Storelectric Ltd

Enabling Renewables to Power the World
Affordably, Reliably and Resiliently

Safe, clean, cost-effective electricity storage and hydrogen technologies at truly grid scale (GW, GWh).

Why is Energy Storage Needed?

Natural resources such as wind and solar are unpredictable, only generating electricity when nature's conditions allow, not when we want, and with little grid stability.

- We deliver massive scale energy storage projects that enable steady & affordable supply of renewable energy.
- We are a developer of geological storage platforms with our own processes, technologies and locations.
- Demand for storage is rising, with requirements for large scale, long duration, high efficiency, stability, operability etc., and outstanding cost-effectiveness.

Electricity Network Costs

Once renewables account for over ~16% of electricity in the grid, the challenges of managing the grid start to rise exponentially. Based on the British experience, these costs fall into three categories:

- ¼ balancing costs, ensuring that there is sufficient energy at any given time;
- ¼ grid stability and operability costs, ensuring the smooth running of the grid;
- ½ grid reinforcement costs, building more grid to accommodate intermittency and connecting up additional plant for the balancing, stability, operability and related services.

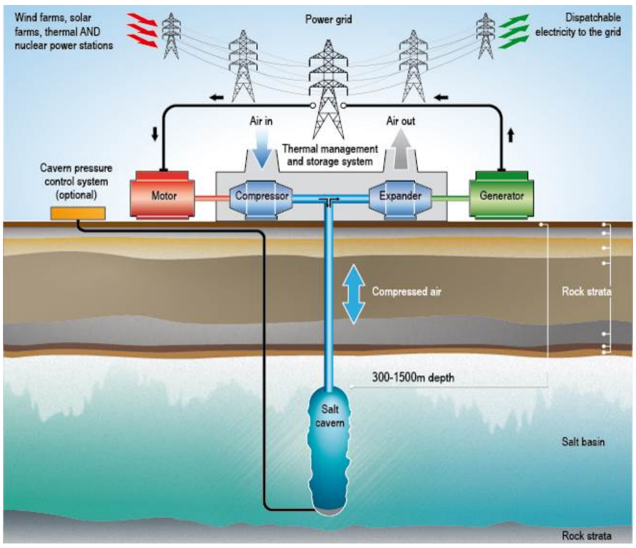
Storelectric's plants, suitably located, address all of these issues. For example, if renewables connect to the grid directly, analysts forecast that they would have to more than triple in size – and each additional GW of renewables incurs (in the UK) ~£1.25bn grid reinforcement costs plus 10% of that every year to maintain, operate and finance it. On the other hand, if the renewables are connected through large-scale long-duration naturally-inertial storage (of which our CAES, is head-and-shoulders better than all others), grid reinforcement can shrink by ~¾.

Batteries cannot do this: their short plant life, too-low lifetime-average grid-to-grid efficiency, lack of real inertia, resource scarcity for manufacture, small size and limited capacity make them suitable for only smaller-scale work. They can be set up to deliver any one of balancing, stability, operability, resilience and grid congestion reduction services (they cannot provide Black Start to other / higher-voltage grid sections, and their stability services are based on much-inferior "synthetic inertia") – Storelectric's solutions can deliver all of these (including Black Start), so one of our plants can deliver concurrently a range of services that would require 4-6 same-sized batteries.

Storelectric Electricity Storage Solutions

Compressed Air Energy Storage (CAES)

Surplus low-price electricity is used to pressurise air, which is stored underground in very high capacity salt caverns, as much natural gas is currently stored world-wide. When needed, this air is released to regenerate electricity. It supports all generation technologies. Built in conjunction with renewables, it greatly reduces grid connection and reinforcement, and improves the profitability of both storage & generation. It is safe, far underground, and salt caverns are naturally hermetic and self-sealing. The application has been proven in Huntorf in Germany (from 1978) and in McIntosh, Alabama, USA (1991), which are both successful and safe, but only 42-54% efficient. Storelectric's plants will achieve close to 70% efficiency and up to 100% renewable, & provide grid stability 24/7. They can satisfy global energy storage needs: there are suitable geologies world-wide.



