Towards 100% Renewables

This paper is presented by SERA Scotland to Scottish Labour's Energy Commission to present arguments which will encourage the Commission to adopt proposals for a zero carbon economy, without recourse to nuclear or doubtful technologies which require large-scale negative emissions instead of decarbonisation. The aim is also to encourage the necessary investment in infrastructure to develop an energy system which can be run on renewable sources some of which are intermittent or variable.

Introduction

Last Summer a team of researchers from Stanford University in California published a paper in the Royal Society of Chemistry's Energy and Environmental Science Journal which provided roadmaps for 145 countries to provide 100% of their energy requirements using wind-water-solar (WWS) energy, efficiency, and storage, ideally by 2035, but by no later than 2050. The compelling feature of these 100% renewable energy scenarios is that they require less energy, cost less, and create more jobs than business as usual scenarios. (1)

Many research groups have examined 100% renewable energy (RE) systems and found that they can keep the grid stable at low cost. In fact, by June 2022 at least 70 peer-reviewed published journal articles from 25 independent research groups with 142 different authors supported this result showing that energy for electricity, transportation, building heating/cooling, and/or industry can be supplied reliably with 100% or Near-100% RE at different locations worldwide. (2) An article published in the journal "Energy" in May 2019 found that 180 studies on 100% renewables had been published since 2004. The authors of that paper say that six months later the number had jumped to 280. (3)

In 2022, a new analysis of energy research by 23 scientists from around the world concluded that the world can reach a 100% renewable energy system by or before 2050 at low cost. Advanced concepts and methods now enable realistic, cost- or resource-optimized efficient transition pathways to be developed without the use of fossil fuels. (4)

Most recently a study carried out by renowned energy modelling academics at LUT University in Finland concluded that a 100% renewable energy mix for the UK would save well over £100bn in achieving net zero by 2050, compared to the UK Government's current strategy. (5)

Flexibility is the Key

Leading technology innovation company, Wärtsilä has produced an Atlas of 100% Renewable Energy which shows the cost-optimal capacity mix for 100% renewable electricity systems in 145 countries and regions around the world. This shows that flexibility using future-proof gas engines powered by green hydrogen, energy storage and optimisation - can enable the massive expansion of renewables we need, and also be the lowest cost route to decarbonisation. Using balancer engines alongside energy storage saves almost 40% compared to the cost of achieving the transition with storage alone. (6)

Yet, here in the UK, National Grid narrowly avoided implementing emergency plans to fire up old coal plants to help avert a potential supply shortage during the cold snap in mid-December with war disrupted natural gas supply. (7) And the *Telegraph* introduced a new German word into the English language – Dunkelflaute - which literally means dark wind stillness or lull. It refers to weather conditions involving thick, heavy clouds and little to no wind. Because wind power has contributed just over a quarter of the total electricity generated in Britain over the last few months, when there's a lack of wind it puts the rest of the generation under pressure. So, the UK has turned to other fuels to generate power, mostly gas, pushing up the cost of electricity, and making the gap between supply and demand uncomfortably small. (8)

Looking beyond the current turmoil, how can we avoid worst-case scenarios in future with the threat of power cuts when renewable generation is low and at the same time end our reliance on fossil fuels? Nuclear advocates promote the idea of building more baseload power stations, implying that these can provide power 24/7, unlike variable renewables. This notion would introduce massive delays into any transformation to a zero-carbon economy, along with security, environmental and cost obstacles.

Questioning the viability of new build nuclear to support a new flexible energy system - The Baseload Myth

Michael Liebreich CEO of Bloomberg New Energy Finance explained to Carbon Brief:

"*Firm power which cannot be switched off when you don't need it will be as much of a problem as variable power which cannot be switched on when you do. What is called for is flexibility, in huge quantities and of all types.*" (9)

In 2015, the CEO of National Grid declared: "*The idea of baseload power is already outdated*." In the US an executive from PG&E, one of the nation's largest utilities, said, "*The idea of a large baseload generator that runs pretty much all the time … just doesn't have as good a fit to the market conditions we expect to see*" in the grid of the future. (10)

The World's largest private bank – UBS agrees that large-scale, centralised power stations will soon become extinct because they are too big and inflexible, and are "*not relevant*" for future electricity generation. (11) Similarly, HSBC Bank has predicted that conventional generators will be the biggest losers from an upcoming energy storage boom. (12)

