ENSGR 2009-21

ENSG 'Our Electricity Transmission Network: A Vision for 2020'

Addendum Report

Further Analysis - 2030 Generation and Demand Scenarios

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Executive Summary

1.1 The ENSG report entitled 'Our Electricity Transmission Network: A Vision for 2020' ('The 2020 Report'), published on 4 March 2009[1] was recognised as an important contribution to the ongoing work to identify solutions which will allow the creation of a network that facilitates the achievement of Government's energy and climate change policy in a economic and efficient manner.

Specifically the 2020 report summarised the results of a study to:

- Develop electricity generation and demand scenarios consistent with the EU target for 15% of the UK's energy to be produced from renewable sources by 2020.

- Identify and evaluate a range of potential electricity transmission networks solutions that would be required to accommodate these scenarios.

1.2 The 2020 report set out, at a strategic level, recommendations for certain upgrades and reinforcements that need to be made on an anticipatory, pre-emptive basis, to accommodate future generation. The pre-emptive upgrades to the network identified in the 2020 report are required because those network upgrades are likely to take longer to deliver than the generation projects whose electricity they will transport. Not starting those upgrades now might delay the generation projects that need them. Other potential upgrades and reinforcements have been excluded from the 2020 report where National Grid has judged that it would be able to deliver them within the required project development timescales. The 2020 report does not preclude transmission developments in other areas.

1.3 This is an addendum to the 2020 report and extends the analysis undertaken to cover the period from 2020 to 2030. The primary objective of this addendum is to ensure that the proposed anticipatory reinforcements set out in the 2020 report remain "fit for purpose" against a set of possible future developments in the electricity generation market and considers the recommendations in that report against generation and demand scenarios to 2030.

1.4 The objective of this addendum is not therefore to determine what a 2030 GB transmission network may look like, or put forward further proposals for developing the transmission network. Instead the objective is to "future proof" the proposed reinforcements for 2020 by ensuring that they are robust against a range of generation scenarios up to 2030, and investigate whether

[1] Our Electricity Transmission Network: A Vision for 2020 A Report by the Electricity Networks Strategy Group' March 2009 http://www.berr.gov.uk/files/file50333.pdf

those solutions require any refinement in light of the results of this additional analysis.

1.5 The Department of Energy and Climate Change published a White Paper on 15 July setting out a low carbon transition plan for the UK. Chapter 10 of the White Paper looks at some of the changes needed as we move through 2030 and towards 2050, and explains how the Government will work with industry and other experts to develop a more detailed roadmap to ensure that choices today make sense for the long term future of the electricity sector. This raises some fundamental questions for how grid infrastructure is planned and designed. The Government is considering what further role it might take in shaping the route map to meeting its energy and carbon policy objectives.

1.6 The White Paper recognises that a key element of the future energy system is the network infrastructure required to support and facilitate the shape of demand and supply on that system. It is possible, therefore, that with further analysis to 2030 and 2050 the Government will conclude that the overall trajectory on de-carbonising the electricity sector needs to be steepened which would have significant implications for the electricity network. It is therefore proposed to keep this under review and be prepared to re-examine the analysis in the light of any developments in this area.

1.7 The analysis concluded that the vision for the 2020 network is robust. However, in a number of areas the proposed reinforcements require some amendments, or need to be developed in such a manner as to accommodate future additional requirements.

1.8 Whilst the objective of the 2020 report was to identify and evaluate a range of potential electricity transmission network upgrades and reinforcements to accommodate renewable generation developments which were consistent with EU targets for 15% of the UK's energy to be produced from renewable sources by 2020, further analysis reported in this addendum also considered whether an anticipatory approach to investment is required to accommodate increased volumes of new nuclear generation.

1.9 The broad conclusion from the analysis is that where reinforcement of the transmission network is solely dependent upon a new nuclear connection, it could be developed in timescales consistent with those of the development of the nuclear generation. As such, at this stage the ENSG analysis has not identified a need for an anticipatory approach for such reinforcements, provided consents for required reinforcements could be obtained in a timely manner.

1.10 A number of questions were raised in response to the publication of the 2020 report and a Q&A is provided in Annex 1.

