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Innovation in Pressure Vessel for Energy-Storage

e-Storage Solutions Ltd. has discovered an alternative approach to designing and assembling pressure vessels with a significant cost advantage compared to conventional pressure vessels in order to store mass-energy in the form of compressing gas.

e-Storage-Solutions Limited was founded October 2011 in order to develop technologies that promise to enhance the reliability, accessibility and efficiency of energy through inexpensive, small to grid-scale energy-storage-systems.

With renewable energy anticipated to become a viable alternative for the generation of energy within the energy mix. However, to overcome their intermittent energy supply linked to their reliance on changing weather conditions, inexpensive and highly efficient energy storages at a grid scale are needed so that any energy-excess can be stored away for when it is required. This allows for renewable energy to become a base-load supplier in the future that will result in a reduction on the dependency of fossil peaker systems and allow for a more effective on-demand energy distribution and management.

Using pressure-vessels to store energy is not new and has commonly been used within industry over decades, however in the past these came with limitations in size and capacity for one reason being the cost factor.

The e-Storage is capable of overcoming these barriers by using a double walled architectural design. With an inexpensive self-consolidating material used as a filament to act as the vessel's reinforcement, this allows for inexpensive storing of energy from small- to mass-capacities as the enhanced durability and modularity comes at a fraction of the cost compared to conventional pressure vessels.

Compressed air energy storage at 300 bar is known to have a similar energy density as lead-acid batteries. These batteries also have a general efficiency of 80-85% with a life expectancy of about 5 years. In comparison with this, compressed air energy storage currently still suffers from a lower efficiency, but has a much longer life expectancy.

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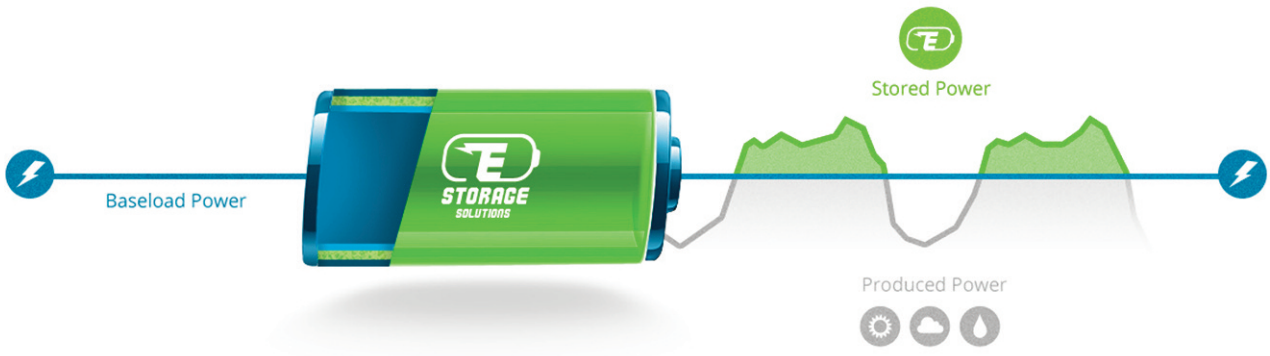

Figure 1: inexpensive energy through mass-storage within an inexpensive and efficient system

1. Thin inside composite layer
2. Thin outside composite layer
3. Filament of self-consolidating material for structural strength

Figure 2: e-Storage "double-walled" Principle

industry over decades, however this came with very limited size and energy capacity for one reason being the cost factor.

e-Storage-Solutions proposes a different approach to building pressure vessels in a more scalable, modular and less expensive way.

This becomes possible because, instead of using conventional single walled pressure vessels, e-Storage-Solutions have conceived a principle of a double walled architecture. The e-Storage, is made from innovative composite material, which demonstrates advanced properties to carbon fibre in terms of the durability, heat and acid resistance at lower costs to glass fibre.

This as a first step already allows cylinders made from this "basalt composite", to become much more durable at a fraction of the cost. Furthermore, e-Storage-Solutions have conceived a concept through which it will become possible to produce these cylinders at any desired length from pre-manufactured basalt sleeving, that is inflated to a desired diameter and then resin infused. This reduces the manufacturing time from previously required hours by a hand lay up lamination process to literally minutes to completion and as a result overcomes the capacity and cost barrier from a conventional system. This will allow for inexpensive yet durable self-consolidating materials be filled to act as an inexpensive reinforcement in addition to the composite cylinders, which will result in the vessels advanced durability at a fraction of the cost compared to conventional systems.

