side the sharpness signals designed to influence behaviour, and on the other the impact on confidence across the four categories mentioned above.

This vision concludes that locational wholesale markets, either zonal or nodal, are unlikely to provide the right balance and that alternatives which evolve the existing system and combine targeted, forecastable investment and operational signals – both price and non-price – are more likely to balance confidence with a broad concept of value.

Implications of a loss of confidence

The implications of a loss of confidence for generation investors and developers is two-fold. Firstly, it creates a risk of an investment hiatus as developers and investors either delay making final investment decisions until they better understand new market arrangements and the level of risk they will face. Secondly, it can increase the cost of capital for those projects that do proceed.

There has been strong feedback from the renewables sector and investment community that the more radical market reform options raise the potential of both risks materialising.

In terms of cost of capital, evidence from Frontier Economics on the potential impact of LMP concludes "it would be reasonable to consider that this analysis is indicative of a range of impact on the WACC [Weighted Average Cost of Capital] of 2-3pp"[82]. Research from UKERC estimates "for every 1%-point increase in the cost of capital, the £15bn annual financing cost of offshore wind increases by £1bn per year"[83]. There is therefore the potential for the increase in the cost of capital to lead to additional costs for consumers of several billion pounds per year. The work by FTI for Ofgem suggest an increase in the cost of capital of 2.3 percentage points would negate the overall welfare benefits from their modelling of the introducing LMP into the GB system[84] under the Leading the Way with Holistic Network Design sceanrio.

A more recent review of transition risk by UKERC concludes exposing projects fully to the transition risk at this stage could increase the cost of transition by at least a third, from around £15 bn to around £18 - £20 bn per year for offshore wind alone[85].

These reports, together with input from stakeholders through the engagement process, make it clear managing the cost of capital is a critical part of the process of managing costs and a move to locational pricing, which includes the implicit removal of firm rights of access to the system, creates significant additional project risks. Some of these risks are inherent to locational pricing itself whilst others are related to implementation risk. Regardless of the root, such a move could work against the principle of confidence and by implication against the first two principles as well.

A second conclusion is that, whilst the scale and risks associated with cost of capital have the potential to be significant, there is a lack of consensus as to the size of those risks (and hence the impact on the cost of capital and possible investment hiatus) and a lack of trust between different participants who take different positions. Developing a more detailed objective evidence base is an important part of good decision making in REMA.

4.5.2. Confidence in transmission: Delivering the right level of network capacity

The importance of strategically developing transmission capacity, for the benefit of electricity consumers and as part of a transition to a fully decarbonised electricity system is discussed under Principle 2. There are two sides to the issue of confidence related to networks. Firstly, confidence within the network sector that a strategic approach to developing the network can be taken, and secondly confidence to market participants that sufficient new network capacity will be delivered in a timely way.

The discussion above mentioned the role of Ofgem's new ASTI framework in allowing investment in new transmission capacity on a strategic, programmatic basis. This new framework also provides significant incentives for transmission owners to deliver projects on time through a series of rewards and penalties for delivering projects early or late respectively and is based on the decrease or increase in constraint costs the project can provide.

82 **https://www.frontier-economics.com/media/gzwnyljs/implications-of-cost-of-capital.pdf**
83 **https://ukerc.ac.uk/publications/zero-carbon-electricity/**
84 **https://www.ofgem.gov.uk/publications/assessment-locational-wholesale-pricing-great-britain**
85 **https://ukerc.ac.uk/publications/transition-risk-investment-signals/**

This represents an important part of the process of providing incentives for organisations that control the risks, in this case transmission owners. Under a GB-wide wholesale market with firm access rights for market participants, the remaining risk is held collectively by consumers, with Ofgem acting on their behalf to manage risk. By contrast under market arrangements without firm access rights, poor decisions on network investment will lead to risks and costs faced by *individual* wholesale market participants including all types – generation, flexibility and end-users. However, these parties have no ability to control or influence either the correct decisions over network planning or the successful and efficient delivery or operation of network infrastructure. Market reform options which remove firm access rights are therefore unlikely to deliver the principle of confidence for market participants.

4.5.3. The role of flexibility and how to ensure it is used effectively

Flexibility is a term that covers a range of technologies. It includes energy storage, international interconnection and demand flexibility (including new forms of electricity demand which can be specifically designed for flexible operation). It also includes the operation of generators in a flexible way – for example traditionally gas peaking plants have provided flexibility to the system through their capability to start up quickly and adjust their output at short notice.