2.0 Approach to Developing Scenarios 2020 - 2030

2.1 The electricity generation and demand backgrounds which were developed for the 2020 analysis have been extended to 2030. In their development, numerous factors have been taken into account; particularly in relation to ensuring that the UK target for a reduction in greenhouse gas emissions of 80% by 2050 could be met. Such factors included the analysis of:

- Contracted new connections for all types of generating plant.
- The potential for, and location of, onshore and offshore wind generation.
- The potential build rates for wind and new nuclear generating plant.
- Developments of power station carbon capture technology.
- Development of wave & tidal energy.

2.2 In developing a detailed background issues such as; security of supply, the ability of the supply chain to deliver, and technological advances have also been taken into consideration.

2.3 The resulting transmission generation background scenario, upon which the studies are based, includes 13.4 GW of wind generation and 1.6 GW of wave and tidal generation in Scotland by 2030. Wind capacity in England and Wales grows from around 19 GW in 2020 to around 27 GW by 2030 and between 1 to 2GW of wave and tidal generation off Wales is assumed by 2030. In determining the timing and location of the potential projects in England and Wales the report produced by Crown Estate (Round 3 Offshore Wind Farm Connection Study[2]) and the report recently published by DECC (National Grid input into DECC Offshore Energy Strategic Environmental Assessment[3]) were used as a basis of the analysis, together with appropriate sensitivity studies.

2.4 The generation scenario assumes 7 GW of new supercritical coal and 5 GW of new gas fired power plant, all with Carbon Capture Storage (CCS) and 10 GW of new nuclear generation capacity by 2030.

2.5 In addition to the growth in low carbon generation connected to the transmission system highlighted above, the scenario also incorporates significant growth in embedded generation, including conventional Combined Heat and Power (CHP), renewable and microgeneration. The numbers below show the forecast increase in embedded generation capacity from 2020 to 2030.

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2 http://www.thecrownestate.co.uk/round3_connection_study.pdf

3 http://www.offshore-sea.org.uk/site/scripts/consultation_download_info.php?downloadID=238

- CHP capacity grows aggressively from 4.4GW to 9GW excluding large scale CHP connected to the transmission network (note that the level of embedded CHP hasn't changed over the last five years).
- Significant growth of renewable embedded generation from around 3.5GW to 11GW by 2030 with contributions from a wide range of sources including wind, wave, tidal, biomass, hydro and biogas.
- Microgen incorporates solar PV (at sustained build rates equivalent to the largest see in Europe historically i.e. Germany at its peak), wind and domestic CHP. If the generation build-up in the embedded system does not arise, then larger volumes of renewable generation would be required on the transmission system than envisaged in this report if the targets are to be achieved.

