

Tuesday, 10/31/23

Hybrid Stand-Alone Systems

1) Drawbacks to PV-Only Stand-Alone Systems

No solar energy at night.

Little or no solar energy on cloudy days.

The amount of available solar energy changes throughout the day and throughout the year.

The sun's elevation angle changes throughout the year.

There is a limited amount of PV power available: approximately 12.5 W/ft² peak power for a typical roof mounted Si PV module.

The PV system requires unobstructed sunshine.

2) Hybrid PV systems

These systems use PV and additional energy sources.

a. Traditional Electrical Energy Sources

(1) Diesel generators

(2) Gasoline generators

(3) Natural gas and other burning fuel (wood, coal, methanol, etc.) powered generators

b. Drawbacks of Fossil Fuel Electric Generators

(1) Fossil fuels are not free, like the sun or wind.

Losses in energy conversion cost money when the fuel is not free.

(2) Fossil fuel must be acquired and transported to the generator

Expensive with variable costs.

Risk in transporting it.

Storage issues (dangerous, expensive, limited shelf life)

Environmental issues (spills, fire/explosion hazard, fumes, exhaust, waste products)

(3) Compared to PV, fossil fuel generators possess moving parts which require additional maintenance.

c. Advantages of Fossil Fuel Powered Generators

(1) Electricity can be generated at any time.

(2) 1 Φ and 3 Φ AC output can be directly produced by the generator.

(3) A fossil fuel powered generator can produce a lot more electrical power than a PV system occupying the same area (real estate).

d. PV-Diesel Hybrid System

Consider Fig 5.14:

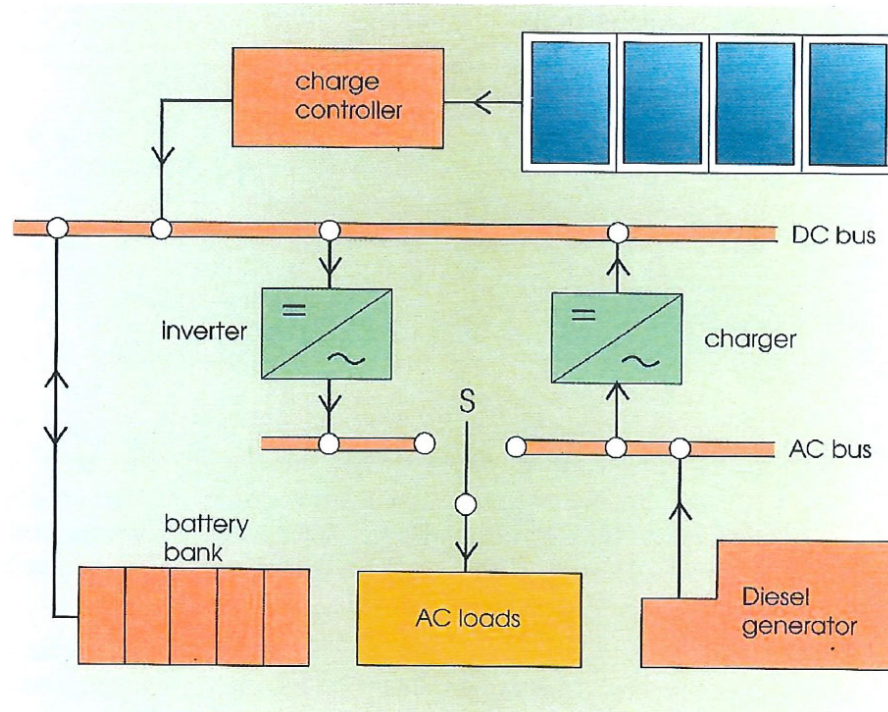


Figure 5.14 A PV-diesel hybrid system.

Here, a diesel generator is combined with PV to take advantage of the best attributes of both.

PV – Pb-acid batteries provide “free” clean energy much/most of the time.

The small diesel generator provides back-up when the PV – Pb-acid batteries are insufficient:

With peak / unusually heavy electrical loads

At night

During winter

During long cloudy periods

Observe that the charge controller used here has to handle both the PV input source and the diesel generator input source. So, an additional AC to DC converter for the generator may be required to charge the batteries with the generator.

Why would the generator be used to charge the batteries?

To keep them sufficiently charged when it is cold or when the PV system cannot do it (winter, multiple cloudy days, etc.).

