Review on Performance of Pumped Storage Power Plant with utilization of Solar and Wind

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ABSTRACT

This project presents on detailed study of pumped storage hydro power plant system based on implementation of solar and wind energy. Nowadays, due to the ever increasing demand of electricity and the rise of environmental concerns, renewable energies are becoming the best option for electrification especially for rural electrification. The biggest problem of wider use of renewable energy sources is energy storage. This project deals with the pumping storage hydropower system analysis. The water reservoir serves for daily and seasonal energy storage, thus basically solving the energy storage problem. The electrical energy produced in excess by the renewable energy system is converted in potential energy by pumping water to a higher elevation where it can be stored indefinitely and then released to pass through hydraulic turbines and generate electricity. These process is occur continuously, the estimation of energy demand for day and night time, stored energy, reservoir dimension and parameters of hydroelectric plant are presented.

The project is trying to present the possible operational aspects for a pumped storage power plant. There are presented the possibilities of the study of operational regimes of the plant using experiments performed. Furthermore, renewable energy sources due to their fluctuating nature cannot maintain or regulate continuous power supply and hence require bulk electricity storage. The present study aims at reviewing the existing global PHES capacities, technological development, and hybrid systems (wind-hydro, solar pv-hydro, and wind-pv-hydro) and recommending the best possible options. The review explores that PHES is the most suitable technology for small autonomous island grids and massive energy storage

Keyword: - *Hydro power plant, solar, wind, pumped*

1. INTRODUCTION

Electricity is an essential role to be comfortable for people in rural area. There are many difficulties without electricity, it can effect on modernize environment for rural area. Renewable energy generation is becoming more prevalent on today's electric grid. [1] Over the past decade, due to concerns about rising fuel prices, energy security and climate change, there has been a large increase in the amount of renewable energy installed worldwide. It is expected that in the next few decades, the amount installed will increase significantly. [2] Pumped storage hydropower is "a special type of hydropower development, in which pumped water rather than natural stream flow provides the source of energy". [3] In general terms, pumped storage hydropower is a technology that stores low-cost off-peak energy or excess or unusable energy (perhaps generated from renewable energy sources) for later use. While pumped storage hydropower projects are a net consumer of electricity, they provide many useful power system operational benefits, including system storage capacity and power grid ancillary services, which allow other types of electrical plants in the system to operate more efficiently. [3]

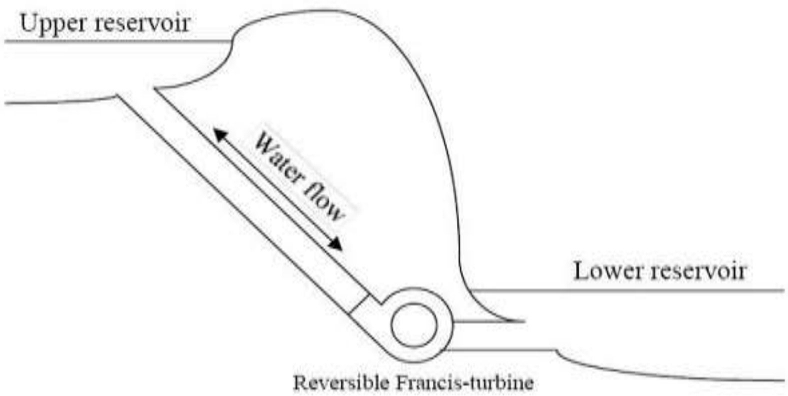

Figure1. General structure of pumped storage hydro power plant

Hydro power plants are classified into pumped storage plants and conventional hydro plants. A pumped storage plant is associated with upper and lower reservoirs and during light load periods in the power grid, water is pumped from the lower to the upper reservoirs using the available energy from the power system, and during peak load the water stored in the upper reservoir is used to generate power. [4] This strategy save the fuel costs and system can be economical because it flattens out load variation on the power grid. The conventional power plant is classified into run-of –the river plant and storage plant. The run of the river plant have little storage capacity of the water reservoir and used water as it became available. [4] The storage plant is associated with one or two (upper and lower) reservoir with significant storage capacity where water can be stored during the period with low power requirement in the grid and released when the power demand is high. In this case the water head variation can be small or big. [4]

1.1 BACKGROUND AND MOTIVATION

Why use pumped storage hydropower? To understand why pumped storage hydropower projects are useful it is first important to develop a general understanding of other types of power plants and how the electrical grid is operated. [3]

Conventional power sources have primarily consisted of coal and nuclear power plants; Coal plants can take up to 4 days to fully ramp up and go into operation, and up to 4 hours to respond to operational changes; consequently they are normally operated at optimal power generation for a period of months. Coal plants also produce fly ash and emit the greenhouse gas carbon dioxide and other toxic chemicals into the atmosphere. Nuclear power plants have low marginal operating cost; however they also have environmental and fuel storage challenges as well as long ramp up periods and response times. [3]