The Scenarios are shown in figures 1 & 2 below

2020 Gone Green Electricity Scenario

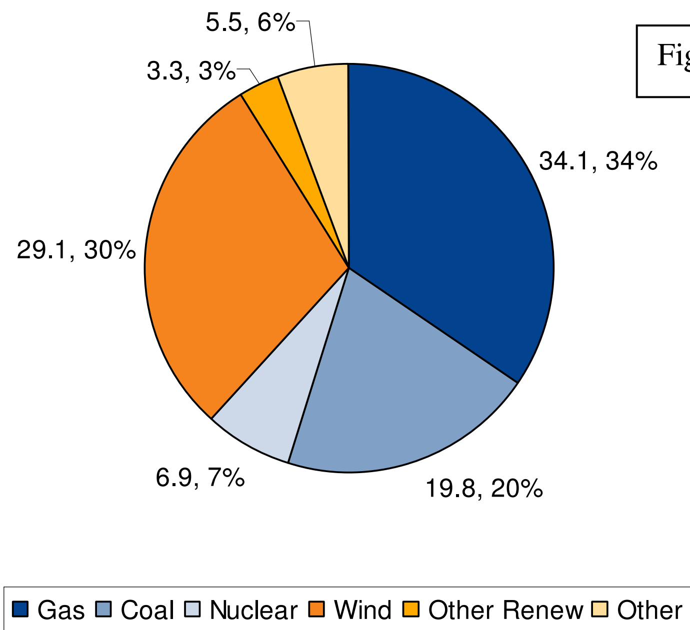

Figure 1

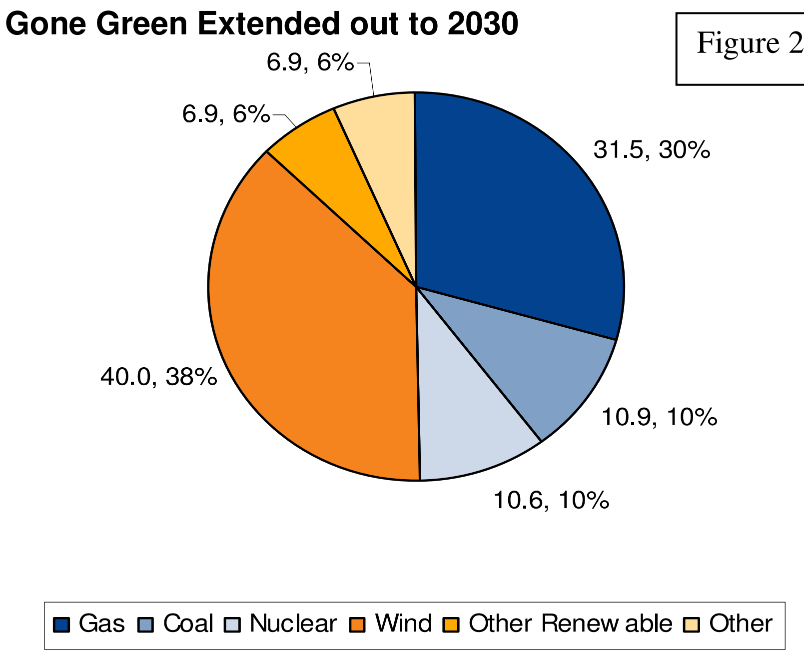

Figure 2

2.6 The demand forecasts have been extended to allow for additional energy efficiency, generic growth (household numbers and number of appliances per home) and new appliances (heat pumps and cars) which result in total overall demand remaining broadly flat but with transmission demand falling due to the growth in embedded generation. However, it is recognised that there is significant potential for demand to increase in large conurbation areas as a consequence of greater electrification of transport and decarbonisation of heat.

2.7 The generation assumptions made for the purpose of this addendum report are entirely independent from, and in no way pre-suppose, the outcome of individual planning decisions about projects on particular sites and, in the case of nuclear, the Strategic Siting Assessment (SSA) process.

3.0 Findings – Power Flows and Transmission Capacity Analysis

3.1 The predominant power flows remain consistent with those identified in the 2020 report, i.e. from the North towards the South. In the North of Scotland, an increasing number of windfarm developments and tidal energy development increase the power transfers on the Scottish Hydro-Electric Transmission Ltd (SHETL) transmission network. Accordingly, there is a predominant net export of energy from the region to the Central Belt of Scotland to England. The circuits between Scotland and England continue to operate at the levels highlighted in the 2020 report.

3.2 Increasing volumes of offshore wind generation in England and Wales, together with the potential connection of further new nuclear power stations results in increases in power flows within Wales (North & Central), the South West and along the English East Coast between the Humber and East Anglia. The overloading of the transmission circuits securing London from the north is further increased by additional generation off the East Coast.

4.0 Amendments to Proposed 2020 Reinforcements Resulting from the Analysis

4.1 In the 2020 report, two stages of upgrades were identified to reinforce North-West Scotland and increase transfer capability south to the Central Belt. The first stage consists of the Dounreay – Beauly – Kintore 275 kV upgrade and the second stage consists of a reinforcement between Caithness and the Moray coast, The options being evaluated for the second stage reinforcement include a High Voltage Direct Current (HVDC) link from Mybster to Blackhillock and a re-build of existing 132kV overhead line routes between Dounreay, Beauly and Keith. The 2030 scenario assumes development of a further 1.0 GW of wave and tidal energy in the North of Scotland. The reinforcements identified to meet 2020 requirements are robust against these increased requirements, but the detailed design will have to give further consideration to the appropriate capacity of the identified reinforcements and also to the local connections required to facilitate connection of this wave and tidal energy.

4.2 In respect of upgrading the main interconnected Scottish system from the North of Scotland to the Central Belt, and onto the North of England, The 2020 report identified three main elements being required by 2020.

- The ‘Incremental’ upgrade, which includes re-conductoring and re-insulation work on existing tower routes, along with development of new and existing substations and the installation of series compensation thus making maximum use of existing transmission routes.

