Regen's response to the Electricity System Operator

Future Energy Scenarios

2024 Call for Evidence

October 2023

About Regen

Regen is an independent centre of energy expertise with a mission to accelerate the transition to a zero-carbon energy system. We have 20 years experience in transforming the energy system for net zero and delivering expert advice and market insight on the systemic challenges of decarbonising power, heat, and transport.

Regen is also a membership organisation and manages the Electricity Storage Network (ESN), the voice of the UK storage industry. We have over 150 members who share our mission, including clean energy developers, businesses, local authorities, community energy groups, academic institutions, and research organisations across the energy sector.

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Introduction

Since 2015, Regen has pioneered the development of Distribution Future Energy Scenarios (DFES) which are based on the annual FES produced by the ESO team. We work with National Grid Electricity Distribution (NGED) and Scottish and Southern Electricity Networks (SSEN) to undertake detailed, evidence-led scenario analysis for the South West, South Wales, East Midlands, West Midlands, North of Scotland and Southern Central England distribution licence areas.

We spend a lot of time analysing and using the FES every year, from liaising with the FES team to a deep digest of the data workbook and suite of reports. When delivering the DFES, Regen carries out comparisons and reconciliations of bottom-up DFES data to the FES data, considering connected baselines, near-term pipelines, regional and local plans and long-term projections.

We also extensively reference the FES in wider policy and market insight work we do at Regen, in line with our mission and strategic goals.

Regen is very supportive of the transition from scenarios to pathways and eventually to what we hope will become an integrated delivery and system plan for net zero.

The FES scenarios have been a very important part of the UK energy landscape since they were introduced in 2011. Our team at Regen looks forward each year to the new publication, and we recognise how much the FES has developed both in terms of its content and presentation.

The original FES had only one scenario that would have achieved the UK's climate change commitments, now the FES has three scenarios that are aligned with the Climate Change Act. This is a sign of how mainstream and embedded the delivery of net zero has become.

The next logical progression would be to move away from hypothetical scenarios, each given equal weight, towards alternative pathways and with one pathway given additional weight as the current "best route" to net zero. How that "best route" is determined will be challenging, and will itself develop over time, but making that intellectual step will help the UK to develop a much clearer delivery plan for net zero and help policymakers confront the key energy issues that must be addressed.

We would anticipate that the analysis and evidence to support the "best route" will develop and improve over time, and so we would urge the ESO to be ambitious even if the first iteration is open to challenge and critique.

Adopting knowledge sharing and continuous improvement processes

As users of the FES, we have seen that the analysis and evidence have improved over time. This is partly due to the team's increasing engagement and input from across the energy industry.

A particular area of interest for Regen is the integration and alignment between the "top-down" national and regional view of FES, with the more "bottom-up" analysis that is coming from the DFES processes within the DNOs and, increasingly, from the various Local Area Energy Planning (LAEP) projects that are happening at a local level.

Regen has for some time suggested that there is a need to create knowledge/data sharing arrangements between FES and DFES processes, with an annual cycle of continuous improvement that will benefit both processes. There will also be a need to incorporate and align FES with the role and outputs from the new Regional System Planner function.

We would like to offer our help and insight to ESO as the Future Energy Scenarios evolve. We also welcome the opportunity to remain closely engaged with the evolution of the FES framework, data and publication.

Keeping FES real and focused on Net Zero and Energy Security

The politics around net zero is becoming more divisive and fraught. We are increasingly seeing lobbying from within the industry for certain technologies and solutions which is then spilling into the general media and discourse around net zero. Often this is being led by a post-truth disregard for actual evidence and facts. The recent campaigns against EVs and heat pumps in the media are a good example of this.

It is going to be increasingly important that the FES (and the ESO in general) can maintain a firm evidence-based approach to pathway development and be very straight in terms of its risk analysis.

From our perspective, we would highlight areas like, hydrogen for heating, Direct Air Carbon Capture (DACCS), biomass, and increasing our dependency on gas as potential areas where the FES will be heavily lobbied.

Response

Publication and engagement

Regen spends a lot of time digesting the FES every year, from liaising with the FES team to a deep digest of the data workbook and suite of reports. We always find that the FES team responds to our numerous queries on all aspects of the FES in a timely and comprehensive manner. The exhibition-style FES launch this year was very helpful for us to understand in greater detail the way that the FES interacts with other programmes within ESO and the development of the FES going forward.

FES 24 framework

Q6. *Ofgem has stated that they require a narrower range of pathways/scenarios to net zero for network planning purposes. How do you believe FES should represent the wider range of outcomes which are credible but not to be used for network planning?*

We would support the idea of identifying one of the pathways as the current "best pathway" which would then become the baseline scenario for network planning and the CSNP.

