Mr. Robert Hull
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Ofgem
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Dear Robert,

Long Term Electricity Network Scenarios

Thank you for your letter dated 15 June 2007 regarding the above. I am pleased to offer EDF Energy's comments on the proposals outlined in your letter.

It is reassuring that Ofgem have recognised the importance of developing longer term network development strategies whilst acknowledging the uncertainty inherent in any prediction of future network investment drivers. The development of a credible suite of longer-term *scenarios* is therefore a welcome approach.

The concept of 'flexible revenue allowances' has potential as a methodology for addressing unexpected investment drivers or transitions between modelled scenarios. However, in the context of forward resource planning and commitment to longer term investment delivery strategies, this flexibility must not be allowed to undermine confidence in terms of assurance of future revenue streams. In particular, in order to provide the necessary investor confidence it will be important that, within this longer-term framework, commitment is made towards funding appropriate medium term investment strategies. It will therefore be important to clarify the intended scope of such a mechanism.

Given the above caveats, EDF Energy fully supports the objective of developing a range of future scenarios. Reference is made in your letter to the work that has already been undertaken by the Supergen Future Network Technologies Consortium (this work being referred to generally as the 'Supergen scenarios') which at a high level, predicts the impact on Great Britain's power systems over two time periods; to 2020 and to 2050. It might be that in light of the Government's Energy Review, these scenarios will need to be revisited, for example in terms of the predicted generation portfolios, noting that even under the 2020 Environmental Awakening scenario, the contribution from

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renewable generation might not be sufficient to meet the UK's contribution to the EU Member States' obligation to ensure that 20% of all energy production is derived from renewable resources by the year 2020. In that context it is interesting to note that whilst the ENSG DWG Horizon Scanning team mentioned in your letter have also based their consideration of future distribution network architectures on the Supergen 2020 scenarios, they have in addition developed a further scenario, 'Power to the People', which assumes a higher penetration of micro-generation and a greater degree of customer participation in the energy market.

Notwithstanding these qualifications to our support for the Supergen work, the scenarios are well constructed and logically derived. For example, the (six) scenarios to 2050 have been developed against the same background issues as the (four) 2020 scenarios; these are: economic growth, technological growth, environmental attitudes and political and regulatory environment. In that sense it is possible to 'map' the 2050 scenarios to the 2020 scenarios (and vice versa). In developing scenarios to 2050 and then 'backcasting' these scenarios to establish way-markers in 2025, such clarity of mapping will be essential. It will therefore be highly desirable to take advantage of the work already undertaken to create the Supergen scenarios, and Ofgem's decision to ask University of Strathclyde to assist with this work is therefore soundly based.

Apart from the Horizon Scanning work, consideration should also be given to the depth of knowledge and experience that can be accessed via the wider membership of the Electricity Networks Strategy Group (referred to in your letter) and its associated Transmission and Distribution Working Groups. These Groups are populated by a representative range of relevant stakeholders. As well as being specialists in their own particular fields, the members of these Groups have developed a strong mutual understanding of each others' business drivers. They have achieved this by jointly identifying and addressing potential barriers to the Government's objectives surrounding the electricity industry's future contribution to a low carbon economy. These members have therefore developed a valuable holistic perspective on the challenges now facing the electricity industry as a whole.

We note your emphasis that the objective of this work is not to prescribe particular strategies for regulated companies. That is entirely correct since it is for individual companies to determine how they will address future network functional performance drivers and meet the needs of their (future) connected customers. Indeed, it will be important to recognise that whilst there is value in developing 'generic' scenarios, in practice there will be differentiating drivers determined by many company-specific factors including: distributed energy penetration levels, legacy network architectures, network disposition in terms of rural / urban / high density urban mix, economic / regeneration activity, local demographic patterns, and overall demand growth.