The range of services flexibility provides are equally diverse. Flexibility services range from automatically providing a very fast response, on the order of less than a second, to changes in frequency through to manual scheduling of the timing of generation and demand a day or more ahead.

Today's focus on flexibility derives from both the need to move away from traditional technologies based on fossil fuels, the consequential growth in variable renewables increases the need for flexibility at several levels.

The need for flexibility in Scotland is also influenced by the balance of generation, demand and network capacity. Curtailment of renewable generation represents an opportunity to leverage flexibility so renewables are used more effectively. Figure 14 shows the capacity of energy storage, as an example of a flexibility technology, in the NGESO 2022 FES scenarios. This show GB storage capacity growing from the current level of about 3 GW to between 20 GW and 40 GW by 2035. In Scotland the range in 2035 is between 3 GW and 7 GW up from 1 GW today.

One of the limitations of current market arrangements is the lack of a framework to match excess renewable generation in an area of the transmission network with opportunities for flexibility. Currently, the main route to do this is through the Balancing Mechanism where flexibility can, as with other market participants, bid to increase its output for a specified price and can be dispatched in preference to curtailing renewables.

However, this mechanism was never designed for bulk dispatch of flexibility and has several important limitations. For example, it is designed for large-scale providers, and although recent changes have allowed some degree of aggregation of smaller projects, this remains a limitation.

Input from stakeholders supports the need for improved mechanisms to incentivise flexibility to operate in ways that reduces curtailment of Scottish wind generation. This would represent an improvement to the system that is of benefit both to Scottish and GB consumers.

Zonal or nodal locational wholesale market pricing is one mechanism that could provide location-dependent price signals to flexibility and incentivise it to locate in constrained areas. However, as discussed above, this would likely be at the expense of confidence for renewable investors and it remains unclear the degree to which locational pricing would deliver revenue sufficiency and revenue certainty to flexibility providers. In particular a number of flexibility providers have made the point that the underlying rationale for the flexibility business case is the development of intermittent renewable generation[86].

Ensuring Scottish flexibility can access otherwise curtailed generation leads to lower electricity costs in Scotland, whilst the relief this provides in terms of constraint costs is a benefit to consumers across the whole GB system. The proposed 'what good looks like for Scotland' outcome proposed below for the exploration of options to do this, such as a regional constraint management market, represents an alternative to moving the entire wholesale market to locational pricing.

An example of how such a system could support Scottish ambitions is in the development of green hydrogen. Hydrogen electrolysers will create additional demand which can use otherwise curtailed wind generation. By ensuring hydrogen capacity can, when there is excess wind, reduce curtailment by consuming electricity at very low cost and can lead to benefits for the electrolyser operator and for consumers who have lower curtailment costs to cover. A well designed and stable set of locational flexibility market arrangements could encourage the development of electrolysers in Scotland and help deliver hydrogen production capacity targets.

Such a system would also encourage other types of Scottish flexibility including battery storage, pumped storage, flexible EV demand, EV 'vehicle to grid' and flexibility from electric heating demand including heat pumps.