Why is Storelectric CAES Different?

Storelectric's CAES can uniquely make both existing and renewable generation more profitable, dramatically cut emissions and provide complete and affordable energy security to countries and regions. The company is developing two CAES technologies: Green CAES ™ based on Thermal Energy Storage (TES) and dual-fuel Hydrogen CAES ™. A CCGT Hybrid ™ version is more efficient, lower emissions and more powerful than Hydrogen CAES. All can deliver real inertia, reactive power/load, voltage/frequency control – all 24/7 – and black start. This makes a reliable and resilient energy transition and Net Zero grid much more affordable and less disruptive.

	Storelectric Green CAES	Storelectric H_2 CAES	Storelectric CCGT Hybrid	Traditional CAES
Capex all-in, 500MW 2.5GWh	£460m first, target £350m	£365m first, target £330m	£400m first, target £350m	£700m
IRR stand-alone, UK	31%, up-side potential	43%, up-side potential	57%	Low, some up-side
IRR with renewables	48% or higher	48%	62%	Improves IRR a little
Efficiency (grid-to-grid)	68-70%	57%	>80% with heat network	50-54%
Emissions % of CCGT	0	~67% (CH_4) => 0 (H_2)	Depends on operating mode	~55-60%

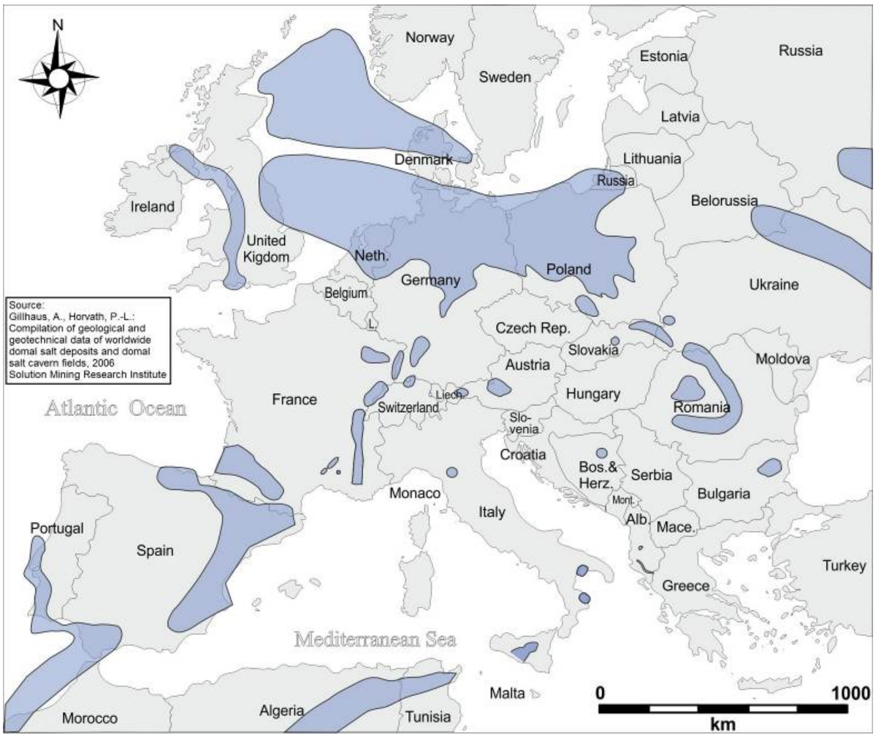
All plants are low-risk simplifications of existing plants that have run for decades, using off-the-shelf equipment well proven in power generation & other industries. Green CAES has been validated by Costain, Arup, Mott MacDonald, Fortum, Mitsubishi Power (MP), Siemens and others; a 40MW first-off commercial plant is planned. H_2 CAES is like a CCGT, so a small plant is not needed; also validated by MP. There is no technical reason not to build why a first plant each at large scale (100s MW or more). Storelectric has a developing consortium of blue-chip multinational partners, with land and salt caverns ready to go, and supportive planning authorities. There is great interest in financing follow-on plants world-wide. Global market potential for peak smoothing alone is 1,750GW (>$1trn capex, $10trn p.a. opex), with first-mover and technology advantages. Siemens and MP say that they can build them with their current range (others can too); MP will consider offering EPC performance guarantees on the first.

