Grid-scale electricity storage
enabling renewables to power grids
affordably, reliably and resiliently

UK Net Zero Strategy – Storelectric Comments

Summary

The British government has published its Net Zero strategy, following much consultation. It's a generally excellent, ambitious, wide-ranging and integrated strategy. These comments focus on aspects of direct or indirect relevance to Storelectric and therefore ignore (for example) industrial processes.

Both the excellent 2035 targets for renewable generation and lax targets for large-scale long-duration electricity storage are both inadequate for grid decarbonisation by 2035. We believe that decarbonising the grid by 2035 is laudable but unachievable (there is insufficient intermittent power and storage planned to make up for the reduction in dispatchable and baseload generation), and even 2050 would be unachievable without a tripling of renewable generation targets and much greater focus on storage of sufficient scale and duration. There is no realisation of how much the grid needs to develop, especially if large-scale long-duration energy storage (with suitably broad and long contracts) is not put between it and renewable generation: modellers find that moving from dispatchable to intermittent generation would require a tripling of the grid, which this arrangement of storage would greatly reduce.

Beyond the electricity system, most of the aims and means of this strategy are laudable, but some (e.g. EVs, power stations + CCS) not deliverable and even counter-productive. The ambition for renewable generation is a fraction of what the energy transition requires, as is energy storage. Poor selection of pathways and objectives (e.g. SMR hydrogen, power stations +CCS) mean an over-dependence on negative-emissions technologies that cannot ever have the capacity to do those jobs as well as the tasks for which it is required such as balancing emissions from aviation and shipping.

Generation

Renewable Generation

The grossly inadequate target of 40GW offshore wind by 2030 with increased onshore, solar and other renewables, is at odds with the objective of 100% clean energy by 2035.

Decarbonising the electricity supply would require three times as much intermittent generation as this 40GW target (as per National Grid's Future Energy Scenarios, even though they under-state demand substantially), plus ~60GW long-duration storage, for the current electricity system and its future growth. And that is even before considering the amount of generation needed for:

- Hydrogen (electrolysis and other processes),
- Transportation (EVs and fuel cell vehicles),
- Heating (heat pumps, electric heating and hydrogen) and
- Industrial processes (via electrification, hydrogen-based processes and synthetic fuels / feedstock chemicals).

Nuclear Generation

The end-of-parliament (i.e. within 3 years) target of one large nuclear power station investment decision, and progress on small modular reactors, is good but will deliver only a tiny fraction of the nuclear power anticipated in National Grid's Future Energy Scenarios, which have consistently been over-optimistic in its expectations of nuclear generation capacity. Given the ages of existing nuclear power stations, the lead times of such plants, and the government's history of prevarication, reviews and delays, the chances of achieving 17GW nuclear output by 2050 are vanishingly small. And, given that nuclear power delivers baseload energy, the effects on the overall energy mix are even greater.

Demand

Transport

It is excellent to see the emphasis on Zero Emission Vehicles rather than EVs (Electric Vehicles) – though this is then contradicted by the focus on EV roll-out, p66 "The transition to EVs is central to decarbonising road transport." Just replacing Britain's car fleet with EVs would use 70% of the world's lithium resources, and a greater proportion of cobalt and rare-earth resources, without considering vans, buses, lorries, electricity grids, domestic batteries, portable devices or replicating the same world-wide (the UK's population is only ~1% of the world's). Smart charging and vehicle to grid are beneficial but will achieve only a fraction of what is envisaged.

Therefore replacing even a high proportion of our vehicle fleet with EVs is not a deliverable solution – they have to be hydrogen / fuel cell vehicles. Consequently the focus on charge point roll-out should be at least balanced with (better, dwarfed by) hydrogen fuelling station roll-out. Other countries are far ahead of the UK in this. Likewise, further support to vehicle electrification should instead be spent on fuel cell related investment. Thus over half of the £1bn Automotive Transformation Fund should be better directed. Please see our fuller analysis of electric versus fuel cell vehicles.

Heating

A strategy for heat pumps to heat homes is excellent; they are, at normal operating temperatures ~5x as efficient as direct electric heating. But as outside temperatures drop to zero or below, the heat pumps become steadily less efficient until they fail completely at between -6 and -8ºC. The government has no plans for the ramp-up of direct electric heating demand under such conditions, which are likely to occur most often during winter high pressure weather systems, when solar generation is low and wind negligible for days at a time. Not only is this only deliverable by stored electricity, needing big reserves of large-scale long-duration storage, but also it requires substantially increased distribution network infrastructure to cope with the increases in domestic, commercial and industrial demand. Reliance on imports through interconnectors is not an answer: such weather patterns usually cover our neighbouring countries at the same time – sometimes for as long as a fortnight at a time, known as the *kalte Dunkelflaute* or "cold dark doldrums".

