NFLA Policy Briefing No.208

Nuclear Free Local Authorities
Councils working for a renewable, safe and peaceful future

Date: 11th November 2020
Subject: Is a 100% renewable energy a possible scenario for the UK and Ireland?

i. Overview of the report

This report is a further part of the NFLA's 2020 suite of Policy Briefings on promoting zero carbon renewable energy in the UK and Ireland. It has been kindly provided to the NFLA Secretariat by the NFLA Scotland / SC Policy Advisor Pete Roche, reproduced from a briefing placed on the influential website https://www.no2nuclearpower.org.uk.

This report focuses on a core energy policy matter - is it possible to create an energy system which is generated by 100% renewable energy solutions? This matter comes into focus as the UK Government, devolved Governments in Scotland, Wales and Northern Ireland, and the Irish Government are all considering their future energy strategies as part of tackling the climate emergency. NFLA has a long-standing energy policy of supporting a wide renewable energy mix, energy efficiency, decentralized energy solutions and energy storage schemes as being the most effective way to respond to the need for rapid carbon emission cuts and a sustainable energy policy. NFLA warmly support this report and are keen for councillors and council officers to be aware of this wider debate.

1. Introduction

On 31st October 2020, on BBC Radio 4's Today Programme, Simon Jack, the BBC's Business Editor, claimed that "even the most ardent environmentalist will confess privately that it is very hard to see how you get to net zero without nuclear".

Tom Burke, chair of the think-tank E3G, strongly disagreed. New nuclear plants aren't needed to get to net zero he said. "There are an enormous number of electricity energy experts who will say we can get there by using renewables and storage" and nuclear is not going to help us because to get to net zero we have got to get fossil fuels out of the power system before 2040.

On the other hand, Emma Pinchbeck, Chief Executive of the energy industries trade association, Energy UK, who previously worked for Renewable UK, says there are "very few 100% renewables pathways that don't start to look quite expensive, which isn't to say that it isn't possible … but there is about somewhere between 15 and 25% of the mix that we are not sure about." She says the independent Climate Change Committee is recommending a mix of technologies including nuclear and carbon capture and storage. "The message for me on nuclear is it's an existing technology and … we are going to need every single tool in the box" (1)

So, who is right?

2. Sizewell C and the 100% 'low carbon mix'

The BBC was reporting that the Government was close to reaching a deal with EDF to construct Sizewell C. Three years ago the National Audit Office delivered a stinging rebuke of the deal with EDF for Hinkley Point C, saying it has 'locked consumers into a risky and expensive project

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with uncertain strategic and economic benefits'; that efforts to ensure value for money had been overlooked; and that there remained a risk that the developer would come cap-in-hand for more cash before the project was finished, at which point the Government would not be in the strongest position to say no.

Based on current reports, it seems that one of the major failures from Hinkley – that the deal was concluded bilaterally, behind closed doors, and with no downward pressure on costs through competition – is being repeated. And it is hard to see how the Government has let itself be backed into this corner, allowing EDF to present itself as 'the only option' for the new nuclear it is no doubt saying is essential to reach net zero. Sizewell has even received public backing from those usually in favour of a small state and as little Government intervention as possible - a position miles away from what is seemingly imminent. (2)

Jonathan Marshall of the Energy and Climate Intelligence Unit says renewable energy solutions offer more flexibility than nuclear: "If you look at the amount of money involved in building nuclear power stations, it's pretty easy to come up with something renewables-based that's as firm and more flexible," he said. "There are not many people saying we should have loads of nuclear apart from the nuclear industry. There's also the risk that by the time power stations are built the grid is running in a different way because they take so long to build." (3)

3. 100% Renewables

However, what is interesting about what the Chief Executive of the energy industries trade association says is that generating 100% of our electricity from renewables is no longer deemed to be impossible. Now the objection is that it would be expensive.

Here we will examine first how we might be able to generate 100% of our electricity from renewables and then, secondly, whether this could be done at a reasonable cost.

