100% Renewable UK

https://100percentrenewableuk.org/

Options for Energy Storage

There are different types of uses for storage as well as a large number of technologies for storage. Broadly speaking, storage uses can be broken into three types: 1) short term balancing 2) balancing between daily peak and low loads and 3) long term storage to cope with up to, say, 20 days, of low output from wind/sun etc. Below are some links to how long term storage can be provided – I focus on this since there is little coverage of it elsewhere, and critics of renewable energy (wrongly) claim that renewable energy will always need nuclear power or fossil fuels to back it up. This is plain wrong.

The first, short term balancing market, is increasingly being met by batteries, which are proving to be more effective than traditional means of ramping up by conventional fossil fuel power plant or smaller decentralised oil and natural gas fired plant. The reaction times are the quickest and the cost of the batteries is falling fast.

The second market, that of batteries helping to match the variable production from renewable energy with consumption throughout the day is only really just getting going. Ultimately there is going to be easily enough battery capacity in electric vehicles as well as other places to ensure that peak demand can be met with a much reduced need for peak generation capacity. Peaks can be supplied by smart charging electric vehicles – to encourage charging of vehicles is done when the price is lower. Vehicle-to-grid transfers of power will also help so that when the grid needs power then some vehicles can send some power to avoid supply needing to peak. Smart systems will also be used so that demand for power to supply heat pumps (needed to substitute for natural gas heating) can be smoothed to avoid peaks and to fit in with variable renewable energy supply. Demand response systems for a variety of demand uses will also be deployed, enabled by 'time of use' pricing – something that will be greatly helped by the introduction of half-hour charging for domestic as well as industrial electricity supply markets. Simple hot water tanks – thermal storage – in buildings can be used to smooth out peaks in electricity demand. This thermal storage can be deployed in association with heat pumps.

The third market, that of 'inter-seasonal' or long term storage is currently only the preserve of models and demonstration schemes, although a increasingly wide range of technological options exist to deliver this service. This will mean that even in days when there is little wind or sunshine there will be enough 'stored' renewable energy in substances such as 'water balloons', hydrogen, thermal energy storage, ammonia, synthetic fuels (including methane made from renewable energy), stored geothermal energy, 'hot rocks' or using electrolyte generated by 'flow' batteries. This will be used to power turbines or engines or fuel cells to generate electricity to cover such periods.

Excess renewable energy is a zero or near zero cost resource that can be utilised as a feedstock for such long term storage. There will be periods of excess renewable energy production in a 100 per cent renewable system because renewable energy capacity will have to be sized to meet at least average daily demand loads. It follows from this that often production will be much higher than needed for anyone time, hence the excess production for some periods.

We need much more money pumped in to provide demonstration schemes for long term storage options. Building extra conventional lithium batteries are not the best means of providing long term storage as they are relatively expensive if used only very occasionally compared to options which involve storing cheap types of fuel material (eg hydrogen, synthetic fuels, ammonia, thermal storage, geothermal energy, hot rocks, water balloons or electrolyte produced by flow batteries).

What are some leading options for long term storage solutions?

Direct Air Capture for synthetic fuels. - Synthetic fuels, like kerosene or methanol could be produced and used in a carbon neutral way by using renewable electricity to capture carbon dioxide from the atmosphere and use the CO2 to generate these synthetic fuels. This Direct Air Capture or DAC is certainly very plausible, although so far it has mainly featured in the media as just a means of taking carbon dioxide out of the atmosphere.

Hydrogen is a much talked about way of storing renewable energy. Indeed the technology involved in first producing it, by electrolysing water with renewable energy and then using the hydrogen that is released to power gas turbines, is straightforward. The less straightforward aspect is storing hydrogen for any length of time because its escapes from even thick metal tanks quite easily. But it can be stored in large underground facilities similar to storage facilities used for natural gas. Indeed the UK has some considerable resources for doing this by mobilising existing or planned storage facilities. For example Centrica has been talking to the UK Government about using its old ('Rough') gas storage facility off the Yorkshire coast for hydrogen storage. This facility alone would store around 10 TWh of hydrogen energy, enough, on its own to power all of (current levels) of UK electricity supply for 4-5 days even if there was not a single kWh of anything else available. A disadvantage of hydrogen burned in conventional gas turbines is that NOx emissions are much higher compared to methane, unless that is, the hydrogen is used in fuel cells (where there are no NOx emissions). The cost of fuel cells is coming down quickly, although they are still a lot more expensive than gas turbines. On the other hand RWE in Germany has recently commissioned a 34 MW model of a new type of gas turbine designed specifically to burn 100 % hydrogen with much reduced NOx emissions.

Renewable Methane There could be advantages in converting hydrogen, as it is produced by electrolysis using renewable energy, into methane. This could be done by using carbon dioxide from the atmosphere to add to the carbon to produce methane (and hence it would be carbon neutral). The advantage of using the methane is that a) NOx emissions from burning methane are much more controllable than hydrogen on the basis of currently used technology and b) a given amount of storage space will store three times as much energy in the form of methane comped to hydrogen (with hydrogen having a lower volume energy density).