The durability of the e-Storage can as a result be determined not by one wall thickness but through the selection of the wall thickness of all three parts of the structure as illustrated in the figure to the left. As a result the most costly component, the composite material can be held to a minimum.

For the first time, with the e-Storage technology, energy may be stored on a mass/grid-scale at economic cost due to the expected round trip efficiency levels of the anticipated conversion system of 85% and the e-Storage capital cost exceeding 75% less of the cost of conventional steel vessels.

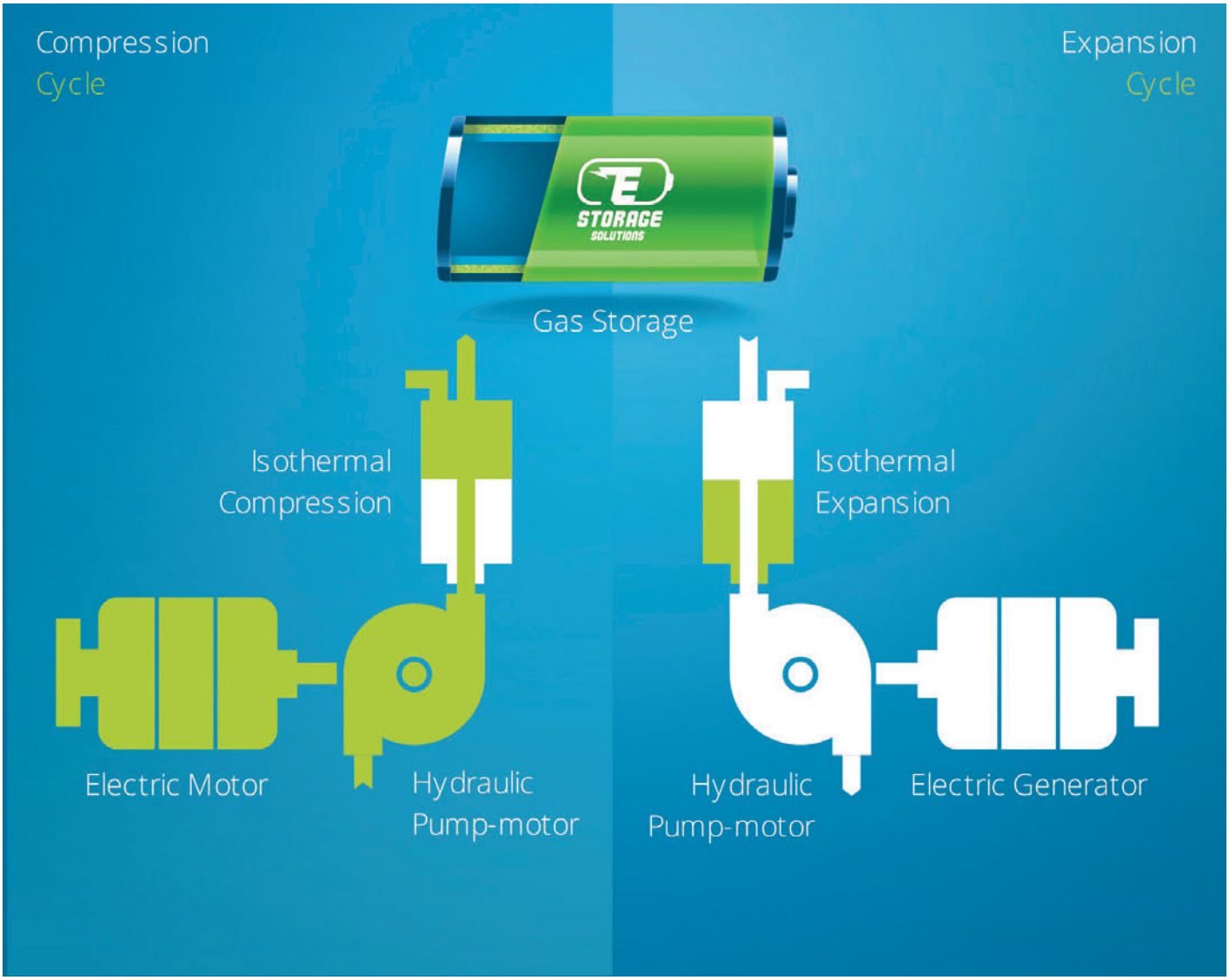

Figure 3: e-Storage accumulation process

Currently, the only truly successful grid-scale energy-storage, which comes at a low price and has high storage capacity is where pumped storage is being used. An example of such a storage plant is "Goldisthal" in Germany. This plant took more than 20 years to build, has an overall energy-storage-capacity of 8.5GWh and cost £520m. Hence, the capital cost per kWh of energy storage is as little as £61. Although this solution can be offered at a low cost, the development time is long and it depends on geographic availabilities whether this technology can be installed.

Another technology that has largely been limited by geography is the use of Compressed Air Energy Storage (CAES), for which currently salt-caverns are used to store the compressed air. There are currently 2 such facilities, one in Germany and one in the US, which have both been operational for over 30 years. Due to the thermodynamics of gas compression and expansion, an overall efficiency of not more than 45% has been reached. Additionally, it is difficult to seal these salt caverns and since storage pressure within them is limited, storage capacity is also limited.

The geographical dependency of these technologies currently prevents much further implementations without starting to create large environmental impacts in the cases

where this would still be possible. For example, in Norway, despite the vast potential energy storage capacity due to its ideal topographic circumstances that are perfect towards building pumped storages, the country does not wish to become a battery for Europe and has decided to limit its construction of pumped storage to limit the environmental impact. Norway's current pumped storage plants deliver energy to parts of Europe, but