Hydrogen-powered boilers are good but, until there is sufficient appropriately-priced hydrogen in the gas grid, and the gas grid is 100% hydrogen, then these boilers will have to be dual-fuel and auto-adjusting as the make-up of the gas changes.

Energy Vectors

An energy vector is a way of transporting energy from source to end use.

Electricity Grids

There appears to be no recognition that energy grids need to triple in size (at least) to accommodate the shift to renewables. Nor is there consideration of the enormous additional loads on the electricity grids of EVs (just three charging concurrently would exceed the capacity of the local distribution transformers) or the elevated loads from heating during adverse weather conditions (see Heating, above).

National Grid's Network Options Analysis 2021 showed that they need £16bn capital investment to accommodate 17GW new offshore wind by 2035, not to mention the costs of connecting separately-sourced balancing and stability services (so we estimate £1.25bn per GW offshore wind), or the operational and maintenance costs (10% of that, per annum indefinitely). These costs will increase as the energy transition advances, there are fewer legacy power stations on the grid, and the 1950s design of the grid gets ever more out-of-touch with 21st-century patterns of generation and demand. Connecting such renewables through Storelectric's CAES will save billions.

Electricity Storage

Electricity storage is mentioned as a key to decarbonising power p78, keeping it reliable with other technologies p98 and providing flexibility p100-101. It is a focus of investment p33&105 and essential to integrating low carbon energy sources into a smart and flexible energy system p86. It is a key part of the Prime Minister's Ten Point Plan for a Green Industrial Revolution p207. It is considered ready to scale up p220. But the promised investment has been announced and awarded, leaving nothing remaining for the future, and the role identified is non-specific. This is an inadequate treatment of it.

Decarbonising the Energy System

The governments blithe assurance p99 that "Markets should determine the best solution for such a system" fly in the face of the fact that the markets are almost perfectly designed to prevent investment into decarbonising the electricity system. Current grid regulations have gone wrong, turning the grid from one of the world's most reliable and resilient into a fragile one, a cheap energy system into one of Europe's most expensive, one of the continent's most modern to one of its oldest with investment far below what is needed to maintain the system let alone decarbonise it. Among many other problems,

- Salami-slicing contracts prevents flexible plants being built; short-duration contracts prevent long-lived plants;
- Chinese walls within the industry without a body able to jump over them prevents solutions that address system-wide challenges;

- Energy prices are the same whether the energy is intermittent (requiring additional balancing services to be purchased) or not, whether asynchronous (requiring additional stability services to be purchased) or not;
- Offshore generation cannot benefit from onshore investments because OFTOs stand between them;
- Renewables cannot monetise the full benefits of connecting to the grid through storage as the system then treats them as having a single meter point;
- Market signals (e.g. at the England/Scotland boundary) fail to create investment because there is no guarantee that the revenue sources will continue – they may be circumvented by another development long before the investment is amortised;
- The obsession against so-called "gold plating" has created a universally saturated grid in which the cost and lead time of connecting new plants is prohibitive;
- Regulations have shrunk electricity costs to below half the electricity wholesale price, and shrinking fast, thereby drowning out market signals;
- Reliance on those market signals (e.g. volatility) go hand-in-hand with efforts to destroy those signals (e.g. DSR).

Hydrogen

Hydrogen is planned to be largely through Steam Methane Reformation (SMR) with Carbon Capture and Storage (CCS), which is heavily promoted by the well-funded oil and gas industry. But no CCS is 100% effective, requiring additional negative-emissions plants to balance them, and CCS imposes a 30-40% inefficiency on any plant to which it is fitted, as well as additional capital and operational costs: current estimates suggest that it doubles the cost of the hydrogen. And that is without mentioning the health and safety risks of CO_2 capture, piping, transportation and storage.

Hydrogen is seen as being able to balance intermittent generation and variable supply (p98). It is not cost-effective to do so: the electricity – electrolysis – hydrogen – power stations – electricity cycle has a potential peak round-trip efficiency of low 40s %, currently mid-20s % achievable, with plant costs much greater than Storelectric's 70% efficient CAES. Moreover, powering electrolysis from solar requires over 6x the electrolysis capacity as powering it from baseload; our CAES can deliver cost-effective near-baseload from intermittent generation, making electrolysis much more cost-effective.

