Best Available Solution for Sustainable UK Energy Supply

Executive Summary 2 December 2021

The proposed best available solution for a viable, sustainable, adaptable energy supply for the UK to enable sustainable economic growth whilst addressing the very significant and increasingly urgent challenges of global warming, air pollution, reducing biodiversity and increasing levels of international conflict for scarce resources (including fossil fuels, fresh water and biomass):

- Uses those renewable natural resources which are readily available and which can be used to generate and to supply electricity and heat energy using proven, cost- effective technology without damaging the environment.

- Provides a resilient supply of 100% renewable electricity to the UK at the lowest unsubsidised price (approximately 4 p/kWh) in the world to satisfy UK's current electricity requirements as well as to replace the existing energy supply for domestic and commercial property space heating and hot water, and road transportation which is currently based upon petrol and diesel-powered internal combustion engines.

- The UK is divided into Sustainable Community Grids (Cities, Counties & Regions) which will use the existing electricity distribution network infrastructure to supply electricity generated by the Community's optimal mix of roof-mounted solar (summer peak generation) and onshore wind systems (winter peak generation) which have complementary generation seasonality will ensure that supply and demand for electricity are matched precisely throughout the year.

- Use of distributed roof-mounted solar PV system generation will maximise electricity supply directly to the supporting domestic and commercial buildings, and minimising Community Grid loading. Consequently, the existing UK regional Electricity Distribution Networks will be unlikely to require any significant capacity upgrades;

- Every individual Community Grid will be balanced at all times so that the Community's expected annual demand for electricity is matched by the Community's forecast annual electricity generation from its own seasonally complementary solar PV systems and onshore wind turbines.

- Each Community's V2G (Vehicle-to-Grid), V2H (Vehicle-to-Home) and V2B (Vehicle-to-Business) -enabled EV (cars, LGVs /vans, HGVs, and buses & coaches) battery storage and supply capacity will provide the necessary dynamic, short term electricity supply to cover any temporary shortfalls between electricity generation and

electricity demand. V2G and V2B EV charge /discharge points will be installed by each Community in all or most of the car parks within its Community area.

- Demand Response measures (e.g. essential EV driving only, working from home) will be developed by each Community to be implemented in the event that multiple consecutive days were forecast with both low daylight intensity and low wind speed which would reduce the Community's solar and wind electricity generation.

- Each Community Grid (CG) will be managed by its own Electricity System Operator (ESO) which will proactively manage the electricity supply system by continuously monitoring current and forecast electricity demand and supply (primarily based upon daylight intensity and wind speed for solar and wind generation respectively), maximising total electricity storage level in Community Grid-connected EV batteries, and, if necessary, implementing agreed Demand Response actions at any times during the year when multiple, consecutive low daylight intensity and low wind speed days are forecast.

- The ESOs will make use of Interconnect Agreements with the National Grid to supply electricity in the extremely unlikely event that the above actions are insufficient to avoid any electricity supply-demand shortfalls for their Community Grids.

- The National Grid will actively manage the installation and operation of bi-directional interconnectors with other countries and set up renewable electricity export /import electricity supply agreements with those countries which are able to supply renewable electricity. A further level of resilience for UK electricity supply could be provided by interconnectors with countries which are generating non-renewable electricity. The intention is that non-renewable electricity will only be required from other countries in the extremely unlikely situation that all of the other levels of resilience in UK electricity supply have been unable to satisfy the UK's electricity demand.

This proposed solution does not require any public sector funding and it will enable the UK to transition to a Sustainable UK Interconnected Community Grid Network Electricity Supply.

Based upon a UK assessment of electricity demand, the forecast estimated total electricity requirement is 526 TWh pa (ref. Note 1 below) after transitioning to 100% air source heat pumps and 100% EVs comprising:

- 104 and 192 TWh pa for existing domestic and commercial electricity usage respectively;

- 110 TWh pa potential electricity required for 100% Air Source Heat Pumps in domestic and commercial properties for space heating, hot water heating and other processes requiring heat energy (ref. Note 8 below); and

- 120 TWh pa potential electricity required for 100% EVs (ref. Note 7 below).

The total annual electricity generation for existing installed roof-mounted (7 GW generating 7 TWh pa) and ground-mounted (6 GW generating 6 TWh pa) solar PV systems, onshore (14 GW generating 35 TWh pa) and offshore wind (10 GW generating 41 TWh pa) turbines & hydro-electric systems (2 GW generating 7 TWH pa) less National Grid transmission losses (6 TWh pa) is 90 TWh pa.

The existing installed solar PV systems, wind turbines and hydro-electric systems will be used to directly supply either the nearest or most appropriate (based upon individual Community Grid electricity demand – supply assessments) Community Grid.

The required additional capacities of installed onshore wind systems, Commercial roof-mounted solar PV systems and Domestic roof-mounted solar PV systems to generate at least 436 TWh pa electricity are 130 GW (i.e. 10,830 no. 12 MW wind turbines to generate 342 TWh pa), 100 GW (i.e. solar PV systems covering approx. 80% total available commercial roof space to generate 87 TWh pa) and 26 GW (solar PV systems covering approx. 9% available domestic roof space to generate 21 TWh pa) respectively (ref. Note 3 below).

The expected annual electricity generation by the proposed additional solar PV system and wind turbine capacities exceed the annual minimum requirement by 14 TWh pa. However, a small surplus in expected annual generation will minimise the risk of any expected time-of-year supply-demand shortfalls.