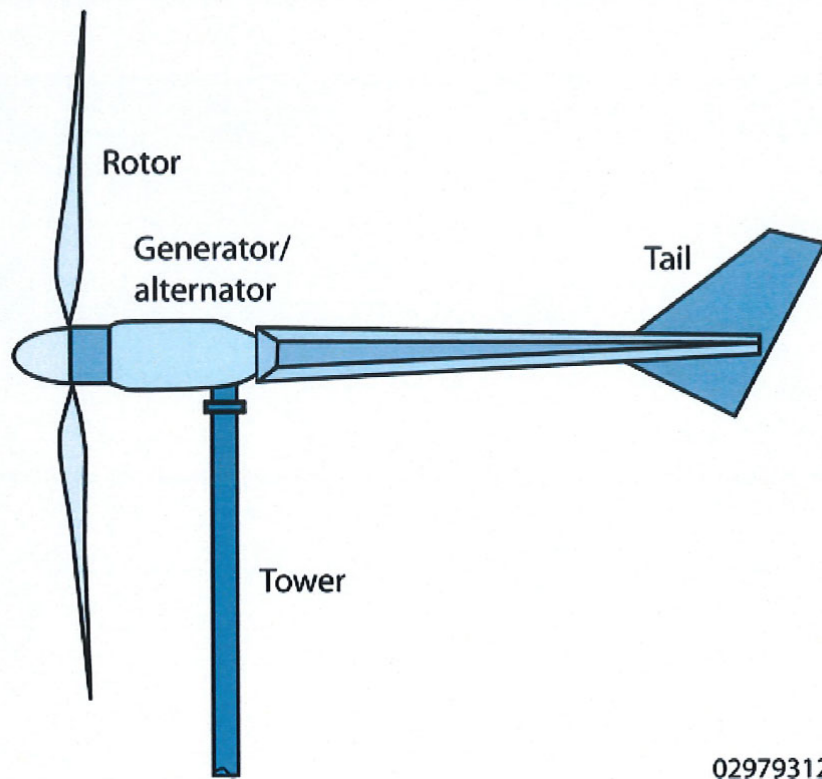
3) Non-Fossil Fuel Electrical Energy Sources

a. Wind Power

Wind power is clean (no exhaust).

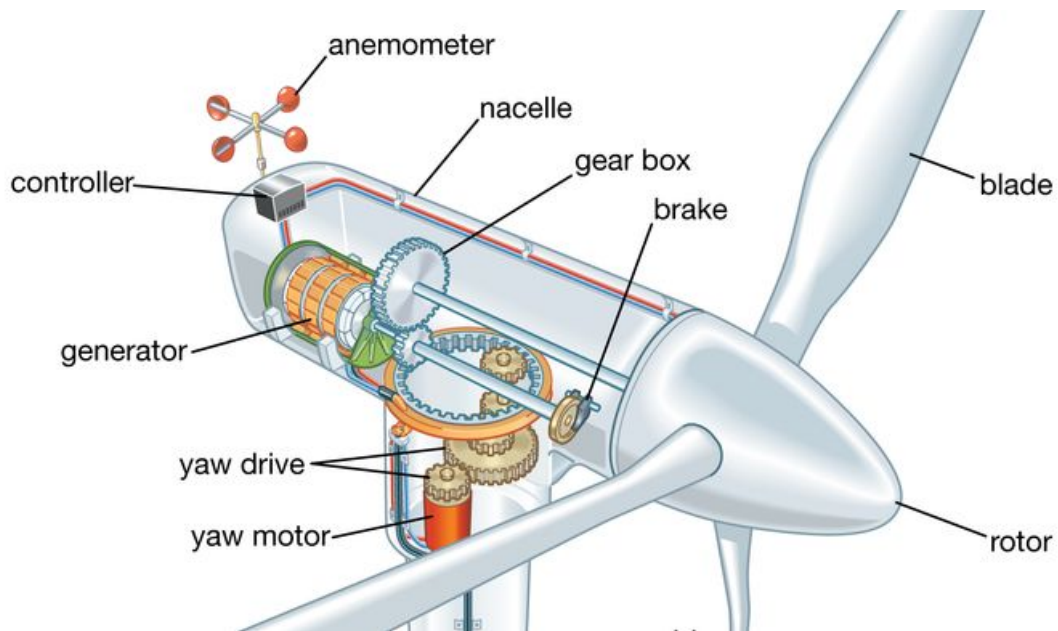
Wind power might be available when sunlight is not available.