Geothermal One option that is being backed by some big energy interests is a sort of (potentially widely available) geothermal energy technology which can both provide, as is necessary, power at any particular time, and also stored energy. This is '**Eavor**', details of which can be seen at https://eavor.com/about. They are undertaking a demonstration project. This looks an exciting technology, which, if it can be made to work properly, should greatly advance prospects for a 100 per cent renewable energy economy. This is a 'closed loop' system which avoids problems associated with with systems that can cause minor earthquakes.

Another recently unveiled potentially large scale source of energy storage is '**hot rocks'**. This is being promoted by Siemens and the claimed advantages include being cheap and able to store energy in 'volcanic' rocks at a very great range of temperatures. For more information see https://www.siemensgamesa.com/en-int/products-and-services/hybrid-and-storage/thermal-energy-storage-with-etes

Hot Water A very cheap option is thermal storage, that is well insulated **large hot water tanks**. This can be done in association with large heat pumps serving District Heating Systems. The heat pumps can generate heat to be stored when wholesale electricity prices are low or negative. Given that heating for domestic and industrial purposes constitutes a substantial proportion of energy use, such a thermal resource could potentially deliver a major proportion of needs for long term energy storage to support a 100 per cent renewable energy system. The hot water cannot be stored efficiently for longer than around two weeks, but even so, this could still be a valuable storage resource since it will reduce the need for longer term storage options.

Ammonia One option that is, essentially, already available in many senses is that of **ammonia**. Ammonia can be produced by mixing hydrogen generated through using renewable energy to hydrolyse water and mixing with nitrogen at the same time. Lots of ammonia is currently stored for use in the fertiliser industry. 'Water balloons' can be stored next to offshore wind turbines (with water pressurised by excess renewable energy) and then, when needed, put through turbines to generate power. Of course 'Eavor' claims to be able to both generate baseload power and store energy at the same time, a claim which hitherto can be made mainly for hydroelectric generators.

Hydroelectricity is an important way of balancing renewable energy – Denmark can, for example, utilise hydroelectricity resources in Norway as a means of balancing its own renewable energy which comes mainly from wind power. Professor Mark Z. Jacobson promotes it as a good means of balancing a putative 100 per cent renewables scenario in the USA. However, in the UK the hydro resources are much thinner than that of the USA, although that having being said, pumped hydro could be a useful source of storage if enough sites can be found in Scotland.

The stored substances can be used to power existing types of engine or turbine equipment that are currently used to burn natural gas. It should be emphasised that such equipment is very cheap – say £250-£300 per kW, which is about 25 times less capital cost compared to Hinkley C nuclear power plant. Fuel cells could also be used, with the advantage that they have greater efficiency (50% compared to 30%). However if the fuel is very cheap (even less than zero when there is a lot of electricity and energy prices are negative), the efficiency is of less importance. The engines and turbines will also be used to provide inertial power in non-electricity generating mode.

Here are some links on some types of long term storage.

There is an account of how ammonia can be used to provide long term storage for renewable at: https://realfeed-intariffs.blogspot.com/2019/11/how-ammonia-beats-batteries-to-supply.html

A very interesting new technology is a form of geothermal energy being pioneered by the 'Eavor' Company. They claim to be able to generate and also store energy to provide 'continuous baseload power'. See https://eavor.com/about

Another interesting storage option is when offshore wind farms could store energy directly in a 'water balloon' onsite to be fed through a turbine to generate electricity when required. See https://stateofgreen.com/en/partners/aarhus-university/news/water-balloon-tech/?utm_source=SoG+Newsletter&utm_campaign=5b381214a3-EMAIL_CAMPAIGN_2020_09_09_02_28&utm_medium=email&utm_term=0_12f9cfabd4-5b381214a3-273169250

'Flow Batteries' are also a potential major source of long term power storage , and this is being researched in Germany. See https://reneweconomy.com.au/german-utility-rwe-may-use-salt-caverns-as-renewable-flow-batteries-36250/amp/?__twitter_impression=true

Various storage options are also covered in:

https://www.energy-storage.news/blogs/contenders-long-duration-energy-storage-technologies-and-whos-behind-them

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pumped hydro seasonal storage – this may work better in places with greater land resources (sparser population), eg USA? (in places), see https://scitechdaily.com/seasonal-pumped-hydropower-storage-could-solve-the-renewable-energy-storage-challenge/

Here's a link to a video by Highview Power who deploy systems of storage using liquid air: https://www.highviewpower.com/

Here is a link to the British trade association for Energy Storage, the Energy Storage Association; https://energystorage.org/

Conclusion

In fact there is a multiplicity of options for storing renewable energy. Yet the British Government effectively dismisses energy storage as a major strategy to back up a 100 per cent renewable energy strategy because of its political priority of promoting nuclear power. This is a losing strategy. At best nuclear power is likely to provide only a small proportion of our energy requirements in a net zero scenario, meaning that the UK Government has to put serious effort into a strategy of supporting the storage of renewable energy. This is given that this will be needed for a system highly dependent on renewable energy. However, as the earlier discussion implies, the storage solution is unlikely to come from one solution, most likely from several. We do not know what the precise mixture will be at the moment (and technologies will change over time anyway). Hence **we badly need to see the establishment of markets for long term as well as short term energy storage. These should include niche development markets for new storage technologies.**

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