Automating the world's first full-scale liquid air energy storage facility

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An environmentally neutral, grid-scale energy storage system that utilises electrical energy to liquefy the air around us, store it, then expand it back through a generator to feed power into the grid - may sound a bit like tomorrow's world. It is however, a very real prospect since the new 5MW Liquid Air Energy Storage (LAES) facility, designed by Highview Power Storage will soon be operational thanks, in part to control and systems integration work from Optimal Industrial Automation.

After having built and tested a successful pilot plant (which has now been moved to University of Birmingham), Highview and project partner Viridor were awarded government funding by the Department of Energy and Climate Change (DECC) to build a pre-commercial scale 5MW Liquid Air Energy Storage technology demonstrator. That LAES plant is now currently undergoing final commissioning in Bury Lancashire, where control panels built and supplied by Optimal are dotted throughout the site ready to manage and synchronise each of the crucial stages of the process.

The LAES system comprises of three primary processes: a charging system, an energy store and a power recovery stage. In its commercial form, these can be scaled independently to optimise the system for different applications.

Mike Weeks, automation project engineer at Optimal describes the control architecture, 'The entire system relies on a Siemens SIMATIC PCS 7 PLC for overall control; this manages I/O from other controllers, inverter drives, RTU units, meters and sensors. Each of the large process items has its own unique set of control parameters, which we have connected over a Profibus network. We also connect to a GE PLC unit over Modbus communications that controls the waste gas turbo-expander, which is connected to the power generator set.

'From a supervisory control point of view the entire system is transparent and information is updated in near real-time whether engineers and operators are viewing the system on-site or remotely from head office in London. For many automation system integration projects, providing secure networking for control and visualisation, trending and analysis has become as important as the actual control over the electro-mechanical equipment on-site and this project is no different.

Stuart Nelmes Head of Engineering at Highview and leading the project comments, 'The beauty of this system is that each component part of the process is built using tried and tested technology, which we know works and has established performance parameters. The design envelope and the application of some of it has been developed a little to meet our particular requirements, but it's the way all the different processes interact which truly delivers the viability of the process.'

The funding has supported the design, build and testing of this LAES technology demonstrator on the same site as Viridor's Pilsworth landfill gas generation plant. 'This has proved to be a smart move for several reasons' continues Nelmes, 'the location was good from a planning permission point of view, but it also has a technical benefit in that we can use low-grade waste heat from the GE Jenbacher generator engines to make our gas expansion stage more efficient.

'Expanding the liquid air, (or Nitrogen as we are using for this full-scale demonstrator project) has a refrigerating effect, so our process is more efficient if we can counteract that by using waste heat energy from combustion. This is why conventional power stations are a good potential site for the final stage commercial installations, which is the next step for us.'

Green credentials are off the scale compared to other large-scale energy storage methods; once constructed the commercial installations will be close to environmentally neutral, output is simply air, or in this case inert Nitrogen, which makes up 78% of the air anyway. Commercial installations are likely to be used as temporary energy banks for larger power stations, which are both slow and expensive to turn down, or turn off.

The solution would also be very effective for storing energy from renewable sources such as wind turbines when there is a grid surplus and then fed back in to the grid when demand peaks. Fast, effective peak-lopping is an extremely desirable function from an energy grid management point of view and is one reason why government funding has been provided. It is also a reason for considerable global commercial interest in the project.

The project will operate for at least 1 year and is intended to demonstrate how LAES can provide a number of electricity grid balancing services, including Short Term Operating Reserve (STOR), Triad avoidance (supporting the grid during the winter peaks) and testing for the US regulation market. Construction on the project began in February 2015 and it is expected to be operational during 2016.

Mike Weeks concludes, 'The system is not massively complex, the main challenge we have is that it is a development project and by its nature some of the fine details of how best to realise various aspects of the control and monitoring architecture have been worked-out as the project has progressed. We have been able to remain flexible and help the design team and all the suppliers come together to achieve a harmonious working system that allows both proof of operational targets and room to fine-tune and learn from it.

So how exactly does an LAES work?

Air turns to liquid when refrigerated to -196°C, which is usually achieved by a cycle of compression, cooling and expansion, it can then be stored in conventionally insulated, ambient pressure vessels at very large scale. Exposure to ambient temperatures causes rapid re-gasification and a 700-fold expansion in volume, which is used to drive a turbine and create electricity.

Highview's technology draws from established processes from the turbo-machinery, power generation and industrial gas sectors. The components of Highview's processes can be readily adapted from large OEMs and have proven operating life times and performances.

Why Liquid Air Energy Storage?

• No geographical constraints

• Close to environmentally neutral in operation

• Competitive capital cost

• Long lifetime 25+ years

• Scalable to 200MW/1GWh

• Components available from a global supply chain

• Integration of industrial low-grade waste heat and waste cold

• Uses no scarce or toxic materials

Other partners include: GE, Heatric, BOC and Metalcraft. KiWi Power are engaged to commercialise the plant's interaction with National Grid.

LAES technology can be scaled to deliver large-scale, long duration energy storage from around 5MW output and 15MWh of storage capacity to more than 200MW output and 1.2GWh of capacity.

It can be considered as being comparable to medium scale pumped hydro-electricity storage, but without the geographical restrictions of mountains and reservoirs. When scaling up LAES technology, the system will be modular and benefit from scale and convenience, an advantage when locating it to different regions and applications.

Final word goes to Highview's CEO Gareth Brett, "This is a breakthrough technology that enables a new and compelling solution for large scale, long duration energy storage. There is nothing else available right now, that can be deployed at this scale and duration and at low cost. This project with Viridor will be an invaluable demonstration for the power sector to evaluate, implement, utilise and capitalise on this, a milestone in Liquid Air Energy Storage."

Photo Caption 1: The LAES system comprises of three primary processes: a charging system, an energy store and a power recovery stage.

Photo Caption 2: An overview of the LAES facility.

Photo Caption 3: Stuart Nelmes Head of Engineering at Highview and project leader.

Photo Caption 4: Matthew Barnett, Head of Business Development at Highview.

Photo Caption 5: One of the control panels on-site built and supplied by Optimal Industrial Automation.

Photo Caption 6: The GE Jenbacher generator engines.

About Optimal Industrial Technologies Ltd

Optimal Industrial Technologies has more than 30 years' experience in the automation and optimisation of control and data management systems for the pharmaceutical, biotech and life science industries.

The demands being placed on manufacturers in relation to production costs, product quality and business sustainability are ever increasing; hence, the company's primary aim is to deliver measurable improvements in all these target areas.

In addition to practical automation and system integration expertise Optimal Industrial Technologies has also developed a world leading PAT based data management software package – synTQ® which is used by over half of the world's largest pharma companies to increase productivity and reduce time to market for OSD and biotech based drugs and therapies.

Editor Contact

DMA Europa Ltd. : Roland Renshaw

Tel: +44 (0)1562 751436
Fax: +44 (0)1562 748315
Web: www.dmaeuropa.com
Email: infoallenquiries@dmaeuropa.com

Company Contact

Optimal Industrial Technologies : Martin Gadsby

Tel: +44 (0) 1454 333 222
Fax: +44 (0) 1454 322 240
Web: www.optimal-ltd.co.uk
Email: mgadsby@optimal-ltd.co.uk