Written evidence submitted by the Department for Business, Energy & Industrial Strategy

Executive summary

Solar photovoltaics is a cheap, versatile, and effective technology that can be deployed quickly in a range of locations on the ground and rooftops. It is a key part of the UK's energy mix and of the Government's strategy for decarbonising the energy system at low-cost and increasing energy performance of buildings. The British Energy Security Strategy set out an expectation of a fivefold increase in solar installed capacity up from the current 14 gigawatt (GW) to around 70 GW, by 2035. We will need sustained growth in both rooftop and ground mounted solar capacity in the next decade and beyond as we move to net zero.

Technological innovations will play a key part in facilitating this growth. Innovation is vital to decarbonising energy generation and transforming the UK energy system to achieve the Government's net zero goals. It can lower costs, help us to develop options, provide information that can reduce uncertainty, and develop new markets and commercialise new technologies to benefit the system and consumers, such as by driving solar panel and network efficiency[1].

1. What role can developments in solar panel technology play in the UK's transition to net zero?

The Government is monitoring developments in research into a number of emerging technologies such as Building Integrated Photovoltaics, thin-film coating technologies, and other technologies that can help to progress innovative solar deployment.

Traditional single-junction silicon cells with an optimal band gap for the solar spectrum have a maximum theoretical efficiency of 33.16%, the Shockley–Queisser limit, whereas the best commercial 'Interdigitated back contact' or IBC cells on sale now have an efficiency of around 23% (lower as they do not have optimal band gap matched to the solar spectrum). We expect traditional solar cells to get slightly more efficient with time, and to decrease in price, but large increases in efficiency will require cells using new materials and structures.

A key area of interest at the moment is in perovskite solar cells which have been demonstrated in the laboratory to have efficiencies greater than 30%. These can be either solid or thin-film designs. However, currently there are large issues to solve in both the lifetime of the cells and manufacturing them consistently on a large scale.

Other areas of active innovation are multijunction solar cells (solar cells with multiple p-n junctions made of different semiconductor materials). Gallium arsenide-based multijunction solar cells are the most efficient solar cells to date, reaching the record efficiency of 47.1% at high light intensities at small scale in the laboratory[2].

The Government supports UK-based innovation in solar power through various innovation schemes, including the Energy Entrepreneurs Fund which has invested over £100 million into developing and demonstrating state of the art technologies[3]. The BEIS Net Zero Innovation Portfolio and the UK Space Agency jointly fund the Space Based Solar Power

[1] https://www.gov.uk/government/publications/transitioning-to-a-net-zero-energy-system-smart-systems-and-flexibility-plan-2021

[2] https://www.nature.com/articles/s41560-020-0598-5

[3] https://www.gov.uk/government/news/11-million-boost-for-energy-entrepreneurs-to-turn-green-dreams-into-reality

Innovation Programme[4]. The Government is also supporting the deployment of floating solar panel projects, which can be eligible for the Contracts for Difference scheme - the main mechanism to incentivise large scale renewable generation deployment.

2. What are the current barriers (regulatory, technological or otherwise) to expanding the number of small and large-scale solar installations in the UK?

The significant increase in deployment of all types of solar and other forms of low carbon generation needed to meet our net zero targets will require change across the whole of society and wider energy landscape and brings both challenge and opportunity.

The shift towards net zero provides an opportunity to level up the country, create new green high skilled jobs and put the UK at the forefront of growing global markets in green technologies. The solar sector will be integral to this transition and will need to employ thousands of new personnel across a range of disciplines, including engineers, electricians, construction workers, project and environmental planners to ensure that the workforce is large enough to meet increasing demand for both rooftop and ground-mount projects. Low Carbon Renewables Energy Economic data[5] shows jobs peaking at c.10,000 in 2015 when deployment historically peaked with c.4GW of additional capacity.[6] It is likely that jobs supported will exceed 10,000 jobs in future as we will likely need to exceed the historic peak annual deployment in order to reach 70GW by 2035. The Green Jobs Delivery Group was formed after the publication of the Net Zero Strategy and acts as the central Government-industry forum for driving forward action on green jobs and skills. To tackle the range of near-term workforce challenges facing the power sector, a Power and Networks Workforce and Skills Working Group has been established with the mandate of developing a joint Government and industry pilot action plan, which will help unlock workforce and skills opportunities across the power sector (including solar) to deliver economic growth whilst meeting the Government's goals on net zero and energy security.