In terms of the envisaged approach to this work, you cite six specific future issues that may have an impact on electricity networks. We would agree that these are all relevant issues. However, whilst I am sure that the list is not intended to be exhaustive, there are other important (or electricity industry-specific) issues that have not been mentioned. We would cite the following examples:

- Customer expectations - including service levels of performance, which will almost certainly increase and be manifested in many different ways over the period under consideration.
- Transport policy - decisions concerning which could have a significant impact on the electricity industry in terms of electricity demand profiles. For example scenarios involving extended electrification of the national rail network coupled with further light railway schemes such as the DLR and perhaps local tramway schemes would create increased demand on distribution networks (as well as potential local power quality challenges). Meanwhile developments in battery technologies could result in both increased night-time usage of electricity as vehicles recharge, and mobile sources of energy storage which might export to distribution networks at times of peak demand.
- Human resources (perhaps a subset of 'demographics') the availability of which could impact on the electricity industry's ability to economically deliver the changes to the electricity infrastructure implied by some of the Supergen scenarios.
- Education policy (closely linked to human resources) which will need to address the risk surrounding a potential acceleration of the current skill gaps facing the electricity industry under some of the Supergen scenarios. A lack of sufficient under-graduates studying relevant qualifications would also adversely impact on the ability of academia to support the research and development necessary to enable the technological transformations implied by the Supergen scenarios.
- The impact on availability and prices of core products (and their component commodity materials such as copper) which will form the foundation of the high levels of network investment implied both by the Supergen scenarios and other investment drivers such as the overall age of the electricity network infrastructure. A key factor here will be the rate at which other economies such as China and India continue to grow, and the extent to which these countries continue to consume high volumes of these core products and commodities.
- Sustainability of a UK-specific market for network component manufacturers. The degree to which the key electricity industry manufacturers (some of which may well relocate to the above mentioned countries) feel that the UK market is worthy of further product development is a further related issue. A possible mitigation here is the extent to which the UK is prepared in future to adopt a

wider range of 'international' standards. The Government too has a potential role here in supporting the relaxation of some aspects of health & safety legislation that can perpetuate the continued adoption of 'UK' (as opposed to international) standards for plant and equipment.

- **Technological development -** the rate and scale of which could present both challenges and opportunities for the industry. For example, over the period to 2050 there is a high expectation that fuel cells will become commercially viable on a wide scale, which in turn will impact on transportation systems and the overall demand profiles for electricity networks.
- **The possibility of a Hydrogen economy** (by 2050) which is an important subset of the 'fuel mix' issue. Whilst there are currently many issues surrounding the acceptability and sustainability of a hydrogen grid, these may not be insurmountable. How such an infrastructure would impact on electricity demand profiles is less clear, and perhaps less easy to model than the impacts of renewables and other conventional fuel sources.
- **Nuclear fusion -** which over the period to 2050 might begin to become viable on a commercial scale. A further subset of the 'fuel mix' issue, it goes without saying that such a development could revolutionise thinking in terms of a UK strategy for low carbon energy production. Indeed it could herald a U-turn in terms of a policy to decentralise electricity generation, with distribution networks then reverting to conventional 'one-way' energy transportation systems, albeit perhaps experiencing greater electricity demand growth due to displacement of other fuel sources such as gas.
- **Planning policy** - which at national, regional or local level can be either supportive of, or resistive to, the changes necessary to achieve the Government's 'low carbon' aspirations, particularly in the contexts of energy efficiency measures for new buildings, and planning consents for new renewable energy power stations and even small 'domestic' wind turbines.
- **Regulatory framework -** which will require development over the period in question. Key to this will be the extent to which regulatory policy is supportive of the necessary investment in electricity network infrastructure. (We would assume that future regulatory policy will be informed by the proposed work).

Your letter cites four possible key network drivers. Paraphrasing slightly to reflect our understanding, these are:

- **Load Growth** (or net load growth taking account of energy efficiency measures);
- **Distance** (or disposition of generation relative to demand centres);
- **Utilisation** (and load factors which in turn will determine sustainable levels of utilisation);

- **Transmission / Distribution** (noting that DNO and TSO drivers may differ in some respects – albeit perhaps less so under future distributed energy scenarios).