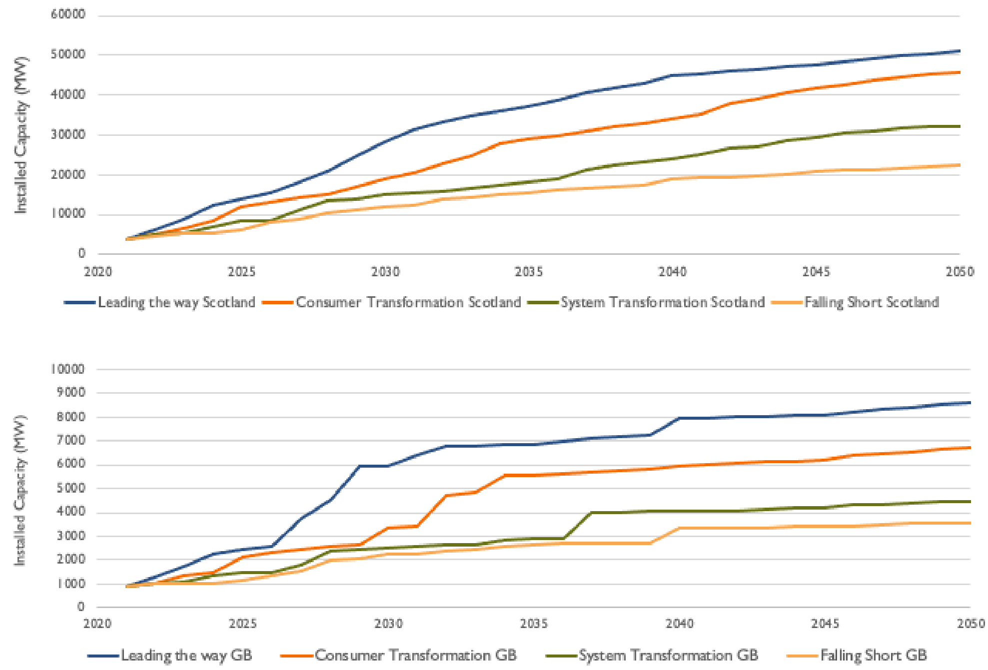


Figure 14: Energy storage capacity in GB (top) and Scotland (bottom) under the four 2022 NGEO FES scenarios.

86 For example see here: **https://strathprints.strath.ac.uk/83868/**

4.5.4. The need for dispatchable low-carbon capacity

The final area where investment confidence is needed is for dispatchable low-carbon generation. This includes hydrogen power stations, gas with carbon capture and storage (CSS) and bioenergy with CCS (BECCS).

These technologies will be needed to fill the gaps when the wind isn't blowing and other flexibility technologies are unable to bridge generation and demand. Delivering these technologies is also an important part of Scotland's wider net zero ambitions. The development of a carbon capture and storage cluster based in eastern Scotland ('The Scottish Cluster') is important for industrial decarbonisation and would be supported by the development of dispatchable CCS power stations.

It is also important for security of electricity supply. Recent work by Regen, shown in Figure 15, illustrates what the dispatch of the GB electricity system in 2035 may look like during a winter day with relatively low wind levels[87]. This day illustrates the importance of dispatchable generation for security of electricity supply: on days like the one illustrated the system will rely on dispatchable low carbon technologies to ensure supply can meet demand.

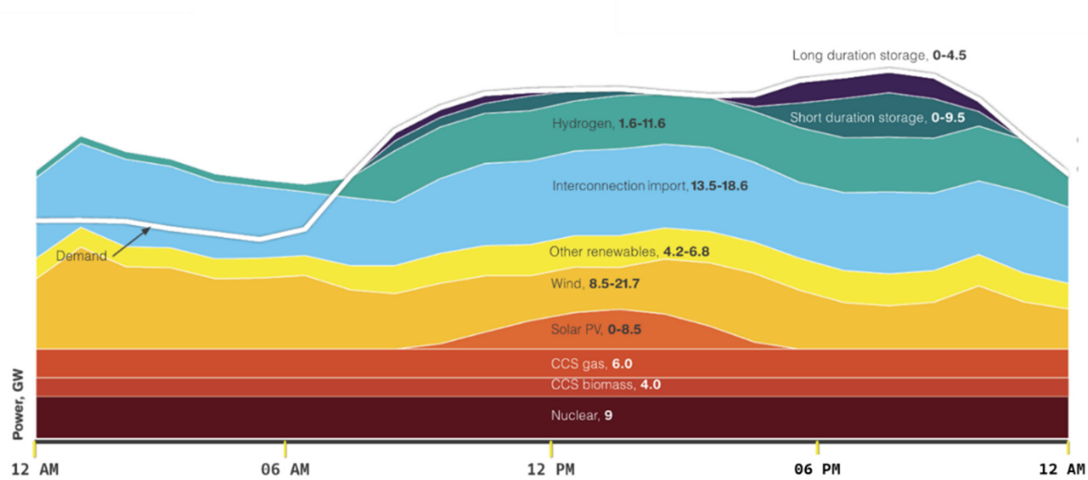


Figure 15: Illustration of dispatch of the GB electricity system for a winter day with low wind, showing the importance of dispatchable low-carbon technologies including gas CSS, biomass CCS and hydrogen power stations.

Despite its importance, dispatchable low-carbon generation will not be needed for the majority of the time when wind and solar generation are available.

To provide the revenue certainty and revenue stability needed for investment in these technologies it will be important to develop frameworks which reward the specific value assets provide, namely security of supply and the ability to deliver flexibility and operability.

87 https://reports.nationalgrideso.com/bridgingthegapdayinthelife/

4.5.5. What good looks like for Scotland

Retain a GB-wide wholesale market and a pricing mechanism, such as an evolution of CfDs, linking long term costs to prices.	Targeted, forecastable, stable, locational investment signals for generation, demand and flexibility, e.g. through reform of TNUoS.	Operational locational price signals to reward flexibility for reducing network constraints e.g. a regional constraint management market.