Solar PV benefits from established and competitive global supply chains. Maintaining and expanding these supply chains in a sustainable manner to match the level of deployment required to meet targets set by countries around the world, including the UK's expectation for a fivefold increase in capacity by 2035, will be critical but challenging[7]. This is discussed further in the response to question 8.

Accelerating our domestic generation of solar power also requires accelerating the development of the additional connecting network infrastructure to support it. The responses to questions 3-5 set out the action that Government is taking to enable this.

Whilst solar enjoys high levels of public support[8], as with other types of new infrastructure, this does not always translate into acceptance on the ground. Local opposition to proposed new projects can lead to legal challenges and delays in planning decisions, increasing the cost of projects and in some cases resulting in projects being abandoned. Government is

[4] https://www.gov.uk/government/publications/space-based-solar-power-innovation-competition
[5] https://www.ons.gov.uk/economy/environmentalaccounts/bulletins/finalestimates/2020
[6] https://www.gov.uk/government/statistics/energy-trends-section-6-renewables
[7] https://www.iea.org/news/the-world-needs-more-diverse-solar-panel-supply-chains-to-ensure-a-secure-transition-to-net-zero-emissions
[8] Solar is one of the most popular renewable energy sources. BEIS public attitudes tracker (June 2022) shows that 87% of the public support solar. Since the tracker has been running, solar has never dipped below 80% support. See: https://www.gov.uk/government/collections/public-attitudes-tracking-survey

aware that some communities have concerns about land-use and the visual and environmental impacts of large-scale ground mounted solar projects, particularly in rural areas. There are established routes in the planning system to consider the impacts of solar projects and to enable communities to raise concerns about developments in their area. The level and quality of community engagement, amongst other factors, are taken into account by decision-makers.

It is important that communities can participate in and benefit from the deployment of new low carbon energy technologies in their local areas. We are aware that solar and other renewable developers currently offer a range of community benefit schemes including funding for environmental enhancements, energy discounts, and investment in local infrastructure such as faster broadband, EV charging points or energy efficiency measures. Renewable projects can also bring wider socio-economic benefits to local people and businesses, including increasing local employment, creating regional supply chains and investing in new training facilities in the community.

It should be noted that ground mounted solar can be beneficial to the environment and enhance biodiversity and soil quality, particularly where sited on land that has been previously intensively farmed[9]. Solar and agriculture can co-exist and provide a route for farmers to cut energy costs, diversify and improve their revenue stream[10].

Rooftop solar projects use no land, have low visual impact and can contribute to a range of wider Government objectives for decentralised and local energy, smart grids and storage, energy efficiency and low carbon buildings. Although rooftop solar is more expensive than ground-mount with higher upfront costs potentially acting as a deterrent, residential solar panels have significantly reduced in cost over the past decade, and the removal of VAT on solar, and solar and storage packages, will make rooftop solar even more accessible. The Government is encouraging the uptake of rooftop solar for businesses installing solar for example, through a business rate exemption. Government is also exploring options to support low-cost finance to help householders with the up-front costs of solar installation.

3. To what extent is the contribution of solar technologies to the UK's renewable energy mix limited by storage and distribution capacity?

Over recent years, the number of renewable technologies that have been adopted and installed into the network in Great Britain has increased substantially, with a significant proportion of Great Britain's energy supply coming from renewable sources. However, we are aware that, in some areas of Great Britain, solar technologies are limited by the current capacity of the electricity distribution network. This is especially the case for large connections where upgrades to the transmission network are required to facilitate the distribution connection, which can delay connection timescales and create higher connection costs.

Ofgem, the independent energy regulator, is responsible for setting the investment framework for electricity networks to build, own and operate the grid. Ofgem does this

[9] The Natural Capital Value of Solar (2019) at: https://www.lancaster.ac.uk/energy-lancaster/about-us/news/solar-park-boost-for-naturer

[10] See National Farmers Union briefing note (December 2021 at: https://www.nfuonline.com/updates-and-information/solar-photovoltaic-electricity-in-agriculture

through the price control process. The next electricity distribution network price control starts in April 2023 and will enable investment in the network to help allow low carbon generation and demand technologies, including solar technologies, to join the network and provide low carbon power efficiently and effectively.

Government and Ofgem jointly published the Electricity Network Strategic Framework[11] in August. This contained commitments to accelerate network delivery and speed up connections to the grid including through the streamlining of infrastructure approval processes and enabling swifter planning approvals.

