The Institution of Engineering and Technology

The Institution of Engineering and Technology (IET) and the Future Power System Architecture (FPSA) group are pleased to offer our response to **Ofgem's Centralised Strategic Network Plan: Consultation on Stage 1 – modelling future supply and demand**.

In responding to the consultation, we have identified the following key requirements:

- **The CSNP should be part of a Centralised Strategic Whole Energy System Plan.**
- **A strategic spatial and temporal development plan for generation is particularly important.**
- **There is a need to begin developing proposals for an accompanying delivery plan.**
- **Government policy and plans should be clear and consistent so that transmission and distribution networks can be planned and built accordingly.**
- **The CSNP should include data and data communication infrastructure requirements.**
- **Attention needs to be given to Ofgem's role as regards the CSNP.**
- **Moving to the front foot for further governance improvements, beyond current proposals, is a necessary enabler.**

These requirements are developed in our commentary below and addressed in our answers to the consultation's specific questions …

Overall Observations

1) Whilst we comment on many individual issues raised in the consultation, one of our most important observations is that **the CSNP should be one part of Centralised Strategic Whole Energy System Plan.** Such a plan would embrace developments for all energy vectors and would be both spatial and temporal. It would provide the fundamental planning assumptions that the CSNP would be built on. **Importantly, this approach would facilitate the development, within the CSNP, of a spatial and temporal plan for new electricity generation capacity** and other assets that fundamentally drive the development of electricity transmission and distribution networks, including flexible and inflexible sources of capacity, opportunities for energy storage, conversion and arbitrage (including across energy vectors) and new energy demand characteristics arising from decarbonisation.

   Such a plan would establish a coherent foundation for generation investment, transmission and distribution network development, and inform the need for aligned enablers including digital systems, regulation, incentives, resources and skills. The scale of the challenge in developing a whole energy system plan is considerable, but until it commences, **and a process of continual learning and refinement** is established, there will be limited confidence in the CSNP for policy makers and investors.

2) We agree that in order to achieve the objective of a decarbonised power system by 2035 and a net zero compliant energy system by 2050, it is necessary to move on from modelling only 'scenarios' to also modelling (a limited number of) 'pathways'.

3) With the above qualification and further important principles and caveats (which we outline later) we generally support the proposition that the FSO should undertake the following …

a) Consider the GB onshore and offshore transmission system as a whole - but not overlooking (i) the increasingly important **role of electricity distribution** in the context of a potential doubling of demand due to electrification of heat and transport, and up to 41% of generation being decentralised by 2050; and (ii) the key enabling roles of **data and data communication infrastructure** in the context of operating smart networks, smart homes and their associated commercial systems. These are substantial areas requiring explicit attention in the CNSP if the strategic investment needed to meet the 2035 and 2050 net zero targets is to deliver benefits to customers.

b) Bring together several existing network planning tools and processes such as the Network Options Assessment (NOA) and Holistic Network Design – **but also DNO Long-Term Development Statements –** the development of which will increasingly need to be aligned with the CSNP process.

c) Build on the current FES **(but also DFESs)** which will play a more critical role as its outputs will help inform network build 'requirements', as opposed to 'recommendations' currently provided via the NOA.

d) Set out strategic pathways (not simply four illustrative scenarios) which would enable the CSNP to be more directive about the type and scale of investment needed, outlining activities (initially) up until 2050.

e) Recognise the importance of high-impact, low-probability events and risks arising from: an increasing dependency on weather-dependent renewables; the variability of weather under climate change increases **(for example as a result of changes to the Jet Stream and/or Gulf Stream)**; and the increasing **potential for cascading impacts** with other sectors (e.g. transport and telecommunications) as a consequence of greater electrification and interdependency.

f) Be capable of incorporating, and testing, extreme data ranges that are high-impact/low-probability, in order to support the FSO's strategic advisory role and advising government and Ofgem of the potential impacts on the future network should an extreme event occur. This would be consistent with Risk Assessment methodologies used in businesses.