How that "best pathway" is defined will be challenging. We would suggest that the ESO adopts a balanced scorecard approach to determine the best route:

- Cost would be an obvious criterion, but cost analysis will be heavily influenced by what assumptions are made. Costs will also be uncertain.
- A second criterion should include the overall delivery risk or viability of a pathway. For example, a pathway that is based on current or achievable technology would be preferred over a pathway that relies on, yet to be deployed, unicorn solutions.
- A balanced system in terms of technologies and locations is also a key criterion.

This approach was used, with the ESO, to develop a scenario used for the Day in The Life 2035 narrative. Ideally the ESO and FES would also work more closely with DESNZ and organisations like the CCC to reach a consensus on the central pathway.

We would also support the idea that the difference between the three net zero pathways could be narrowed. Rather than create scenarios that explore the outer edges of the

envelope of possible outcomes, it would be better to centre all scenarios on the most likely and credible solutions and then include a more limited number of sensitivities. Alternative, more speculative, technologies could then be included in the accompanying commentary and risk analysis. New technologies that become viable alternatives can be introduced to future FES iterations.

A key area of uncertainty is the solution for dispatchable low-carbon generation, and whether this will be in the form of Gas with CCUS, Hydrogen generation and/or bioenergy. One approach would be to group these technologies together and then discuss the alternative options with an analysis of their relative strengths and challenges.

Q7. *Ofgem has set out their expectations for our scenario (pathway) work to feed the CSNP. They have stated that FES should include a counterfactual, though this should not be used for network planning. We currently present Falling Short alongside our net zero scenarios which assumes some policy intervention beyond today, but does not reach net zero. What do you believe should be the purpose of a future counterfactual scenario and what should this include by way of progress beyond today?*

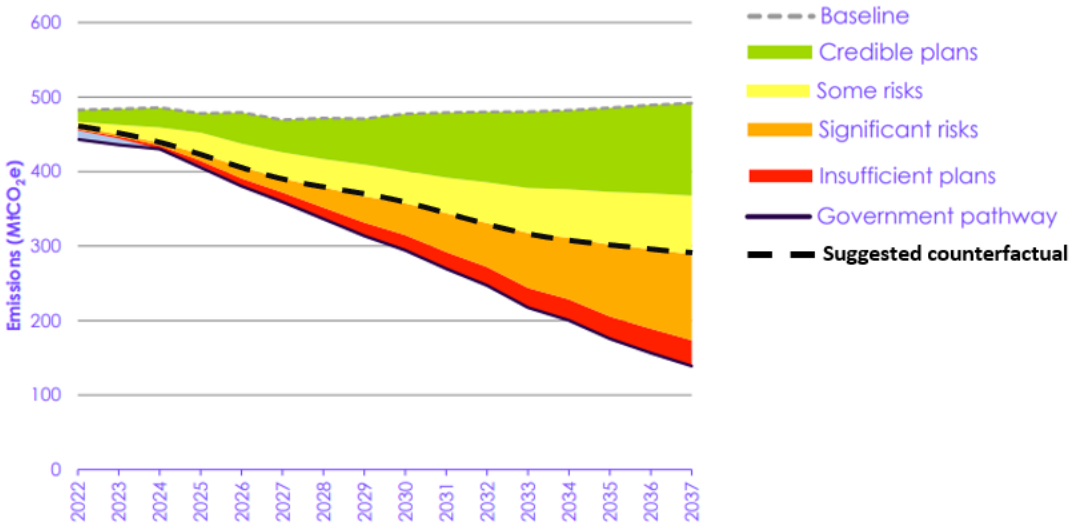


Figure 4 from CCC Progress Report showing suggested counterfactual

Regen would suggest the use of a counterfactual scenario that explicitly resembles the UK's current trajectory based on the current rate and projection of deployment and the current, delivered policy environment. This could be similar, or even aligned with, the

assessment made by the Climate Change Committee for the current trajectory with credible plans and some risks.

This would then highlight to policymakers and investors the areas of progress as well as where the delivery of the future energy system is falling short. So, for example, while the target for offshore wind is 50 GW by 2030, the current trajectory given projects with CfDs, the current build pipeline and historic construction rates may be closer to 30-35GW.

Q8. *We have received feedback that we should include scenarios with high levels of natural gas. a) What levels do you believe are reasonable to include as a sensitivity or core planning pathway b) Do you believe the carbon budgets will be met in a higher gas world? If so, how? Please include any reference to evidence that you may have to support your view.*

The UK demand for natural gas is currently around 800 TWh. There is no credible route to net zero that maintains a high dependency on natural gas at anything like that level. Regen recently contributed to this BBC More or Less episode on gas licences.

