**Grid-scale electricity storage**
using an innovative form of
**Compressed Air Energy Storage**

# Storelectric Use Cases

Storelectric has developed what they claim is the world's most cost-effective large-scale long-duration electricity storage technologies based on advanced forms of Compressed Air Energy Storage. These will greatly reduce the cost of the transition to a Net Zero grid, and of enabling the electricity system to help with the decarbonisation of heating, transportation and industry. They deliver enormous benefits to grids while greatly enhancing the profitability of renewables, even while enhancing their own profitability. This document gives example use cases.

**Doubling an Offshore Wind Farm**

An existing 1.2GW wind farm is having a further 1.2GW built nearby. The wind farms have a de-rating factor (actual energy out divided by nameplate capacity, on average) in the low 40s %. Storelectric proposes a Green CAES ™ plant at or before the grid connection of the existing farm, to take the output of both wind farms:

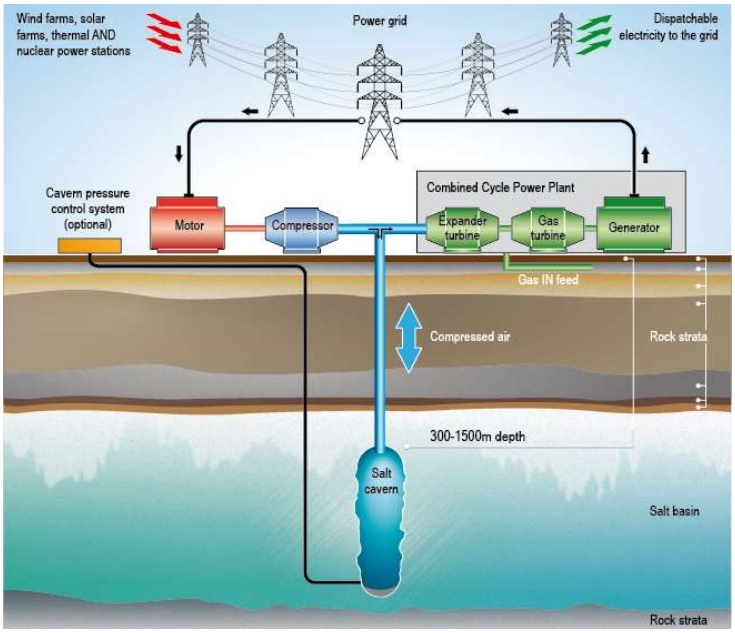
- Plant specification
  - 1.2GW rating for charging (compression)
  - 1.2GW rating for discharging (expansion)
  - 6 hours duration (i.e. 7.2GWh capacity)
    - Extendable later to 12 hours or more
  - Expected to deliver 80-84% of generated electricity to the grid
- Benefits to the wind farm
  - Eliminates capital cost for the grid connection of the new wind farm, and related grid reinforcement
  - Annual grid access charges for the two farms remains the same as for the first
  - Eliminates the grid charges per MWh electricity sold
- Benefits to the storage
  - Eliminates capital costs for the grid connection as it piggy-backs on that of the wind farms
  - Eliminates annual grid access charges for the same reason
  - Eliminates the grid charges per MWh electricity purchased
- Benefits to the grid
  - Eliminates grid reinforcement for the new wind farm
  - Eliminates the need to purchase high-cost services such as
    - Balancing services (as the electricity is input dispatchably)
    - Stability services (as the plant is naturally inertial)
    - Potential purchase of additional grid stability 24/7, over twice the natural inertia of an equivalent-sized power station
- Optional enhancements
  - Doubling of duration with hydrogen combustion, in times of system need
  - Black start at transmission grid scale

**New Solar Plus Storage**

A regional grid is looking to procure both renewable generation and grid balancing / storage services with long-term contracts, for which they invite tenders for new plants. Being in a very sunny region, Storelectric is working with partners to offer a storage plus Green CAES ™ solution.

- Solar generation
  - 400MW rating, with single-axis trackers
- Plant specification
  - 300MW rating for charging (compression)
  - 100MW rating for discharging (expansion)
  - 5 hours duration (i.e. 500MWh storage capacity)
    - Extendable later to 12 hours or more
  - Expected to deliver ~75% of generated electricity to the grid
- Benefits to the solar farm
  - Reduces grid connection capital cost by ¾, and related grid reinforcement
  - Annual grid access charges are reduced correspondingly
  - Eliminates the grid charges per MWh electricity sold
- Benefits to the storage
  - Eliminates capital costs for the grid connection as it piggy-backs on that of the solar farm
  - Eliminates annual grid access charges for the same reason
  - Eliminates the grid charges per MWh electricity purchased
- Benefits to the grid
  - Reduces by ¾ the grid reinforcement for the new solar farm
  - Eliminates the need to purchase high-cost services such as
    - Balancing services (as the electricity is input dispatchably)
    - Stability services (as the plant is naturally inertial)
    - Potential purchase of additional grid stability 24/7, over twice the natural inertia of an equivalent-sized power station
- Optional enhancements
  - Doubling of duration with hydrogen combustion, in times of system need
  - Black start at transmission grid scale

