Focused Sun
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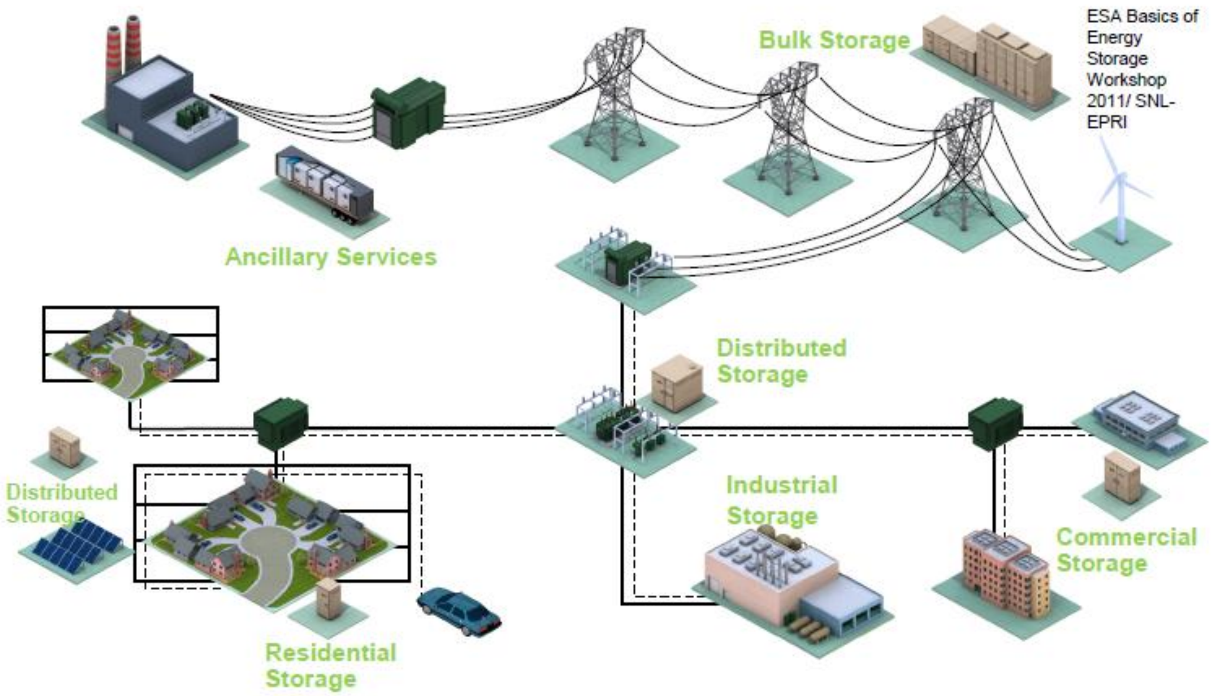
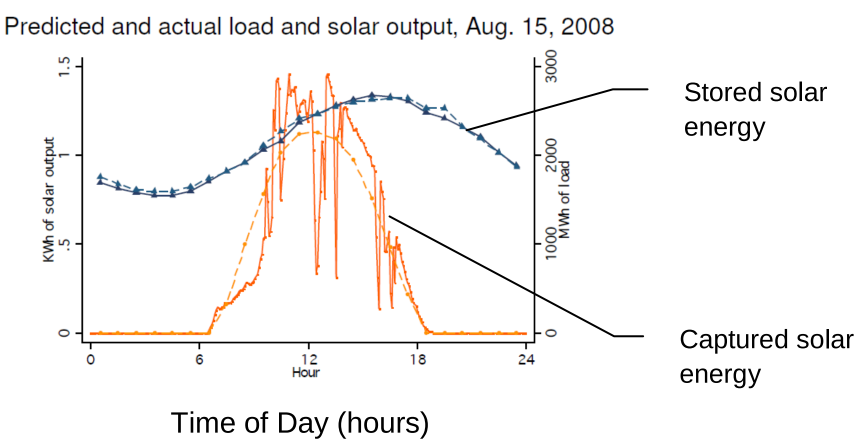
Microgrid Power

Powering a microgrid starts with what is a microgrid. Essentially it's an electrical grid that powers small communities, industrial parks, agricultural projects and industrial plants. They are connected to "the grid" itself but have the option of disconnecting from it during power outages or other emergencies.

