Written evidence submitted Dr Sugandha Srivastav and Mr Brian O'Callaghan

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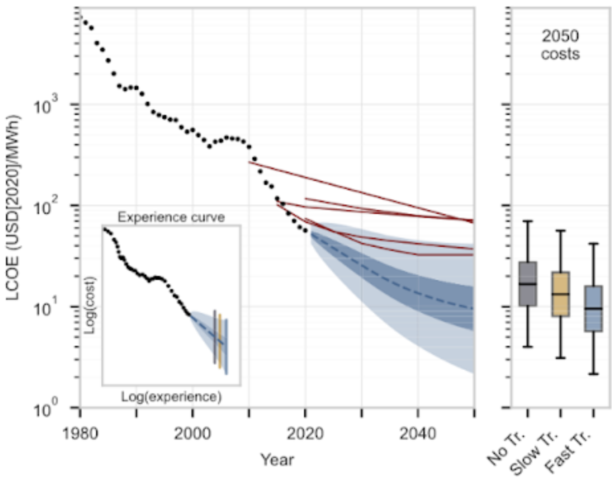
Reason for Submitting Evidence: to contribute to evidence based policymaking and serve the public interest through our roles as academics at the University of Oxford. The authors take full responsibility for any errors in this call for evidence. Statements reflect individual views and not that of SSEE or the University of Oxford.

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

Existing and forecasted efficiency improvements will make solar one of the cheapest sources of power (Way et al. 2022). The cost of solar panels is declining exponentially at a rate of about 10% per year. Previous forecasts have systematically underestimated these technological improvements. Way et al. 2022 highlight how the energy transition to renewables can save trillions.

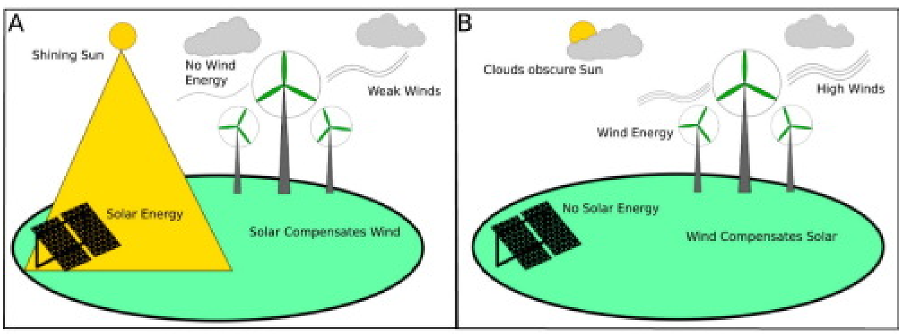
Figure 1: Solar Panel Cost Declines



Notes: Red lines show cost projections from IEA/IAMs, black dots show real data, and blue fans show probabilistic forecasting method adopted by Way et al. 2022.

Solar is complementary to wind and will play an important role in ensuring security of supply in a decarbonised grid (Prasad et al. 2017). On average, solar peaks during the day while wind usually peaks at night. Seasonally, solar peaks during summer while wind peaks during winter (National Grid ESO, 2022). This complementarity helps in grid balancing.[1]

Figure 2: Solar and Wind are Complementary



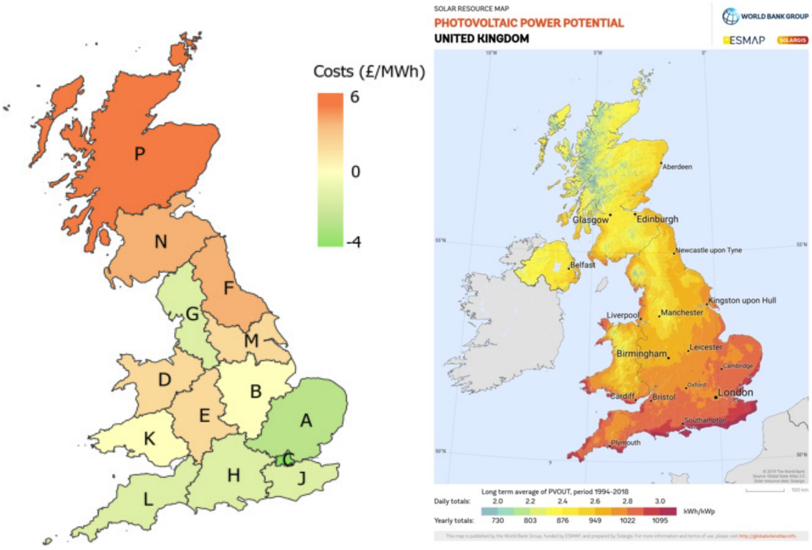
Source: Graphical exposition by Prasad et al. 2017

Solar irradiation is highest in the South which is a key area for further power development to reduce congestion costs. System balancing costs are higher up North where the majority of offshore wind

[1] These statements are true *on average*. This does not mean the statement will hold on any one particular day.

is concentrated. Most of the UK's solar potential is in the South, which is close to important demand centres. Research shows that "deploying renewables in the south of GB can decrease congestion cost by £4.04/MWh" (Savelli et al. 2022).