considering the rising energy demand, will not be sufficient for the years to come. Especially considering that storage demands will increase immensely with countries like Germany moving towards wind energy for 25% of its consumption in its process to shutting down nuclear power plants as a response to the recent Fukushima disasters. Such increases in the use of renewable energy, also leads to an increasing need for storage.

The e-Storage offers higher energy density than Salt Caverns, since the pressure in the latter generally goes only up to 70 bar, while the caverns have a volume of up to 100,000 m^3. On the other hand, the e-Storage can be designed for pressures up to 450 and possibly even 700 bar, which results in a much higher energy storage density. Additionally, the e-Storage is a modular, scalable system that can be implemented where required and therefore be positioned as necessary, to reduce distribution losses.

The e-Storage's manufacturing approach towards its pressure vessels, allows them to also be applied in specialized applications i.e. pipeline segment at virtually endless lengths with each segment designed to interlock with the next through a pre-determined moulding

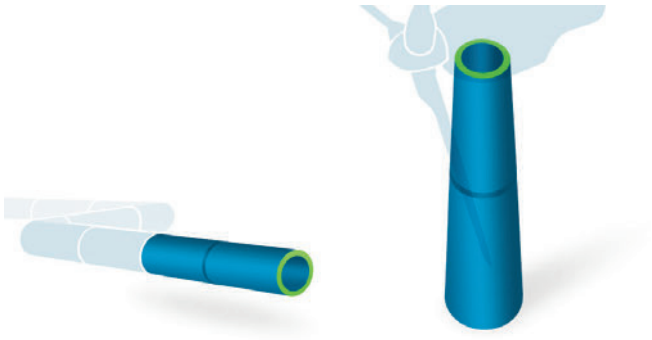

Figure 4: Pipeline and wind turbine tower construction under the e-Storage principle

system. Another application of the e-Storage is the construction of structures i.e. Wind turbine towers or other hollow structures that can equally be used to store energy within.

Additional applications of the e-Storage may also see use in hydraulic hybrid vehicles, which use an electro-hydraulic system to compress gas using hydraulic fluid. The cost advantage of the e-Storage would present itself as a useful alternative making the systems cost more viable and sustainable. Also the natural gas driven vehicles majorly in South America and other Developing countries may see the cost benefit of the e-Storage fitted to their car.

e-Storage-Solutions has partnered with various Companies and a local University in order to develop the pressure vessel and facilitate the necessary training and knowledge transfer for the distribution of this technology on a licensing basis which is to serve the purpose of an accelerated distributions of the technology and implementation of energy-Storage around the globe.

“There is nothing more powerful than an idea whose time has come!”

Victor Hugo