A Review on Hydropower Generation based Smart Grid.

C H. Venkateswra rao, S. S. Tulasiram and B.Brahmaiah

Abstract: By using water for power generation, people have worked with nature to achieve a better lifestyle. The mechanical power of falling water is an age-old tool. As early as the 1700's, Americans recognized the advantages of mechanical hydropower and used it extensively for milling and pumping. Hydroelectric power is important to our Nation. Growing populations and modern technologies require vast amounts of electricity for creating, building, and expanding. Hydropower based smart grid is very important to meet the load demand for consumers. In order to make smart grid, other renewable energy sources are incorporated to hydro power generation. In this paper, review on hydro power is presented and optimized the smart grid with hydro, diesel, wind and battery is presented by using Homer software.

Keywords: Hydro power, Homer software, renewable generation, smart grid.

INTRODUCTION

By the early 1900's, hydroelectric power accounted for more than 40 percent of the Nation's supply of electricity. With the increase in development of other forms of electric power generation, hydro powers percentage has slowly declined to about 10 percent. However, many activities today still depend on hydropower.

Niagra Falls was the first of the American hydroelectric power sites developed for major generation and is still a source of electric power today. Power from such early plants was used initially for lighting, and when the electric motor came into being the demand for new electrical energy started its upward spiral.

Power plants were installed at the dam sites to carry on construction camp activities. Hydropower was put to work lifting, moving and processing materials to build the dams and dig canals. Power plants ran sawmills, concrete plants, cableways, giant shovels, and draglines. Night operations were possible because of the lights fed by hydroelectric power. When construction was complete, hydropower drove pumps that provided drainage or conveyed water to lands at higher elevations than could be served by gravity-flow canals.

Surplus power was sold to existing power distribution systems in the area. Local industries, towns, and farm consumers benefited from the low-cost electricity. Much of the construction and operating costs of dams and related facilities were paid for by this sale of surplus power, rather than by the water users alone. This proved to be a great savings to irrigators struggling to survive in the West. Hydropower provides about 96 percent of the renewable energy in the United States. Other renewable resources include geothermal, wave power, tidal power, wind power, and solar power. Hydroelectric power plants do not use up resources to create electricity nor do they pollute the air, land, or water, as other power plants may. Hydroelectric power has played an important part in the development of this Nation's electric power industry. Both small and large hydroelectric power developments were instrumental in the early expansion of the electric power industry.

Hydroelectric power comes from flowing water winter and spring runoff from mountain streams and clear lakes. Water, when it is falling by the force of gravity, can be used to turn turbines and generators that produce electricity.

Hydroelectric power is important to our Nation. Growing populations and modern technologies require vast amounts of electricity for creating, building, and expanding. In the 1920's, hydroelectric plants supplied as much as 40 percent of the electric energy produced. Although the amount of energy produced by this means has steadily increased, the amount produced by other types of power plants has increased at a faster rate and hydroelectric power presently supplies about 10 percent of the electrical generating capacity of the United States.

Hydropower is an essential contributor in the national power grid because of its ability to respond quickly to rapidly varying loads or system disturbances, which base load plants with steam systems powered by combustion or nuclear processes cannot accommodate.

HOW HYDROPOWER WORKS

Hydroelectric power comes from water at work, water in motion. It can be seen as a form of solar energy, as the sun powers the hydrologic cycle which gives the earth its water. In the hydrologic cycle, atmospheric water reaches the earth's surface as precipitation. Some of this water evaporates, but much of it either percolates into the soil or becomes surface runoff. Water from rain and melting snow eventually reaches ponds, lakes, reservoirs, or oceans where evaporation is constantly occurring.