Based on published information, the plants that competitors have built are (at similar scales) ~55-60% efficient and ~60% dearer than our 68-70% efficient plant. China has built a plant with such performance and cost, and has a programme to build many more, validating the need for it in a Net Zero economy.

Projects using any of our technologies are eligible for approval as **Projects of Common Interest** in the 35 European countries of ENTSO-E, giving access to the multi-€bn Connecting Europe Facility and ECB funding for energy, and assistance with permits: one has already been approved. This shows that it is important infrastructure at a continental scale. See video.

The European Opportunity

Most European countries are decarbonising fast. To power grids mainly by wind and solar would require tripling or more the grid's size to take the intermittency of renewable generation, as well as procuring the balancing and ancillary services. If the renewables are connected through our storage, most of this would not be required.



Any project that is still in the study phase or pre-study, and is on the salt basin (see map) will be of interest: project lead times are 3-7 years (mainly due to the time to make the caverns), therefore take longer than the wind and/or solar farms. Storelectric's technology is much less affected (e.g. efficiency, cooling) by heat than are batteries, and deliver (concurrently with balancing and ancillary services) all the stability services that the grid will start to need when renewable supply exceeds ~25% of grid demand.

Potential Locations

Initial locations will use salt caverns for their air storage: these are man-made cavities within the salt basin, on-shore or off-shore. The general areas of salt basin are in this map; specific locations need to be validated geotechnically. Salt basins and other hard rock geologies (mines etc.) are suitable for 4-12 hour storage durations. Longer storage durations will be provided by storing the air in porous rocks, again on-shore or off-shore, e.g. saline aquifers, depleted hydrocarbon wells; they need to be developed. Salt caverns are well known as ~⅓ of Europe's natural gas stocks are held in such caverns, also being widely used in the petrochemicals and other chemicals industries.

Storelectric Hydrogen and Integrated Solutions

There are many synergies between CAES and hydrogen. Storelectric supports the hydrogen economy in six ways:

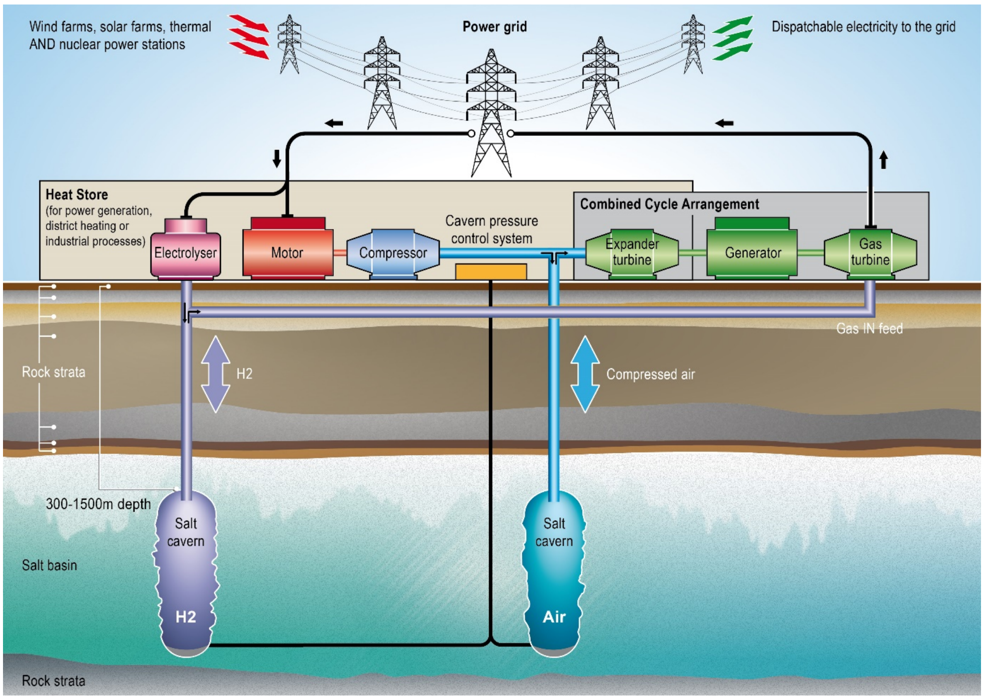
1. Hydrogen storage
2. CAES and Hydrogen Projects
3. Integrated Projects
4. Hydrogen CAES
5. High temperature hydrogen patent
6. Consultations