A GB-wide wholesale market

Although a locational market could lead to a *theoretically* more efficient electricity system under a relatively limited scope of economic value, it is highly uncertain whether that value would be delivered in practice. In addition, moving to a nodal or zonal system will create significant additional risk for market participants of all types and on a broader concept of value is unlikely to support delivery of societal or consumer needs and outcomes.

The risks associated with locational markets can be grouped into three:

- **Risk of change:** developers are already aware that significant change to market arrangements is likely over the remainder of the decade and will respond to that risk aiming to mitigate or manage the uncertainty over future revenue streams and costs. This group of risks is not limited to LMP, but applies to all options which involve significant changes to market arrangements.
- **Implementation risk:** the transition to an LMP system will be a complex project and is inherently risky. Market participants are likely to factor in their confidence in government's ability to make good decisions, and their confidence in delivery bodies in implementation. The risk associated with implementing LMP in GB is increased by the fact there would likely need to be significant innovation. For example, LMP markets have not previously been combined with CfD mechanisms, and the preponderance of wind-led network constraints may require a radical adaption of LMP market mechanisms such as Financial Transition Rights[88].
- **Inherent risk:** LMP significantly alters the balance of risks between market participants. In particular, by removing market participants' firm access rights, it increases the risk on all individual parties (generators, flexibility providers, and end-users via their supplier) associated with the delivery, or not, of new transmission capacity. Some of these inherent risks can be mitigated by the wider set of market reform arrangements, although as noted against implementation risks, this will depend on significant innovation which itself will introduce further risk.

For these reasons, the introduction of nodal or zonal markets is unlikely to be consistent with the principle of confidence for investors in generation, flexibility or consumption.

This conclusion does not imply there is not value from locational signals, or from changing the risk and cost exposure of some market participants in a locational way. However, rather than attempting to deliver these signals through a wholesale transition to locational prices, more targeted approaches can be used. The next two outcomes focus on developing those alternative options.

88 For a detailed discussion see **https://strathprints.strath.ac.uk/83869/**

Recommendation:

4. UK government and other organisations who are leading the discussion should rebalance the focus of the REMA debate away from discussions focused on locational wholesale pricing towards options which evolve the existing GB-wide wholesale market design. Options for providing locational signals within the current market design have not yet been explored in sufficient depth and more emphasis is needed to support good decision making.

Targeted, forecastable and stable locational investment signals

Locational investment signals are those which are delivered to potential market participants ahead of their decision to invest at a particular location. Timescales for final investment decisions can vary significantly by technology, from around a year for smaller solar projects or some battery projects through to four or five years for large offshore projects or longer for some large dispatchable low-carbon power stations.

There are several investment timescale signals in today's market. The strongest investment timescale locational prices signal for generation comes from Transmission Network Use of System Charges (TNUoS) which aim to provide a signal on investment timescales and which are cost-reflective. Although there are concerns around the design of TNUoS (and work is being undertaken to review and reform their design), it is clear they do deliver a strong locational signal[89].

Figure 21 shows the locational TNUoS prices forecast by NGESO for 2027/28 and these have been converted into £ per MWh for a generic intermittent generator with a 45% load factor (representing a conservative estimate of the load factor for an offshore wind farm)[90]. More northernly locations in GB are to the left of the graph and more southernly ones to the right. It highlights that the price differential between a generator in the north of Scotland and one connected in south Wales could be as much as £12 / MWh.