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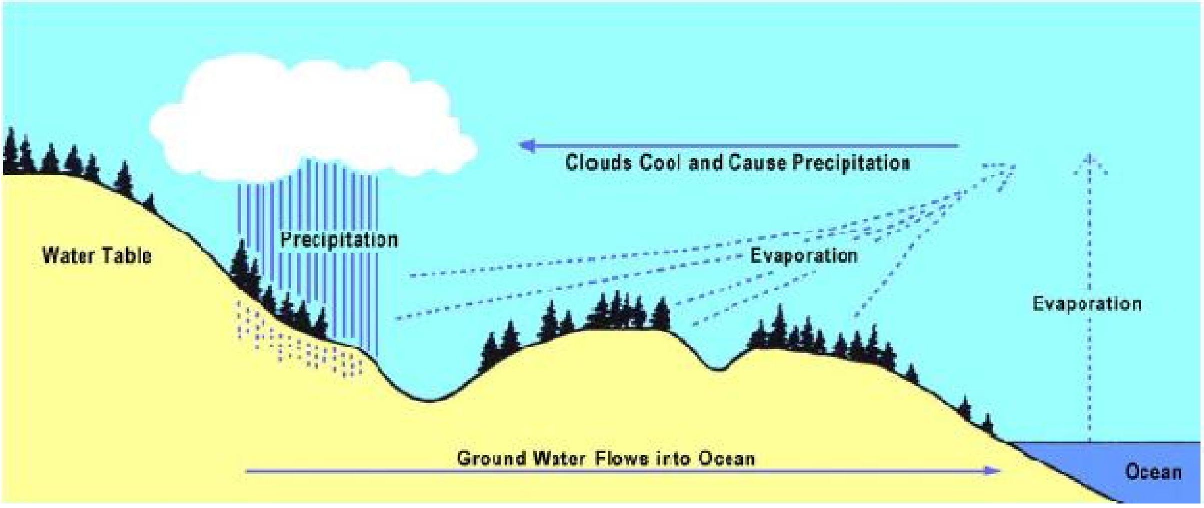


Moisture percolating into the soil may become ground water (subsurface water), some of which also enters water bodies through springs or underground streams. Ground water may move upward through soil during dry periods and may return to the atmosphere by evaporation.

Water vapour passes into the atmosphere by evaporation then circulates, condenses into clouds, and some returns to earth as precipitation. Thus, the water cycle is complete. Nature ensures that water is a renewable resource.

Generating Power

In nature, energy cannot be created or destroyed, but its form can change. In generating electricity, no new energy is created. Actually one form of energy is converted to another form. To generate electricity, water must be in motion. This is kinetic (moving) energy. When flowing water turns blades in a turbine, the form is changed to mechanical (machine) energy. The turbine turns the generator rotor which then converts this mechanical energy into another energy form -- electricity. Since water is the initial source of energy, we call this hydroelectric power or hydropower for short.

At facilities called hydroelectric power plants, hydropower is generated. Some power plants are located on rivers, streams, and canals, but for a reliable water supply, dams are needed. Dams store water for later release for such purposes as irrigation, domestic and industrial use, and power generation. The reservoir acts much like a battery, storing water to be released as needed to generate power.

The dam creates a Ahead or height from which water flows. A pipe (penstock) carries the water from the reservoir to the turbine. The fast-moving water pushes the turbine blades, something like a pinwheel in the wind. The waters force on the turbine blades turns the rotor, the moving part of the electric generator. When coils of wire on the rotor sweep past the generator's stationary coil (stator), electricity is produced.

This concept was discovered by Michael Faraday in 1831 when he found that electricity could be generated by rotating magnets within copper coils.

