EDF's Response to the National Infrastructure Commission's Baseline Report for the Second National Infrastructure Assessment

Summary
EDF is the UK's largest producer of low carbon electricity. EDF operates low carbon nuclear power stations and is building the first of a new generation of nuclear plants. EDF also has a large and growing portfolio of renewables, including onshore, offshore wind and solar generation, and energy storage. With about six million electricity and gas customer accounts, including residential and business users, EDF aims to help Britain achieve net zero by building a smarter energy future that will support delivery of net zero carbon emissions, including through digital innovations and new customer offerings that encourage the transition to low carbon electric transport and heating.

We are pleased to respond to the Commission's call for evidence. The scope of the call for evidence is very wide and our response concentrates mainly on the challenges of decarbonising the power sector and decarbonising heat. In both cases, there are some clear actions which must be progressed urgently. Alongside this, there is a need to resolve several uncertainties to enable the UK to set a clearer path for delivering the net zero transition,

The areas for urgent action include, but are not limited to:

- Delivering a massive increase in large scale low carbon generation assets, including offshore and onshore wind and solar, through the 2020s and 2030s, complemented by the development of the transmission network to support this.
- A final investment decision for Sizewell C based on the Regulated Asset Base (RAB) model enabling construction to start; alongside this, we will bring Hinkley Point C into operation. These developments will lead the way for the further nuclear development needed for net zero.
- Much greater effort to improve the energy efficiency of the UK's housing stock, going beyond existing plans.
- The delivery of the policy measures set out in the Heat & Buildings Strategy to start a programme of heat pump installation; followed by further actions to step up the pace of this programme.
- Continued growth in electric vehicles, supported by a strategy for the development of the charging infrastructure to support this.
- Establishment of the policy measures set out in the Hydrogen Strategy to enable the first hydrogen production projects.
- Delivery of smart metering and mandatory half hourly settlement to pave the way for a more active role for the demand side; this should be complemented by ensuring that the electrification of transport and heating has smart operation designed in from the outset.
- The establishment of an independent electricity system operator, with the respective responsibilities of BEIS, Ofgem and the system operator clearly set out.
- The placement of a duty to facilitate the net zero transition on economic regulators and also on public bodies with responsibilities for planning and environmental regulation.
- As we move beyond the current crisis of rising consumer energy bills, a clear strategy to rebalance the burden of the policy costs of decarbonisation to provide the right incentives for electrification.
- Establishing the UK Emissions Trading System (ETS) to provide a stable carbon pricing signal aligned to the net zero trajectory, re-establishing linkage to the EU ETS.

Some of the areas of significant uncertainty requiring further work to develop consensus on the right way forward include:-

- The right market design for a net zero electricity system;
- The extent of the role for hydrogen in the future energy system;
- The right way to extend carbon pricing signals across the economy beyond the current scope of the UK ETS.

Question 5: What are the main opportunities in terms of governance, policy, regulation and market mechanisms that may help solve any of the Commission's nine challenges for the Next Assessment? What are the main barriers? Your response can cover any number of the Commission's challenges.

We support the government's plans set out in the December 2020 Energy White Paper and the October 2021 Net Zero Strategy to drive the next stages of the net zero transition. It is important that government follows through on the delivery of the policy measures set out in the Net Zero Strategy and essential that it accelerates the pace of policy delivery. Much more needs to be done beyond these plans and the National Infrastructure Assessment can help to advise on these next steps, recognising the need to prioritise and to deliver the right enablers in good time for future progress.

Governance

Government and Ofgem have also consulted on proposals to create an independent Future System Operator (FSO). We support the broad intention of these proposals, which would create a body able to give independent, strategic advice on how to decarbonise the energy system, recognising the central role that electricity will play. Although it may take some time to pass legislation and to implement the changes to establish the FSO, it is important that the decision in principle is taken quickly and that there is clarity about the role and responsibilities of the FSO. The FSO should be accountable for the resilience and reliability of the electricity system in both the short term and the long term. Government must also clarify the respective roles of BEIS, Ofgem and the FSO.