We expect future energy networks to be like today's networks with two major elements: hydrogen and electricity; today, they are methane and electricity. With investment, methane grids can be converted to hydrogen grids; much of recent years' grid investments in recent years in many countries has been hydrogen compatible. Of course, electricity is needed to make the hydrogen, and hydrogen in turn will be used to make synthetic fuels, but what is transmitted along networks will mainly be these two. As with today's gas and electricity grids, they are mutually complementary, compete little with each other and, again as at present, some applications use both.

The part hydrogen will play in the energy transition is huge, focusing primarily on the gas grid, industrial processes (e.g. iron and steel making), heating, transportation, synthetic fuels and catalysing other processes such as CAES. So most hydrogen solutions must be at the same scale as the gas plants and equipment that they replace.

Hydrogen Storage

An average 40-ft 20bar tank carries only 75kg of hydrogen. So massive-scale storage is required. Salt caverns can store hydrogen at such scale, tens of millions of times larger and at pressures better suited to both the output of electrolysis and the needs of the grid. Indeed, these caverns are very similar to those used for CAES, and adjacent to them, though with higher-grade materials in their drill strings, wellheads and other pipework and sundries. Those designed for hydrogen can carry air, but not vice-versa. Storelectric can locate hydrogen caverns adjacent to its air caverns, and to build at least some air caverns to hydrogen standards for future convertibility. These can also provide large-scale storage for leasing to other companies' hydrogen projects.



CAES and Hydrogen Projects

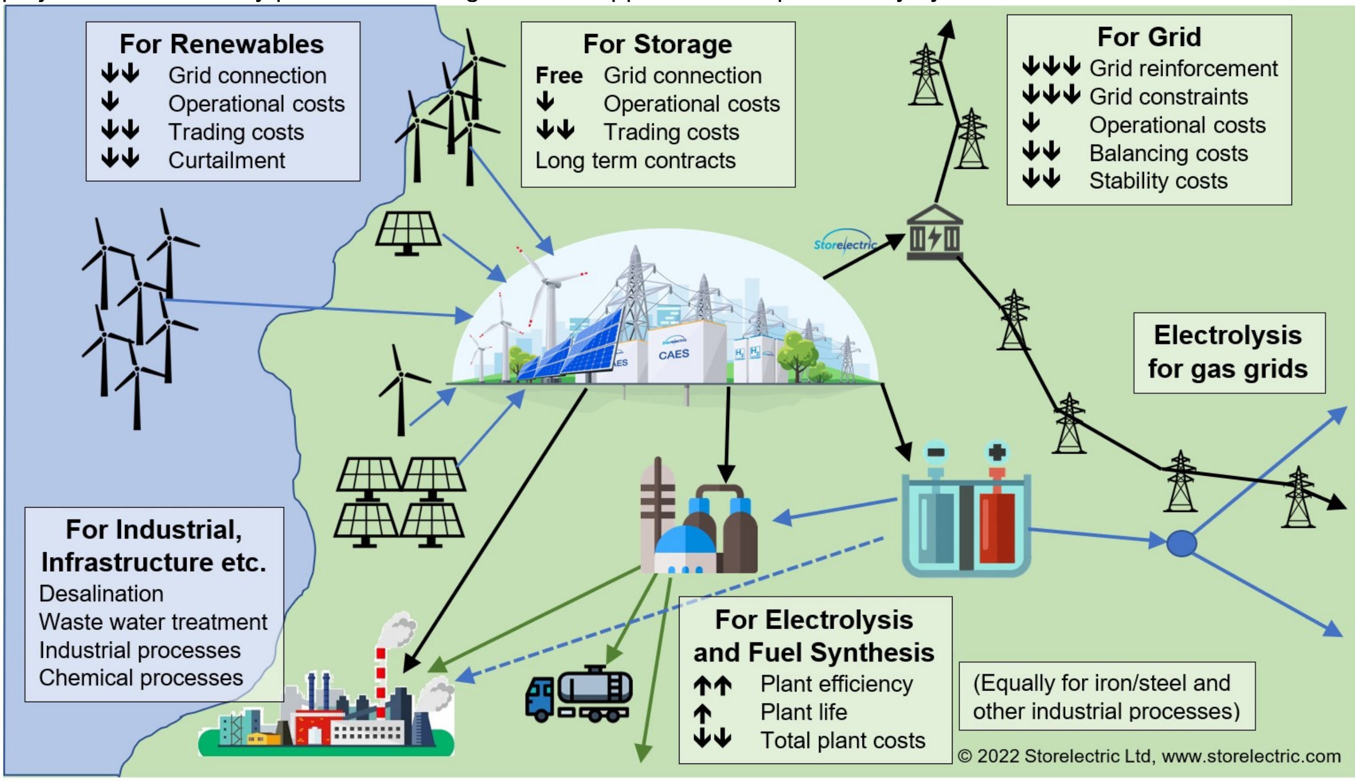
Electrolysis hates intermittency, which reduces both efficiency and plant life of electrolysers, and requires 2-4 times as many to be built per unit of output. (The same applies to other hydrogen formation processes.) Including CAES in a renewables + hydrogen project can deliver near-baseload energy to the electrolysers, with or without additional high-value services to the electricity grid / other applications such as integrated projects (below). This increases efficiency and plant life, greatly reducing capital costs and somewhat reducing operational costs. Thus CAES acts as both a provider to the grid and a project-and-performance enhancer to the hydrogen and other plant.

