Case 60

Batteries Made of Water

By Gunter Pauli

This article introduces a creative approach to energy storage 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

The world market for batteries will reach in 2011 nearly $74 billion. The Chinese market is the largest and growing the fastest. The United States represents approximately $15 billion in turnover, good for 15 billion batteries. The expensive batteries enjoy the highest growth. The world market for materials to make batteries is expanding to $3.8 billion for the same year. The value added generated from mined metals to produce a finished product is nearly factor twenty. Making and selling batteries is definitely a profitable business. While car batteries are nearly 100 percent recycled, it has been estimated that some 40 billion batteries will end up in landfills this year. This means that about $ 2 billion worth of precious and scarce metals will be discarded.

Whereas the first battery dates back two thousand years, it was Thomas Edison who created the first alkali battery with a power of 1 to 1.35 V. Today, electric power from batteries is calculated in Joules equals one Watt per second, or one Watt equals one Joule per second. One Watt per hour thus represents 3,600 Joules. The world market of batteries has evolved tremendously over the past few years, from the lead-acid ones that cost $0.17 per Wh, the cheapest and the one that gets the car going, to the nickel-cadmium battery that costs nearly ten times more ($1.50), and the mid-range type made from lithium ion which is the standard used in the Nissan electric vehicle with an associated cost of $0.47 per Wh. Few people realize that a kilowatt hour of electricity from the battery can cost 100 to 500 times more than the power from the grid. Society is prepared to pay a high price for mobility. The largest size energy storage battery was built by ABB in Fairbanks, Alaska. The massive nickel-cadmium battery provides 40 MW, enough electricity for 12,000 people for up to seven minutes. The smallest battery is 2.9 mm by 1.3 mm, the size of a pencil tip and can be charged for up to 10 years.

The Innovation

A major drawback for batteries is weight. Lightweight batteries are a priority for the industry. The refueling of batteries by pumping a rechargeable electrolyte instead of having to replace or recharge a whole unit is another innovation that is eminent. The arrival of the vanadium-based battery that could be recharged at least 10,000 times is another breakthrough, even though the medium is in short supply to satisfy world demand. However, batteries are limited in terms of mining, recycling, and sheer energy potential. One kilogram of crude oil represents 50 MegaJoules (MJ) of energy while one kilogram of lead-acid batteries can only generate 0.1 MJ of power, or 500 times less. This explains why energy from batteries is so expensive, and why the recovery of excess electricity into a storage battery power will always face a competitive disadvantage. Weight for weight, even the best batteries in the world could theoretically only generate 6 percent of the power that petroleum offers.

Professor Bo Nordell from the Luleå University of Technology in Sweden had long been impressed with the capacity of water to store heat. He studied thermal energy storage and realized that one cubic meter of water can contain 334 MJ or 93 kWh of heat. The opportunity to either use ice, storing the energy from freezing winter months, or to use water heated by solar (See Case 53), represents a cheap storage mechanism that operates very efficiently when applied at a larger scale with minimal infrastructural cost. There is no limit in the number of recharges. Prof. Nordell supported Kjell Skogberg's doctoral thesis which lead to the building of the world's first snow cooling plant in Sundsvall, Sweden for the main city hospital, exploiting the coolness embedded in snow collected during the winter.

The First Cash Flow

Per-Erik Larsson, the project leader appointed by the County Council of Västernorrland decided to design and operate the energy plant. The main purpose back in 2000 was to avoid hazardous ozone refrigerants, to reduce electricity use and to capture winter snow, mainly collected from roads, roofs and parking lots. As the snow melts it is circulated through pipes. The design is rather basic: before the water reaches the pipes of the hospital, it is filtered and passed through heat exchangers. The heat exchangers have a capacity of 3 MW, and transfer heat from the hospital to the melted snow. The water from the hospital is cooled from 12 to 7 degrees Celsius. The heated cold carrier is then circulated back to the snow storage to melt more snow, which is further pumped towards the heat exchangers and the hospital, to continue the delivery of cooling. After installation of snow cooling, the hospital reduced its cooling related electricity consumption more than 90 percent. This long-term solution has a minimal life-length of 40 years, meaning that the system will be recharged 40 times over 40 winter seasons. The inventors went on to create the company Snowpower AB which is now commercializing this simply battery technique.

The Sundsvall experience is a large scale application of the multiple smaller examples that have been developed using water as a storage medium of energy. However, most of the systems used heat (instead of cool) but since the process works on the basis of a temperature differential, it does not matter if the starting point is ice or hot water. Josef Jenni pioneered in 1989 with the first solar house, and then in 2005 a solar tank that holds 205 cubic meters of hot water storing energy that can be converted to electricity. The City of Heerlen, the Netherlands, pioneered the use of warm water in the old and closed coal mine shafts. Even though the deep mine provides water of 35 degrees Celcius, it is sufficient - through a series of heat exchanges - to provide all heating needs in the winter and cooling in the summer for 350 homes and a shopping center. Water can retain five times more heat than concrete, and therefore is an ideal alternative for replacing batteries in large scale operations.

The Opportunity

Every home, and every city has an elaborate water storage system. When we realize heating and cooling of air, plus the heating of water represent 80 percent of energy consumption in a traditional home, the real opportunity before us is to not only opt for renewable energies, but to opt for the most efficient storage system for energy. The cheapest and the most abundant medium is water. This offers a fresh look at the need for energy storage, since we can heat (or capture cool) water and store it. The first advantage is that hot water eliminates the risk of bacterial contamination. Hotels in Spain have to maintain all water at 90 degrees Celsius in order to fight the proliferation of E.coli, only to be cooled down in a shower or a bath to 38-40 degrees loosing more than 50 percent of the embedded energy.

If we apply the principle of "use what you have" then the heated water becomes one of the major sources of electricity. Solid state heat exchangers only require a 3 degrees temperature differential to generate electricity, a phenomenon known as "thermo electricity". Next time you take a shower, think about the wasted energy that mixing cold and warm water implies. At the same time, think about the potential if all water tanks already built could become energy storage tanks, converting a passive service into an active component requiring a new kind of smart grid. This offers so many opportunities for entrepreneurship that it could well define the job of the "water electrician".

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