Subject to further clarification of context, these are indeed relevant drivers. However, this is by no means an exhaustive list. For example, over the period under consideration (i.e. to 2050) there will remain peaks and troughs of asset renewal activity reflecting the overall age (or more specifically condition) profile of the network assets. Whilst these cyclic peaks and troughs might, in the longer term, be expected to exhibit an element of 'damping' (i.e. as the impact of the initial 1950s / 60s installation peak subsides over successive renewal cycles) there will remain an ongoing significant asset renewal driver.

Indeed, by the year 2050 (irrespective of any new paradigms implied by future scenarios) much of the existing network will have been substantially renewed due to the natural degradation and obsolescence of network components which by then would otherwise be operating way beyond their design life. SKM's June 2007 report to The Energy Networks Association regarding long term capital expenditure forecasts for Great Britain's electricity networks indicates future investment profiles under each of the four Supergen 2020 scenarios. Under each scenario, for distribution networks, a steady rise in (non load-related) renewal expenditure over both the 1st and 2nd quarters of the century is indicated (albeit with a temporary plateau over the transition period between the two).

This of course is both an investment driver and also a natural synergy in terms of the opportunity to develop networks with the design features and component specifications that will be required by the 2050 scenarios. However, this is a potential synergy that might be difficult to realise in practice. A whole-life-cost approach to asset management will not necessarily favour some of the network transformations that might be implied by some of the Supergen scenarios since these may involve early retirement of serviceable assets in order to create the required future architecture.

Other network drivers that have not been specifically cited but which might reasonably be expected to be prominent over the period under consideration include:

- **Network design security levels.** It is at least conceivable that ER P2/6 design security levels might in future be considered unsuited to mid 21st century expectations of assured continuity of supply. In November 2006, Ofgem commissioned a study - 'Review of Distribution Network Design Performance Criteria' examining the case for a review of ER P2/6. The findings of the report are understood to be under consideration. Within the envisaged timescale for this project, it is also expected that the work currently being undertaken under the auspices of the Energy Emergencies Executive, namely the E3-Electricty Task Group, will have culminated in some conclusions regarding societal impacts

and requirements for urban security of supply, and the consequential implications for a review of ER P2/6.

- **Urban security of supply.** Albeit a subset of the above, special consideration will need to be given to the future security, resilience and quality of service expectations for major commercial centres such as the capital city, London. By way of example, the networks of Tokyo, Hong Kong, Singapore, New York, and Paris (to name but some) have been designed to a significantly higher level of supply security and, by virtue of their inbuilt levels of redundancy, are inherently more resilient. This in turn is reflected in significantly superior quality of supply performance metrics. It is clearly in the national interest for the capital city to retain its status as a global financial centre and a pathway for inward investment. For this position to remain sustainable in the longer term, serious consideration will need to be given to a radical redesign of key elements of London's electricity infrastructure; particularly in the central area. Indeed by the year 2050, the availability of a highly secure and reliable electricity infrastructure might be a critical issue for other major UK cities too. This is a matter of the utmost importance to the UK's continued economic prosperity.
- **Requirements for network resilience** - especially given possible climatic changes that might lead to more frequent and/or more severe weather, and the almost inevitably heightened customer intolerance (by the year 2050) to prolonged supply interruptions; for example due to lightning, storm force winds, blizzards and flooding. Terrorist activity, and the extent to which this might escalate or subside over the period, is a further issue.
- **Quality of Supply and Power Quality drivers -** in particular customer expectations in terms of frequency and duration of supply interruptions under 'normal' weather conditions due to random events (including short-duration supply interruptions) and in terms of voltage waveform quality.
- **Health and safety expectations -** both from the perspective of network operators and the general public who (especially in the case of distribution networks) will often be in close physical proximity to electricity networks for sustained periods (if not almost continuously). For example, irrespective of any lack of supporting scientific evidence, concerns over the possible effects of electric and electromagnetic fields are unlikely to subside, at least over the medium term.
- **Growth in summer loading** - a fast-emerging issue as air cooling (perhaps catalysed by the effects of global warming) assumes the status of a necessary component to comfort level expectancy. This will have a major influence over network design standards and plant and equipment specifications as traditional cyclic loading patterns, and hence presumptions over achievable cyclic ratings, will need to be revisited.