A smaller volume of natural gas could play a role in a more limited role in a net zero energy system:

- Gas with CCUS for power generation is an option but we would expect these plants to be expensive and to have a low capacity factor – may be as low as 5-10% - so the volume of gas used would be far less
- Gas could be used to produce Blue Hydrogen – although this seems an increasingly unlikely solution in the longer term due to costs and energy security concerns, as well as the lack of investment in CCUS plant.
- Unabated gas for power and heat will continue in the short term but should be reduced rapidly from 2035 onwards

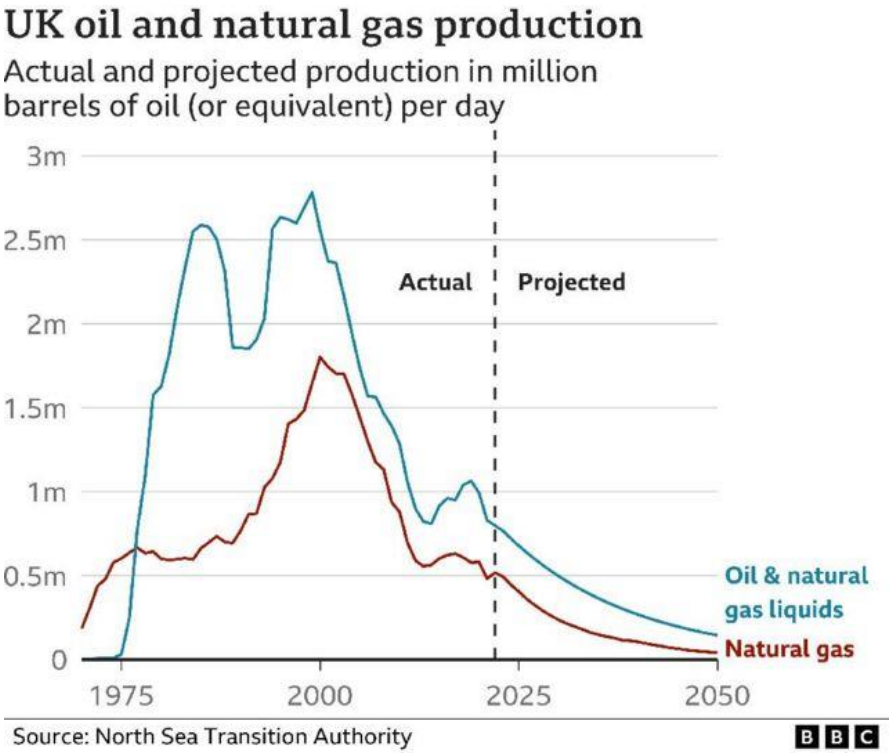
Any scenario that is reliant on natural gas must be able to justify how that gas can be used in a way that is **net zero compliant** and **where that gas will come from**.

Retaining high levels of natural gas will lead to a greater reliance on CCS to meet carbon budgets. Regen sees the scaling of CCS as a key risk to net zero delivery and so we would advocate for designing an energy system that minimises its role where possible.

One of the key benefits of moving to a net zero power system is the greater energy security that generating energy from domestic sources brings. Retaining high levels of natural gas will leave us dependent on importing fuels in what is likely to be a tight

market as fossil producers are unwilling to invest in a market destined for long-term decline.

Analysis from NSTA suggests that, even with recent licences, the UK's production of natural gas is in terminal decline and will fall rapidly from 2030 onwards.



Q9 *As the ESO becomes the Future System Operator (FSO) we will have a wider whole energy remit and focus as an organisation. Does this change what you would like to see in our scenarios? If yes, please set out what changes you would expect and why.*

Yes, we would expect the FSO role to give the FES more authority and credibility such that the FES "best route" view would become the central delivery plan for the UK.

The movement to pathways, with one pathway representing the "best route to decarbonisation", presents an opportunity to gain consensus around a central decarbonisation pathway. Regen suggests that ESO should work with Ofgem and DESNZ towards public endorsement of the FES pathways so that ultimately "pathway one" can become the UK's decarbonisation plan.

Ideally, the "best route" FES pathway should then form the base case for any studies and analysis conducted by DESNZ, Ofgem, and CCC and become the reference scenario for Regional System Planning. This will require the FES team to work more closely with

these organisations. The FES should also be aligned with any future Spatial Strategic Energy Plan.

For 2024 the FES team could take a step in that direction by providing a reconciliation against the latest CCC Balanced Pathway scenario.

Other responses relevant to FES 24 framework

Interim carbon budget compliance: Regen agrees with ESO that all three pathways should be Net Zero compliant. This must include compliance with interim carbon budgets as well as the 2050 target.

