Thermal storage.

Energy Storage: A Critical Path to Sustainability

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Regardless of the source, we must look at how to store the energy

Fossil fuels, such as coal, gas and oil, are not just energy; they are forms of stored energy. They are relatively easy to hold, transport inexpensively, and are typically available when and where you need them. When burned, the chemical reaction produces heat and useful energy. Due to their negative impact on the environment, we now must figure out how to minimize the use of fossil fuels. But how can we take what is good from them—the storage—and apply it to other energy sources?

To understand the importance of storage, it is imperative that one understands the electric power grid. If you have ever lived in a warm environment, you have probably experienced a brown out. Brown outs typically happen in the heat of day, when the temperatures are high and buildings across the area are turning up the air-conditioning and creating an enormous need for energy. Because of this, in the middle of any day, the demand on the power grid is the highest. In addition to the air-conditioning running at full power, more lights are on and multiple appliances are in use.

Because of the strain on the grid, the costs for electricity are highest during those "on-peak" hours and the generation is often the dirtiest since all the old plants are turned on to help meet the demand. On the flip side—at night—when the majority of people are sleeping, there is a very low demand on the grid, and sometimes, even over-capacity. This is called "off-peak."

Storage is the Answer

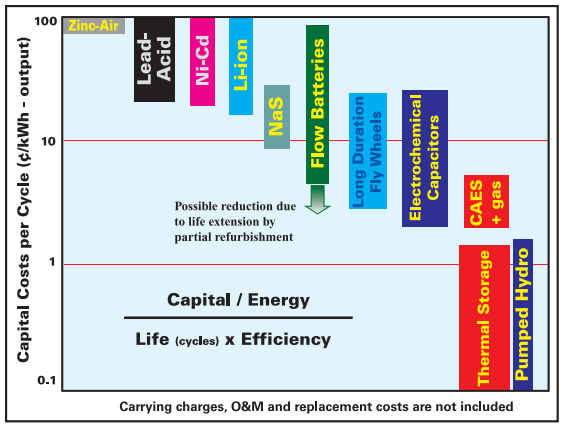
In its present configuration, our electric grid has almost no "storage" capability so that electricity must be produced exactly when it is needed. This is possible when your source of energy is fossil fuel (stored energy) but is very difficult and expensive when it is renewable energy (wind or solar). Adding energy storage to the grid will be critical in our quest to lower societies' carbon emissions.

Forms of Energy Storage:

There are a number of types of energy (potential, kinetic, chemical and thermal) and each can be stored (See Figure 1). One example is referred to as pumped hydro. At night water is pumped up a mountain into a temporary lake and then released down the mountain through turbines to create electricity. This is a form of potential energy storage. Flywheels use kinetic energy and can be wound up using off peak energy and released when needed. And of course, batteries in our cars, iPods, boom boxes

or cell phones, are examples of chemical storage that can be charged at night or when the sun shines. All of these approaches can store energy that can later be re-converted into electricity.

Figure 1



The chart compares the life cycle capital costs for different types of energy storage methods. Initial capital costs, lifetime of storage device and the cycle efficiency are used to determine the rating.

Thermal energy is normally stored at the point of use and committed to a specific purpose, for example, hybrid cooling systems for buildings that use ice-based thermal storage. In this type of system, ice is generated and stored at night (off-peak) which will then be used to cool a building during the following day. So stored energy (ice) is used, instead of electricity, when the demand for energy is high. Essentially, you have committed the more plentiful nighttime electricity to a purpose (cooling) and stored the energy in the form it is needed in for later use.

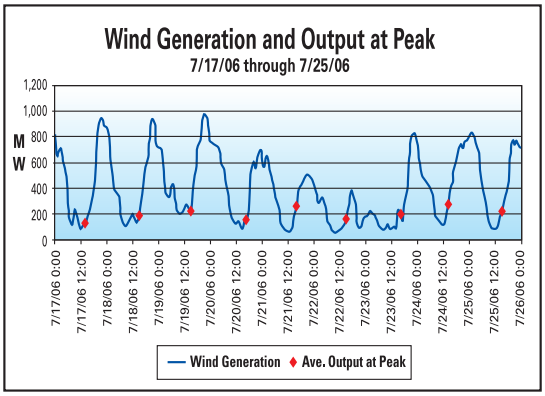
Understanding the Numbers

The cost of energy storage varies by type; however, some types have relatively low cost compared to the value they bring to the electricity grid. For instance, California has 1,000 MW of wind urbines installed; however, only 20% (200 MW) of it has typically been available when the utilities hit their peak (See figure 2).

The installation of thermal storage at a building provides the ability to store energy when the wind is blowing at night and to then use the stored energy during peak hours the following day. With storage you can get 100% of wind's output during peak hours (20% from wind and 80% from energy storage) for less than 33% of the installed cost of adding additional wind turbines. Ultimately, the peak capacity of the wind resource is increased by a factor of 5 and the cost per delivered peak kW is decreased by 1/3.

Thermal storage at the building is the least expensive of all the energy storage types and also the most practical (for example with pumped hydro, it is not very easy to get a permit to create a lake on top of a mountain). And since the largest component of on-peak energy use is the creation of cooling, there is plenty of need for the stored cooling. As with any form of storage there are some losses. Think of it as energy storage efficiency. With the pumped hydro system, off peak electricity is used to pump water up a mountain and during the peak period the water flows down through a turbine to create electricity. The round trip "cycle efficiency", which is the amount of electricity used versus what you get back out, is about 65% to 70%. Other forms of large scale energy storage have similar numbers. Thermal storage at a building can have cycle efficiency of anywhere from 80% to 99%.

Figure 2



The graph shows the varying electrical output of a wind turbine installation in California during the hottest week of the year in 2006. The red dots represent when the electric utilities were hitting their electrical peak demands for each day. It is clear that when the utilities needed the most power they were getting only approximately 20% of the installed wind capacity.

All forms of energy storage are going to be needed in our move towards a lower carbon world. But when you look at costs and science, thermal energy storage is already a viable technology to consider when designing high-performance buildings. Moreover, it is ideally suited for the urban environment — whether it's a new construction or retrofit. Though it does take some space, it is relatively little compared to what it is cooling (about 0.25% of the conditioned area) and can be located in the basement or the roof or anywhere in-between. Thousands of companies around the world are utilizing thermal storage to cool their buildings. Recent installations in New York City have been done for the Durst Organization, Credit Suisse, Rockefeller Center, Morgan Stanley, TIAA CREF and Bank of America.

Thermal energy storage isn't a new technology, but its application now has an entirely new dimension because of the move towards renewable energy resources. The Edison Electric Institute recently reported that the only form of energy that has not increased in cost in the past 40 years is off-peak electricity. Therefore, the most reliable way for building owners to stabilize energy costs is to design or retrofit a building to shift as much energy use as possible to off peak. Thermal storage does just that. The ROI is very reasonable, especially when combined with other energy efficiency measures, creating a cost competitive, environmentally-friendly HVAC solution.

***Mark M. MacCracken** is the CEO of CALMAC Manufacturing Corporation, which is the largest manufacturer of Thermal Energy Storage equipment in the world, with over 3,300 installations in 35 countries. In his over 30 years with the firm, MacCracken has been involved in all aspects of the company including, R&D, contracts, patents, manufacturing, marketing and finance. He was the Principal Investigator on research projects with Oak Ridge National Labs, NASA and National Renewable Energy Research Lab. In his continual support of energy efficiency he is regularly in contact with the DOE, EPA, EPRI and electric utilities across the country and around the world.*