Below is an image from the U.S. Dept, of Energy (http://energy.gov/articles/how-microgrids-work) that shows various microgrids: residential, industrial and commercial.



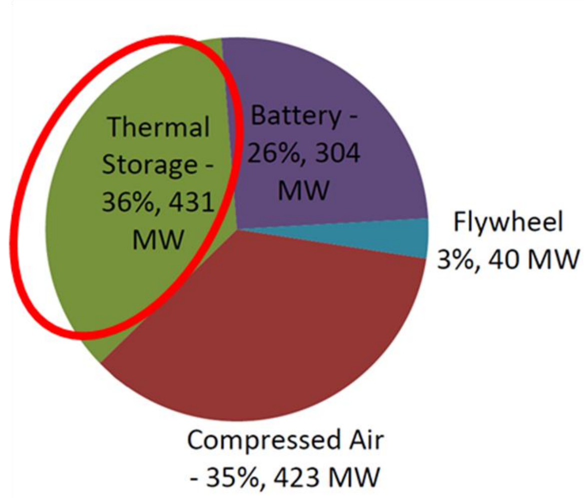
Microgrids need power when the sun isn't shining: at night or during cloudy periods. A solution is storing the energy from when it is captured during the day to when it is needed at night.



http://web.mit.edu/ceepr/www/about/November%202011/nove

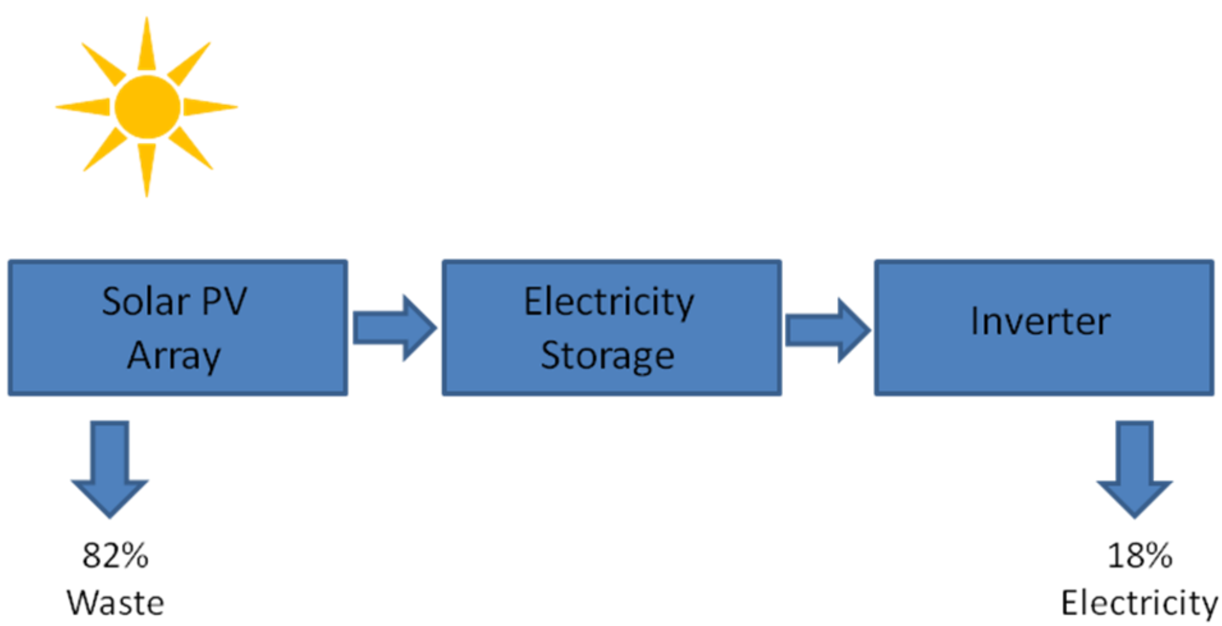
The graph is from MIT's Intermittency and the Value of Solar Energy report. It shows the effect of storage using current technology. The red line is the solar energy that's captured during a typical day. Notice that the captured solar energy varies from hour to hour: sometimes it's sunny and sometimes it's cloudy. More important, there is no sun at all at night: before 6 AM and after 6 PM on this day.