- **The adoption of new paradigms for network asset risk management**. The expectation is that there will be an increased emphasis in future on probabilistic (rather than deterministic) assessment criteria, facilitated by an increased availability of utilisation and condition monitoring technologies, and improved state-estimation techniques. Excellent examples of such approaches can be found in the current Registered Power Zones and in DNOs' annual IFI reports. Such innovation, which has been due in no small part to the availability of sensible regulatory incentives, is likely to become more widespread as companies seek to maximise the utilisation of their assets.
- **Environmental and aesthetic expectations of electricity networks -** for example in terms of the visual acceptability of overhead line networks and the environmental sustainability (including carbon footprint) of the network component assets over their whole life (including manufacture and end-of-life disposal). Through our proactive engagement with key stakeholders, EDF Energy has experienced a very high level of enthusiasm for selective undergrounding of overhead lines in Areas of Outstanding Natural Beauty.
- **Network accessibility** - to both new and existing customers, including both conventional demand customers and developers of distributed energy sourced power stations (and indeed an increasing body of customers who will wish to own demand-side generation – including CHP and micro-generation).
- **Actively controlled networks** - the capability of distribution networks to in future accommodate very high levels of distributed energy resources (including possibly upwards of a 30% contribution from renewables) which would require, inter alia, that such networks would be actively or dynamically (rather than passively) controlled.
- **Technological development** (cited above as one of the key issues, but here the context is specifically *electricity network* technologies). For example, over the period to 2050 (or indeed by 2020) the expectation is that major progress will have been made in the development of power electronics, superconducting devices and energy storage technologies. Such developments, assuming that they lead to economically (as well as technically) viable products have the potential to make a major impact on electricity network architecture.
- **The potentially developing role of distribution networks as energy transportation systems** - facilitating trading of electricity derived from small distributed energy resources. Such a scenario is entirely consistent with the wider adoption of new paradigms for energy supply management and demand-side participation; for example, the Energy Services Company (ESCo) model where discrete energy network cells are managed by companies who will seek to optimise energy usage within the energy network cell and who may wish to arbitrage between different fuel sources and trade surpluses across public distribution networks.

- **The Large Scale Virtual Power Plant (LSVPP)** - an emerging business model whereby widely distributed energy sources are managed and aggregated in real time (via an 'Aggregator' using highly developed information Communication Technologies) and traded in much the same way as the output from a conventional power station, using the distribution grid effectively as a transportation system. This has important implications for the way in which DNOs might in future need to become actively involved in generation scheduling, curtailment, and constraint management (see below).
- **The ability of future distribution network architectures to support a system balancing role** and provide a range of ancillary services which might become essential under a scenario involving very high levels of distributed energy resources. In this sense the 'DNO' role might change to that of 'DSO' and key technologies might include energy storage (both as a means of compensating for intermittent forms of generation and as a means of improving load factor to ease network constraints) and information communication technologies (ICT).
- **The need for convergence of transmission and distribution network architectures**, particularly at the interface, recognising the increasingly active nature of distribution networks and the extent to which elements of such networks might in future regularly export to transmission networks. For example, distribution networks might increasingly provide export transportation paths for large onshore or offshore wind farms, including providing a linkage between offshore and land-based transmission networks. In this particular respect, the fourth of the networks drivers cited in your letter may prove somewhat academic in the context of 2050 scenarios.