Michael Grubb, Professor of International Energy and Climate Change Policy at University College London, told the House of Lords Selected Committee on Economic Affairs: "*If you are*

worried about how to provide power during winter periods when there is a cold dark windless night, you do not want to build a spanking new plant designed to run 100% of the time." (13)

The problem is that baseload is not helpful in balancing a variable energy supply – it simply leads to further overproduction of energy at times when renewables can meet demand on their own. In a grid which has a large contribution from variable renewables, what is required is flexible electricity supply which can be turned on and off quickly to fill the troughs when renewables aren't able to supply. Baseload power which operates 24/7 actually constrains the expansion of renewables because they are only able to supply that percentage of demand not covered by baseload. For instance, a report by a leading energy consultancy, Cornwall Insight, for the 100%RenewableUK group found that, in 2017, 94% worth of windfarm output that had been turned off (constrained) could have been generated had nuclear power plant not been operating. In 2019, 77% of the windfarm output that had been turned off could have been generated if nuclear was not operating. Windfarm compensation payments in 2017 were close to £100 million, and around £130 million in 2019. (14)

Baseload generators are not needed in an all-renewable future and their use will almost certainly increase overall costs to consumers according to the Claverton Energy Group of experts. Detailed modelling of the entire heat, power and transport system in the UK shows that the continuing fall in wind and solar energy costs, along with cheaper storage of heat and power, means that an entirely renewable and highly reliable power supply as a replacement for fossil fuels for heating and transport through electrification is available to the UK at a lower cost than any alternative, even when wind and solar droughts (i.e. periods of low wind or solar) or imported fuel hiatus are considered. The report shows that the claim that nuclear energy is needed to provide baseload power is a myth. Because nuclear cannot readily be turned off for economic reasons, its presence on the grid limits the amount of much cheaper renewables that can be used, as nuclear would have to take precedence over renewables – thus increasing the total cost. Renewables can provide continuous power 24/7 by making use of green-hydrogen-fuelled generators to compliment wind, solar and storage and at a lower cost. (15)

Another modelling exercise from UCL published in September designed cost-effective net-zero energy systems for 2050, using any mix of technologies, such as nuclear fission, interconnectors with other countries, bioenergy with carbon capture, hydrogen storage, lithium batteries, wind and solar power. The study found that renewables and storage technologies, such as wind, solar and batteries, are becoming so competitive on price that they are upending traditional thinking about energy grid design. The report's author, James Price concluded the government's backing for new nuclear is "*increasingly difficult to justify*". (16)

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So how could a renewable dominated system operate without baseload?

Almost a decade ago Michael Liebreich, CEO of Bloomberg New Energy Finance postulated that "…*there are plenty of ways of managing intermittency in renewables without resorting to expensive backup power*."

"*First, you improve your resource forecasting. Second, by interconnecting the grid over larger areas, much of the variability of renewable energy can be evened out. Third, just when an increased proportion of renewable energy means you start losing control over supply, the introduction of digitally controlled smart grids gives you better control of demand. Finally, there is power storage, currently mainly in the form of pumped hydroelectric power but, in future, most likely in the form of batteries for electric vehicles. The cost of each of these techniques is coming down just as rapidly as the cost of renewable energy*." (17)

There are several ways of balancing a variable renewable energy system:-

First and foremost, by reducing overall demand with a comprehensive energy efficiency programme. New research from the Centre for research into Energy Demand Solutions' (CREDS) suggests UK final energy use could be reduced by as much as half by 2050 while at the same time improving energy security, enhancing quality of life. CREDS stressed that reducing overall energy demand is a critical part of the zero-carbon transition and has suggested that energy use reductions could be achieved through a number of social changes, including but not limited to changes to the ways in which people travel, use consumer products, and heat our homes, as well as through the use of new energy efficiency technologies. (18) Another study by the UK Energy Research Council found that cost effective investments in domestic energy efficiency alone between now and 2035 could save around 140TWh of energy – roughly equivalent to the output of six power stations the size of Hinkley Point C. (19)