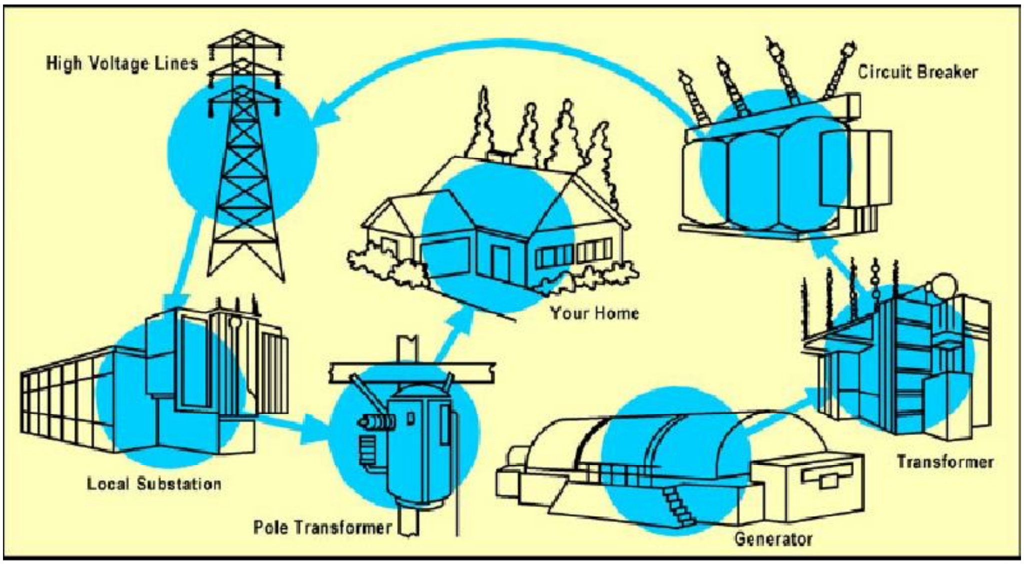
When the water has completed its task, it flows on unchanged to serve other needs.

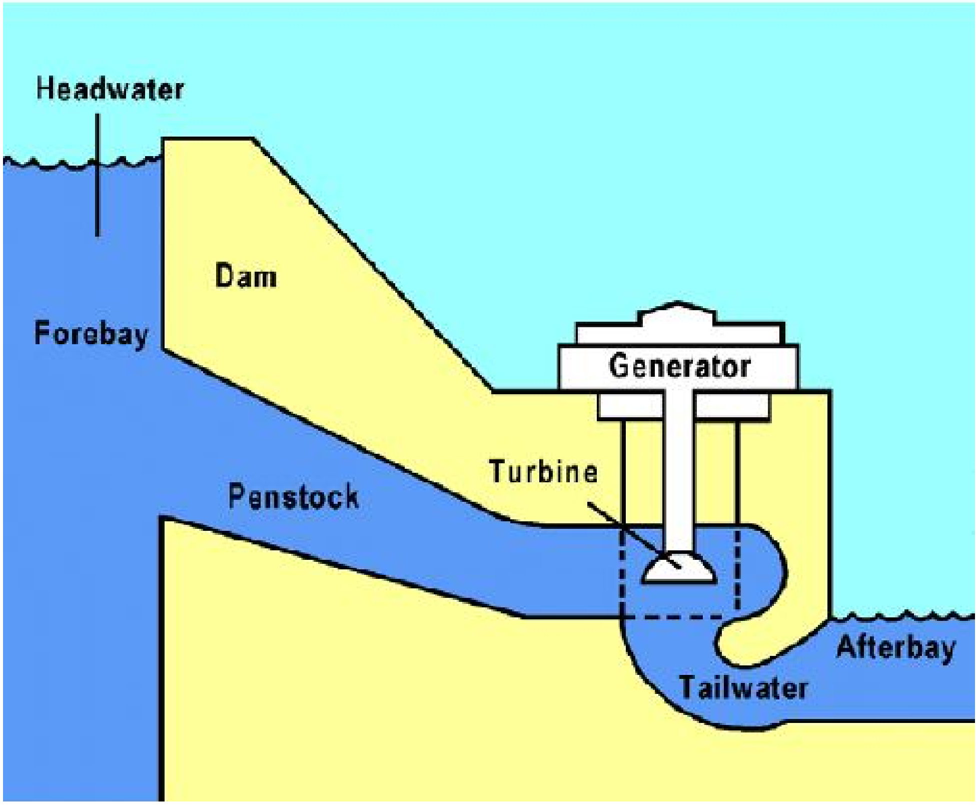
Transmitting Power

Once the electricity is produced, it must be delivered to where it is needed -- our homes, schools, offices, factories, etc. Dams are often in remote locations and power must be transmitted over some distance to its users.