Net Zero Duty

We welcome the proposal in the government's recent Economic Regulation Policy paper to review the duties of economic regulators, including consideration of their duties in respect of long term priorities such as the net zero target and interim carbon budgets. We support the inclusion of a duty in respect of the net zero transition in the duties of economic regulators.

The delivery of the infrastructure development for Net Zero is often hampered by delays.
Low carbon generation projects and associated developments face challenges in gaining consents and positive statutory advice, as there is no legal priority for climate change regulation alongside other environmental areas. Regulatory challenges can also be experienced in seeking to upgrade or maintain existing low carbon generation assets. This can lead to a lack of proportionality in decision making; for example, a relatively small residual environmental impact could be judged to outweigh the large climate change benefits of a low carbon generation project. We believe that there is a strong case for placing a similar duty to take the net zero transition into account on a wider set of public bodies with responsibilities in areas such as environmental regulation and planning.

Successful delivery of net zero requires that the planning system supports timely decisions on infrastructure projects and that regulatory bodies work with each other and with developers to find ways to facilitate the delivery of these projects. It is essential that these bodies are adequately funded to ensure that they can meet these challenges.

Prioritisation – the need for investment in low carbon generation
As noted in our response to Question 8, the government's Net Zero Strategy envisages the full decarbonisation of the power system by 2035, subject to security of supply, and a doubling of electricity demand by 2050 as decarbonised electricity displaces fossil fuels in many areas of the economy.

Although there will be some uncertainty about the precise requirements (the Net Zero Strategy estimates electricity demand growth of 40% – 60% by 2035), there is a clear need for massive investment in large scale low carbon generation during the 2020s and 2030s to underpin the delivery of net zero. The right policy measures are needed to bring forward private investment, striking the right risk/reward balance to provide the right incentives while also minimising the cost of capital. The CfD mechanism has proven to be successful and it can continue to play the key role in supporting the delivery of offshore and onshore wind and solar PV. Further mechanisms, such as the Regulated Asset Base (RAB) model to support new nuclear, will also be required.

There is widespread acceptance that there is a serious problem with the current approach of recovering the costs of decarbonisation largely from electricity customers and applying a carbon price to the use of fossil fuels for electricity generation but not to fossil fuels used for heating. This provides a strong disincentive to switch to lower carbon forms of heating such as heat pumps (discussed further in our answer to Question 9 below). Addressing this distortion remains extremely important but is clearly more challenging to progress under the current circumstances of rapidly rising energy bills; a gradual approach over the next decade is therefore needed alongside protective measures for those most affected by the changes.

Market design – the challenges
In recent months, there has been increasing discussion of the case for radical reform of the wholesale electricity market design, including proposals, for example, to adopt locational marginal pricing (LMP) following either a zonal approach or the more radical nodal pricing approach used in some US markets. Although the technical changes to implement such a change might be delivered quite quickly, it is essential to consider the wider political and economic background. We highlight three aspects: the impacts on generation investment; the operational signals that LMP could provide; and the impacts on business and household electricity consumers.

Impact on generation investment
It will be challenging to deliver a major change in market design at the same time as continuing to achieve high levels of generation investment. At the very least it will be essential to consider grandfathering arrangements to maintain investor confidence to avoid adverse impacts on cost of capital and a potential investment hiatus. There is a need to make the right decisions about optimising investment in generation, networks and demand before the investment takes place; this requirement exists irrespective of market design and it is vital to ensure the right planning now in areas such as offshore grid development to support the growth in offshore wind without waiting for any change in market design.

Operational signals
LMP has the potential to deliver reductions in the costs of operating the power system although it is challenging to estimate these accurately. This will be a key element of the Cost Benefit Analysis of any proposed change in market design. This benefit will be accompanied by a significant reallocation of cost between different users of the system; it is necessary to consider whether, for example, some of the savings from lower prices offered to wind generators in Scotland at times of high wind output will be offset by the need to grandfather existing projects and to provide larger

support payments to deliver future investment in wind generation. We will also need to consider whether the impacts of LMP would exacerbate concerns over wholesale market liquidity.