The blue curves shows stored solar energy over the same day. Stored energy is available over the entire 24 hour period. Storing energy smoothes the daytime cloudy periods. They have little effect on the temperature of the stored solar energy. It also smoothes over the 12 hour night time period when no solar energy is produced. Depending on the amount of storage and usage, solar energy may be available even a day or two later.



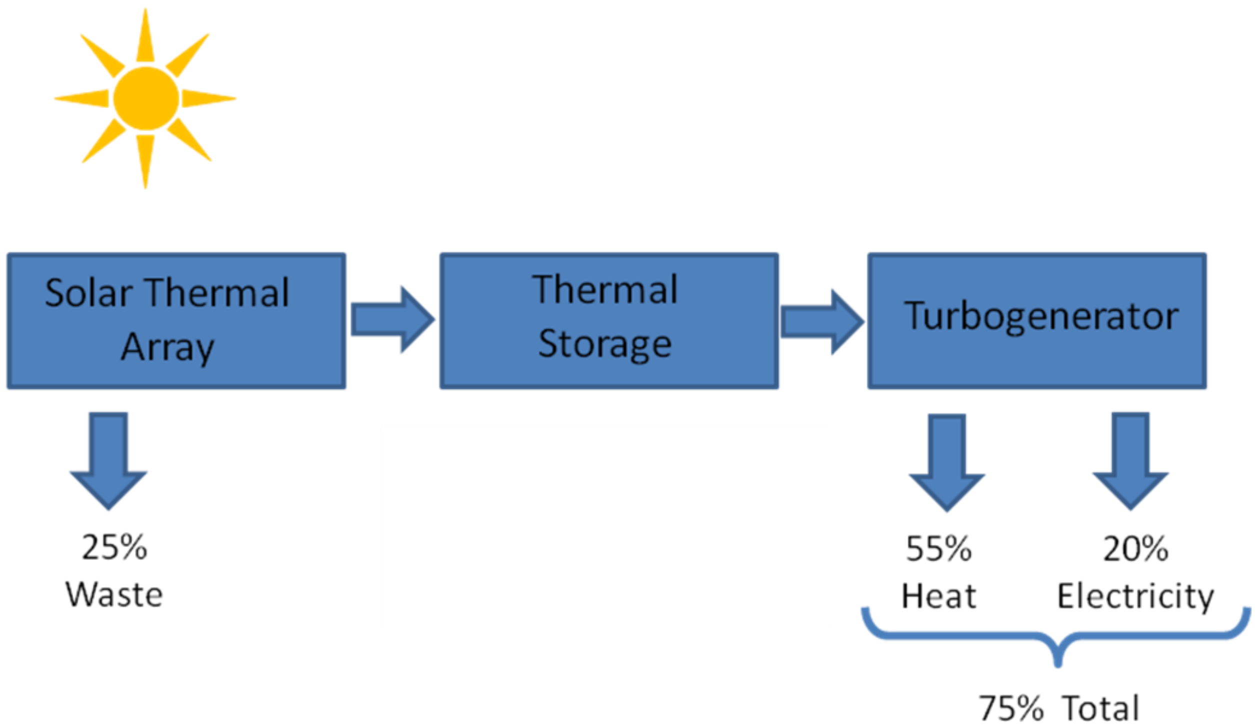
Solar energy can be stored in various ways. One way is to use batteries, another uses flywheels, a third uses compressed air. One of the most common methods of storing energy today is thermal storage: storing solar energy as heat (from www.energystorageexchange.org/projects).