g) Factor-in network constraints and the impacts on generation **(including distributed generation)** in the near term but model and ultimately design an unconstrained network in the longer-term (noting that decisions over hydrogen are likely to have a direct impact on transmission constraints, which are potentially beneficial in exporting areas).

h) Provide GB-wide and regional pathways (e.g. North Scotland, Central Belt, South Scotland) plus, industrial hubs with high generation and/or demand.

i) Where a decision affects wider industry, or groups such as Local Authorities, provide the underlying data for re-use, planning and future analysis, hence providing greater clarity and detail to support regional planners who use the FES **- but allowing DNOs and GDNs and ultimately RSPs to exercise regional energy planning at an appropriate level of granularity and devolved working**. The key principle here is for subnational energy planning bodies to be able to exploit opportunities that might be opaque at a national level, whilst at the same time remaining aligned with the national strategic objective

through multiple parties sharing planning data and having other inter-dependencies. This will require careful coordination, including freeze dates and mechanisms for promptly resolving inconsistencies. Joint planning will require 'two-way' iterative processes not simply the issuing and exchange of data sets and documents.

Fundamental Principles and Caveats

4) Under conditions of complexity and evolving design, system engineering is greatly assisted by establishing **an ethos, a set of high-level principles**. A declared ethos not only guides designers, but can assist wider communication with policy makers, other sectors and the general public. Maintaining an ethos helps inform markets and accelerate innovation.

   The creation of a Centralised Strategic Network Plan as part of a Centralised Strategic Whole Energy System Plan could be based on high-level principles, such as the following…

   a) **Creating zonal balances** between demand, generation sources, reactive sources, rotating inertia, synthetic inertia, generation flexibility, and energy storage (zones with balanced resources will be more resilient, including an ability to resist energy security shocks, weather extremes, cyber-attacks, and should the situation arise, help facilitate a full system restoration).

   b) **Coordinated DG development** overseen by Regional System Planners and DNOs would feed-in to the CSNP to provide a total system generation perspective. Taken together with regionally coordinated development of public EV charging infrastructure, this would help inform the creation of transmission zonal balances between generation and demand whilst also enabling strategic (rather than piecemeal) development of distribution systems.

   c) **Targeting CCS** applications and infrastructure towards areas that can accommodate CO_2 sequestration – for example depleted gas fields (such areas would ideally include locations with abated fossil-fuelled generation and blue hydrogen production).

   d) **Large-scale inter-seasonal** storage should ideally be located where it can connect to a strong 'grid backbone' (able to move energy to all parts of the national system). In the case of hydrogen-based long duration energy storage a key dependency will be the availability of natural H_2 storage sources (e.g. salt caverns).

   e) **Energy storage and demand flexibility** should be recognised as means of mitigating transmission constraints. This should include the potential for flexibility from distributed heat networks and heat storage, and integration within community energy enterprises. In the future, system balancing with a high-level of inflexible generation may need to take primacy over network constraint management in the overall CSNP.

   f) **To address environmental objections** it will be helpful if new transmission line proposals selectively deploy less aesthetically intrusive and/or environmentally impactful options. This might include high-temperature, low-sag conductors (which have a higher current carrying capacity and can reduce the number of required pylons), T-pylons (which are generally regarded as aesthetically less intrusive) and gas-insulated lines (ideally using alternatives to SF_6) where overhead line routes would be unacceptable (e.g. AONBs). There may be advantages in incorporating higher capacity assets, for example utilising

Transmission voltages above 400kV, as is not uncommon elsewhere in the world. A spatial plan will help identify priority geographic areas for alternative approaches, whilst considering interactions from a whole system perspective will ensure optimisation of transmission capacity and new infrastructure investment.

g) **Innovation and new technology** should be incorporated within the CSNP in a systematic way, taking account of levels of confidence in promising technologies not yet fully developed but likely to be commercially available at scale within the CNSP planning horizon (for example current SIF projects). The CSNP has considerable scope to accelerate the pace of innovation roll-out.