Vast networks of transmission lines and facilities are used to bring electricity to us in a form we can use. All the electricity made at a power plant comes first through transformers which raise the voltage so it can travel long distances through power lines. (Voltage is the pressure that forces an electric current through a wire.) At local substations, transformers reduce the voltage so electricity can be divided up and directed throughout an area.

Transformers on poles (or buried underground, in some neighbourhoods) further reduce the electric power to the right voltage for appliances and use in the home. When electricity gets to our homes, we buy it by the kilowatt-hour, and a meter measures how much we use.





While hydroelectric power plants are one source of electricity, other sources include power plants that burn fossil fuels or split atoms to create steam which in turn is used to generate power. Gas-turbine, solar, geothermal, and wind-powered systems are other sources. All these power plants may use the same system of transmission lines and stations in an area to bring power to you. By use of this A power grid," electricity can be interchanged among several utility systems to meet varying demands. So the electricity lighting your reading lamp now may be from a hydroelectric power plant, a wind generator, a nuclear facility, or a coal, gas, or oil-fired power plant … or a combination of these.

Because hydropower generation begins the minute water starts to fall through the turbines, it is capable of rapid response to peak demands and emergency needs, contributing to the stability of our nation's electricity grid and energy security. Hydropower is also one of the most economic energy resources and is not subject to market fluctuations or embargos, which helps support our nation's energy independence — and it can provide that support for years to come. The average lifespan of a hydropower facility is 100 years. By upgrading and increasing the efficiencies and capacities of existing facilities, hydropower can continue to support our nation's growing energy needs.

While there are many advantages to hydroelectric production, the industry also faces unique environmental challenges. Potential environmental impacts include changes in aquatic and stream side habitats; alteration of landscapes through the formation of reservoirs; effects on water quality and quantity; interruption of migratory patterns for fish such as salmon, steelhead, American shad, and sturgeon; and injury or death to fish passing through the turbines. The challenge facing hydropower researchers today is how to take advantage of

Hydropower

Hydropower is the largest renewable resource used for electricity. It plays an essential role in many regions of the world with more than 150 countries generating hydroelectric power. A survey in 1997 by The International Journal on Hydropower & Dams found that hydro supplies at least 50 percent of national electricity production in 63 countries and at least 90 percent in 23 countries. About 10 countries obtain essentially all their commercial electricity from hydro, including Norway, several African nations, Bhutan and Paraguay. There is about 700 GW of hydro capacity in operation worldwide, generating 2600 TWh/year (about 19 percent of the world's electricity production). About half of this capacity and generation is in Europe and North America with Europe the largest at 32 percent of total hydro use and North America at 23 percent of the total. However, this proportion is declining as Asia and Latin America commission large amounts of new hydro capacity. Small, mini and micro hydro plants (usually defined as plants less than 10 MW, 2 MW and 100kW, respectively) also play a key role in many countries for rural electrification. An estimated 300 million people in China, for example, depend on small hydro.

Large Hydropower

Although definitions vary, DOE defines large hydropower as facilities that have a capacity of more than 30 MW.

Small Hydropower

Although definitions vary, DOE defines small hydropower as facilities that have a capacity of 100 kilowatts to 30 MW.

Micro Hydropower

A micro hydropower plant has a capacity of up to 100 kW. A small or micro-hydroelectric power system can produce enough electricity for a home, farm, ranch, or village.