4. Firm Power – do we need 'baseload'?

It was only a little over a year ago, in July 2019, that former UK Business Secretary, Greg Clark, said government analysis showed that Britain needs to build up to 40GW of non-intermittent low carbon power stations to hit climate change targets. (4) Unfortunately, the government's justification for this appeared to rest on unpublished model simulations run internally. Michael Liebreich CEO of Bloomberg New Energy Finance told 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." (5)

New nuclear plants are not flexible – they cannot balance the output from variable renewables like wind and solar. (6) Nuclear energy has the lowest flexibility and the worst response speed compared to all other power technologies What is needed is flexible supply and demand side balancing systems, smart grids, and storage, including electrolytic 'Power to Gas' hydrogen production, using surplus renewables power, stored ready for conversion back to electricity when renewables inputs are low. (7)

As long ago as 2014, UBS Bank was forecasting that "Large-scale power generation … will be the dinosaur of the future energy system: Too big, too inflexible, not even relevant for backup power in the long run", as the cost of batteries declined. (8) Similarly. HSBC Bank was predicting that conventional generators would be the biggest losers from an upcoming energy storage boom. (9)

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, a flexible electricity supply which can be turned on and off quickly to fill the troughs when renewables aren't able to supply is what is needed. Nuclear power is a very poor fit for a 21st century grid system and acts against increasing renewable energy capacity. (10)

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.” (11)

In fact, nuclear power is forcing windfarms in Scotland to be switched off. The 100% Renewables campaign commissioned leading energy consultants, Cornwall Insight, to estimate the quantity (in MWh) of windfarm constraints that could have been avoided had nuclear power plants in Scotland been shut during recent years. Two years were selected; 2019 as the most recent completed calendar year but when nuclear sources were partly shut down, and 2017 the most recent calendar year when both nuclear plants in Scotland (Hunterston B and Torness) were fully operational. The study found that higher generation of nuclear power is associated with a higher proportion of wind power being switched off. In 2017, 94% worth of windfarm output that had been turned off (constrained) could have been generated had nuclear power plant not been operating. And in 2019, 77% of the windfarm output that had been turned off could have been generated if nuclear was not operating. (12)

5. Dealing with Intermittency

So how could a renewable dominated system operate without firm power or baseload? Liebreich says “…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.” (13)

There are several ways of balancing intermittency:

- First and foremost, by reducing overall demand with a comprehensive energy efficiency programme; an accelerated programme of LED lighting installation could, on its own, reduce peak electricity demand by almost 8GW. (14) 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, according to a report by the UK Energy Research Council. (15)
- Demand management – using various techniques to reduce demand at peak times. This would include, for instance, introducing time-of-use tariffs and smart control systems which would charge electric vehicles and operate heat pumps at times when renewable energy is plentiful. Cold storage company Norish works with Flextricity, for instance, so that at times of high national electricity demand, or if a major power station fails, 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. (16) 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. (17)
- 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. (18) Heat batteries can be used in conjunction with heat pumps, (19) and electric vehicle batteries can be used, with vehicle-to-grid technology, to supply the grid at peak times – especially during the early evening peak when many fleet EVs will have returned to their depot with some charge remaining. (20)

- 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. (21)
- 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 just 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. (22)
- Gravitricity - an Edinburgh company - is planning to use old mine shafts as batteries to store renewable energy. Initially it plans to build 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 producing power. (23)
- Combined heat and power stations working in conjunction with heat 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. (24)
- By using the right mix of renewables intermittency can be reduced for instance by adding biomass, or geothermal generation into the mix;
- By increasing grid connections to other countries so that electricity can be imported at peak times when indigenous renewable production is low, and so that surpluses can be exported.

Mark Jacobson and colleagues at Stanford University have come up with a similar list for matching demand to wind, water and solar (WWS) supply, including batteries, pumped storage, heat pumps and heat storage. This study matches 2050 power demand with 100% WWS supply, storage, and transmission for 20 world regions encompassing the 139 countries for which 2050 roadmaps have previously been developed. Here we are talking about renewables supplying electricity and direct heat for all energy sectors, including transport. The study assumes efficiency improvements compared with Business as Usual (BAU) and it assumes that all energy, not just electricity, is decarbonized by 2050. Grid balancing solutions include heat storage in rocks and water; cold storage in water and ice; pumped hydropower; batteries; hydrogen storage; and demand response. (25)

Jim Lazaar, formerly of the Regulatory Assistance Project, has put together a handy list of strategies that can be used to manage the impact of intermittency. (26) PV Magazine has modified this list to:

- Electric rates designed with controllable loads in mind;
- Inter-regional trading;
- Peak-oriented renewables;
- Targeted efficiency;

PV Magazine goes on to suggest that the best way of dealing with intermittency might be to overbuild renewables, because they are so cheap and expect to waste perhaps 30% to 40% of total production. It says where possible we should use software over hardware. Do not subsidize batteries so a few rich people can have Powerwalls. Give all consumers price signals and then watch the 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. When there are weather events which lower the production of renewables down to a fraction of rated output. These events occur multiple times a year and can stretch out for multiple days in a row. We could use a clean and renewable fuel in existing gas capacity for solving this problem and getting us to a reliable, affordable and clean grid. (27)

The idea of discarding available wind or solar output when production exceeds what the grid can accept may be anathema, but it may be the least expensive path to an electric grid powered largely by renewables. (28)

6. 100% Renewables – a question of cost?

So, there are pathways to an energy system based on 100% renewables. But what would it cost? Would it still be cheaper to build some so-called ‘firm power’ to balance intermittent renewables?

In July 2019, the Department for Business Energy and Industrial Strategy (BEIS) published its Consultation on a RAB model for new nuclear projects. (29) This claimed:
“[T]here will still be a crucial role for low-carbon ‘firm’ power in 2050…to meet net-zero while maintaining security of supply and keeping costs low…While advances in technologies, system flexibility and energy storage may eventually provide additional options for fully decarbonising the power sector, it is clear that a significant capacity of new nuclear power stations and gas-fired power plants with CCUS [carbon capture, utilisation and storage], alongside renewables, will also be required.”

Recent advice from the Climate Change Committee on reaching net-zero broadly supported this internal BEIS analysis. The CCC technical report on net-zero says:
“Reducing emissions towards net-zero will require continued deployment of renewables and possibly nuclear power and other low-carbon sources such as carbon capture and storage and hydrogen, along with avoiding emissions by improving energy efficiency or reducing demand.” (30)

But the CCC says variable renewable electricity - such as large-scale onshore wind, offshore wind and solar PV - is now the cheapest form of electricity generation in the UK and can be deployed at scale to meet UK electricity demand. (31)

The CCC’s Further Ambition scenario for the power sector sees low carbon sources providing 100% of power generation in 2050, through a mixture of variable renewables (57%), firm low-carbon power like nuclear or plants fitted with carbon capture and storage (38%) and decarbonised gas such as hydrogen (5%). It says:
“…uncertainty remains about the additional costs weather-dependent renewables will impose on the system at high annual and instantaneous penetrations. [But] Intermittency does imply a real, but likely high, economic and technical limit to shares of individual renewable technologies within the UK's generation mix.”

However, evidence suggests integration costs could be around £10-25/MWh for annual penetrations of up to 50-65% renewables but could increase further at higher penetrations. (32)

But the CCC is just putting forward possible scenarios. It says “while the policy challenge in delivering these scenarios is undeniable, there is good reason to believe that the range of options could be wider and/or cheaper than we have assumed”. (33) The CCC also notes that “current trends in technology will tend to support larger renewable shares and lower system integration costs”. (34)

So, a future based on a much higher percentage of variable renewables could actually turn out to be cheaper and more feasible than implied by the CCC’s scenarios.

Lord Deben, Chair of the CCC says:
“By the time you get to the need for the next nuclear power stations, there will be alternative ways of doing this. If we get better at balancing the grid and the amount of baseload energy, the need becomes smaller. Nuclear isn’t the best way of getting that base energy because you can’t turn it on and off: you have to use it all the time. If you are really concerned about what happens when the sun doesn’t shine and the wind doesn’t blow, you install in people’s homes hybrid boilers that can run on electricity or gas.” (35)

The National Infrastructure Commission says there is great scope for flexibility technologies to balance a system with very high renewables. (36) At a Spectator Energy Summit, chaired by Andrew Neil, Phil Graham (Chief Executive, National Infrastructure Commission) argued there is not a strong case for more than one more new nuclear plant beyond Hinkley Point C because the cost of renewables is low and getting lower. (37)