Net Zero

Q10. *What are your thoughts on current net zero policy and what is needed to deliver a net zero economy?*

The UK is not on track to deliver its net zero commitments. This has been highlighted by the recent CCC progress report. From our perspective, the major gaps are:

- Deployment of renewable energy technologies has stalled and is now under threat. The recent CfD AR5 means that the UK is falling behind in offshore wind and is unlikely to meet its 50 GW by 2030 target. 35 GW is a more likely outcome.
- The rollout of heat pumps is increasing but is still a long way from the 600,000 target that was set. Heat, in general, is a high-risk area due to the complexity of asset replacement.
- EV uptake is increasing but could be jeopardised by the lack of investment in the charger network and the recent softening of the government's milestone to end the sale of ICE vehicles
- Progress to invest in new CCUS plant is woefully late and must be considered high risk
- Investment in low carbon dispatchable generation (Gas and CCUS, hydrogen generation) is too slow with significant amounts of unabated fossil still in the transmission and distribution connection queues

Q11. *What is the biggest challenge for the UK in meeting net zero by 2050 and what must be done to overcome it?*

Key barriers include:

- **Planning and grid capacity:** Grid investment needs to be stepped up and accelerated. Some of the enablers to do this have been identified by the Winser Study. We are also pleased to see this on the agenda for Labour.
- **Net zero investment environment:** Government must re-establish the UK's leadership position for net zero investment.
- **Heat:** Decarbonisation of heat is critical and requires a radical approach to ensure that the value of low carbon heat is reflected in the value of properties. Regen's decarbonisation of heat paper written several years ago is still relevant today.
- **Market reform**: Market reform ought to be an opportunity to make the UK more attractive for investment and to ensure that the value of low carbon energy benefits the consumer. However, at the moment market reform is being distracted by an unhelpful debate around LMP which would hinder investment and not deliver the benefits claimed. Regen recently wrote to the REMA team outlining our recommendations.

Q12. *What is the biggest opportunity for the UK in reaching net zero by 2050?*

Net Zero presents a fantastic opportunity for the UK to:

- Provide global leadership to tackle climate change
- Create new jobs and businesses in the green economy
- Support innovation and technology development
- Support levelling up and regional development
- Reduce dependency on imported fuels
- Reduce pollution and secure public health benefits
- Invest in the UK building stock
- Support nature-based solutions that protect the environment and add to biodiversity
- Reduce consumer bills in the longer term and tackle fuel poverty

Q13. *What role do you believe emissions removal technologies such as Direct Air Carbon Capture and Storage (DACCS) should play in delivering net zero by 2050? If you believe they play a role, what is needed to scale up its application? If you believe DACCS plays a role, should the power required be considered as additional demand or only operated using otherwise curtailed electricity?*

The FES team should be very wary of scenarios which rely on DACCS. DACCS could have a role but at the moment the technology is not mature at scale and the costs are unknown. It is therefore too early to include DACCS as a scenario solution.

It would be unhelpful and misleading to present a scenario with high emissions which then relies on a unicorn solution like DACCS to meet net zero targets. Any surplus renewable electricity should be used to reduce our use of fossil fuels before being to power DACCS.

Energy demand

14. Where are our current assumptions/scenarios about the future of demand most and least credible? What do you think we need to change and why? What evidence should we be considering?

Overall the FES assumptions for the future of demand have a strong level of credibility at a national level. Ensuring consistency of demand assumptions year-on-year, except where major baseline changes or policy decisions (e.g. hydrogen for heating decision in 2026) necessitate wide-scale changes is valuable for network planning at TSO, DNO and Local Authority level. Ensuring a clear interface with DFES and the future RSP to ensure the understanding at a regional level is equally strong would be a sensible focus for future rounds of FES.

There are some areas where we think assumptions could be revisited:

Hydrogen electrolysis capacity

- H2 electrolysis is hard to forecast because we are still at an early stage of technology roll-out
- The national FES projections for hydrogen electrolysis are reasonable but we are finding that the regional view of H2 electrolysis does not always correspond to what we are seeing in the distribution pipeline.
- A key assumption that we would query is that annual capacity additions are added to the distribution network if under 50 MW and to transmission if over 50 MW.
- We would be happy to share our analysis with the FES team and to discuss trends

Capacity factors for gas generation

- As the power system moves increasingly towards very high levels of renewable energy generation it is logical that output from dispatchable gas (fossil and hydrogen) will fall. However, the assumed capacity factors mustn't be so low that they fall below what will be commercially viable. In recent FES editions gas plants have had extremely low capacity factors in the long-term projections. If this is the

case, the FES could explicitly state that very low capacity factors will need to be supported by new markets or updated Capacity Market.