Electricity storage can enable us to use energy more flexibly and de-carbonise our energy system cost-effectively – for example, by helping to balance the system at lower cost, maximising the usable output from intermittent low carbon generation (e.g. solar and wind), and deferring or avoiding the need for costly network upgrades and new generation capacity. Electricity storage includes a range of technologies that can deploy at different scales and provide output for different durations such as lithium-ion battery storage, and pumped hydropower storage as well as emerging technologies including liquid air energy storage and flow batteries.

Government is facilitating the deployment of electricity storage at all scales through the joint BEIS and Ofgem Smart Systems and Flexibility Plan[12]. Our approach centres on creating a best-in-class regulatory framework by removing regulatory and policy barriers to the implementation of storage, ensuring that markets reflect the value of flexibility to the system and investing in innovation. This will ensure storage can enter the market and compete fairly alongside other new or established energy solutions.

4. How significant are current technological developments in energy storage and distribution networks for the potential contribution of onshore solar to the UK's renewable energy mix?

A smart and flexible energy system is essential for integrating high volumes of low carbon power, heat, and transport into the distribution network – improving system resilience and delivering savings as electricity demand increases. Flexibility also helps to deliver a more secure low carbon energy system – efficiently matching supply and demand for energy, and minimising waste.

Flexible connections, for example through active network management schemes run by distribution network operators, allow more generation to connect to the network faster and at lower cost. In return, developers accept that under certain network conditions they would not be able to export their full capacity.

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Flexibility from technologies such as electricity storage, smart charging of electric vehicles, flexible heating systems and interconnection could save up to £10 billion per year by 2050 by reducing the amount of generation and network needed to decarbonise and create

[11] https://www.gov.uk/government/publications/electricity-networks-strategic-framework
[12] https://www.gov.uk/government/publications/transitioning-to-a-net-zero-energy-system-smart-systems-and-flexibility-plan-2021

24,000 jobs. Increased flexibility could reduce system costs between £30-70bn from 2020 to 2050.

5. What needs to be done to facilitate solar farm access to grid connection, to enable wider distributed energy generation from solar installations?

At the local level, the grid is managed by Distribution Network Operators (DNOs). DNOs recover their costs from the bill payers in their region and Ofgem oversees their performance and investments through 5-year price controls known as "RIIO". Ofgem ensures that while investment into the network continues, customer bills are not impacted by unnecessary or inefficient expenditure.

As mentioned above, RIIO ED2, the next price control which runs from 2023 to 2028, will incentivise DNOs to take a strategic approach to network investment. Increased monitoring and modelling of their low-voltage networks will also allow DNOs to plan proactive reinforcements ahead of need.

Other work is also underway to address distribution network capacity issues. For example, the Electricity System Operator is working with distribution network operators through the Regional Development Programmes[13] to improve coordination, approaches to network methodologies, and procurement of flexible services in order to release network capacity across the country.

Additionally, the Energy Networks Association (ENA) has also developed a common approach to Connection Queue Management Milestones on the distribution network. These milestones provide strong commercial drivers to keep connection projects on track and ensure network capacity allocated to developers is fully utilised.

Furthermore, Ofgem have decided to socialise a further proportion of the cost of network reinforcements triggered by connections among billpayers, reducing the upfront cost of connecting for solar farms. These changes will come into effect from April 2023[14].

Under these changes to connection reinforcement charges, where reinforcement will take time to deliver or is delayed, DNOs will be required to procure services, such as storage, to allow projects to connect. This should accelerate connections to the network. With more costs being socialised, DNOs will also be incentivised to plan their networks more strategically and efficiently, based on anticipated future connections.

6. Are government support schemes sufficient to encourage small-scale solar technology deployment by consumers? What role does the pricing of energy under these schemes play in the uptake of solar technology by domestic and commercial properties?

Solar is an important part of the Government's strategy for increasing energy performance of buildings and contributes to meeting the Government's fuel poverty targets. As such, the Government's energy efficiency schemes, such as the Social Housing Decarbonisation Fund, Home Upgrade Grant, and the Energy Company Obligation all include solar panels as an eligible measure, subject to certain requirements.