Integrated Projects

Storelectric's CAES (electricity storage) and hydrogen are ideal jointly as inputs to many other processes that need both to be delivered concurrently. These include:

- Renewable generation of almost any types, including mixed, at large scale;
- Fuel and chemical synthesis, e.g. ammonia (NH_3) and methanol (CH_3OH), both of which are both fuels and feedstock into other processes –
  - The CAES plant can also support nitrogen and carbon extraction processes;
- Iron and steel making, where hydrogen replaces coal for both heat and chemical reduction processes;
- Synthesis of other hydrocarbons;
- Other industrial and chemical processes.

Indeed, the more integrated the project is, the more efficient and cost-effective the resultant plant can be. And such projects can use many proven technologies from suppliers of complementary systems.



Hydrogen CAES

Storelectric's Hydrogen CAES is hydrogen ready. Until sufficient hydrogen is available at suitable prices, it can burn methane or any mix of hydrogen and natural gas. Thus it will decarbonise as the energy transition progresses, making it an excellent transitional technology as well as hydrogen-based one. The hydrogen could be obtained either from the gas grid (which many countries will convert to hydrogen and, sooner, mixes of hydrogen and methane) or dedicated production on-site or near-site. Unlike most hydrogen-consuming plants, it can operate with mixed hydrogen and natural gas, making it suitable for those gas grids which plan a gradual change-over.

High Temperature Hydrogen Patent

Breaking water into hydrogen and oxygen takes energy, and the more of that energy that comes from heat, the less is required from electricity. Storelectric has a granted patent (PCT/GB2019/052168) in using the heat of compression to catalyse electrolysis. This has potential to provide large amounts of very cost-effective green hydrogen for the hydrogen economy, a possible game-changer due to the cost of electrolysing hydrogen today.

This patent has been granted and, within the above description, is relatively broad and strong. But it needs a few years' R&D to turn it into a commercial reality. We intend to use the proceeds of CAES plants, and/or investment, to finance this work, and are open to doing it in partnership with other companies.

Consultations

With all this evident expertise, Storelectric is increasingly being consulted for other projects involving hydrogen and its storage, including optimising complex systems that involve many linked processes, which may or may not involve CAES.

Conclusion

Storelectric's innovative technologies and integrated solutions, most using well-proven standard equipment, are ideally placed to support the needs of ~90% of the world's energy transition …

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