In battery storage, photovoltaic (PV) solar panels convert about 18% of sunlight into direct current electricity. The other 82% is wasted as unrecovered heat. The DC electricity is stored in batteries such as lead acid or lithium ion batteries. Later an inverter converts the energy stored in the batteries to alternating current (AC) electricity, the same as the grid provides.

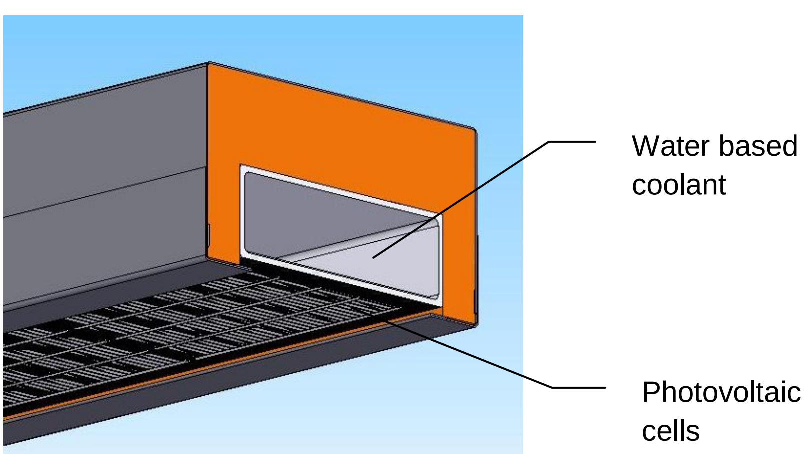


The most popular way to store energy is as heat. Solar thermal concentrators convert solar energy directly to heat. Again energy is wasted, but this time only 25% is lost. The heat is stored thermally as "high grade" heat (>100C) either as sensible heat storage or phase change heat storage. Later, the stored high grade heat can drive a turbogenerator that produces both electricity and "low grade" heat (<100C).

The advantage is that more of the sun's energy is stored: 75% instead of 18%. The low grade heat from the turbogenerator can power boilers, heat homes and heat hot water.



Turbogenerators come in various flavors defined by their thermodynamic cycle, e.g., Rankine Cycle or Stirling Cycle. To get the highest efficiencies, these cycles need high input temperatures, so-called high grade heat.



The Focused Sun Fourfold module has an absorber that produces electricity from PV. The PV cells are cooled by a water based coolant, making low-grade heat (i.e., below 100C). It does not produce a high enough temperature to run a turbogenerator.

By replacing the Fourfold module absorber with a high temperature absorber, we can get high grade heat for a turbogenerator. In the figure below, the absorber