## Stand-Alone Storage




Storelectric is developing a stand-alone storage plant with partners that is distant from renewable generation and therefore does not benefit from such synergies. The partners are keen to develop hydrogen technologies, but require a plant that is profitable immediately. So Storelectric is proposing a 75MW Hydrogen CAES ™ plant.

- Plant specification
  - 75MW rating for charging (compression)
  - 75MW rating for discharging (expansion)
  - 5 hours duration on discharge (i.e. 375MWh output capacity)
    - Extendable later to 12 hours or more
  - Expected to deliver 57% total efficiency (electricity out divided by all energy in, measured grid to grid)
- Features of the storage
  - Dual fuel turbines, methane / hydrogen
    - Initially methane, convertible to hydrogen when it becomes available cost-effectively and in sufficient quantities
    - Can take variable proportions of the two gases, therefore well suited to the energy transition
    - Zero carbon when burning hydrogen
  - As it burns gas, compression time is roughly half of expansion time, enabling it to take advantages of more extreme troughs in the energy price
  - If and when stored energy is depleted, then the plant can operate as a power station, meaning that energy can be generated indefinitely
- Optional enhancements
  - Fitting thermal storage to the cycle
    - Upgrades the plant to 106MW
    - Greatly increases efficiency and flexibility
    - Retro-fittable
  - Black start at transmission grid scale

## Powering Hydrogen Electrolysis

Electrolysis powered by renewable generation requires sufficient electrolysis equipment to cope with the peaks in renewable energy generation. The electrolysis is most cost-effective and efficient when powered by baseload electricity, rather than intermittent. Thus the benefits above of connecting renewables to the grid are achieved. As storage duration and the ratio between input and output power both increase, the plant approaches baseload output and the efficiency of electrolysis improves.

A combined system in which the storage supplies both electrolysis and the local grid will provide dispatchable (on-demand) power to the grid while increasing the size of storage and thereby enable it to deliver closer to baseload energy. In this way a combined project will provide improved returns over a discrete one.

**Supporting Interconnectors**
The issues with interconnectors, at the feed-in side of electricity, are very similar indeed to those of powering electrolysers. At the output side of the interconnectors, Storelectric's storage can turn asynchronous baseload electricity into synchronous dispatchable (variable on demand) electricity, thereby increasing its value and the range of value-added services it can deliver. Adding storage to an interconnector system, at either end (or both), can enable the interconnector to ship electricity when there is insufficient demand at the other end, for use when that demand picks up.

**Supporting all zero-carbon energy supplies**
Desalination, waste water and other applications are ideal for powering with renewable generation and Storelectric's CAES. While a CAES plant can be built to deliver true baseload electricity more cost-effectively than any other storage technology, like electrolysis they are very well suited to the most cost-optimised whole-system designs with Storelectric delivering near-baseload and the plants storing sufficient output to ride out longer-duration adverse weather patterns.

Data centres and other consumers seek to operate on zero-carbon electricity. Unless this electricity is nuclear or hydro-electricity (or a few much less common power station fuels such as biomass and bio-methane), it is intermittent. This means that any contract for zero-carbon electricity supplies would only be statistically so, using a "credit" of fossil fuel generated electricity when renewable generation is low, and "repaying" it when renewable generation is high. Storelectric's CAES can deliver both baseload and near-baseload; the longer-duration the storage, the nearer to baseload; baseload is achieved (in Europe – other regions would need evaluating) at two weeks' storage, achievable more cost-effectively by Storelectric's CAES than any other storage technology.

**Multi-Tasking Technology**
In considering different storage technologies, it is important to determine the number of services that the storage can deliver concurrently, using the same resources (i.e. not sub-dividing the plant's output or storage capacity), e.g. one of Storelectric's plants can deliver concurrently a range of services that require many same-sized batteries:

- Balancing services and arbitrage (based on power and duration);
- Ancillary services (based on speed of response);
- Inertial services (based on inertia, and including related services, such as phase-locked loops) –
  - Distinguish between real and synthetic inertia, the former being best for preventing failures and the latter for recovering from them, as shown here;
- Reactive power and load;
- Voltage and frequency regulation;
- Black start (without having to reserve capacity);
- Other services, e.g. constraint management, curtailment avoidance.

**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.

- 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.