Consumers

Changes in market design can also help to reward consumers for actions that help to reduce the overall costs of the system, for example, charging an electric vehicle at low cost times. However, they also have the potential to make significant changes to customers energy bills, raising some important questions about the economic impacts and fairness of these changes. Will it be acceptable for customers in some parts of the country to see significant reductions in their bills while customers in other areas see significant increases? Will it be necessary to introduce some form of rebalancing, particularly for residential customers, so that average costs remain relatively unchanged, while also delivering meaningful marginal price signals? Are there risks that some types of customer, particularly more vulnerable customers, will be put at a disadvantage?

Market design – the way forward

Changes in electricity market design will be required for a net zero electricity system and must take account of the much greater level of interdependency between electricity and other infrastructure systems which the Commission has rightly identified. The implications of a major change in market design are far-reaching with impacts well beyond industry participants; this makes it essential that there is a wide-ranging consensus on the way forward and that the necessary change programme has strong political leadership and legislative backing provided by the government.

The current Net Zero Market Reform exercise being undertaken by National Grid ESO has the potential to start the necessary thinking. The government should consider how to build on this work. We believe that it is more important to get it right than to do it quickly and it is essential that we ensure that the pace of infrastructure investment is maintained at the same time. There is also much that can be achieved in the near term through further incremental development of current arrangements.

Carbon pricing

The government recognises the role of a strong and consistent carbon pricing signal to drive decarbonisation in conjunction with other policies. The UK ETS remains immature and it is important that the government takes early steps to provide clear direction by consulting on, and implementing a net zero consistent trajectory for the cap on UK ETS allowances. As a relatively small scheme, the UK ETS is at risk of illiquidity and excessive price volatility; establishing linkage between the UK ETS and the EU ETS could benefit both the UK and the EU.

While the long-term aim of an economy-wide consistent carbon price is right in principle, we recognise that the practical delivery of this will be far from straightforward. There is, for example, a strong case for applying a carbon price signal to the use of fossil fuels for residential heating; however, it will be important to introduce such a signal gradually and to address affordability concerns for the financially vulnerable at the same time. It is unlikely to be sensible to include heating demand in the UK ETS in the near term; we note that the EU proposes to tackle the same issue by establishing a parallel ETS for heating and transport; however, a carbon tax could provide a simpler solution, with the ability to step up the tax rate in a measured way.

Question 8: What are the greatest risks to security of supply in a decarbonised power system that meets government ambition for 2035 and what solutions exist to mitigate these risks?

The government's Net Zero Strategy envisages the full decarbonisation of the power system by 2035, subject to security of supply, and a doubling of electricity demand by 2050 as decarbonised

electricity displaces fossil fuels in many areas of the economy. It recognises that this will require a balanced generation mix, with most of the volume coming from low cost intermittent renewables, including offshore and onshore wind and solar PV.

The government is right to recognise the challenges to security of supply; we can identify four key areas of risk:

- Ensuring adequate capacity and flexibility to balance supply and demand, particularly when intermittent generation sources are not available;
- Ensuring the provision of system services to maintain a stable system at all times;
- Managing a successful transition away from the UK's current dependence on natural gas; and
- Ensuring the timely delivery of new generation, transmission and other assets.

Ensuring adequate capacity and flexibility

It is necessary to consider both capacity (ensuring adequate resources are available to meet demand) – and flexibility (ensuring the ability to vary generation or demand to keep the system balanced). In both cases, there are possible solutions on both the supply side and the demand side; the challenge is to deliver the required standard of security of supply at an acceptable cost. While a secure supply of electricity is increasingly essential, the UK's Reliability Standard[1], which seeks to balance the benefits of security of supply with costs to consumers, is comparable with that of neighbouring countries. The key mitigations are to develop a balanced generation mix, mechanisms to ensure the cost-effective procurement of capacity and flexibility and well-targeted support for zero carbon solutions using developing technologies.