[13] https://www.nationalgrideso.com/research-publications/regional-development-programmes
[14] https://www.ofgem.gov.uk/publications/access-and-forward-looking-charges-significant-code-review-decision-and-direction

Another way we ensure small-scale exporters are supported is through the Smart Export Guarantee (SEG). This is a new mechanism that significantly differs from previous support policies. It was not designed to replace the Feed-In Tariffs scheme (FIT) and incentivise deployment; rather it is a cost-reflective and market led mechanism helping to level the playing field for small-scale low-carbon generation whilst supporting the transition to a smart and flexible energy system. It ensures that householders with roof-top solar continue to have a route to market for any exported electricity following the closure of the FIT scheme.

At the time of its introduction, the main objective was to facilitate a competitive market and Ofgem reports annually on the range, nature and uptake of tariffs offered by suppliers which can be found at:
https://www.ofgem.gov.uk/publications/smart-export-guarantee-seg-annual-report-2021-22.

To date, the market has responded positively, with a range of SEG tariffs available to consumers.

Several factors need to be considered before deciding whether to install solar PV. Self-consumption and the protection this provides against the price volatility within energy market plays a more important role in the uptake of domestic and commercial solar. Battery storage supplied as part of a solar installation will benefit from a VAT zero rate for the next 5 years.

Levels of new small-scale solar deployment are now at levels previously seen under the FIT scheme before the tariff reductions introduced in 2016 and therefore, we have not considered it necessary to offer a replacement subsidy scheme, although we continue to keep this under review.

7. Does Government policy and current planning guidance adequately address the issues raised by proposals to install solar farms on land with high agricultural or ecological value?

Planning policy and guidance for renewables[15] is designed to strike the right balance between enabling delivery of the new infrastructure needed to generate secure clean, energy whilst taking into account local impacts. The Government recognises the need to protect local communities, environment and wildlife, and preserve our most productive arable farmland and continues to encourage large scale solar projects to locate on previously developed, or lower value land.

Where a solar project proposal involves land under Natural England's 'Best Most Versatile Agricultural land' classification (grades 1, 2, 3a), or greenfield land, developers are required to justify using such land and design their projects to avoid, mitigate and where necessary, compensate for any impacts. The weight given to these issues will depend on the project

[15] Solar projects above 50MW in England are determined by the BEIS Secretary of State under the Nationally Significant Infrastructure Project (NSIP) regime, whilst projects below 50MW are determined by local authorities under the he Town and Country Planning Act. The National Planning Policy Framework (NPPF) associated technical guidance and the National Policy Statements (NPSs) provide the frameworks for determining planning applications for ground-mount solar. The energy NPSs are currently being reviewed and it is our intention to publish updated documents in due course. The NPPF was last updated in 2021 and includes established policy principles that local authorities use when designating suitable areas for development, including for the use of any agricultural land. The Planning Practice Guidance for Renewable and Low Carbon Energy was designed to help local authorities in developing renewable and low carbon energy policies, and sets out environmental and amenity impacts from deployment, including use of agricultural land, that local authorities should consider when evaluating solar planning.

application. Factors, such as whether the project proposal allows for continued agricultural use where applicable and/or encourages biodiversity improvements around the proposed solar arrays may be taken into account by decision makers.

The planning system provides a robust framework for assessing impacts on the environment and amenities, including visual impacts. Proposals that are likely to have significant effects on the environment must be accompanied by an Environmental Statement, which will include an assessment of the impacts on ecology, wildlife and biodiversity, and the mitigation measures proposed. Planning guidance[16] also recognises that large-scale solar farms can have an impact on the rural environment, particularly on undulating landscapes. This has to be taken into account by decision makers when deciding whether or not to approve individual planning applications. Whilst it may be the case that the development can cover a large surface area, it should be noted that with effective screening, for example using native hedges, trees and woodlands, and appropriate land topography the area of a zone of visual influence can be minimised.

Government has been looking into options to support farming and energy security, which is why we are reviewing the frameworks for regulation, innovation and investment that impact farmers and land managers to make sure that our policies are best placed to boost food production, increase resilience, drive growth and protect the environment.

BEIS continues to work closely with the Department for Levelling Up, Housing and Communities and Department for Environment, Food and Rural Affairs on issues relating to planning, land use and environmental protection for renewable projects including solar.

8. How sustainable is the supply chain for solar panel manufacture? Do levels of sustainability differ between mature and emergent technologies?