There are two main types of hydro turbines: impulse and reaction. The type of hydropower turbine selected for a project is based on the height of standing water — referred to as "head" — and the flow, or volume of water, at the site. Other deciding factors include how deep the turbine must be set, efficiency, and cost. Impulse Turbine The impulse turbine generally uses the velocity of the water to move the runner and discharges to atmospheric pressure. The water stream hits each bucket on the runner. There is no suction on the down side of the turbine, and the water flows out the bottom of the turbine housing after hitting the runner. An impulse turbine is generally suitable for high head, low flow applications. There are two types of impulse turbines, the Pelton and the cross-flow.

Pelton — A pelton wheel has one or more free jets discharging water into an aerated space and impinging on the buckets of a runner. Draft tubes are not required for impulse turbine since the runner must be located above the maximum tailwater to permit operation at atmospheric pressure.

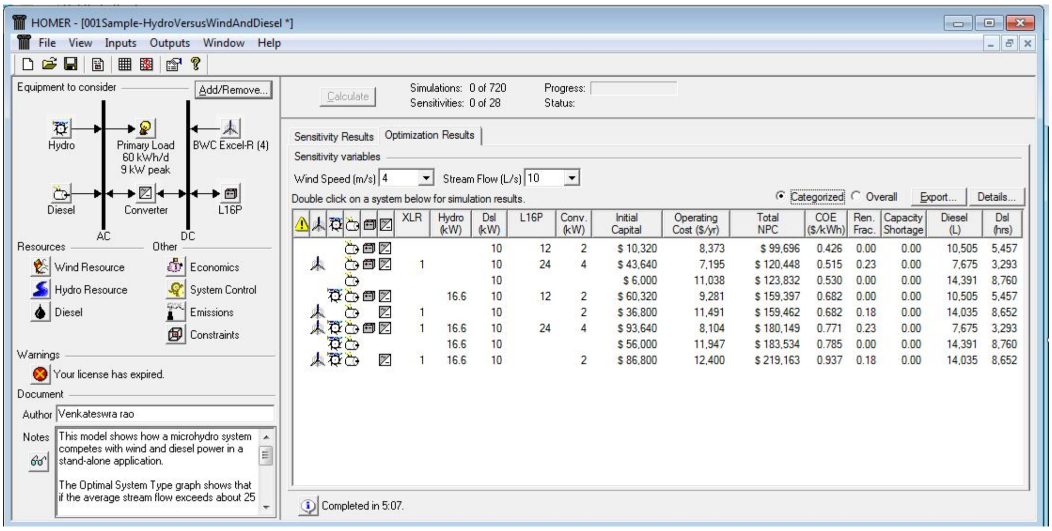
Cross-flow — A cross-flow turbine is drum-shaped and uses an elongated, rectangular-section nozzle directed against curved vanes on a cylindrically shaped runner. It resembles a "squirrel cage" blower. The cross-flow turbine allows the water to flow through the blades twice. The first pass is when the water flows from the outside of the blades to the inside; the second pass is from the inside back out. A guide vane at the entrance to the turbine directs the flow to a limited portion of the runner. The cross-flow was developed to accommodate larger water flows and lower heads than the Pelton. Reaction Turbine A reaction turbine develops power from the combined action of pressure and moving water. The runner is placed directly in the water stream flowing over the blades rather than striking each individually. Reaction turbines are generally used for sites with lower head and higher flows than compared with the impulse turbines.