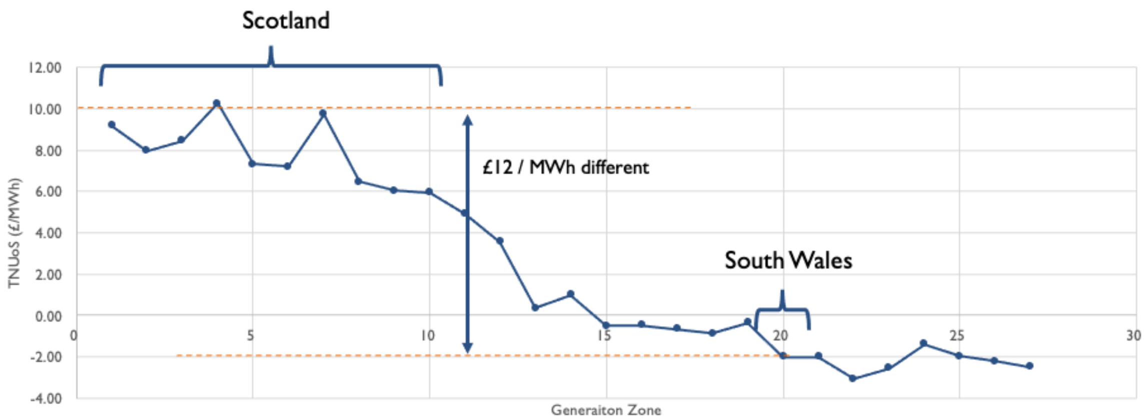


Figure 16: Forecast 'wider generation' TNUoS costs for an intermittent generator with 45% load factor in 2027/28 converted into £/MWh.

The concerns raised around the existing TNUoS price signal include the fact the way it is calculated is not transparent, future prices are volatile and unpredictable, and the locational signals it introduces is too strong and forms a barrier to net zero. This highlights three difficulties REMA will need to engage with when setting investment-scale price signals:

- Identifying what is truly cost-reflective can be challenging and is sensitive to the model being used or on the sub-set of costs being considered. For example, the TNUoS calculation is based on a notional model of the GB transmission network and high-level assumptions about how it is operated.

89 https://www.ssen-transmission.co.uk/information-centre/tnuos/

90 https://www.nationalgrideso.com/document/248611/download

- Considering the degree to which full cost-reflectivity is consistent with other objectives. For example, both TNUoS and locational wholesale price signals are likely to reduce the value of generation in Scotland and potentially make the development of renewable generation that is beneficial to both Scotland and the whole of GB more difficult.
- Ensuring price signals designed to inform investment are delivered in a way that can lead to meaningful responses from market participants. A concern raised regarding TNUoS is that it is recalculated annually using a methodology with unpredictable outcomes, leading to volatile and non-forecastable changes over time. Once built there is nothing a generator can do to respond to the annual changes in TNUoS charges imposed.

TNUoS also provides demand-side locational price signals, however at present these are blunted because the lowest value the locational element of demand-side TNUoS can take is set at zero. Without this rule, charges consumers in the majority of northern Britain would otherwise face would be negative, representing a payment to demand. The price floor removes a potentially important locational signal for the demand side. Figure 17 shows the scale of impact on a £/MWh basis for a half-hourly metered load with a load factor of 50% calculated against its triad demand. The negative values in zones 1 – 5 represent demand payments.

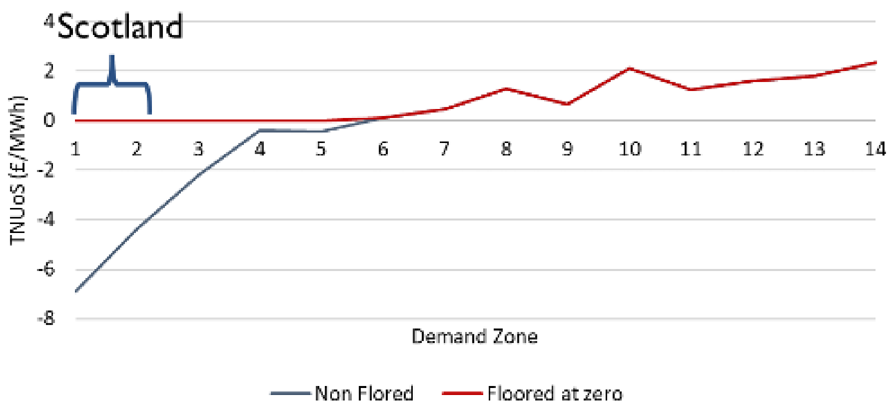


Figure 17: Demand TNUoS, for 2023/24 converted into £/ MWh for a load with a 50% load factor against its triad demand and showing results that (a) included the rule which floors the value at zero (current arrangements) and (b) with the 'floor at zero' rule removed.

Recommendation:

5. Scottish stakeholders should work with Ofgem and National Grid ESO (NGESO) to explore options to reform current arrangements for TNUoS that deliver appropriate locational investment signals, in a way that can support good decision making from all sides. Where market participants, including end-users and flexiblity providers, create system savings they should benefit from low transmission charges or income from transmission payments.

Operational locational signals

In addition to signals on investment timescales there is value in market participants receiving signals which can influence their operation. This is particularly important in shaping the behaviour of flexibility and aligning the operation of storage, demand response and dispatchable low-carbon power with the prevailing balance of renewable availability, inflexible demand and network availability.