All generation sources have their strengths and weaknesses and a balanced generation mix with some diversity of sources can help to mitigate risk. A generation mix with a significant proportion of low carbon baseload power will reduce exposure to weather variability affecting intermittent sources and will also reduce reliance on the development of less proven or higher cost sources of flexibility to replace unabated gas-fired generation. This can contribute to reducing the overall costs of a low carbon power system. For example, a generation mix with a significant contribution from new nuclear power is likely to deliver a lower overall system cost than one with a nuclear contribution coming only from the existing Sizewell B and under-construction Hinkley Point C. By providing more energy to the system when it is needed, nuclear will reduce the reliance on expensive storage capacity to absorb surplus renewable generation and re-supply it to the system at a later date.

The Capacity Market has proved an effective mechanism to ensure adequate capacity and we welcome the government's recent call for evidence which explored how to align the Capacity Market with Net Zero by developing it to provide greater support to the procurement of low carbon sources of capacity. It will also be necessary to develop better means of ensuring the procurement of flexibility; however, while the Capacity Market is based on a clear definition of de-rated capacity, no such clear definition exists to specify flexibility requirements or to assess their delivery. An essential first step is to establish a clear and measurable definition of flexibility. It is important that arbitrary definitions of flexibility requirements do not exclude potentially useful technologies.

Future sources of capacity and flexibility will include various forms of storage; batteries are proving a useful source of short duration storage (e.g. within day) but they are capital intensive, making them economic only where they can be cycled rapidly. Other technologies will be needed for longer durations with hydrogen storage potentially providing a solution for seasonal storage. Demand side

[1] 3 hours per annum loss of load expectation (LOLE) as defined in the Electricity Capacity Regulations 2014

response (DSR) will also have a valuable role; while we should recognise that there will be limits to the extent that many households and businesses will be prepared to change their daily routines to provide DSR, the growing use of electricity for electric vehicles and heat pumps is likely to provide significant opportunities for smart operation to provide DSR; it is essential that the capability and the right incentives to do this are designed in from the outset.

Ensuring system stability

The changing mix of assets connected to the GB electricity grid present new challenges to maintaining stability; many of the services on which the system depends have traditionally been provided by large fossil-fuelled thermal generators. National Grid ESO is working with the industry to develop alternative ways to provide these services to manage thermal constraints on the capacity of transmission lines, to maintain voltage across the system, to maintain frequency, to provide the inertia required to keep the system stable if a large infeed (such as a generator or interconnector) loss occurs and to restore the system if thre is a major failure. The ESO's work in this area is essential to facilitate the delivery of a decarbonised power system; it is important to develop the right market arrangements to procure these services from new sources while also properly rewarding delivery by existing assets.

The transition away from natural gas

The UK's energy system remains critically dependent on natural gas, much of which is imported, as a generation fuel as well as for heating and as an industrial fuel; the development of hydrogen production through methane reforming with carbon capture and storage would maintain and could even increase this dependency. The UK must move away from natural gas towards low carbon alternatives as fast as possible but this transition will not be completed until the late 2030s at best.

Meanwhile, as the events of recent months have demonstrated, exposure to global gas markets carries very significant price risks. Countries like the UK are reducing gas demand as they decarbonise while other countries, especially in Asia, are increasing gas demand to support economic development and to move away from coal. With overall demand for gas likely to decline over the longer term, investment in production will also decline and many investors and governments are no longer willing to invest in fossil fuel industries. These factors create the conditions that could lead to further periods of extreme volatility in gas prices over the next two decades. It is vital that, while the UK moves away from dependence on natural gas, it also manages the security of supply and price risks associated with this dependence.

The Climate Change Committee (CCC) estimates that the carbon intensity of electricity was 182g/kWh in 2020 and recommends that this should fall to less than 50g/kWh by 2030 and around 10g/kWh by 2035[2]. Such recommendations will require that gas-fired generation is very largely replaced by low carbon sources; we believe that this should be achievable; however, as the use of gas-fired generation and carbon intensity both fall, further reductions will become progressively more difficult to achieve while also maintaining security of supply. However, we would caution against measures "to drive gas off the system"; a strong and consistent focus on building new low carbon generation will be a more effective decarbonisation strategy.