Heat (including residential, industrial, and commercial)

- **Hybrid heat pumps:** Our DFES stakeholder engagement and analysis has shown that hybrid heat pumps (both natural gas and hydrogen) have limited prospects for uptake, given the additional costs associated with this dual solution. We think that the gas network standing charge will provide a deterrent to retaining a gas network connection for infrequent boiler usage.
- **Blending hydrogen:** Due to the high cost to consumers (or requirement for subsidy), Regen does not envisage blending as a likely route to hydrogen market development. The best route to market for hydrogen will be via industrial clusters and high-value applications. There is significant existing industrial demand for hydrogen that could used to stimulate green hydrogen production.
- **100% hydrogen for domestic heat:** We realise this is still a theoretical option but the cost, delivery and safety issues would suggest that this will not be a significant solution for net zero. If a high hydrogen scenario does include use for domestic heating we suggest this should be minimal and should be highlighted as a significant risk

Residential (excl. heat)

- **Domestic batteries:** Adoption of batteries has accelerated as homeowners install rooftop solar to avoid high electricity prices. The low levels of adoption in System Transformation are at odds with the rate of adoption currently being seen on the ground. But we are not seeing the very high levels of deployment envisaged in Leading the Way. This is a good example where a narrowing of scenario outcomes would be helpful.

Industrial and commercial (excl. heat)

- **Data centres** have become a significant problem for DNOs in recent years, most notably in West London along the M4 corridor. Regen would be happy to support ESO in developing capacity projections (MW) in addition to energy projections (MWh).

Biomass and BECCS

- Along with a number of stakeholders we are very concerned about the sustainable use of biomass and the assumptions that large-scale biomass combustion can be carbon neutral or (with CCUS) carbon negative

- We are also concerned that Biomass operated as baseload will displace lower cost and lower carbon renewable energy at significant cost to the consumer
- We would recommend not modelling biomass as base load electricity generation but instead to model biomass and BECCS as dispatchable generation and peaking plant. This would then give a more realistic estimate of the volume of biomass needed.
- An analysis of biomass fuel requirements and the source of biomass would add to the analysis

Transport

- **Autonomous Vehicles**: Regen is not confident in the high levels of AV adoption forecasted in the 2040s under Leading the Way. We suggest a narrowing in the range of AV adoption.
- **Shipping:** We understand that the shipping projections are derived from the pathways produced by the CCC.
    - Maritime decarbonisation pathways are still highly uncertain and more research and engagement is needed in this area. Regen has been engaging with a number of ports and maritime clusters to consider future energy in this sector. We have also looked at a number of new propulsion systems. We would be happy to discuss further with the FES team.
    - Regen has significant reservations about the deployment of ammonia as a maritime fuel because of risks to crew safety and marine life. Regen expects short-range applications will be electrified, with longer-range vessels being powered by hydrogen, methanol, or biofuels (and hybrid combinations of these). We understand that the CCC prioritises biofuel use in other sectors such as aviation and BECCS.
    - Through our work with the DNOs we are also aware of increasing electricity demand to service shore power at ports, an area not explicitly mentioned in the FES.
- **Off-highway vehicles and machinery:** vehicles such as tractors and non-road mobile machinery used in sectors such as construction are likely to switch from diesel combustion to battery-electric, hydrogen-electric or hydrogen-combustion powertrains. There are currently 300,000 NRMMs in the UK construction industry.

Hydrogen, gas and bioenergy supply

Q21. *What are the drivers and challenges in determining the location of low carbon hydrogen production? What are the challenges or barriers to delivering low carbon hydrogen to expected locations of demand if this is further from the production location?*

Regen develops a projection for electricity distribution-connected hydrogen electrolysis production capacity as part of the DFES. Modelling production location is particularly challenging for hydrogen because:

- there is significant uncertainty around future hydrogen demand sectors and therefore the location of demand
- hydrogen has a complex value chain with the option to sell hydrogen into multiple markets and via several distribution channels
- in the near term hydrogen production is likely to be co-located with demand, however in the longer term we may see longer distribution channels including the use of H2 pipelines

In our near and mid-term projections we assume that H2 electrolysis production is located near to demand, with short intra-site pipelines, as transport is prohibitively expensive as it is only possible by tube-trailer. In the short-term, our projections are driven by location of electrolysers in operation and in development. Regen maintains a database of ~80 electrolysers in operation and in development across the 6/14 licence areas where we carry out the DFES. We would be happy to share this with the FES team.

Q23. *Do you believe ammonia should become a significant part of energy storage and/or shipping and/or other applications?*

As mentioned in our response to question 14, Regen has significant reservations about the deployment of ammonia as a maritime fuel because of risks to crew safety and marine life. **See Question 14**

Q24 *The last few years have seen a sharp increase in LNG imports to the UK for export to Europe. How long do you see this role being sustained? What is the nature and scale of LNG in the UK's future energy mix?*

It depends on the global energy markets and demand for gas from Europe and Asia.

Ideally the UK would import very little LNG – it is expensive and has a far higher carbon footprint for production and distribution (79kg CO2/boe) compared to domestic (25kg/boe) and Norwegian gas (8kg/boe).

Recent increases in LNG have been caused by concerns over energy security, the war in Ukraine and the very high price of gas in Europe.