Secondly, demand management – using various techniques to reduce demand at peak times. This would include, for instance, introducing time-of-use tariffs. The National Grid's Electricity System Operator (ESO) began testing a demand flexibility system at the end of 2022 during which participants were paid to turn down their energy demand at peak times in order to reduce peak demand. (20) Smart control systems could be used to charge electric vehicles and operate heat pumps at times when renewable energy is plentiful. The City of Nottingham, for instance aims to maximise the use of locally generated renewable energy to cut the carbon emissions and costs associated with charging electric fleet vehicles, as well as reducing peak demand by using vehicles for short-term storage. (21) Imagine a local authority whose fleet of electric vehicles returns to base at around 4pm and is then able to sell any electricity still stored in the vehicles back to the grid at peak prices. The vehicles are then recharged overnight using cheap non-peak electricity and are ready for the road in the morning. (22)

Similarly, cold storage company Norish works with Edinburgh-based flexibility services company, Flextricity, so that at times of high national electricity demand, Flexitricity turns down Norish's cooling plant for short periods to reduce the stress on the electricity network. Critical temperatures are monitored to ensure the integrity of the stored product. This allows Norish to earn extra revenue without disrupting its normal business operations. (23)

A report from the Carbon Trust shows that flexibility could deliver up to £16.7 billion in savings per annum in 2050. As such investing in flexibility is a “no-regrets decision”. Flexibility can be created through a range of technologies, including battery storage, thermal storage, interconnectors and demand side response technologies across domestic, non-domestic and electric vehicle (EV) sectors. Across the different scenarios detailed in the report, up to around 48GW of flexibility from EVs, 12GW from domestic smart appliances, 11GW from non-domestic Demand Side Response (DSR), 83GW of battery storage and 900GWh of thermal storage were deployed. (24)

A project is underway to use excess wind generation to heat Highlands homes. National Grid ESO spends tens of millions of pounds curtailing output from wind farms each year. It does this to keep the grid stable. With more wind coming on to the system, there will be more periods of excess generation. Using excess power to heat homes helps solve that challenge. If the heat infrastructure is also made smart, it can become an additional source of flexibility for local and national system operators. (25) In another example, an Irish social enterprise that offers fuel-poor households free hot water using surplus electricity from wind is hoping to expand across the UK later this year. (26)

Batteries allow surplus renewable electricity to be stored either as electricity or heat. These supplies can then be called upon when wind and solar production is low. Battery storage systems in homes can be amalgamated and controlled in unison to create what is known as a Virtual Power Plant which relieves pressure on electricity grids. (27) Heat batteries can be used in conjunction with heat pumps, allowing heat pumps to take advantage of cheaper off-peak electricity. (28)

Electricity can also be stored by using Pumped Hydro Storage Systems. Surplus electricity is used to pump water back up to a reservoir when there is a surplus. This water can then be used to generate electricity at peak times. SSE Renewables has received consent to build the Coire Glas scheme in the Great Glen, 19 miles south of Fort Augustus, which will be the first new pumped storage scheme to be developed in the UK since 1974. (29)

Gravitricity - an Edinburgh company - is planning to use old mine shafts as batteries to store renewable energy. It has built a demonstration project showcasing the technology in Leith. Using large weights on cables attached to winches surplus electricity would be used to lift the weight to the top of the mine shaft. Then when demand is outstripping supply the weight can be lowered, with the movement of the winches generating electricity. (30)

Highview Power is currently building the world’s first commercial liquid-air energy storage facility — a 50MW/250MWh unit —in Greater Manchester, after the technology company received a £10m ($12.5m) grant from the UK government. The cryogenic energy-storage system uses frozen liquid air as its storage medium providing a long-duration energy storage solution. (31) Highview Power now has more than a dozen firm projects around the world in its pipeline adding up to roughly 400MW/4GWh. (32)

Surplus renewable electricity could also be used to create hydrogen through electrolysis. Hydrogen could then be used to generate electricity at times of peak demand or for other uses, for instance in Orkney it will be used to power ferries. (33) Along with environment

consultancy Arup, Gravitricity has secured £299,985 from the Department of Business Energy & Industrial Strategy (BEIS) to study the feasibility of purpose-built underground shafts where gravity storage could be combined with hydrogen and inter-seasonal heat storage. (34)

Combined heat and power stations working in conjunction with heat storage and electricity storage can be called on to generate electricity at peak times. For instance, the Gateshead District Heating scheme, which incorporates heat and power generation and storage, works with Flextricity to provide balancing services to the National Grid. (35)

By using the right mix of renewables variability can be reduced. Tidal and geothermal power, for instance are not reliant on wind and sunshine in the same way as other renewables. The cost of tidal stream energy (TSE) looks set to plummet below £80/MWh by 2035 according to a new report, produced by the Offshore Renewable Energy (ORE) Catapult. (36) At Rosyth, the FastBlade rapid testing facility for tidal turbine blades - a partnership between the university and Babcock – is aiming to deliver a range of innovations to improve the performance of tidal turbines and reduce costs. (37)

Grid connections to other countries are also helpful so that electricity can be imported at peak times when indigenous renewable production is low, and surpluses can be exported.