5) In order to create a robust Centralised Strategic Network Plan, **the FSO will need to develop reasonable assumptions as to the applications the network will be required to serve** (including generation, demand, energy storage, and new demands such as hydrogen production, CCS, etc.); the type and spatial disposition of generation, energy storage, and conversion resources; their point (or voltage level) of connection to the (transmission or distribution) network; and how these will develop over time.

Taking generation as an example …

a) Current energy policy / aspiration is to have 50GW of offshore wind by 2030, 70GW of solar by 2035, and 24GW of nuclear (of some form - conventional / modular) by 2050.

b) However, these numbers appear modest when compared with current (2022) net zero-compliant NGESO FES scenarios which assume up to 370GW of generation at 2050 (of which up to 230GW is wind and solar) serving a doubling of current peak demand of up to 115GW and at least a doubling of annual electricity consumption of up to 750TWh (not including electrical energy to supply hydrogen electrolysis plant).

c) Current ESO Future Energy Scenarios assume that by 2050, up to 41% of generation capacity will be decentralised and connected to the distribution system. This will include the bulk of onshore wind and solar PV (at least in England and Wales) and battery energy storage (BESS).

d) Up to 230GW of wind and solar at 2050 contrasts with 280GW of generation apparently already in a connection queue today. Much of this queue comprises speculative applications, the processing of which consumes vast resources and creates delays in offering firm connection dates for developments more likely to proceed.

However, whilst 'reasonable assumptions' might be a starting point which might help inform the direction of government energy policy, **the need for government to firm-up and commit to its energy policies and plans is fundamental to the FSO being able to design a pathway which we can be confident will achieve the 2035 and 2050 objectives**.

6) These headline numbers clearly illustrate that in order to produce a robust CSNP, there is a fundamental need for a complementary **strategic spatial temporal development plan for generation** incorporating sufficient firm / flexible / dispatchable generation to ensure **security of supply and system operability.**

7) This in turn requires that the CSNP and strategic spatial temporal development plan for generation must together **incorporate designed-in SQSS-compliance capability from a system security and operability perspective**, including in respect of credible HILP events.

8) From a HILP event perspective, **the CSNP must be capable of** Electricity System Restoration Standard[1] **(ESRS) compliance**.

9) Other less common (but not improbable) events that must be catered for by design include:
   a) severe storms and flooding which might become more prevalent as a consequence of climate change;
   b) the possibility of more extreme ambient temperatures – with very high temperatures reducing plant and line ratings, and low temperatures giving rise to higher heating demand; and
   c) the potential for extended periods of very low wind (and limited solar) generation output requiring alternative sources of sustainable or long-duration flexible capacity.

10) The consultation mentions 'refined modelling to reflect interactions between wind, electricity storage, short-term network constraints, hydrogen economy, and modelling interconnectors'. Whilst we agree with this, the ultimate objective must be to create pathways to 2050. However, the concept of a 'hydrogen economy' is open to wide interpretation. Future energy policy decisions around hydrogen will impact upon the CSNP and will need to describe …
   a) the extent to which hydrogen will be used for transport, heating, long duration energy storage, and electricity generation; and
   b) the relative contribution from different technologies towards zero-carbon hydrogen, its production (steam methane reformation with CCS, auto-thermal reformation and electrolysis) and how hydrogen will be stored and transported.

11) The above factors will have **a significant impact on transmission and distribution power flows and hence the design of the whole electricity system, and its interfaces with other energy vectors**.

12) Ultimately this illustrates that a **CSNP is valid only as part of a Centralised Strategic Whole Energy System Plan**. Such a plan would have a hierarchy of more focused plans within it.