- The Western subsea HVDC Link, a 1.8 GW HVDC connection from the Hunterston area to Deeside. This provides additional capacity across the Anglo-Scottish border and additional capacity across the upper North of England.

- The Eastern subsea HVDC Link, a 1.8 GW HVDC connection between Peterhead and Hawthorn Pit. This provides additional capacity across the Scottish networks, the Anglo-Scottish border and the upper North of England.

4.2.1 Whilst there is an increasing trend in power flows from Scotland to England from 2020 to 2030, analysis has shown that the three stages of reinforcements identified for 2020 provide a robust solution to accommodate the range of potential transfers which may arise up to 2030.

4.2.2 In considering future network requirements, it was recognised that a number of sites in the west Cumbria have received nominations into the new nuclear SSA process and therefore consideration was given to teeing the west HVDC interconnector into this area to provide additional transmission capacity. However, due to technology limitations, this is not a viable technical solution in the timescales being considered.

4.2.3 However, due to the potential for a higher percentage of offshore wind generation in Scotland than considered in the 2020 report the connection of this offshore wind generation to the onshore network could be via a dedicated cable network or possibly by teeing the offshore wind generation directly into the Eastern subsea HVDC link. However, whilst presently the technology does not exist to facilitate teed HVDC links at this rating, the longer lead times for developing an Eastern HVDC link will allow for further evaluation in light of any technical developments.

4.2.4 Clearly, the choice of technology to connect generation to demand has to be determined on a case by case basis. The use of HVDC cable links are suited to applications where relatively low power is to be transmitted over long distances. If the power to be transmitted increased significantly then the choice of transmission technology would need to be re-evaluated against the obligations in the Transmission Licence, to provide the most economic and efficient connection solution.

4.3 *Wales*

4.3.1 The scenarios have considered the potential for 4 to 5 GW of Round 3 offshore wind generation in the Southern Irish Sea, upto 1 GW of onshore wind, a range of possible nuclear power stations up to 3.3 GW and a potential for between 1 to 2 GW tidal stream in the Skerries off Anglesey which may connect in this area by 2030. The reinforcements identified in the 2020 report provide a robust solution in developing the transmission system to accommodate this further increase in volumes of generation. A potential requirement to interconnect the North Wales network to Central Wales by 2022 was identified in the 2020 report. The 2030 analysis has confirmed that additional transmission capacity between Pentir to Central Wales will be required along with additional transmission capacity from Treuddyn to Legacy by around 2025 to accommodate increased volumes of generation in the North West.

4.3.2 The Scenarios have also considered the potential development of a further 1 to 2 GW of wave energy off the Pembrokeshire coast along with up to 1 GW of onshore wind in the South Wales area by 2030. The 2030 analysis demonstrated this level of renewables can be accommodated by undertaking local reinforcements and there is no need to undertake any additional reinforcements on the main transmission system to that already being planned.

4.4 *English East Coast Reinforcement, Humber – Stage 1*

4.4.1 Previously published investigations such as The Crown Estate 'Round 3 Offshore Wind Connection Study' and National Grid's input to the DECC Offshore Energy Strategic Environmental Assessment (see footnotes 2 and 3) have considered a total of up to 12 GW of Round 3 offshore wind generation from the Dogger Bank and Hornsea areas connecting into the onshore transmission network in the Humber area. However, scenarios utilised in this analysis assume a maximum of between 8 - 12 GW by 2030.

4.5 *English East Coast Reinforcement*

4.5.1 It is anticipated that between 3 to 5 GW of Round 3 offshore wind generation will be developed in waters directly east of East Anglia. The reinforcements proposed for 2020 in this area of the network are robust against the increased level of generation.

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4.5.2 With the volumes of offshore wind generation in the region of 10 to 15 GW by 2030, new connections between Walpole and the Cottam – Eaton Socon line and/or Grimsby West and Keadby substations will be required.

4.6 *London – Stage 1*

4.6.1 As discussed in the 2020 report, several factors associated with the scenarios and sensivities investigated, including the introduction of new low-carbon generation and liberalisation of European energy markets, drive a need for additional transmission capacity in the London area. Specifically, increased generation in East Anglia and the Thames Estuary, potential increase in interconnection with mainland Europe and the potential for future demand increases associated with the electrification of transport and/or the decarbonisation of space heat. As a consequence there will be a need for additional transmission feeding central London from the north-east, and ultimately a need to reinforce east-west ties.

