Case 71

Gravity Power Electricity Storage

This article introduces a creative approach to storing energy as one of the 100 innovations that shape "The Blue Economy". This article is part of a broad effort to stimulate entrepreneurship, competitiveness and employment.

The Market for pumped hydro energy storage

The world market for pumped storage hydro (PSH) has reached by 2010 just over 127 GW. Hydro-electricity, including pumped storage is the most widely used renewable generating technology today. PSH is the co-generation of the hydro-electricity, as steam is for the coal fired power stations. PSH uses low cost off-peak electricity to pump water from a lower reservoir to a higher elevation. During periods of high demand, the water flows through turbines to produce electricity. Even though the pumping implies an energy loss, the revenue increases by selling electricity at higher prices during peak demand.

The European Union had just under 40 GW net capacity, good for more than one third of the world capacity, representing 5 percent of the EU baseload electricity generation capacity. Europe is the most active in expanding storage capacity. Japan has invested over the years and has 26 GW good for a quarter of the world capacity. United States has 22 GW, about one fifth of the world storage accounting for 2.5 percent of the US baseload energy generating capacity of 1088 GW. The pumped storage market is expected to grow 60 percent over the next four years, accumulating in 203 GW by 2014. The additional investments represent just under 60 billion dollars of capital outlay.

The World Bank and the European Investment Bank are pro-active in providing funds for the expansion of PSH from Portugal, Switzerland, Spain and the United Kingdom, to Russia, Indonesia, China and Vietnam. An interesting new development is the cooperation between RWE, one of Europe's leading electricity provider and RAG, Germany's coal mine operator, to co-develop an integrated PSH and wind project at the coal slag mountains. The concept integrates intermittent wind output with hydro that could supply within one minute. The system will use wind power at times of high output and low demand to pump water 50 meters higher on the top of the waste mountain. It is expected to be operational by 2016. Voith Hydro (Germany) is a market leader in the supply of generators and turbines, with over 40,000 units installed. Last year this company experienced a strong competition from Toshiba, Mitsubishi and Sumitomo of Japan and Alstom of France.

The Innovation

Since renewable energy is generated intermittently it requires a back-up through energy storage. The traditional storage technology has been batteries, however this chemical solution is only viable for small facilities. The Sodium-sulphur battery only reaches a capacity of 200 MW. Compressed air energy storage (CAES) as an alternative has difficulty imposing itself on the market, with only 2 commercial scale applications in the world. A flywheel with extremely low friction and placed in a vacuum, stores energy made from composite materials to provide centripetal forces. Hydrogen, compressed or liquified is stored to be converted back to energy and/or heat. Thus while PSH is the most applied system today, one of its major hurdles is its environmental impact and permitting which on average takes one decade.

James Fiske, scholar of magnetic levitation (maglev), received his degree in Electrical Engineering and Computer Science from Massachusetts Institute of Technology in 1978. He worked for Hughes Aircraft in signal processing systems, is the principal architect of a mini-supercomputer and designed cutting-edge computer assisted engineering software. He holds six patents. While he was imagining a new class of maglev freight transportation, he became attracted to the use of gravity as a grid-scale electricity storage system. He looked at the PSH and decided to push this proven technology in a new direction: down. He realized that the two large reservoirs and the environmental disruption could be overcome by installing a gravity power module (GPM) underground. This modular system has a small ecological footprint and can be located almost anywhere power storage is needed. James went on to create Gravity Power as a spin-off from LaunchPoint Technologies where he serves as Vice President of Advanced Systems.

The First Cash Flow

James realized that we should not only focus on how to catch the power of the the sun, the wind and the waves, but have the capacity to save it for many hours after the sun sets and the wind dies down. He assessed the total capital cost per KW and realized that batteries vary between $1,750 and 3,640 per kW, whereas PSH could reach the lower end of $1,500 - comparable to the cheapest batteries, but for more than double the hours of storage (10 hours). With a vast access to computer aided design and simulations, James concluded that a 2 GW storage facility requires less than 2 hectares. Since the technology relies on a deep shaft, filled with water reinforced with concrete, it will withstand earthquakes.

The GPM is a vertical column excavated a couple hundred meters into the earth and filled with water. A huge piston comprised of massive pancakes made from concrete and iron ore for high density and low cost, rests on the column of water with sliding seals to prevent leakage, to store energy and lowered to discharge energy using a return pipe. When energy is in abundance, water is pumped down and moves the weight and the water column up. Releasing the weight drives water through a turbine, produces power when needed. One shaft could store more than 50 MW of energy for four hours, or 200MW hours of storage.

Gravity Power is collaborating with Robbins Co., the inventor of the mole machine to adapt their technology to vertical tunneling capable of digging 100 meters deep in 24 hours. The speed, low cost, and construction from readily available cheap materials expects the investment costs to reduce by at least half and the time between decision and implementation in terms of a few years instead of a decade. The first unit is installed in Texas in 2011.

The Opportunity

The introduction of renewable energies requires utility-scale energy storage, which is a gargantuan scale. So one of the opportunities is to work with available shafts, of which thousands have been dug over the past few centuries by mining companies all over the world. The MineWater project in Heerlen, the Netherlands already uses the thermal difference of deep mines for cooling and heating of residential zones. Now one would not only use the temperature, which is a proven technology in the Dutch case, one uses the presence of water, locates ideal shafts, installs sealants and exploits the widely available water in defunct and abandoned mines, which very often has to be pumped out, at the core of a GPM. In a country like South Africa, where the mining industry pumps millions of gallons of water out, representing up to 25 percent of all energy consumption of the mines around Johannesburg, the breakthrough offered by James and his team would secure a permanent power supply. With the shafts going down 4,000 meters the mining companies are only now coming to grasps with the enormous potential.

GUNTER PAULI

Further information on the 100 innovations at www.blueeconomy.de and www.zeri.org.

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