13) We note from Ofgem's 'Decision on the initial findings of Ofgem's Electricity Transmission Network Planning Review' in November 2022 that Ofgem (at that time) was unclear as to the extent to which the FSO would advise on the development of the gas network, or just the siting of a hydrogen production electrolysis plant through a CSNP, and concluded that at this stage in the development of the CSNP, it would not be possible to estimate this impact. **We believe these are fundamental considerations in the construction of a CSNP and hence require urgent resolution.** We are not advocating that the FSO should determine the location and timing of assets such as large hydrogen electrolysers, rather that the responsible parties

[1] https://www.nationalgrideso.com/industry-information/balancing-services/electricity-system-restoration-standard

should be **obliged and incentivised to work in a timely way with the FSO** to ensure that such material point loads are properly accounted for in the CNSP.

14) To that end, our view is that the **UK Hydrogen Strategy (and business model) needs to move on quickly** from its Aug 2021 ambition of 5GW of low carbon hydrogen production capacity by 2030 (later doubled to 10GW including 5GW green hydrogen) - building on lessons from its funded trials and pilot studies - **to become a UK Hydrogen System & Infrastructure Strategy** (also embracing CCUS infrastructure) – based on the hydrogen economy archetypes depicted in the UK Hydrogen Strategy Roadmap.

15) Notwithstanding in our view the need for the FSO to develop into a whole energy system strategic planner, in terms of Ofgem's regulatory remit, **we believe there is a need to distinguish between the duties of the FSO as a system (electricity only) 'operator' and the FSO's duties as a (gas and electricity system) strategic planner**. The former will require the regulatory oversight that has been hitherto applied to the ESO; the latter requires more of a facilitating role by Ofgem, ensuring that the **FSO follows agreed processes and that it has the powers to obtain necessary information in a timely way and having appropriate validity**.

16) **We believe the centralised strategic network (and whole-energy) planning process would benefit from a 'light-touch' regulatory approach**, with **Ofgem approving the methodology (only)** leaving the FSO to develop whole energy system strategies in liaison with DESNZ, and to advise Ofgem on the implications for energy (and energy-related) infrastructure investment. Developing the CNSP is a challenging task and the FSO **should not be burdened with the overhead of reporting to two parties.**

17) Once the CSNP has been finalised and agreed by relevant stakeholders (subject to periodic review as suggested by the consultation) **we would then anticipate Ofgem applying its wider regulatory oversight to the TOs, DNOs, GDNs, CCUS operators, heat network operators, etc**. focussing on optimising cross-vector efficiencies and synergies in its capacity as an economic regulator with a specific net zero mandate under the Energy Bill, and protecting existing and future consumers' interests. However, **Ofgem should not be the arbiter of the technical content of the Centralised Strategic Network (or whole energy system) Plan itself.**

18) However, the immediate priority is to have a development strategy for the FSO. **We would urge firming-up of the target date for establishing the FSO (currently sometime between now and the end of 2024)** whilst ensuring a development plan for the FSO to ensure it has appropriate terms of reference and is adequately resourced, skilled and empowered to perform the required whole energy system strategic planning function. Many external investment decisions hinge on the CNSP and **we would recommend that works start in a 'shadow form'** ahead of finalising the formal establishment of the FSO.

Answers to Ofgem's Specific Questions

Q1. Do you agree that we should move towards pathways instead of scenarios, to provide greater clarity on the type of investments required under the CSNP?

A move from 'scenarios' to (a limited number of) 'pathways' is essential to achieving the objective of a decarbonised power system by 2035 and a net zero compliant energy system by 2050, not least because we believe that both these target dates will prove very challenging - hence the need for 'pathways' to identify the critical-path elements of the CSNP.

Q2. Do you agree that there should be a single forward view of the near term for all pathways?