4.6.2 The 2030 studies have demonstrated significant benefit in establishing a major 400kV substation at Wymondley Main and connecting the Pelham-Sundon 400 kV circuit into this substation. This reinforcement significantly improves load sharing of northern circuits supporting London, further analysis is required to determine optimum timing for this development.

4.6.3 As the offshore wind generation connected to the East Coast increases, a section of the 275 kV ring between Tilbury, Warley, Waltham Cross and Elstree will need to be uprated to 400 kV to provide additional capacity between the Estuary and North London.

4.7 *South West*

4.7.1 This area of the network, around the Severn Estuary, is characterised by large volumes of localised generation, high demand levels and a limited export capacity. Future changes in the generation connected in this region, including the potential for large amounts of gas fired generation and possible nuclear replanting at Hinkley Point and/or Oldbury-on-Severn drive the need for additional transmission capacity. Planned Round 3 offshore wind generation in this area and a potential for the development of a Severn Tidal Scheme further add to this requirement.

4.7.2 Proposed reinforcements to accommodate the agreed 2020 scenario provide a robust solution when considering increased volumes of generation connecting to the South West.

5.0 Further Strategic Investment to accommodate New Nuclear Generation

5.1 The 2020 report identified a need to undertake anticipatory investment to accommodate both nuclear and wind generation (and potentially other types of generation) when this generation was competing for capacity and the lead time for the required transmission reinforcement was longer than that for the generation under consideration i.e. delays in connecting new renewable generation have historically occurred due to the different timelines for building new renewable generation and new transmission lines.

5.2 Since publication of the 2020 report, the Government has received nominations into the new nuclear SSA process[4]. A condition of nomination was that the site would be deployable by 2025. Eleven sites were nominated: Bradwell, Braystones, Dungeness, Hartlepool, Hinkley, Heysham, Kirksanton, Oldbury, Sellafield, Sizewell and Wylfa. The Government is currently assessing those nominations against the SSA criteria, and conducting

[4] http://www.nuclearpowersiting.decc.gov.uk/

appraisals of sustainability and relevant environmental assessments under the Habitats Regulations. Potential development at several of these sites (Sizewell, Hinkley, Oldbury and Wylfa), which is potentially competing for transmission capacity with other generation developments, such as round 3 offshore wind generation, was taken into account in developing scenarios for the 2020 report. In these cases, ENSG judges that the 2020 analysis remains robust.

5.3 For the other sites identified by the nomination process, (the three potential new nuclear sites in West Cumbria (Braystones, Kirksanton, and Sellafield), plus Heysham, Dungeness, Bradwell and Hartlepool), National Grid judges that the additional local transmission reinforcements required to accommodate the individual site could be delivered to similar timescales as the development of the nuclear power station subject to obtaining consents in a timely manner. Indeed, in terms of the West Cumbrian sites, the site nomination for Sellafield included a summary of a feasibility study undertaken by the National Grid, which concluded that: "the addition of new nuclear generation in the Cumbria area is technically feasible and that, in principle, there are no fundamental reasons to prevent its connection into the wider network around 2020"[5].

5.4 Presently there are signed generation connection agreements for a further 21 GW of new nuclear generation to be connected to the transmission system by 2030. Whilst there may be contractual arrangements in place between National Grid and Nuclear Developers, it does not imply that all these projects will proceed or that they will proceed to these timescales, merely that the necessary transmission reinforcements could be completed in the timescales set out in the connection agreement, subject to planning permission.

6.0 Conclusions

6.1 The reinforcements identified in the 2020 report have been found to be robust against the Gone Green 2030 scenario and a range of sensitivity studies. This ensures that sufficient transmission capacity can be delivered in a timely manner, particularly in areas where there are significant volumes of different types of generation competing for transmission capacity and where the lead time for required transmission capacity is longer than the lead time for new generation.

6.2 The need for further strategic reinforcement has been considered and some further incremental reinforcements beyond 2020 have been identified. However, the lead time for their delivery is such that it is not necessary to commence pre-construction engineering at this time.