Contrastingly, the government under-values hydrogen in transportation – see above. They are about right in industry and heating.

This is a summary of our analysis of the hydrogen economy.

Converting the Gas Grid to Hydrogen

The strategy of "Blending hydrogen into the gas grid" (p113) will greatly multiply the cost and disruption of the energy transition.

To carry the same amount of energy in hydrogen as in methane takes about 1.5 times the volume, i.e. flow rate through the system. And hydrogen burns much hotter. Therefore flame characteristics differ greatly. Therefore adding 20% hydrogen to the gas grid will require a massive conversion activity comparable to the country's conversion from town gas to North Sea gas in the 1960s and 1970s, including replacement of domestic and industrial appliances at a massive scale. Going to 40% would require the same again, and again to 60%, 80% and 100%. Conversion from zero to 100% is a single conversion. Therefore the most practical and cost-effective, and least disruptive, method is to start at hydrogen hubs (of which the government is currently supporting the development of seven around the country), with 100% conversion of the neighbouring area. Adjacent areas can then be converted 100%, and so on through the country.

Miscellaneous

CCUS – Carbon Capture, Use and Storage

The government is correct that there are industries that are very hard, if not impossible, to decarbonise without CCUS, and the cluster strategy is sensible in order to pool the costs of CO_2 transportation and storage among many polluters. They are therefore correct to put considerable support and funding to this.

Where there are viable alternatives, such as electrolysis for hydrogen manufacture and CAES for electricity storage, those alternatives are much safer, more efficient and more cost-effective. No support or resources should be put to such uses of CCS, e.g. for SMR hydrogen or power generation.

As stated above (see Hydrogen), carbon capture is not 100% effective – the more effective, the greater the costs and inefficiencies imposed on the parent plant – so any CCUS will require negative-emissions plants (in this report, Greenhouse Gas Removals GGR) to balance out residual emissions. Since there are many sectors that are harder to decarbonise (e.g. aviation, shipping), there will be more need for negative-emissions plants than the available biomass supply unless all the technologies with viable alternatives to CCUS use them.

Cross-Cutting Action

The flexibility of support for "cross-cutting actions", i.e. those that don't neatly fit into any of the categories defined elsewhere, is excellent. We hope that such actions are not over-defined but retained as a general catch-all pot of funding for all projects that don't fit other categories but have strong 2050-compatible objectives and capabilities.

"Government … embedding climate into our policy and spending decisions, increasing the transparency of our progress on climate goals, and providing funding to drive ambitious emissions reductions in schools and hospitals" is excellent. We hope that the Treasury incorporates emissions into its Cost/Benefit and other analyses, possibly by comparing any proposal with the alternatives that yield similar climate change (as well as all the other purposes of the investment) objectives.

In all initiatives, life-cycle climate and environmental effects should be included; for example the mining and refining of metals being built into batteries.

The Journey to Net Zero

All major investments must be 2050 compatible, not 2030 or 2040 compatible unless there will be cost-effective mid-life upgrades. That is because major investment will have an operational life of at least 30 years, so knowingly building a plant or infrastructure that will become obsolete before its end of life is a wanton waste of resources.

Moreover, investing compatibly with (say) 2030 goals makes those goals unachievable because of the legacy asset base that is not 2030 compliant. The only way to achieve 2030 goals (and 2040, for that matter) is to make all investment 2050 compliant, so the average emissions achieve intermediate goals as the old plant, equipment and infrastructure is retired or replaced.

An example of what not to do is the (thankfully avoided) “second dash for gas” in the electricity system, touted by government a few years ago to achieve 2030 targets. It was already known that 2040 targets would make such gas-fired power stations obsolete, leaving the country with tens or hundreds of billions of pounds worth of stranded assets.

Consequently, the government’s entire strategy for investment into the gas network (p112 onwards) is investment into stranded assets, enhancing a lobby group that will complain of asset stranding and job losses were we to come close to achieving 2050 targets and thereby raising the hurdles for decarbonisation.