- Increased gas storage will also tend to reduce LMG imports.
- Increased LNG capacity in the EU will also reduce the volume of imports through the UK
- As the EU reduces gas demand, in the medium term, LNG imports may also decline

Q25 *Where do you believe policy should go with regard to negative emissions from biomass and imported fuel stocks?* ***Q26*** *What do you believe should be the enduring role and scale of bioenergy in the GB energy mix?*

BECCS (negative emissions) should play a limited role in the UK net zero systems. The current methodology for accounting for negative emissions is flawed:

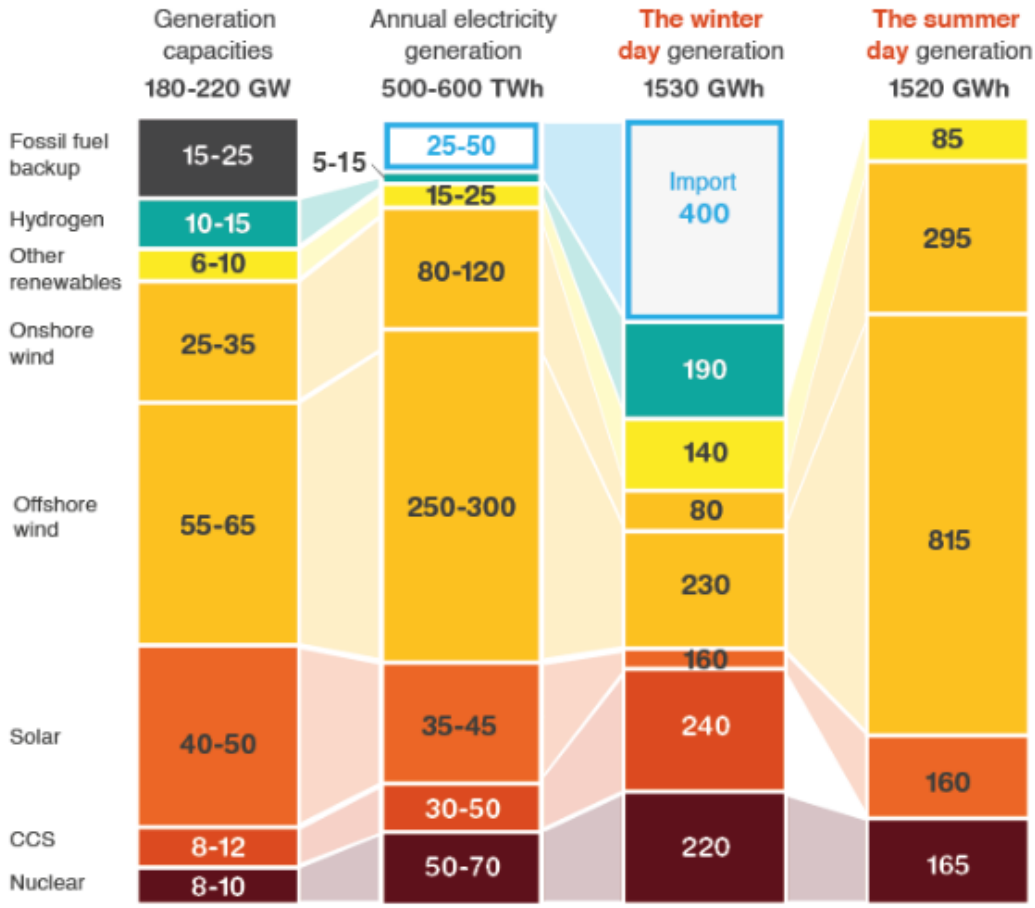
- Along with a number of stakeholders we are very concerned about the sustainable use of biomass and the assumptions that large scale biomass combustion can be carbon neutral or (with CCUS) carbon negative
- The problems with large-scale biomass from woodland include:
    - Doubts about its true sustainability over the long term
    - Carbon emissions associated with soil degradation, pellet production and logistics (especially for imports)
    - Lack of carbon accounting and the risk of double-counting
    - Doubts about the cost and efficiency of CCUS
- Biomass must be from properly sustainable and accredited sources
- Biomass carbon emissions from pellet production and transport must be included
- The time delay between combustion and the creation of a negative emission (when news trees reach maturity) must be considered in the context of the imperative to reduce emissions in the short term
- Imported biomass will almost never be sustainable or carbon neutral
- Current carbon accounting opens the risk of double counting – especially if biomass is imported. Forests in North America, for example, may be replanted but their carbon credits sold to another emitter while still being claimed as a negative UK emission.