It is proposed that each Community will set up a Sustainable Community Fund (SCF) to fully finance (i.e. without public sector funding) all of the required investments in:

- roof-mounted solar PV systems on commercial and domestic properties, onshore wind turbines;

- EVs for 100% cars, vans /LGVs, HGVs, and buses and coaches (ref. Note 16 below);

- air source heat pumps for 100% commercial and domestic properties (ref. Note 17 below); and

- the required improvements in loft, cavity wall and solid wall insulation and in secondary glazing for those domestic properties which are without these forms of insulation and /or double /secondary glazing (ref. Note 18 below).

The SCFs for all of the UK Communities will deliver a competitive investment return (forecast pre-tax IRR = 4.9% pa on a total investment of £1,885 billion spread over 10 years duration investment programme) for debt funders and equity investors.

Individual domestic and commercial property owners and road transport vehicle owners will be able to use their own funds /funding arrangements to purchase roof-mounted solar PV systems, air source heat pumps and property insulation improvements on their properties and to purchase their own EVs.

There will be no requirement to rely on natural gas or hydrogen supply from the UK Gas Network if air source heat pumps (for space heating and hot water) are installed in all domestic and commercial properties. The assessment of the requirements for loft, cavity wall and solid wall insulation, and secondary glazing will be managed by the local City /County /Region CG Electricity System Operator (ESO) to ensure that only the essential improvements in the insulation of the domestic properties are carried out cost effectively in order to enable effective operation of air source heat pumps in these properties.

With the adoption of 100% EVs the air in all UK Communities will be clean and there will be no CO2 emissions from petrol /diesel engines.

There will be no requirement for electricity generation by coal, gas, nuclear, biomass, biofuel, biogas or CHP (combined heat & power) power stations. Also, this proposal does not require any electricity generation from a range of unproven (in cost effectiveness terms) new technologies (including wave, tidal, nuclear fusion, green hydrogen, and carbon capture & storage combined with non-renewable generation) which are not expected to be more cost effective than solar PV systems and onshore wind turbines unless there are significant future electricity generation cost reductions resulting from, currently , unanticipated technology developments.

The total cost of additional capacity of installed onshore wind and solar PV systems for all of the UK Community Grids is £261 billion in total comprising £163, £75 and £23 billion for the required additional capacities of installed onshore wind systems, Commercial roof-mounted solar PV systems and Domestic roof-mounted solar PV systems respectively (ref. Note 6 below).

The total installed cost (for all UK Communities) of 100% Air Source Heat Pumps in domestic and commercial properties is £196 billion (comprising £165 and £31 billion for domestic and commercial properties respectively). The average air source heat pump installed costs are based upon future achievable costs resulting from economies of scale of manufacturing combined with developments in the design of the main components plus benefit of Community purchasing power.

The total installed cost (for all UK Communities) of loft, cavity wall and solid wall insulation, and secondary glazing in domestic properties without loft /cavity wall /solid wall insulation and /or double /secondary glazing is £111 billion (comprising £3. £6, £96 and £6 billion for installation of loft, cavity wall and solid wall insulation, and secondary glazing respectively.

The total cost (for all UK Communities) of 100% replacement of all cars, LGVs, HGVs, and buses & coaches with EVs is £1,316 billion (comprising £960, £176, £150 and £30 billion for Cars, Vans /LGVs, HGVs, and Buses and Coaches respectively. The average EV costs are based upon future achievable costs resulting from economies of scale of manufacturing combined with developments in the design of the main components (including batteries, electric motors and vehicle control units) plus the benefit of Community purchasing power.

Onshore wind turbines located within and /or adjacent to the outer boundary of each Community area will be able to supply electricity to the Community Grid at a tariff of approximately 3.3 p/kWh (varies slightly across UK depending upon the local wind speed). By comparison the latest offshore wind farms are supplying electricity as an "input" to the National Grid at a CFD (Contract-for-Difference) price of approximately 5 p/kWh. However, the "output" tariffs to domestic and commercial customers from National Grid electricity suppliers are approximately 21 and 14 p/kWh for domestic and commercial customers. It is anticipated that the residents of UK Communities will almost certainly be in favour of low tariff electricity supplied by local onshore wind turbines directly to their local CG for use by domestic and commercial customers in their Community area only.

The air source heat pumps will be able to supply heat energy more cheaply than a natural gas-fired boiler. Currently, natural gas boilers have an average efficiency of approximately 80% and the current natural gas tariff is approximately 3.85 p/kWh, so the effective tariff for the useable heat energy supplied is approximately 4.8 p/kWh. The tariff for the net heat energy (i.e. 2 kWh net heat energy per kWh electricity based upon a COP [Coefficient of Performance] of 3.0) supplied will be 4.1 p/kWh for MCG domestic and commercial customers.

All owners of cars, vans /LGVs, HGVs, and buses and coaches will have a compelling financial reason to lease EVs procured by the Sustainable Community Funds since the annual lease and electricity costs will be less than the current annual cost of petrol /diesel for their current ICE (Internal Combustion Engine) vehicles.

The annual savings [i.e. (Average annual cost of petrol /diesel for current on-road ICE vehicle) – (Annual net EV rental charge + Average annual cost of electricity)] per vehicle per vehicle owner which will result from exchanging ICE vehicle for EV are approximately

£100, £200, £8,000 and £1,200 pa for cars, LGVs /vans, HGVs and buses /coaches respectively.

The attached “UK Community Grid Electricity Supply Model” and supporting text document provide more detailed information and analysis to support this Executive Summary for both an example of a Community Grid (1st worksheet; Greater Manchester) and the UK as a whole (2nd worksheet). This model can easily be customised for any other UK Community Grid (i.e. city, county or region).

An example of a Community proposal entitled “Sustainable Manchester Community Grid (MCG) Electricity Supply” is attached and this proposal was emailed to the Mayor of Greater Manchester on 17th November 2021. Similar proposals will be prepared for other UK City, County and Region Communities.

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