In terms of the three envisaged phases of the proposed work programme, no doubt further context will emerge from the workshop on 17 August. However, in the meantime, our provisional comments are as follows:

Phase 1 – as stated above, in order to avoid 'reinventing wheels', it will be important to build on the conclusions of the existing Supergen scenarios. Moreover, whilst further 'primary modelling' will perhaps refine or reinforce these scenarios, such modelling must be holistic, recognising the many emerging network development drivers. The pragmatic need for tightly defined modelling parameters must be balanced by a recognition that overly simplistic modelling is unlikely to produce meaningful or confidence-inspiring results. An essential first step must be to recognise the key inputs to scenario development. A number of these are cited above, but the extent to which the scenarios ultimately prove to be truly representative of reality will depend critically on accurately weighting the relativity of these (and other) network drivers.

Phase 2 – the decision to limit the syntheses to around four or five scenarios is reasonable. Fewer scenarios would probably be insufficiently representative of all

credible outcomes over such a long-term study, whilst many more would prove difficult to contemplate, leading to possible dilution of effort in fully developing each scenario to an acceptable level of confidence. That said, it is important to appreciate that modelling scenarios to 2050 involves a great deal of uncertainty (particularly in terms of how various issues and network drivers will pan out in practice) and there can be no guarantee that any of the scenarios modelled will actually come to fruition. The authors of the Supergen 'Electricity Networks for 2050' report acknowledge that some of the more radical 2050 scenarios which could be contemplated have been deliberately omitted from their studies in favour of scenarios which are more probable but which might have less impact. Given that 'health warning', and bearing in mind our comments under Phase 1 above, the extent to which these six Supergen scenarios might already be broadly representative of the range of scenarios now required should be given careful consideration before embarking on further new work.

Phase 3 – It is encouraging to note (from the brief description provided) that one of the objectives of Phase 3 appears to be to establish (or consider) the regulatory framework(s) that would be consistent with the 2050 scenarios. It is likely, at least under certain scenarios, that a very different regulatory framework might be necessary. However, careful consideration should also be given to the different commercial market frameworks that might also be necessary under some of these scenarios. It will be readily apparent from our suggested list of possible network drivers that existing concepts of regulatory and commercial market structure could be suboptimal, if not an actual barrier, to the realisation of the envisaged paradigms.

In terms of the indicative programme, it is encouraging to note that a reasonable period of time has been allocated to the three phases of this work. An overly constrained programme would be counter-productive in terms of the quality of analyses undertaken and hence the degree of confidence in the outcome. Nevertheless, it is clear that a great deal of high quality work is called for, and it will therefore be important to establish a strong project management discipline with clearly defined milestones, but allowing sufficient time-contingency to explore any unexpected or counter intuitive outcomes to the modelling and subsequent syntheses. That said, the proposal to issue a report in May 2008 (your letter does not state whether this would be a final report) is a matter for concern in the context of the DR5 timetable; in particular the submission of company Forward Business Plan Questionnaires. If the expectation is that the outcome of this work will influence companies' (long-term) network investment forecasts then it will be necessary to at least share some early messages from this work, perhaps through the issuing of staged / interim reports.

It follows from the above that it will be equally important to ensure that the project is adequately budgeted, such that the work can be properly resourced and executed to the required quality and within the specified timescale. Any shortfall in funding would be a false economy in terms of the eventual cost to the industry, and indeed to the

nation as a whole, arising from pursuing network development strategies based on what might eventually turn out to be a set of flawed scenarios.

Finally, we would suggest that it might be beneficial to set up a stakeholder consultation group to provide both advice and feedback to Ofgem (and its consultants) on the emerging outcomes from the work. As you will be aware, this approach is being adopted with respect to the DR5 customer survey.

I hope you will find our comments constructive and helpful. You may be assured that EDF Energy are committed to supporting this important piece of work, and I look forward to further developing these long term electricity network concepts at the forthcoming workshop on 17 August.

Yours sincerely,

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