  We are concerned that Biomass operated as baseload will displace lower cost and lower carbon renewable energy – at significant cost to the consumer

- We would recommend not modelling biomass as base load electricity generation but instead to model biomass and BECCS as dispatchable generation and peaking plant. This would then give a more realistic estimate of the volume of biomass needed.
- An analysis of where biomass is expected to come from would be a useful addition to FES. Our analysis suggests that hydrogen for peaking plant could potentially be sourced in UK from sustainable sources – forestry arisings, waste wood etc. An analysis of biomass fuel requirements and the source of biomass would add to the analysis. The role of UK biomass crops – short rotation coppice, hazel, miscanthus etc could be explored

Electricity Supply

Q29. In 2035, which of these electricity supply technologies do you feel should have the highest installed capacity within GB? Rank them from greatest capacity to smallest capacity.



The 'Day in the Life 2035' report, produced in partnership with ESO, tested how a net zero generation mix would fare in two challenging weather windows. The generation mix resembles Consumer Transformation (from FES 2021) with a number of changes:

- Unabated gas-fired power was replaced by Gas CCS and BECCS, based on System Transformation figures (thereby remaining within the FES 'credible scenario range')
- Battery storage and interconnector capacity was increased based on known project pipelines
- Hydrogen-fuelled generation capacity was increased based on CCC Balanced Pathway.
- A strategic reserve of fossil fuel plants is retained in 2035 but only used for energy security under the control of the ESO

Generation technology	**Capacity (GW)**
Fossil fuel – strategic reserve	15 to 25
Hydrogen generation (peaking and reserve)	10 to 15
Other renewables	6 to 10
Onshore wind	25 to 35
Offshore wind	55 to 65
Solar	40 to 50
CCS – Gas and BECCS (peaking and reserve not baseload)	8 to 12
Nuclear	8 to 10
Total	**180 to 220**

Q34. Low carbon, renewable energy generation is expected to make up the dominant share of generation in our net zero scenarios in 2050. However, the output of the majority of this generation is weather dependent. We need to understand how periods of atypical weather might influence the electricity system, for example extended periods of low or high wind or sunshine.

Could you give examples of rare weather events either locally or nationally that you think may have the greatest impact on the energy system, especially our ability to meet

demand? This could be events that influence generation or demand. It could also include coincidences of several weather patterns.

For an efficient and resilient decarbonised electricity system, renewables need to be geographically as well as technologically diverse. Drawing on energy from different technologies from different regions across GB, and from neighbouring energy markets via interconnection, makes the system more resilient as diversity and market integration will help to reduce generation and price volatility caused by the weather.

Regen produced the 'Day in the Life' report in partnership with ESO which provides more detail on how a net zero power system could operate through challenging weather periods where resilience is tested.

Regen's 'Go West' paper demonstrates the energy system benefits of a more geographically diverse offshore wind portfolio. **Our analysis of 20 years of wind data suggests that a more diversified wind farm portfolio, with more wind capacity in the west and north west of the UK, could help reduce the number of very low wind periods by around 65-75%.** The results also showed:

- The duration of a 1-in-20 year very low power event could be halved
- The number of occurrences of below 10% offshore wind capacity factor output could be reduced by 76%
- These benefits would be achieved without reducing annual yield (TWh)

Regen would be more than happy to share more detail from this analysis with ESO.

Other responses relevant to electricity supply

Network constraints: The outputs of pathway and scenario analysis should, by definition, be used to inform where and when network investment needs to be prioritised to enable energy project development. To apply existing constraints would be at odds with the aim that pathway analysis is informing network planning - not the other way around. We would therefore support the modelling of network constraints in the near term only (less than 5 years from present).

Regen undertakes detailed analysis on project pipelines from delivering DFES assessments for six of the UK's DNO licence areas. The status of this pipeline already, to some extent, accounts for in-place network constraints because developers do not attempt to build projects in constrained areas. To re-apply these constraints at a holistic level in the pathways could be doubling up the impact of constraints on network and project development.

Regional Assumptions

Q37. *Within our net zero scenarios, we see a significant increase in the amount of storage technologies, for example battery or compressed air storage.*

We are interested in which policies, markets or drivers may impact the growth of these services at a local level, the balance between short term (e.g. less than four hours) and longer term storage, and the suitability of technologies for a particular region.

Long duration energy storage: Regen is currently working with LCP Delta on scenario analysis for DESNZ on the amount of LDES that is required to balance a net zero system out to 2050. This includes an analysis of the amount of LDES required in MW and hours, the technology mix and a locational analysis. This work is unpublished at the moment but is close to completion. The DESNZ policy team will be able to advise on the details of this work. We have recommended that the government sets a target for electricity storage capacity for 2035 in collaboration with National Grid ESO/FSO and industry.