A single forward view has to be based on the ultimate objectives (decarbonised power system by 2035 and, more importantly, net zero by 2050) and hence is feasible only in so far as it is consistent with any credible medium and longer-term pathway. Including network investment common to all pathways is clearly appropriate but **there may well also be short-term investments, critical to achieving the ultimate objective, which might not be common to all pathways**. Nevertheless, accepting a limited risk of asset stranding is preferable to following a pathway which further increases the risk of missing the 2050 (2045 for Scotland) target date.

Q3. Do you agree with our proposal to have Net Zero compliant pathways (number to be determined by FSO), with a separate counterfactual demonstrating the scale of activities and investment that falls short?

A counterfactual is helpful to understanding the incremental cost of network investment for a decarbonised power system by 2035 and one which is net zero compatible 2050. But **there is also value in a 'falling short' pathway as well as a pathway that sets aside 2035 and 2050 objectives** (for example if a pathway were to be identified that represented a significant cost saving and/or security of supply benefit in return for a slightly delayed decarbonisation date). In view of the work involved, the number of counterfactual studies should be limited and undertaken only after careful consideration as to the value of insights that the counterfactual is seeking to reveal.

Q4. Do you agree that the pathways should run to 2050, and if not, why not?

The pathways should initially run to 2050, and thereafter (i.e. after 2025) continue to have a minimum 25-year horizon due to lead times in respect of planning approvals, resource implications, and supply chain considerations; hence each 2 to 3 year cycle should represent a 25-year rolling horizon**.** It is important to note that **the decarbonisation pathway will not be linear; the path will become progressively steeper before levelling off as we approach 2050** (assuming progress remains on target)**. Planning to a 2050 horizon with clearly identified milestones will be essential to ensure that earlier activities are consistent with the ultimate goal.** We note that the Scottish government has declared its **net zero target for**

2045. It would be helpful to clarify how the differing horizons will be accommodated in the CNSP.

Q5. Do you agree that the model should develop the capacity to include extreme data ranges when requested of the FSO in its role as strategic advisory body?

The ability to cope with a HILP event is fundamental – i.e. the network (and wider power system) must be designed to handle credible HILP events – for **example it must be possible to restart the system following a total system shutdown**. However, **extreme weather events and prolonged anticyclonic conditions are not 'improbable'.**

Q6. Do you agree with our consultation position on modelling network constraints?

In principle yes – but the ability to do that assumes knowledge of where and what generation will be connected (including at distribution level – noting that current FES scenarios assume between 28 and 30% of generation is decentralised at 2030 - and between 28 and 41% at 2050). Moreover**, decisions over hydrogen production – including from electrolysis powered by surplus wind energy – are likely to be material in terms of transmission power flows**. New material demand can be helpful in reducing flows at constrained boundaries if sited in an exporting zone. In this situation, it may be possible for electricity transmission reinforcement to be deferred or cancelled. It should not in any case be assumed that network constraints should dictate where generation is sited as especially offshore wind farms have limited locational options. Ultimately, network constraints can be justified only where the economic cost of resolution would outweigh the benefit in terms of avoided generation curtailment – for example under infrequent very high generation / low demand periods.

Q7. Do you agree with our consultation position, and do you have a view on which data principles should be possible to adopt for the first FES?

We agree that data and algorithms used by the FES should be open and publicly available – as should the assumptions built into the modelling (an exception might be if the FSO is required to undertake studies which by their nature include confidential or sensitive data relating to matters of national security). **This should also include data used to support the overall rationale for the pathways and any sensitivity analyses – stating confidence levels as appropriate.**

Q8. Are there specific stakeholder needs cases for publication of data, including the format of outputs?

Stakeholders will have legitimate specific requirements, but they will also have obligations to provide the FSO with the data required to undertake pathway analysis. It follows that **data requirements applicable to all parties should be clearly specified and remain under continual review**.

Q9. Are there specific data outputs associated with the FES that we should mandate?

There should be mandatory specified modelling outputs agreed by relevant stakeholders through consultation – and these requirements kept under continual review – but a more important output is a stakeholder-agreed pathway and a delivery plan with clear milestones.