Finally, some analysts suggest overbuilding renewable capacity so that you're spilling up to 30% to 40% of total production. This idea involves using price signals which allow flexible consumers adapt to those price signals using software to manage existing loads. The cheapest form of flexibility we have on the power system is price signals combined with demand response. (38) The idea of discarding available wind or solar output when production exceeds what the grid can accept may be anathema, but it may be cheaper than installing more battery storage. (39)

Conclusion

Large baseload plant cannot provide the flexibility required, because they need to operate 24/7, and will, in fact, hamper the growth of cheaper renewables. Future policy should, therefore, focus on encouraging the necessary investment in infrastructure required to support an energy system which operates on variable renewable sources.

The concern over whether a 100% renewable energy system can match demand with supply can be overcome by combining variable generation with storage and demand response. In addition, interconnecting geographically dispersed wind solar and marine power can smooth out the supply of these generators. The future grid will contain many more flexible loads due to the electrification of heat and transport and the expansion of district heating networks. Flexible loads can be met ahead of time with storage or by shifting demand forward in time. Flexibility alone can deliver billions in cost savings.

A 100% renewable system requires less energy, costs less, and creates more jobs than Business as Usual. (40) Scotland and the UK should be looking to increase investment in flexible energy technologies, such as battery energy storage and advanced flexible gas, to

facilitate a rapid increase in the share of renewable generation in the UK by 2030. The overall cost to consumers of such a strategy would be much less than building obsolete baseload generating capacity. In a Wartsila Report, which does not support nuclear power as the way forward, it is acknowledged that “Carbon intensity of Renewables plus Nuclear is lower overall due to the inclusion of nuclear as non-fossil fuel baseload power alongside renewables.

However, as analysis shows, the additional cost per year is substantial compared to a relatively small improvement in carbon intensity." The modelling shows that Max Renewables plus Flex scenario is the most cost effective for the UK to accelerate its ambitions over the next decade. Speeding up the transition to renewable energy does not need to cost more – in fact, it can cost less. Under this scenario, by adding 7 GW flexible capacity to the system, the UK can install 5 GW more renewable energy capacity and achieve a lower total cost of energy compared to the Adding Renewables Only scenario – costing £270 million less per year by 2030. It is also £660 million per year less than the Renewables plus Nuclear scenario. (41) Additionally, SERA Scotland supports the flexibility argument because of the downsides of unresolved long term waste disposal, delays to transition, security risks – all the more starkly shown with the plight of Zaporizhizhia Nuclear Power Station in Ukraine. We also highlight the inhibitive effect of nuclear power on finance, research and development on renewables and flexibility system.

SERA Scotland strongly supports the ideas in this submission. We note the huge transition that will be required to move from our unsustainable present to a sustainable future powered by green energy. A commitment to clear long term planning by Government is essential and Scottish Labour and Labour need to start developing these plans now with a clear commitment to -

- the scale of public sector spending that will be required;
- the training of workers with skills in the new technologies;
- a clear commitment that the new investments will be used to create a fairer and more equal society;
- commitment to land use and energy system planning that aims to minimise impacts on wildlife and the natural environment while addressing the “energy trilemma” - affordability and access, energy security and environmental sustainability;
- the rooting of energy policy in sustainable development principles, based on demand reduction where possible and the promotion of integrated benefits - for example in linking action on transport and housing to public health outcomes.

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ABOUT SERA:

Founded in 1973 as the Socialist Environment and Resources Association, SERA is the only environmental group affiliated to Labour, and campaigns for the party to adopt ambitious environmental policies.

From climate change to community energy, we're passionate about tackling the most important environmental and social challenges facing Britain; challenges only Labour administrations can tackle.

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