Ensuring the timely delivery of new assets

Decarbonisation of the power system will require the delivery of significant volumes of new power sector assets by 2035, with continuing investment beyond 2035 to support further stages of decarbonisation of the economy. We have outlined some issues in our answer to question 5 to enable us to meet the three key requirements to the cost-effective delivery: minimising the cost of

[2] CCC Progress Report to Parliament June 2021

capital; coordinated planning across generation, networks and demand; and removing barriers to rapid delivery of low carbon infrastructure.

Question 9: What evidence do you have on the barriers to converting the existing gas grid to hydrogen, installing heat pumps in different types of properties, or rolling out low carbon heat networks? What are the potential solutions to these barriers?

Our response is mainly focussed on heat pumps, these being widely accepted as an essential element of the switch to low carbon heating in all scenarios. We touch on the role of hydrogen in heating at the end of our response this question.

Today there are number of barriers to greater adoption of heat pumps, including challenging economics/costs, low consumer familiarity with heat pump technology, more complex installation processes, the need for "heat pump ready" properties and the lack of a large skilled workforce trained in heat pump installations.

Of these barriers by far the most significant and important to address is heat pump economics. At present, due to a combination of higher up-front capital costs and an absence of operational cost savings, heat pumps are not an attractive or compelling whole life economic proposition in most circumstances, especially compared to natural gas boilers which heat around 85% of existing UK homes and most heat networks.

Although it is likely that some capital cost premium will remain, the higher up-front costs of heat pumps can be reduced over time through growing the size of the UK market, which is likely to deliver economies of scale in procurement and reduced installation costs due to greater experience, higher volumes and more repeat processes. The recently published Heat & Buildings Strategy takes some important steps in this direction with the proposals for new grant schemes, a market mechanism to drive higher installation volumes and plans to phase out new fossil fuel heating installations in the off-gas grid. It will be important that these measures are implemented effectively and expanded in scale over time as the market grows.

Alongside this, government must resolve the operational cost barriers to heat pump adoption through addressing the major distortions in policy and carbon cost charging which exist today between electricity and gas, with electricity subject to a significant carbon price and substantial policy costs (in particular from the Renewables Obligation and Feed-in-Tariff schemes), neither of which are placed on fossil fuel gas used for residential or commercial heating. Heat pumps are a highly efficient technology and, if it were not for the current distortions in policy cost charging between gas and electricity, they would offer consumers of all kinds significant running cost savings[3]. The government gave a broad intention in the Heat & Buildings Strategy to address these distortions but early and material progress on this agenda is essential to achieving sustained growth in the heat pump market.

Delivering a positive economic case for heat pumps will in itself drive significant progress over time in addressing wider barriers to adoption. Consumers will be more interested in the technology and more open to planning for a switch to heat pumps, companies will be more motivated to enter the

[3] This is illustrated in detail in the2021 Public First report Options for Energy Bill reform: https://www.publicfirst.co.uk/options-for-energy-bill-reform.html. This work estimated, that under current charging regimes, a household with a heat pump could pay up to ~£300 more per year for their energy than one with a gas boiler, but if existing distortions were removed, they would likely save ~£160 per year

sector and market solutions to their customers. More skilled workers will be attracted to the sector on the back of these changes. However, this will not be enough on its own to ramp up the delivery of heat pumps to the extent required. The government must further support this transition through energy efficiency programmes and incentives which encourage more properties to become heat pump ready (see our response to Q10 below) and through working with the private sector to develop training programmes which will expand the necessary skills base and encourage more gas boiler engineers to retrain for work on low carbon heating systems. There should also be regulatory measures to ensure high quality standards in heat pump installation and mandatory minimum levels of smart control. Network regulation also needs to allow for the necessary network investment at distribution level to support the timely connection of heat pumps (alongside electrification of transport).