The myth that a very high level of renewables can't be integrated into the electric grid is being demolished by the clean tech and battery storage revolution. "By 2040, renewables make up 90% of the electricity mix in Europe, with wind and solar accounting for 80%," according to projections by Bloomberg New Energy Finance (BNEF) in their annual energy outlook. "Cheap renewable energy and batteries fundamentally reshape the electricity system," explains BNEF. Since 2010, wind power globally has dropped 49% in cost. Both solar and battery prices have plummeted 85%. BNEF says combining batteries, demand response, and fast-ramping natural gas plants for peak power generation helps "wind and solar reach more than 80% penetration in some markets." When you add in the other forms of renewable power — such as hydropower and geothermal — total renewable generation becomes 90% or more. (38)

According to the 100% Renewable UK website, the latest BEIS report on electricity generation costs (39) which tries to take into account the extra system costs of integrating renewables, ignores the cheapest ways of doing so, but still shows that renewables comes out much cheaper than Hinkley Point C. BEIS fails to analyse the impact of V2G technology; fails to mention storage technologies involving ammonia, storage at sea by offshore windfarms or indeed various other promising options that can take us to 100 per cent renewable energy. (40)

The National Grid Electricity System Operator (ESO) has suggested demand-side response (DSR) is more reliable than nuclear power in its latest Capacity Market auction guidelines. (41)
Global Studies Show Renewables Pathways are Cheaper

An article published in 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 has jumped to 280. (42)

Mark Jacobson and his team from Stanford University, reckon that 100% of all global energy can come from renewable sources (with biomass excluded) by 2050 with full grid balancing and the full final cost per unit of energy, in every scenario, was about one-quarter what it would be if the world continues on its current energy path. (43)

A new report by LUT University in Finland and the Energy Watch Group (EWG) in Germany outlines a cross-sector, global 100% renewable energy system. The full modelling study simulates a total global energy transition in the electricity, heat, transport and desalination sectors by 2050. It claims that a transition to 100% renewable energy would lead to a system that was economically competitive with the current fossil and nuclear-based system. It could also, the study says, reduce greenhouse gas emissions in the energy system to zero by 2050, or perhaps earlier, without relying on negative CO2 emission technologies. (44)

A team from Aalborg University look at how an existing energy system can be transformed into a 100% renewable energy system. The transition is divided into a number of key stages which reflect key radical technological changes on the supply side of the energy system. Ireland is used as a case study, but in reality this reflects many typical energy systems today which use power plants for electricity, individual boilers for heat, and oil for transport.

The seven stages analysed are 1) reference, 2) introduction of district heating, 3) installation of small and large-scale heat pumps, 4) reducing grid regulation requirements, 5) adding flexible electricity demands and electric vehicles, 6) producing synthetic methanol/DME for transport, and finally 7) using synthetic gas to replace the remaining fossil fuels. For each stage, the technical and economic performance of the energy system is calculated. The results indicate that a 100% renewable energy system can provide the same end-user energy demands as today's energy system and at the same price. The results suggest that the transition to a 100% renewable energy system can begin today without increasing the costs of the energy system and by creating more local jobs. (45)

In a briefing for the Leonardi DiCaprio Foundation, Mark Jacobson puts the issue in sharp relief: "Nuclear power plant takes on average about 14-1/2 years to build, from the planning phase all the way to operation. According to the World Health Organization, about 7.1 million people die from air pollution each year, with more than 90% of these deaths from energy-related combustion. So switching out our energy system to nuclear would result in about 93 million people dying, as we wait for all the new nuclear plants to be built in the all-nuclear scenario. Utility-scale wind and solar farms, on the other hand, take on average only 2 to 5 years, from the planning phase to operation. Rooftop solar PV projects are down to only a 6-month timeline. So transitioning to 100% renewables as soon as possible would result in tens of millions fewer deaths. Nuclear advocates claim nuclear is still needed because renewables are intermittent and need natural gas for backup. However, nuclear itself never matches power demand so it needs backup. Even in France with one of the most advanced nuclear energy programs, the maximum ramp rate is 1 to 5 % per minute, which means they need natural gas, hydropower, or batteries, which ramp up 5 to 100 times faster, to meet peaks in demand. Today, in fact, batteries are beating natural gas for wind and solar backup needs throughout the world. A dozen independent scientific groups have further found that it is possible to match intermittent power demand with clean, renewable energy supply and storage, without nuclear, at low cost." (46)

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