Using Reservoirs to Store Surplus Renewable Energy

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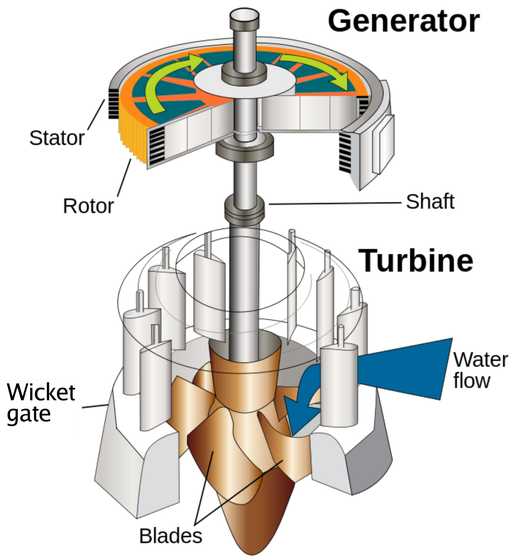
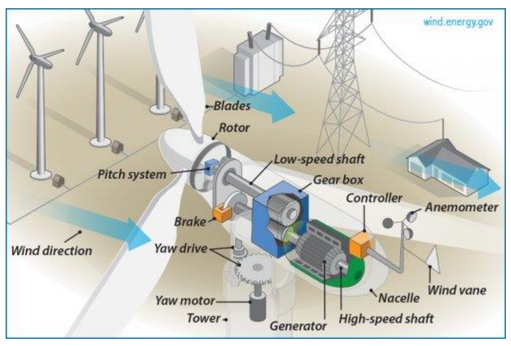
Introduction

Wind turbines (and other sources of renewable energy) are capable of producing energy exceeding the loads. The surplus energy can be stored for later usage. Therefore, it is required to have a storage system with energy output that is easily variable to match changing conditions, but can also remain stored for long periods of time.



Hydroelectric generator diagram

Water Turbine image courtesy of Wikimedia Commons user: Old Moonraker, derived from work by U.S. Army Corps of Engineers: https://en.wikipedia.org/wiki/Water_turbine



Cross-section diagram of wind turbine

Cross section diagram courtesy of Department of Energy, https://www.energy.gov/eere/wind/inside-wind-turbine-0

Ideas and Discussion

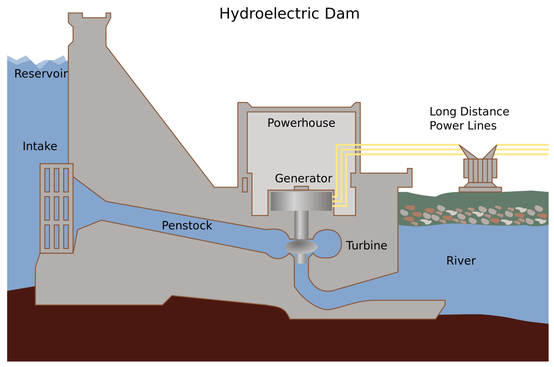


Diagram of basic Hydroelectric plant

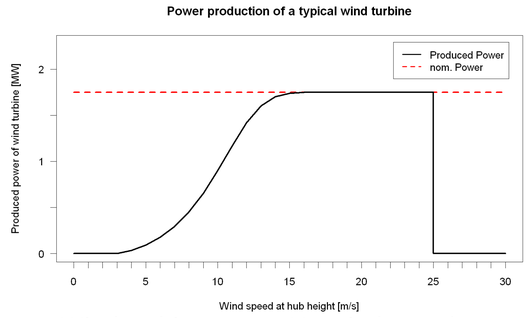
Hydroelectric plant diagram courtesy of Tennessee Valley Authority: https://web.archive.org/web/20071211102139/http://www.tva.gov:80/power/hydroart.htm

Merging wind turbines with hydroelectric generators is one way to store renewable energy. The process would be as follows:

1) System has set target power output that is lower than rated output of wind turbine.
2) In optimal wind conditions, turbine produces higher amounts of energy than the target output.
3) The extra power is tapped to power a water pump to drive water to an uphill reservoir.
4) When wind conditions are poor enough that the turbine's power output falls below the target, the reservoir can release water downhill to power a hydroelectric generator to make up the difference and reach the target output
5) Barring major shifts in wind patterns, this will create a consistent power output for a wider range of wind conditions

Proof

Turbines are designed for the area they will be located. Determining factors include average wind speed and local energy needs.



Wind turbine power Vs. wind speed

Image © User:Isjc99 / Wikimedia Commons / CC-BY-SA-3.0 at: https://commons.wikimedia.org/wiki/File:Powercurve.png

In some areas, it may be possible to have a larger generator, but power output would be stable for a lower range of wind speeds. Also, if production exceeds needs, the extra power would be wasted unless it can be stored.

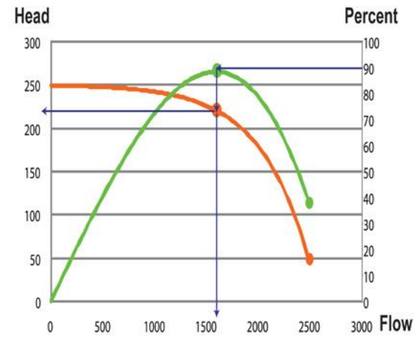


Fig. 3. Head and flow at BEP

Pressure head (orange) and Percent Efficiency (green) vs Flow rate[1]

All pumps and generators have inefficiencies. Additionally, the water will experience some friction while moving up- and downhill. Therefore, it is necessary to design the system with a turbine power output large enough that the energy stored is not lost to inefficiency.

Future works

This method of energy storage can be used to introduce higher rated wind turbines to existing wind farms or bring turbines to areas with lower wind speeds while still maintaining stable output. Going forward, testing exact inefficiencies to determine design constraints for this system must be conducted. Additionally, the potential to apply this concept to other sources of energy should be explored.

Other possibilities for usage of this technology

Image courtesy of pixabay: https://pixabay.com/en/energy-solar-panel-renewable-energy-3191780/

Acknowledgements

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References

1. Eugene Vogel, "The Importance of Best Efficiency Point (BEP)" (2013) In Efficiency Plant. Accessed on: October 2018. Available at <https://www.efficientplantmag.com/2013/05/the-importance-of-best-efficiency-point-bep/>