Investment in New Technologies

The paper recognises the need for investment in new technologies but government policies don’t incentivise it. For example, the EIS / SEIS investment schemes incentivise new ventures, not new technologies, providing the same incentives for a new restaurant as for a world-changing invention. The natural aversion to technical risk in the financial services industry, especially as they mis-define it as “first-of-a-kind of anything” rather than “risk of a technical nature”, means that they divert their investments into me-too opportunities rather than innovation. Instead, the government should (at no net cost) halve the incentive if there is little technical risk and provide full and double incentive for some and lots of (respectively) technical risk investments.

Emissions Charging

Green investment needs proper carbon costs. The emissions trading scheme is inadequate: it is crude and covers only a sub-set of industries. It also hits a ceiling as emitters complain about unfair competition from imports. Much better would be an Emissions Added Tax, run like a Value Added Tax for all CO_2 equivalent emissions, with deductions for input carbon and charges for output (like VAT) and both credits on export and charges on imports if the trading country doesn’t have an equivalent scheme. It would be perceived as fair by all, deliver a level playing field for all industries and greatly accelerate the energy transition – financed privately. Moreover, the investment it incentivises would include domestic investment as well as industrial, commercial and financial.

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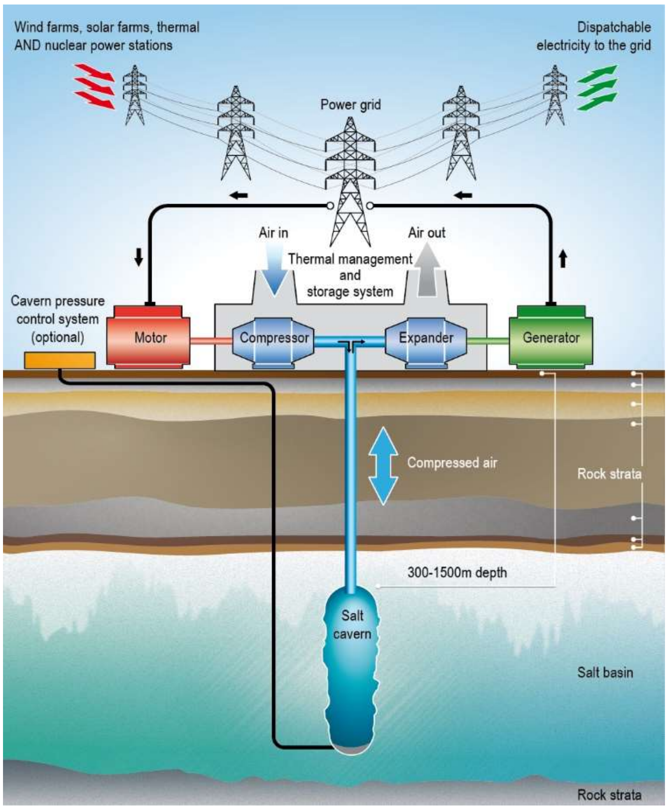
About Storelectric

Storelectric (www.storelectric.com) is developing transmission and distribution grid-scale energy storage to enable renewables to power grids reliably and cost-effectively: the world's most cost-effective and widely implementable large-scale energy storage technology, turning locally generated renewable energy into dispatchable electricity, so… ***enabling renewables to power grids cheaply, efficiently, reliably and resiliently***.



- Innovative adiabatic Compressed Air Energy Storage (Green CAES) will have zero / low emissions, operate at 68-70% round trip efficiency, levelised cost significantly below that of gas-fired peaking plants, and use existing, off-the-shelf equipment.
- Hydrogen CAES technology converts & gives new economic life to gas-fired power stations, reducing emissions and adding storage revenues; hydrogen compatible.

Both technologies will operate at scales of 20MW to multi-GW and durations from 4 hours to multi-day. With the potential to store the entire continent's energy requirements for over a week, global potential is greater still. In the future, Storelectric will further develop both these and hybrid technologies, and other geologies for CAES, all of which will greatly improve storage cost, duration, efficiency and global potential.

About the Author

Mark Howitt is Chief Technical Officer, a founding director of Storelectric. He is also a United Nations expert advisor in energy transition technologies, economics, regulation and politics – invitation here.

A graduate in Physics with Electronics, he has 12 years' management and innovation consultancy experience world-wide. In a rail multinational, Mark transformed processes and developed 3 profitable and successful businesses: in commercialising a non-destructive technology he had innovated, in logistics (innovating services) and in equipment overhaul. In electronics manufacturing, he developed and introduced to the markets 5 product ranges and helped 2 businesses expand into new markets.

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