Basic Parts of a Small Wind Electric System



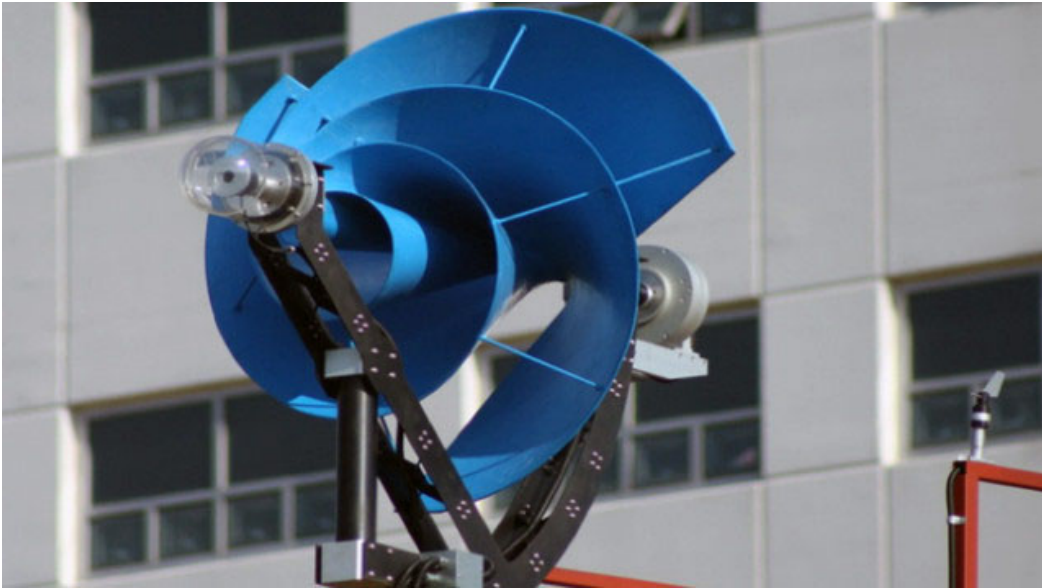
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http://www.energysavers.gov/your_home/electricity/index.cfm/mytopic=10900



<https://www.britannica.com/science/wind-power>

Archimedes Home Windmill



<https://www.goodshomedesign.com/silent-rooftop-wind-turbines-could-generate-half-of-a-households-energy-needs/>



Big Windmill Farm in Kansas



Windmills on a ridge in western NY

b. Possible Drawbacks to Windmills

- (1) Maintenance requirements (moving parts)
- (2) Wind levels can be unpredictable
- (3) A danger to birds, bats, and insects
- (4) Low frequency and audible noise
- (5) Environmental costs to manufacture windmills
- (6) Disposal of windmill components

c. Micro-Hydroelectric

Use a small-scale hydroelectric generator.

Many types of implementations are possible:

Fixed or mobile

Above water or below water

In moving water or using falling water

Example:



<https://hydro-electric-barrel.com/>

d. Thermal Solar

Use a thermal solar water/air heating system along with PV for building use.