Figure 3: Solar in the South can Reduce Congestion Costs



Source: Figure on the left is about congestion costs from Savelli et al. 2022. Figure on the right on solar irradiation is from World Bank and ESMAP.

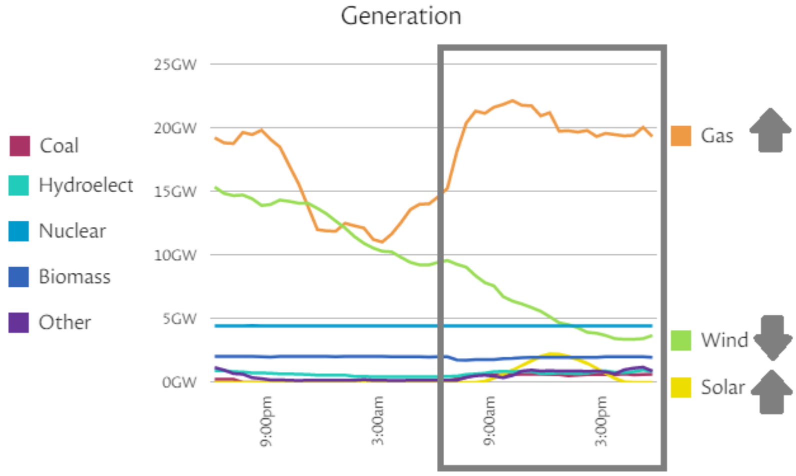
Solar is one of the few technologies that is modular enough to allow households and smaller agents to participate in the net zero transition, creating valuable buy-in.

Improvements in solar panel efficiency have vastly mitigated land-based limits on what solar may provide to the GB grid. In 2008, Sir David MacKay estimated that utility scale solar panels would operate with 10% efficiency. However, we now regularly see commercial efficiencies above 20% (Robertson 2020) and efficiencies in the lab have reached 47.1% (NREL 2022). This means we can get more from less, mitigating the land-use trade-offs.

Solar can serve up to 35% of demand during peak sunlight hours. Average yearly and monthly statistics conceal solar power's important role in serving daylight demand. Solar power accounts for 7.3% of monthly generation during summer but during peak sunlight hours, solar power's contribution can jump up to 35%. During winter months, solar power's contribution falls to 1-5% but this conceals that during peak sunlight hours, even in winter, solar serves 6-11% of power demanded (National Grid ESO, 2022).

Solar can help push out expensive gas. Using 22 November as an example, one can see that between 9am and the afternoon, wind generation fell but this was when solar power's contribution rose (Figure 4). The fall in wind generation required gas to ramp up. However, with more solar, gas can be pushed out, which will help reduce emissions, costs and reliance on geopolitically sensitive gas imports. Estimates show that if the UK were to match its "Balanced Net Zero pathway" between 2022-30, it could avoid spending a cumulative amount of ~£25bn on meeting its demand for gas during this period (Walsh, Sen, Hepburn 2022).

Figure 4: Snapshot of Daily Power Generation (November 22, 2022



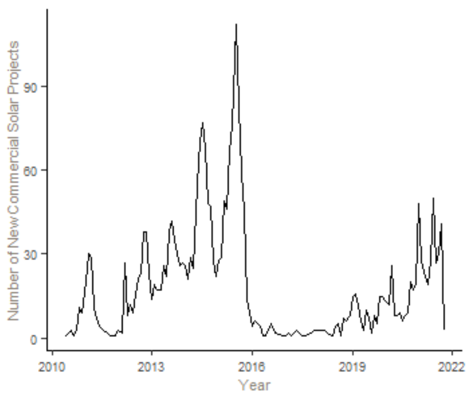
Source: National Grid Live using data from Balancing Mechanism Reporting System with annotations from the Author. Extracted on 22 November 2022.

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

Bans on what land solar power can develop on have severely shaken market confidence for utility-scale solar. There is merit in letting land-owners, who have the most detailed information about the productivity of their own land, make decisions on whether that land would be best used for farming, solar development or other uses. Blanket bans are economically inefficient as they prohibit the market from efficient allocation.

Uncertainty in the policy environment has negatively affected investment in utility-scale solar and policymakers should create more trust through stability in policy stance. Solar project developers value price certainty which has been offered through schemes such as feed-in-tariffs and contract-for-differences (Srivastav 2022). [2] However, unexpected changes to these schemes have shaken market confidence. The biggest shock was in 2016, when a suite of changes to UK energy policy caused a collapse in new solar project development and capacity (Srivastav 2022). Today with geopolitical tensions around imported gas, the cost of this lost domestic capacity is more tangible (CarbonBrief 2022)[3].