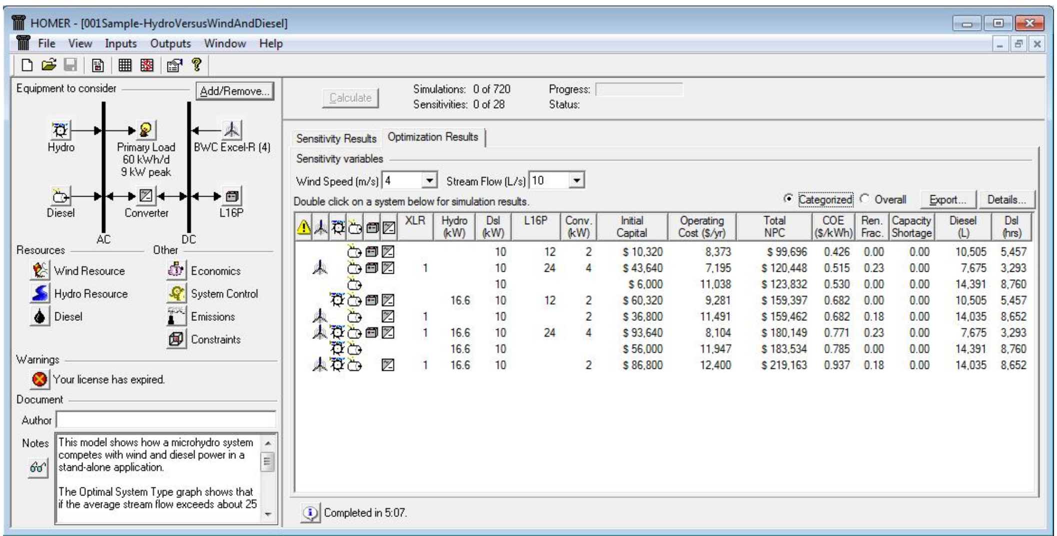
Propeller — A propeller turbine generally has a runner with three to six blades in which the water contacts all of the blades constantly. Picture a boat propeller running in a pipe. Through the pipe, the pressure is constant; if it isn't, the runner would be out of balance. The pitch of the blades may be fixed or adjustable. The major components besides the runner are a scroll case, wicket gates, and a draft tube.

Francis — A Francis turbine has a runner with fixed buckets (vanes), usually nine or more. Water is introduced just above the runner and all around it and then falls through, causing it to spin. Besides the runner, the other major components are the scroll case, wicket gates, and draft tube.

Kinetic — Kinetic energy turbines, also called free-flow turbines, generate electricity from the kinetic energy present in flowing water rather than the potential energy from the head. The systems may operate in rivers, man-made channels, tidal waters, or ocean currents. Kinetic systems utilize the water stream's natural pathway. They do not require the diversion of water through manmade channels, riverbeds, or pipes, although they might have applications in such conduits. Kinetic systems do not require large civil works; however, they can use existing structures such as bridges, tailraces and channels.

Generally load always varying; hence, to improve the stability and reliability of the smart grid, it is required to interconnect other sources such as diesel, wind and battery etc. Therefore, for better economical aspects first it is required to optimize the sources. In this paper, homer software is used to optimizing the sources. The optimizing results are presented as shown in bellow.





Conclusion

Renewable energy sources are helping to meet the needs of our country, and one of the most pressing needs is the growing demand for electric power. Hydro power plants annually generate more power with high efficiency. The deregulation of wholesale electricity sales. This restructuring increases the importance of clean, reliable energy sources such as hydropower. Hydropower is important from an operational standpoint as it needs no "ramp-up" time, as many combustion technologies do. Hydropower can increase or decrease the amount of power it is supplying to the system almost instantly to meet shifting demand. With this important load-following capability, peaking capacity and voltage stability attributes, hydropower plays a significant part in ensuring reliable electricity service and in meeting customer needs in a market driven industry. In addition, hydroelectric pumped storage facilities are the only significant way currently available to store electricity.

Hydro powers ability to provide peaking power, load following, and frequency control helps protect against system failures that could lead to the damage of equipment and even brown or blackouts. Hydropower, besides being emissions-free and renewable has the above operating benefits that provide enhanced value to the electric system in the form of efficiency, security, and most important, reliability. The electric benefits provided by hydroelectric resources are of vital importance to the success of our National experiment to deregulate the electric industry. Water is one of our most valuable resources, and hydropower makes use of this renewable treasure. As a National leader in managing hydropower. Homer software based optimization results are presented for economical analysis.

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