Six ways of providing base load power from wind

The ability to store and dispatch the power generated from renewable sources
will enable increasing amounts of clean power to supply our energy future.
[Photo: Tim Weis: Pembina Institute]

1. Interconnecting geographically-dispersed wind farms and solar power systems
2. Using another renewable energy source, such as hydroelectric power, to smooth out supply or match demand
3. Managing demand based on (weather) forecasted production from wind and solar power
4. Storing the electric power for later use,
5. Providing electric power to and drawing from vehicles in such a way as to smooth out electricity supply
6. Making all renewable power sources "friendly" to grid operators using connection protocols, providing flexibility, and balancing supply with demand.

1. Interconnecting Geographically Distributed Wind Farms

The wind is always blowing somewhere so if widely distributed farms are linked together, we can always count on some wind production. How much? A study in the US mid-west showed that one third or 33% of annual power production from distributed wind farms could be counted on to supply base load with the same reliability as a coal power plant. Because generation sites would also be closer to demand, grid distribution losses would be cut from 7% to less than 2%. In Spain, where wind farms are distributed over the entire country, hourly variations in the supply from wind are effectively eliminated - smoothing out the electricity supply from wind. On a particularly windy day in March 2008, Spain reached a point where 40% of its power was coming from wind.

2. Coordinating with Hydro

The output of most hydro-electric power plants can be controlled by grid operators and therefore can be used to complement the variable output from wind farms. This is made even easier because of new forecasting techniques that allow grid operators to estimate wind farm output a day ahead. The effectiveness of this approach has been proven in the Nine Canyon area in the State of Washington. The output from a new 63 MW wind farm was successfully integrated with 65 MW of existing hydro power generation. Little, if any, energy imbalance occurred, and there was no need for utility action beyond normal grid management. Grid operators estimate the additional costs of coordinating wind and hydro to be only 0.09 cents/kWh.

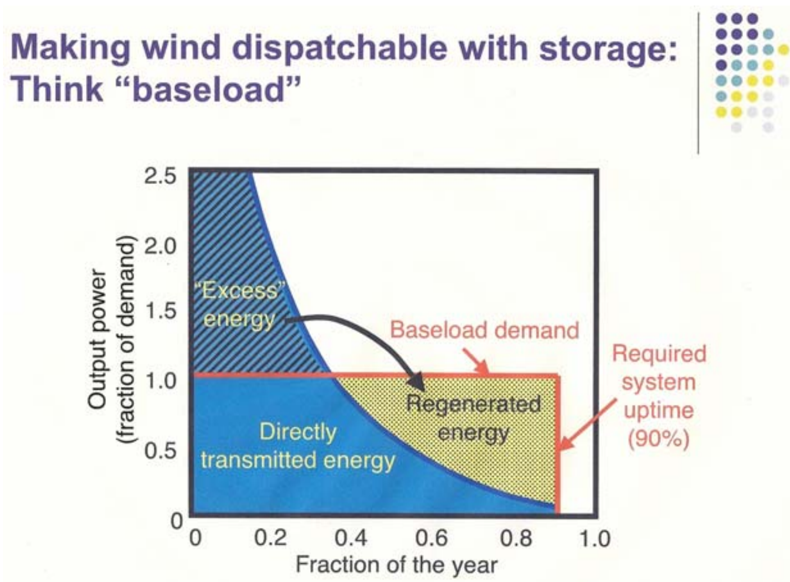
3. Managing Demand

Power utilities often encourage customers to modify the timing of their power usage to reduce peak demand. This is done either by encouraging voluntary action through incentives, or taking control of customer equipment like air conditioning and water heaters in return for a break on power bills. This approach is now being used to reduce power demand when supply from solar or wind farms drops – effectively matching demand to supply variations.

In California "smart" techniques for controlling the demand of customers will provide system operators with a tool for matching demand and supply. Built-in programmable thermostats will be re-set to higher or lower temperatures by the grid system operator. Hot and cold storage will be used to ensure the customer is not affected. This will allow grid operators to lower demand when power from resources like wind and solar are low and increase demand when excess power is available.

4. Storing Renewable Power

Adding power storage to the grid allows power produced by variable renewable generators like solar, tidal, wave and wind power that have variable outputs to be stored during periods of high output or low demand. Power can then be provided at constant or controlled rate to meet base load and peak power needs.



[Samir Succar, Princeton Environmental Institute]

Power storage can be located at several locations within the grid depending on the role it plays:

- At the generation site to provide the power generator with dispatchable high quality power and lower connection costs.
- Within the grid close to load centres to provide flexibility and ancillary services.
- At a customer's site where storage provides more options for demand response measures.

Storage facilities can be owned and operated by the generator, a separate storage entity or a customer — again depending on the role storage plays. The following is a summary of the options available for storing electrical power on a large enough scale to allow deployment of large proportions of renewable power sources into the grid:

Pumped Hydro Storage: water is pumped into a new or existing water reservoir and released as needed through a turbine generator.