For conventional mature silicon, single-junction, crystalline, solar cells, the main raw material used is sand (silicon dioxide). This is then purified and reacted to form polycrystalline silicon from which the crystals are grown that form the basic structure of solar cells. Small amounts of dopants are used in the construction of the panels which also incorporate glass and metal frames. All the materials are widely available. Over 85% of solar cells can be recycled.

The main greenhouse gas emissions from the manufacture of conventional solar cells are from the generation of electricity used in their manufacture. The US-based National Renewable Energy Laboratory (NREL) estimates[17] that solar power currently produces lifetime emissions of 40g CO_2 equivalent per kilowatt-hour (CO_2 eq/kWh) compared to new built natural gas fuelled CCGT plants without carbon capture of around 350g CO_2/kWh. A study[18] published by Nature Energy was more optimistic, with estimated emissions below 21g CO_2 eq/kWh. As electricity grids decarbonise, these numbers will significantly decrease further.

For emergent technologies, it is hard to determine a specific measurement of carbon intensity, as this and other sustainability metrics will depend on the technology, and will vary considerably with the approach taken. In many cases, the technology has only been demonstrated at small scale in the laboratory and the large-scale manufacturing routes are

[16] Guidance on Planning for Renewable and Low Carbon Energy at: https://www.gov.uk/guidance/renewable-and-low-carbon-energy

[17] https://www.nrel.gov/docs/fy13osti/56487.pdf

[18] https://www.nature.com/articles/s41560-017-0032-9

yet to be established. It is worth noting that many of these technologies use thin film designs, which intrinsically use less material overall than conventional solar cells.

Sustainability must also be considered with respect to social and governance impacts.

The Government is supporting the solar sector's development and the piloting of an industry-led initiative to further develop a responsible, transparent and sustainable solar value chain[19] .

The Government is deeply concerned by reports of forced labour in China and the impact of this on global supply chains, including the mining of polysilicon used in the manufacture of solar panels. The UK has led efforts to hold China to account at the UN. Over the last year we have introduced new guidance on the risks of doing business in Xinjiang, introduced enhanced export controls and announced the introduction of financial penalties under the Modern Slavery Act. This followed the Government's announcement in September 2020 of an ambitious package of changes to the Modern Slavery Act. These changes will require businesses and public sector bodies to report on specific areas in their modern slavery statements, including due diligence in relation to modern slavery. These measures will be included in the Modern Slavery Bill that was announced as part of the Queen's Speech in May 2022. Last year, under our G7 Presidency, G7 members committed to eradicate the use of all forms of forced labour from global supply chains. We will continue to keep our policy response under review.

9. Does the concentrated global distribution of solar panel supply chains (80% manufacture in China) pose a risk to solar technology expansion in the UK? If so, how could this be mitigated?

Solar is a mature technology with established and competitive global supply chains, with industrial-scale solar panel manufacturing mainly concentrated in the far-east, Canada and Germany. Increasing the capacity of solar PV installed in the UK required to meet 70GW by 2035 and net zero comes with the challenge of both diversifying the solar value chain and promoting the sustainable sourcing of solar panels, particularly in competition with other countries following the same trajectory. For example, during the Covid-19 pandemic, lockdowns in these manufacturing hubs squeezed the solar supply chain and resulted in delays to deployment of both ground-mount and rooftop installations.

Whilst the Government has no plans to intervene in the market to enable the UK to become self-sufficient in the manufacture of solar panels, renewable supply chain development is a key Government priority. The Government supports UK-based supply chains through developing robust supply chain plans as part of its flagship Contracts for Difference scheme, which supports large-scale solar deployment, and set to do so annually from 2023.

Several small firms based across the UK, for example, in South Wales, and England's Midlands, South and Northeast, are involved in producing conventional solar panels at a small scale as well as more innovative, building-integrated roof slates, and thin film technology that can also suit structurally lighter roofs. Several other firms also produce mounting structures and composite electrical equipment for ground mounted and rooftop solar installations.

The Government also supports supply chain innovation through a range of schemes, such as the Energy Entrepreneurs Fund, and initiatives funded by UK Research and Innovation

[19] https://solarstewardshipinitiative.org/

(UKRI). Some producers that have received such support have quickly grown to provide high-skilled jobs by opening larger premises in former industrial heartlands, such as those in the Northeast.

10. Are there opportunities for solar energy generated abroad (e.g in the Sahara Desert) to be delivered to the UK via interconnectors?

BEIS have had early-stage discussions with Xlinks, the project to import renewable energy (solar and wind) from Morocco to the UK.

December 2022