[5] http://data.nuclearpowersiting.decc.gov.uk/docs/sellafield/support_letter.pdf (pg.3)

6.3 The development of the anticipatory reinforcement proposals set out in the 2020 report are phased to achieve a 2020 delivery date with the initial phase being delivered in 2015 based on the prospective growth in renewable energy in each region. The generation volumes in the scenarios used fall within the ranges considered by consultants engaged in similar work. Some sensitivity analysis around the scenarios has been undertaken to improve the robustness of the conclusions and recommendations. However, there remains a level of uncertainty about the development of generation, and its diversity, towards 2030.

6.4 It is recognised that there will continue to be a degree of uncertainty about the volume and timing of generation growth in any given area. It is therefore proposed to continue to monitor the developments of the market and update the scenarios and underlying assumptions accordingly. This will help to ensure that where there is a need to undertake anticipatory investment ahead of user commitment that it is identified at an early stage. It will also help ensure that the analysis remains robust as policies, technologies and capabilities develop to 2030 and beyond.

Annex 1

Q&A for 'Our Electricity Transmission Network: A Vision for 2020' ('The 2020 Report')

In the areas where a need for additional transmission capacity has been identified, does this mean that there will be new lines built?

Maximum use will be made of the existing transmission infrastructure. This could be in the form of replacing overhead line conductors with higher capacity conductors and, where the structures are suitable, re-insulating of overhead lines to operate at higher voltages. The completion of the proposed Beauly to Denny overhead line is an important part in releasing the capacity of the other routes on the Scottish grid network. Where the options for increasing existing infrastructure capacity have been exhausted, an assessment of alternative options including overhead lines and HVDC connections will be investigated taking into account technical, economic and environmental factors.

Where a need for anticipatory investment in new transmission capacity has not been identified in a particular area, does this mean that no transmission re-inforcements will be undertaken in that area by 2020?

Where transmission reinforcements are required for individual new generation developments (usually classified as Local Works), or where transmission re-inforcements can be undertaken in similar timescales to generation development, they are not considered as anticipatory and hence do not appear in the 2020 report. However, should such generation developments proceed then additional transmission reinforcements to those identified may be required.

Does the 2020 report place too much reliance on large centralised generation? Would additional transmission capacity still be required with small decentralised generation plant?

To secure demand across the GB system to an acceptable level and to permit access to the network when and where generation developers require it, a transmission network is required. The introduction of large quantities of decentralised renewable generation leads to uncertainty in terms of the energy supplied and large variations in network flows at the distribution level. Consequently, the transmission system is required to allow the system operator to balance the system and secure the wider GB customer demand.

The 2020 report clearly demonstrates offshore networks are the best solution, why is there not more offshore transmission being planned?

Offshore HVDC links provide an effective means of gathering remote offshore generation and, in the right circumstances, providing supplemental transmission capacity. However, they are normally point to point devices and have disadvantages compared to AC networks in their ability to harvest distributed generation, serve demand centres and to isolate faults without shutting down. In addition, HVDC links have very different availability characteristic compared to onshore transmission with cable fault repair times in the order of 3 to 6 months compared to normal return to service times for overhead lines of less than 24hours. They also have limited capacity compared to onshore 400kV overhead lines and are considerably more expensive on a £/MW basis. Consequently, offshore HVDC can be used in cases where particular circumstances justify its use, however it is not sensible to use as a general replacement for onshore AC transmission networks.

Why has the 2020 report not investigated the wider proposals for HVDC connections with Europe?

The Gone Green Scenario considered in the 2020 report models two HVDC links with Europe. The development of additional HVDC links (and possibly a European Grid) may materialise between 2020 and 2030 but the business case to support such an investment has yet to be established. The proposals to connect offshore wind to the GB system as set out in the report are the most economic solution to meeting the transmission requirements for the 2020 renewable energy targets.

Would the introduction of large scale energy storage reduce the requirement for transmission infrastructure?

In principle, the availability of appropriately sited large scale energy storage may impact on transmission reinforcement investment decisions for renewable/variable generation. However, we are not aware of any energy storage technology with sufficiently high capacity and sufficiently low cost per MWhr which can be considered as a technically viable or an economic alternative in the timescales for the proposals in the 2020 report.