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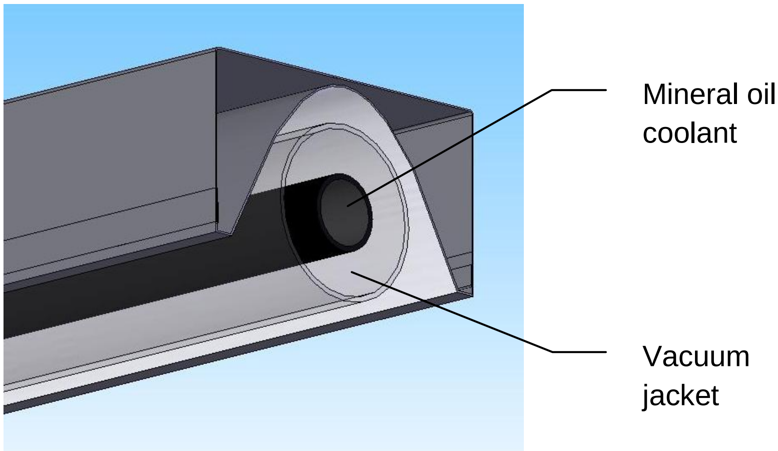
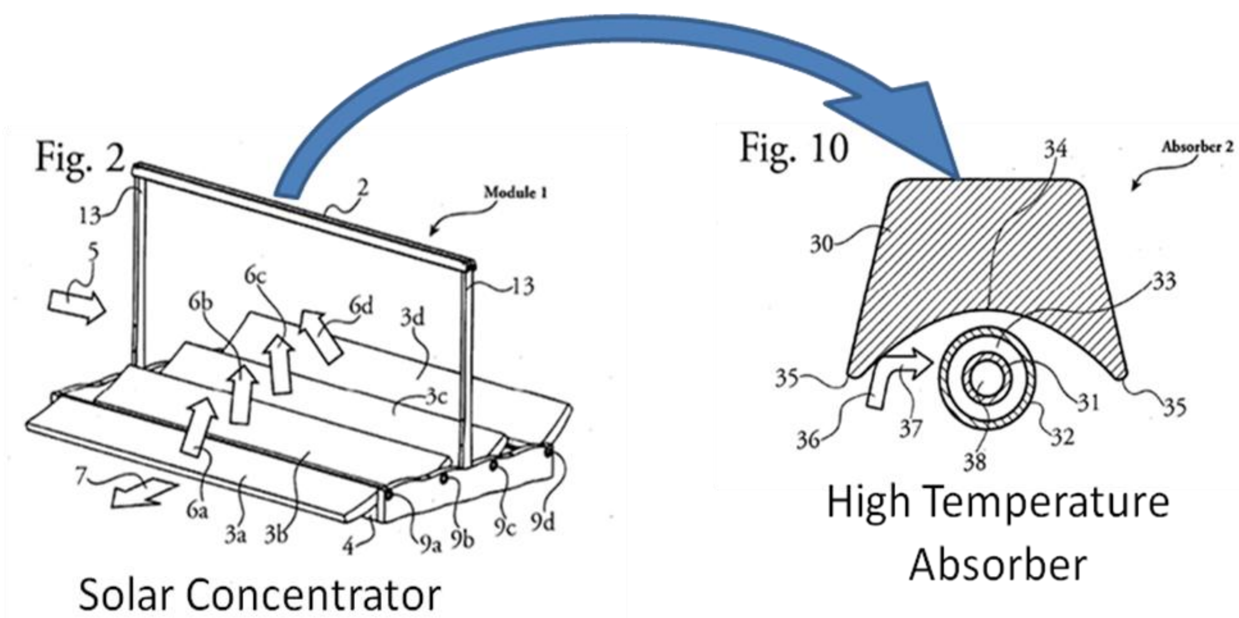
has a black colored tube that contains mineral oil, a coolant that can take the high temperatures (300C) needed by the turbogenerator. Heat losses from this surface must be very low else the solar energy will be lost. The solution is a vacuum jacket, a glass tube surrounding the black tube that in filled with a vacuum (no gas at all). The vacuum jacket also has coatings on it that helps prevent heat from radiating away.



Mineral oil from the absorber is pumped to thermal storage, storing heat there for as long as a day. The mineral oil flows through a loop that begins in the solar absorbers, flows in heat transfer pipes through thermal storage and then returns cooler to the solar array. In a second loop, a pump removes heat from thermal storage through other heat transfer pipes and delivers it to the turbogenerator. Low grade heat from the turbogenerator is available as process heat, for space heating or for hot water heating.

Focused Sun recently received approval from the U.S. Patent and Trademark Office on our patent application for this technology (US Patent application: 12/661,32; http://www.google.com/patents/US20100229852).



The figure below shows how a microgrid array could be deployed. In the simplest arrays, heat storage is located below each solar concentrator, either above grade or below grade. In many

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solar farms, space beneath the concentrator array is usually lost. Placing storage beneath each concentrator reduces the land required for the array. More important it makes the system modular: each concentrator is matched to the right amount of thermal storage. The array below having 400 concentrators each with 2 m^2 of surface area will produce over 100 kW of electricity and over 300 kW of low grade heat.