With respect to the conversion of the existing gas grid to hydrogen, EDF supports a relatively cautious approach which would see further small-scale trials progressed over the next few years to enable longer-term decisions about the extent of the future role for low carbon hydrogen in home heating. In addition to addressing technical barriers, the low system efficiency (and thus likely high costs relative to direct use of electricity) associated with using hydrogen as a heating fuel needs to be considered in any analysis. Considering net zero requirements in the round, priority use for low carbon hydrogen should be directed to those sectors of industry and heavy transport where few if any alternative decarbonisation options exist. Even on a very ambitious timetable, it will take many years to grow volumes of low carbon hydrogen production to the levels likely to be needed to decarbonise industry and heavy transport at scale. Over the longer-term supplies of low carbon hydrogen may prove to be sufficient for the fuel to also play an important role in heat decarbonisation, either at a regional level or as part of a more nationwide hybrid solution alongside heat pumps. But we would draw the Commission's attention to analysis conducted by the Climate Change Committee in its 6th carbon budget advice to government, which concluded that

"*Full hydrogen conversion is unwieldy due to the low system efficiency which poses a significant supply-side challenge. As a worked example, 800 TWh of hydrogen would require 100-150 GW of gas reforming with CCS; or 300 GW offshore wind capacity if just using electrolysers. On this basis we do not recommend planning on a full hydrogen conversion*"[4]

Question 10: What evidence do you have of the barriers and potential solutions to deploying energy efficiency in the English building stock?

Extensive analysis by CCC has illustrated that a substantially expanded programme of energy efficiency installations is an essential element of the least cost pathway to decarbonising heat, whichever final mix of technologies are used for heating fuel supply[5]. More energy efficient homes are also important for maximising the number of properties which are heat pump ready.

The barriers to improving energy efficiency are well known and relate principally to the age and nature of building stock, up-front costs and low motivation of property owners to progress measures (eg due to inconvenience, long pay-back periods or energy costs falling on tenants). Over the past decade these barriers have been successfully overcome by successive tranches of energy supplier obligations, the most recent of which is the Energy Company Obligation (ECO) scheme, which has seen, since 2013, over 3.1 million energy efficiency measures installed in over 2.3 million homes.

[4] https://www.theccc.org.uk/wp-content/uploads/2020/12/Sector-summary-Buildings.pdf see p61
[5] See the same CCC report – eg p40-42

Ofgem analysis and evaluation has determined that previous phases of the ECO scheme have been cost-effective and have exceeded their targets for lifetime carbon and cost savings[6].

However both the current ECO3 and planned ECO4 schemes remain modest in scale, both when compared to the size of earlier energy supplier obligations (eg the Carbon Emissions Reduction Target (CERT) and Community Energy Savings Programme (CESP)which ran between 2008-2012 delivered some 8.5 million insulation and heating measures[7]) and to estimates of the scale of annual new installations needed to achieve net zero – which CCC estimates will need to increase by large orders of magnitude for loft, cavity wall, and solid wall insulation[8]

The current ECO scheme is constrained both by the budget envelope (level of expenditure energy suppliers can incur under the scheme) and by eligibility – which is limited to low income and vulnerable energy consumers. While EDF recognises the case for prioritising energy efficiency measures for these kind of customers, and we welcome the additional programmes on social housing and public sector buildings announced in the Heat & Buildings Strategy, if net zero targets are to be most cost effectively achieved it is essential that the number of installations increases substantially from today's levels amongst the wider owner-occupied "able to pay" category which accounts for the majority of UK properties. Current energy pricing challenges arising from record high gas prices only increase the case for a renewed national focus on energy efficiency and, even for measures which have relatively longer payback periods, the long lived nature of the building stock means that the ultimate lifetime national economic and carbon return on energy efficiency investment provides excellent value for money.

It is clear that current policies are not delivering new installations at the necessary volumes and EDF would therefore favour exploration of new measures – including the option of an expanded ECO scheme, supporting a broader category of customers and offering part-funding of measures rather than the full funding provided under the existing ECO. Other financial and regulatory incentives for driving increased installation of energy efficiency and low carbon heating measures should also be explored, including lower/zero VAT rating on all relevant equipment and measures, adaptation of Energy Performance Certificates (EPC) to provide a more rigorous and broader focus on lower carbon outcomes. Policies which provide incentives for installation during periods when a property is most commonly being up-graded, such as prior to, or shortly after, a sale, also deserve further consideration and the option of a variable, EPC linked stamp duty has been frequently raised in this context.