Other responses relevant to regional assumptions

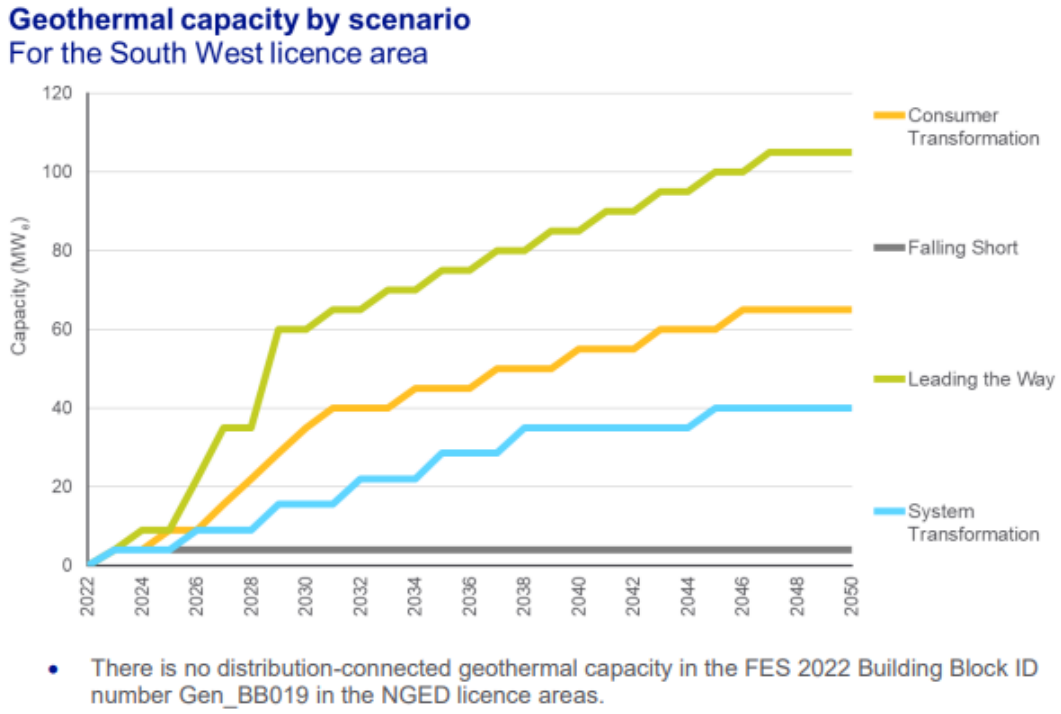
Incorporation of regional datasets: The regional outputs of FES are a key interface between the FES and DFES. Currently this occurs as a 'compare and reconcile' exercise, where the outputs of the DFES are compared against the GSP-level outputs of the FES at a DNO licence area level, and any discrepancy is investigated and explained. Ideally, the DFES would be *the* main form of granular data and evidence for where regions may differ from the national trajectory.

This is particularly valuable for niche or emerging technologies such as electrolysis, geothermal, marine energy etc. that are currently modelled on a project-by-project basis in the DFES, involving substantial project research and regional stakeholder engagement. These technologies tend to be less accurately represented in the GSP-level outputs of the FES, compared to the known baseline and foreseeable near-term.

For more established technologies such as wind, solar and storage, the DFES outputs tend to be more correlated with the FES GSP-level outputs over the longer term. However, the detailed pipeline research and developer engagement in the DFES can lead to discrepancies in the near term, where the pipeline of developing projects dictates these near-term projections. Additionally, understanding of local ambition and appetite for technologies such as onshore wind can lead to deviation between the DFES and FES in some scenarios.

While the details of each pipeline project can be obtained from the DNO Embedded Capacity Registers (which remain a sensible data source to use as an input to FES), the level of additional research and engagement undertaken on the FES on verifying and understanding both existing and accepted connections means that the DFES outputs should be used to directly inform the GSP-level FES projections (and potentially distribution-connected generation at a national level, at least in the near-term).

Geothermal energy is a good example where the DFES differs from the FES:



- There is no distribution-connected geothermal capacity in the FES 2022 Building Block ID number Gen_BB019 in the NGED licence areas.

Microgeneration technologies: With regards to micro-generation technologies, our DFES research of developing 'pipeline' projects has shown a near total drop-off of small-scale anaerobic digestion, hydropower and wind projects, due to removal of subsidies and, for hydropower, unfeasible environmental licence costs. This appears unlikely to change by 2035 or 2050. In comparison, rooftop solar PV and small-scale batteries (both domestic and for commercial properties) are currently seeing explosive growth as a result of current high energy prices, and will likely continue to be the dominant form of microgeneration in the foreseeable future.

FES Modelling process and publication

We have received requests for more data. We publish the data behind the charts presented in FES, and more, in our data workbook which can be found on the FES section of the ESO website. Do you have any feedback on the data presented in the workbook?

Further increasing the transparency of the FES data is something Regen strongly supports. Further visibility of modelling methods, assumptions, input data and approaches to feeding in stakeholder input would be valuable to multiple energy and spatial planning bodies. In particular, the publication of input data and proxy variables would help align the DFES with the FES.

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