Figure 5: Dramatic collapse in new commercial solar projects in 2016, UK



Source: Srivastav, S. 2022. "Bringing Breakthrough Technologies to Market: Evidence from Renewable Energy Feed-in-Tariffs". Working Paper.

[2] This blogpost contains the summarized version of the findings from Srivastav, S. 2022. "Bringing Breakthrough Technologies to Market: Evidence from Renewable Energy Feed-in-Tariffs". Working Paper.
[3] While the headline of this article talks about wind being cheaper than imported gas. The same is true for domestic solar.

Regarding contracts for differences, policymakers should reassure investors that solar would continue to be eligible for the scheme across future auction rounds.

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

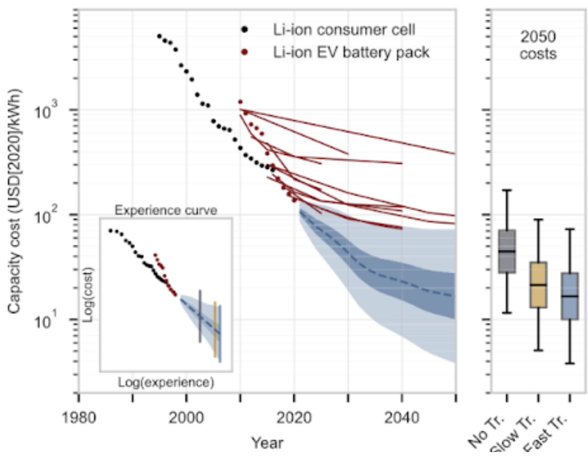
Given that solar generation is currently a small part of the UK grid, storage and distribution are unlikely to limit solar power's potential in the short-term. However, as solar capacity starts growing, investing in storage solutions and thinking about strategic placement will become important.

An "Enhanced CfD" proposed by Savelli et al. 2022 can optimise the placement of renewables taking into account system costs related to storage and distribution. This will "incentivise more efficient investments by signalling where renewable assets can offer more value from a whole system perspective, promote fairer competition between renewable energy technologies with different levels of intermittency, and reduce actual carbon emissions by accounting for the effect of grid redispatch."

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?

Battery costs have declined faster than predicted which bodes well for integrating renewable energy into the UK grid cost-effectively (Way et al. 2022)**.** The red lines show how many forecasts underestimated actual and observed cost declines in batteries. The superior probabilistic forecasting methods proposed by Way et al. 2022 (in blue) illustrate that battery costs are expected to fall substantially.

Figure 6: Declining Battery Costs alleviate Concerns about Costs of Integrating Solar



Notes: Red lines show cost projections from IEA/IAMs, black dots show real data, and blue fans show probabilistic forecasting method adopted by Way et al. 2022.

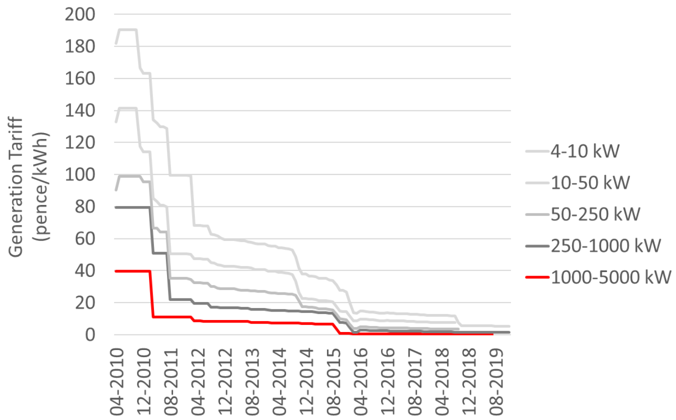
Are government support schemes sufficient to encourage small-scale solar technology deployment by consumers? What role does the pricing of energy under these schemes play in the uptake of solar technology by domestic and commercial properties?

Providing a risk-hedging mechanism for the price at which solar power can be sold to the grid increases the incentive for uptake (Srivastav 2022). The Smart Export Guarantee, broad eligibility base of the ECO4, and VAT reduction will help domestic and commercial players adopt rooftop solar. However, efficient design is important.

Past schemes such as the FiT provided substantially larger subsidies to the smallest scale solar, generating concerns about efficiency. Small-scale solar received subsidies were as much as 4.5 times larger relative to ground-mounted utility-scale solar (Figure 7). Since there are well-documented economies of scale between 1-1000 kW (Farrell 2016), this raises concerns about efficiency losses and value-for-money.

Policy design should consider distributional impacts. The feed-in-tariff scheme for rooftop solar was regressive (Grover 2013). While the costs of the feed-in-tariffs were passed on to all households, a disproportionately high share of high-income households took advantage of the policy to install solar panels. Support for utility-scale solar did not have the same distributional implications as power fed into the grid.

Figure 7: More generous FiTs for small-scale solar generation



Source: Srivastav S. (2022). "Bringing Breakthrough Technologies to Market: Evidence from Renewable Energy Feed-in-Tariffs". Working Paper.

December 2022

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