This option is good for long term power storage and smoothing out seasonal fluctuations. It has a fast response and does not need a large flowing river – just a difference in level between hills and valley. There are 90 GW of pumped storage in place world wide.

Flow Batteries (Regenerative Fuel Cells): A flow battery is a reversible fuel cell that stores and releases electricity by means of an electrochemical reaction, which occurs when the electrolyte flows across a membrane/cell stack.

Flow batteries are modular and are available in any size. They can be placed anywhere and be cycled many times without loss of capacity. They are ideal for shorter term (up to 10 hours) storage. They have long life – up to 15 years, and a very fast (millisecond) response time.

Compressed Air Energy Storage (CAES): Air is compressed in underground caverns and then released as needed though a gas turbine supplemented with natural gas.

This option is good for mid to long term storage applications. It can use disused salt, gas or other caverns and has a high efficiency.

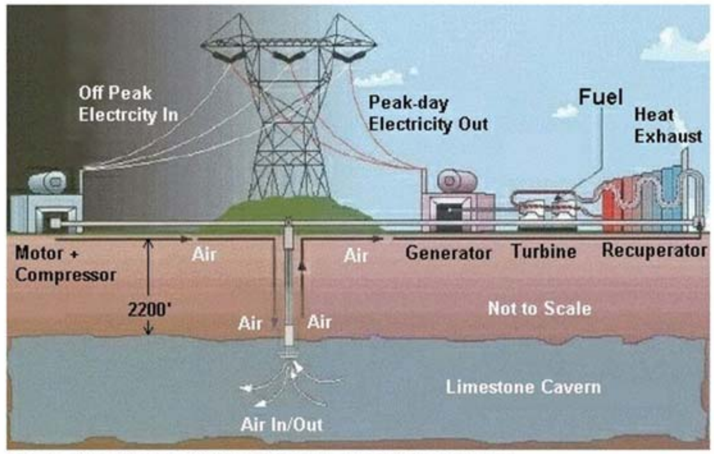


Photo Courtesy of CAES Development Company

Advanced Rechargeable Batteries: Sodium sulphur (NaS) batteries contain liquid sulphur and sodium separated by a solid ceramic electrolyte. Lithium-ion (Li-ion) batteries contain metal oxides and graphitic carbon separated by an electrolyte containing lithium salts.

Flywheels: A rotating cylinder is enclosed within a low pressure or a vacuum environment and connected to a motor/generator that draws electrical energy from a primary source. The motor driving the flywheel acts as a generator when power is needed.

Supercapacitors: Two electrodes (plates) of opposite polarity are separated by an electrolyte and store electric charges of equal and opposite magnitude on the surface of each electrode plate. During discharge, the built-up charges on the plates create a current.

Hydrogen Storage: Water is electrolyzed into hydrogen (and oxygen), which is stored in compressed form. The hydrogen is used to generate power using a fuel cell or a reciprocating engine when needed.

High Temperature Fluids: Pressurized hot water or other thermal fluid produced by a solar thermal power plant is stored until it is needed and then used to produce steam and power.

Applications of Storage Technologies

	Wind Farm	Solar Rooftop	Solar Farm	Solar Thermal
Pumped Storage	X			X
Flow Batteries	X		X	
Compressed Air Storage	X			
Advanced Rechargeable Batteries		X	X	
Flywheels		X	X	
Capacitors		X		
Hydrogen	X			
High Temperature Fluids				X

5. Vehicle to Grid Connection

The rapid trend towards the use of "plug in hybrid" and all electric vehicles has focused interest on "Vehicle to Grid (VTG)" systems where vehicle batteries act as multiple power storage units throughout the grid. In Austin, TX the city plans on using local wind power that is generated at night to charge plug-in hybrid car batteries, and then tap into those same car batteries for extra power during the day time.

6. Grid Friendliness

Grid operators want flexibility to balance supply and demand. They prefer many smaller, predictable, flexible resources. Wind farm output that can be forecast a day ahead or wind farms whose output can be controlled fit the bill really well. The Alberta power system operator has developed simple protocols for new wind farms to ensure that they provide this "grid friendliness" and flexibility.

Solar system output matches summer peak demand perfectly and is distributed throughout the grid, making management of other generators much easier.

Large inflexible, "must run" plants like nuclear power plants are often a worst case scenario for grid operators – particularly if they make up a large proportion of the grid power capacity. In New Brunswick, the Point Lepreau nuclear plant makes up a significant fraction of the total and makes grid operation much more challenging. In Ontario, large industrial users have sometimes been paid to use power because nuclear plants cannot be turned off in times on low demand. This will only get worse as demand is reduced though conservation and efficiency or more nuclear plants come online.

In Portugal a study compared how much power storage capacity would be needed to meet future power demands if nuclear power or wind and solar power were used. Nuclear needed 10 times more storage than wind and solar because of its inflexibility to meet varying demand.

Further Reading

"Storing Renewable Power". The Pembina Institute 2008. http://re.pembina.org/pub/1651

For more information on the Canadian Renewable Energy Alliance visit www.canrea.ca