Q10. Do you agree that regional and/or industrial hub pathways should be included in the FES?

Liaison between the FES and (future) RSPs will be essential to identifying subnational energy challenges and opportunities, and to reconciling local area energy plans with national strategic objectives. This should include industrial hubs and cross-vector opportunities such as hydrogen and CCUS. **Pending the development of RSPs, liaison with DNOs (and their distribution FESs) and GDNs will be essential to informing the CSNP.**

Q11. Do you agree with our proposal for a 'major' FES in the year prior to the main CSNP publication, with smaller annual updates in the intervening years?

This sounds reasonable – but the periodicity should remain sufficiently flexible to respond to any new major inputs (for example changes in government energy policy).

Q12. Do you consider that longer-term evolution of energy supply and demand modelling should head in the direction outlined above and if so how?

Yes, we broadly agree that developments should head in the direction outlined and, more importantly, result in a CSNP with a firm development pathway and a delivery plan. However, we believe there are some fundamental issues that need to be addressed if outcomes are to be effective, timely and customer-focused. **Three key points are as follows:**

a) Ultimately **a CSNP will be credible only as part of a Centralised Strategic Whole Energy System Plan.** Whilst the consultation refers to a 'hydrogen economy' this might take many forms depending on the extent to which hydrogen plays a future role in heating (industrial, commercial and domestic); electricity generation (hydrogen fuelled CCGTs and OCGTs as an alternative to conventional methane gas fired stations with carbon capture); transport (HGV freight, long-haul buses, marine and rail - noting that GB has one of lowest percentages of electrified rail routes in Europe), and long-duration energy storage (especially in the form of green hydrogen produced using surplus wind energy). **Choices between electrification and hydrogen as a means of energy decarbonisation will have a major influence on required transmission and distribution network capacity.**

b) The CSNP has the potential to make a key contribution in meeting the government's 2035 and 2050 net zero goals. It would be timely now to begin developing proposals for an **accompanying delivery plan,** without which it is unlikely the CNSP's aspirations will become a reality. **Delivery is not the role of the FSO**, although it has a role to play. Complex new infrastructure requires a delivery plan, with coordination mechanisms for many parties, supply chains, skills and resources. The FSO does however have a key role

in delivery as regards system access and the planned network outages necessary for infrastructure works, connections and commissioning. Planned network outages will inevitably involve a risk to system security even assuming compliant with SQSS planning criteria, especially given the construction outage implications of current NOA projects. It follows that outage scheduling will be a critical factor in the timely delivery of infrastructure investments. The requirement for carefully **planned construction outages is not a trivial consideration** given the scale of transmission network extensions and upgrading required, even under the current NOA 2022/23 refresh (which covers projects with earliest optimal delivery dates only up to 2037).

c) **Sector governance remains a key issue.** The programme of work to be brought forward by the CSNP is large scale and complex. It will involve multiple parties, interactions with data and data communications, and require engagement across traditional power sector boundaries. Notably, this is not incremental growth of Britain's energy system, there will be innovative developments and potentially paradigm changes (such as the participation of community energy enterprises, deep use of storage and inter-vector energy exchanges). New solutions, new products, and new parties can be expected to bring **significant challenges for sector governance mechanisms** which if not resolved promptly will become serious bottlenecks.

   It is hoped that the governance changes in the current Energy Bill will be helpful but, looking at experience from other sectors, they are unlikely to be sufficient. We would draw attention to the extensive work undertaken by the ***Future Power System Architecture***[2] programme and the proposals outlined for fundamental governance change. We would advise moving to the front foot as regards making further improvements to governance, **flagging this to the sector** and giving consideration to the **role of the FSO** in enhancing the governance process. **The IET's FPSA group has no commercial alignment and will be pleased to discuss this report further**.

[2] IET/ESC report from FPSA programme. Fast Track to Britain's Future Power System