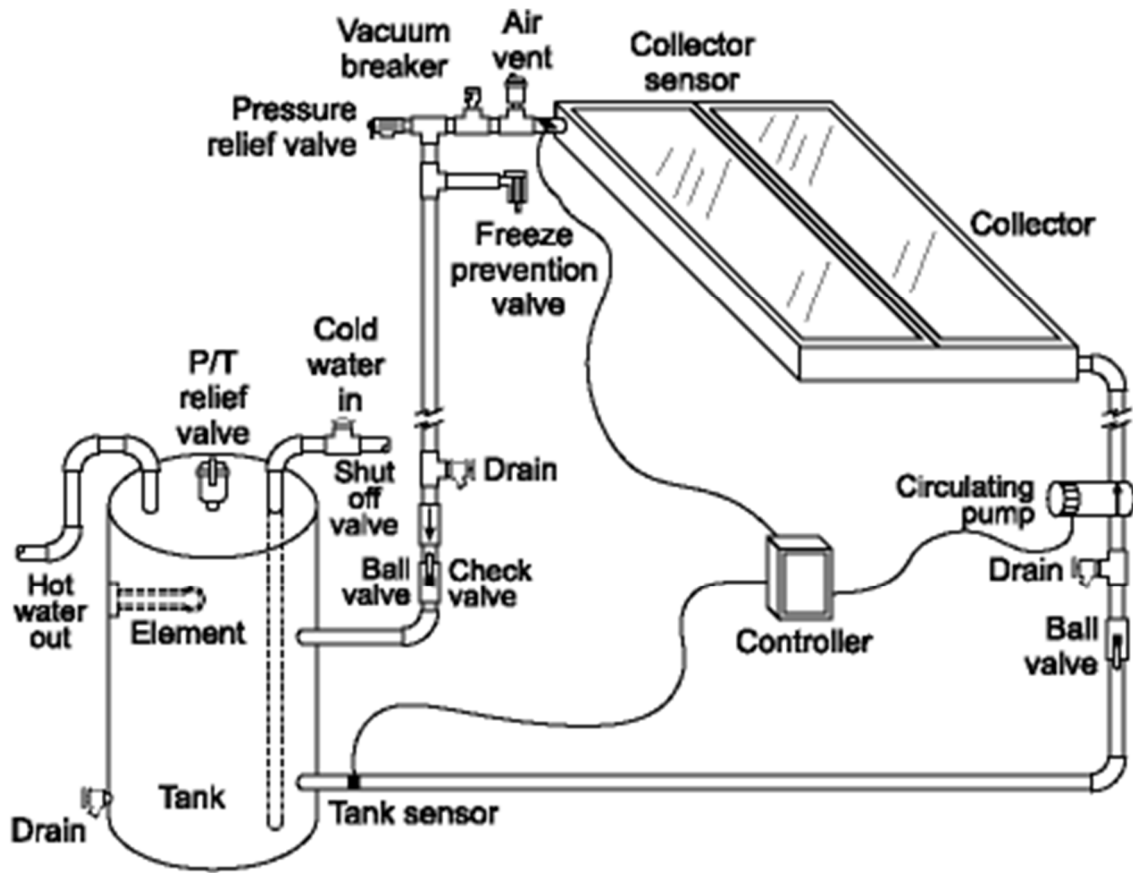
PV → electricity

Thermal → heat water and/or air

Thermal solar energy systems can capture up to 70% of the heat received from the sun.

Higher efficiency than PV devices

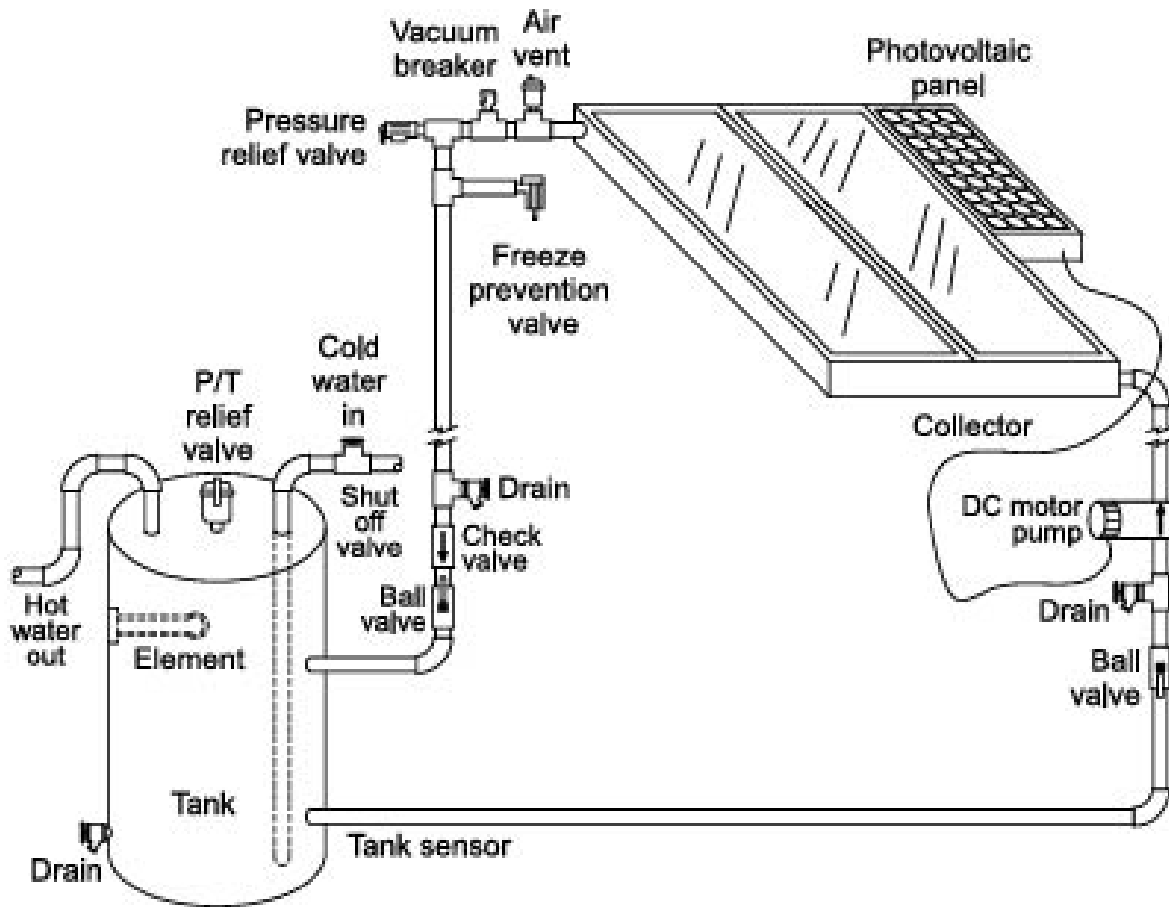
Thermal solar energy systems are relatively simple and can be built at home.



https://www.fsec.ucf.edu/en/consumer/solar_hot_water/homes/system_types.htm

Using thermal solar energy to heat air or water does not incur any fees owed to utility companies!

Home thermal solar energy systems were very popular in the 1970s and 1980s. They seem to be much less popular now.



https://www.fsec.ucf.edu/en/consumer/solar_hot_water/homes/system_types.htm