Question 11: What barriers exist to the long-term growth of the hydrogen sector beyond 2030 and how can they be overcome? Are any parts of the value chain (production, storage, transportation) more challenging than others and if so why?

EDF anticipates that low carbon hydrogen will play an important role in the transition to net zero, in particular (as noted above) for certain industrial sectors and heavy transport modes which are hard to decarbonise via alternatives such as electrification. The full extent of hydrogen's role across the economy remains uncertain and there are a wide range of scenarios; ultimately this should be determined principally by the cost reductions that can be achieved for low carbon hydrogen and how competitive hydrogen is versus other net zero consistent alternatives.

[6] See Energy Companies Obligation (ECO1) Final Report, Ofgem (September 2015) and Energy Company Obligation (ECO2) Final Determination Report, Ofgem (April 2019)
[7] See the House of Commons Library briefing paper on ECO – July 2020
[8] CCC Buildings Report for 6th carbon budget advice – p.41 (previously referenced)

The scope for long-term growth of the UK hydrogen sector beyond 2030 will be significantly impacted by decisions made and progress achieved over the coming decade. At present the main barrier to low carbon hydrogen adoption is its high cost relative to fossil fuels. The priority for this coming period should therefore be to grow the market for low carbon hydrogen to a scale where cost reductions can be delivered through economies of scale, learning by doing and continued technological development. EDF considers support for electrolytic hydrogen produced from renewable or nuclear power should be a particular focus; this form of hydrogen production is both the most net zero consistent on a full life cycle basis[9] and has the greatest potential for cost reduction over time through a combination of economies of scale in electrolyser manufacturing, efficiency improvements in electrolyser design and operation and lower cost low carbon power. The potential for hydrogen production from nuclear energy should also be further explored; nuclear can support hydrogen production at scale and, through combining low carbon heat from nuclear generation with solid oxide electrolysis, there is potential to achieve substantial increases of around 20% in the efficiency of hydrogen production using relatively low temperature steam from nuclear power. Even larger improvements may be possible over the longer-term utilising high temperature heat from new nuclear designs such as advanced modular reactors[10].

EDF welcomes the policy development government has undertaken as reflected in the Hydrogen Strategy published in August 2021. The combination of the Net Zero Hydrogen Fund, the hydrogen business model scheme and the low carbon hydrogen standard have the potential to support a meaningful pipeline of early low carbon hydrogen production projects. Nevertheless, to achieve the necessary scale to have transformative impacts on costs and UK industrial competitiveness, these schemes must be implemented quickly with a pragmatic approach which allows for early delivery. Further funding and more ambitious targets will be needed to realise the full potential of the UK hydrogen sector, alongside demand side incentives to switch to low carbon hydrogen, including a strong and consistently applied carbon price, and equal regulatory treatment for all low carbon forms of hydrogen including that from nuclear power

We support the government view that the initial priority for the sector is to grow low carbon hydrogen production. Alongside this, further work is needed to understand the potential long-term demand for hydrogen in different sectors and to consider a variety of possible technical approaches to hydrogen storage, including the interactions between the future hydrogen and electricity systems in managing seasonal imbalances between supply and demand. This work will the enable the development of the right strategies for hydrogen networks and hydrogen storage over the course of this decade. At this stage, it would be premature to make large long-term capital intensive commitments to specific approaches to hydrogen networks or hydrogen storage infrastructure.

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[9] See HMG's consultation on a low carbon hydrogen standard for latest assessments of the full life cycle emissions of different forms of hydrogen production.

[10] A project in Germany has already demonstrated the potential to improve hydrogen production efficiency utilising heat – further details at: https://www.green-industrial-hydrogen.com/project/news/sunfire-delivers-the-worlds-largest-high-temperatur-electrolyzer-to-salzgitter-flachstahl