In today's market there are limited locational operational signals. The GB-wide nature of the wholesale market means wholesale trading up-to gate closure is, by design, location agnostic. Operational signals are then delivered during the final hour before delivery through the BM which is able to pay market participants to adjust their contracted position. There are several limitations with this approach. Firstly, the quantity of adjustments being made through the BM has been growing over recent years, reflecting the growing level of transmission constraints and secondly, as discussed under Principle 2 above, the cost of those constraints is expected to grow significantly over the remainder of this decade. The system was originally designed to take residual actions rather than to redispatch a large percentage of market actions, and the processes which underpin the BM at times struggle to deliver an efficient redispatch.

A second limitation is that, historically, the BM has only been open to wholesale market participants and the majority of the demand side has not been able to participate. This reflected the assumption that, with the exception of a few large consumers, most demand was not responsive to price. In recent years, rules have evolved to allow aggregators to draw together demand and other small users into 'virtual BM units' which can participate in the BM with the aggregator spreading the response required across the virtual BM's portfolio[91]. However, this does not overcome the challenge that BM signals are only delivered at most an hour ahead of operation. Energy storage for example needs to consider its charge and discharge cycle over periods of at least a day. Whilst relatively short-notice signals suit some forms of flexibility, others would be able to respond more effectively if operational signals were delivered further ahead, for example day-ahead or longer.

An enhancement of the BM approach has recently been introduced in Spring 2023 by NGESO to manage the constraint between Scotland and England[92]. This process involves operating a day-ahead market for participants capable of turning down generation or turning up demand and operates when there is a clear expectation Scottish wind generation will need to be curtailed in order to manage network constraints.

Although the Scottish local constraint management market is being introduced as an interim solution, its ideas could form the first step in the evolution of an enhanced form of constraint balancing across GB. Table 4 highlights some of the elements of the trial project which could be expanded to provide a full-scale mechanism.

The feasibility of a regional constraint management market needs to be explored in detail. There are some significant potential issues that need to be explored before deciding to pursue the approach. For example, the constraint management market would be operating parallel to the wholesale market with market participants potentially able to trade in both. This creates the risk the two markets can be gamed and there may be unintended interactions between the two.

91 **https://www.elexon.co.uk/about/roles/virtual-lead-party/**

92 **https://www.nationalgrideso.com/industry-information/balancing-services/local-constraint-market**

Table 4: Opportunities to evolve the transitional local constraint market currently being introduced in Scotland into a wider mechanism to provide locational operational signals alongside a GB-wide wholesale market.

2023 Scottish local constraint market	Full scale regional constraint management market
Operates day-ahead and intraday	Could operate up to several days ahead of delivery with timescales decided based on the ability to forecast likely constraint behaviour
Operates 'behind' the constraint only for generation turn down and demand turn up	Operates both behind and ahead of the constraint to reduce costs associated with both constraining of renewables and constraining on replacement generation
Operates across a single constraint	Operates across multiple constraints

Recommendation:

6. Scottish stakeholders should work together with UK government, Ofgem and NGESO to explore in greater detail how a regional constraint management market could operate alongside a GB-wide wholesale market.

Annex A: Glossary of Terms

ASTI	Accelerated Strategic Transmission Investment
BECCS	Bioenergy with Carbon Capture and Storage
BEIS	UK government Department of Business Energy and Industrial Strategy
BM	The Balancing Mechanism
CCC	The Climate Change Committee
CCGT	Closed Cycle Gas Turbine
CCS	Carbon Capture and Storage
CfD	Contract for Difference
CM	Capacity Market
CSNP	Centralised Strategic Network Plan
DESNZ	UK government department of Energy Security and Net Zero
ESO	Electricity System Operator
ETS	Emissions Trading Scheme
EV	Electric Vehicles
FES	Future Energy Scenarios
FSO	Future System Operator
GVA	Gross Value Added
GW / MW / kW	Gigawatt, Megawatt, Kilowatt
HND	Holistic Network Design
LCoE	Levelised Cost of Energy
LMP	Locational Marginal Pricing
MT CO2e	Mega Tonnes of Carbon Dioxide equivalent
NGESO	National Grid Electricity System Operator
NOA	Network Options Assessment
REMA	Review of Electricity Market Arrangements
SFT	Scottish Futures Trust
SWESS	Scottish Whole Energy System Scenarios
TNUoS	Transmission Network Use of System charges
TWh, GWh, MWh	Terrawatt hour, Gigawatt hour, Megawatt hour.
UKERC	UK Energy Research Council
UKG	UK government