Most nuclear and coal plants use steam to generate power and are designed and optimized for steady state operation to provide base load electrical power. Due to thermal stresses induced during the startup and shutdown of both nuclear and coal plants it is preferable to minimize frequent startups and shutdowns [3] Natural gas, fuel oil plants and the hydropower plants are the most ideally suited plants for supplying peaking power. Natural gas plants are an attractive means to supply peaking power due to their shorter startup, shutdown, and downtime requirements as well as their moderate operating costs; however this technology utilizes non renewable sources and produce carbon dioxide emission. Fuel oil and diesel plants are popular for supplying peaking power because their fuel source is generally readily available; however they have high operating costs and negative environmental impacts. Hydropower is another attractive means of supplying peaking power. Hydropower projects require a large initial financial investment, but have low operating costs and short startup and shutdown requirements [3]

1.2 Principle and Purpose of Pumped Storage Hydropower

Pumped storage hydropower uses the potential energy in water to produce electricity in turbine mode. In pump mode, electricity is used to pump water to a higher elevation to store energy as potential energy in water. A pumped storage hydropower plant is attached to an upper reservoir and a lower reservoir by a conduit system consisting of a headrace tunnel and pressure shaft, draft tube, and tailrace tunnel, in the same way as in conventional hydropower. One may either install two separate aggregates, one pump and one turbine, or use a machine that runs both ways. These types of hydraulic machinery are called reversible pump turbines

(RPTs).The main purpose of PSH is to allow efficient base load generation by covering periods of peak demand and absorbing energy during hours of low demand, in addition to providing ancillary services, such as black start capability and stabilization of the network frequency and voltage level [5].

1.3 PROJECT OBJECTIVES

- To utilized a free energy sources to generate electricity.
- To make a pump whose efficiency above 80% and is consume power below 40% as turbine generation.
- To provide an alternative power solution for remote location such as hilly area and villages.

2. LITERATURE SURVEY

Wunna Swe, 'pumped hydroelectric energy storage for photovoltaic based rural electrification', in these chapter a review of the literature is discussed about the methodology 'The technical feasibility of a the PV and PHES installation on the rural area' and also introduced PV and PHES system sizing design depends on many variable such as upper and lower reservoir design, penstock design. [1]

Aidan Tuohy, Mark O' Malley, 'Impact of pumped storage on power systems with increasing wind penetration', in these chapter a review of the literature is discussed about the 'Various impact of pumped storage on power system with increasing wind penetration'. [2]

Brandi A. Antal , "Pumped Storage Hydropower: A Technical Review" in these chapter a review of the literature is suggested about the Pumped storage hydropower is a proven large scale energy storage technology that allows for better integration of renewable energy into the power grid by allowing storage of excess energy for later use. [3]

Shafiqur Rehmana, Luai M. Al-Hadhramia, Md. Mahbub Alamb, "Pumped hydro energy storage system: A Technological review" is discussed about that, among all existing storage technologies, PHES is the most suitable technology for small autonomous island grids and massive energy storage both technological maturity and economical compatibility over the lifespan of the project. [6]

Shashikant Gonalde, Manohar kalgunde, 'Energy Storage using Pumped Hydro Storage based on Standalone Photovoltaic Power Generation system', in these chapter a review of the literature is taken a methodology 'Pumped storage system is based on standalone photovoltaic power generation system' and also introduced Store a energy with minimum losses. [7]

Istvan Taczi, "Pumped Storage Hydroelectric Power Plants: Issues and Applications" , in these research paper discussed about the regulation of the pumped storage hydro power system, role of hydro power in electric power system. [8]

A. Botterud, T. Levin, and V. Koritarov, "Pumped Storage Hydropower: Benefits for Grid Reliability and Integration of Variable Renewable Energy" in these technical reports suggested about more details on the pumped storage hydropower (PSH) technology and its role in providing reliability and integrating variable renewable energy sources into the power grid. [9]

Jiaqi Liang Ronald G. Harley, 'Pumped Storage Hydro-Plant Models for System Transient and Long-Term Dynamic Studies' in these chapter a review of the literature is suggested about the modern methodology 'dynamic model for pumped storage hydro power plant' is used and also introduced, 'A rigid model and elastic model is sufficient for transient dynamic studies and long term dynamic studies resp. [10]

3. CONSTRUCTION

For the construction of pumped storage hydro power plant we need following part:

1. Reservoir (upper and lower reservoir)

The dam is artificial concrete barrier constructed. The catchments areas behind the dam create a huge upper and lower reservoir. A hydroelectric reservoir is a large collection of water behind a hydroelectric dam that makes use of potential energy of water for generating electricity. This water is held back by the dam, and is allowed to fall to generate electricity when it is needed. These reservoirs are one type of water storage that is especially important to hydroelectricity. The water held in the reservoir of a hydroelectric facility is at a higher elevation than the rest of the dam. The height that this water is at is known as the hydraulic head and is one of the major factors in determining how much electricity can be generated.

2. Turbine

Water turbine design for small scale hydro energy. The water turbine, also known as a hydro turbine, is a fairly simple machine that produces a rotary turning action at a medium to high rotational speed. Also, water turbine can be used as a part of a home hydro electricity system by installing electric generator.

3. Waterway

Pumped storage hydropower projects typically have two sections of waterways. The first section is the high head portion between the upper reservoir and the pump/turbine unit(s) and the second section is the low head portion between the pump/turbine unit(s) and the lower reservoir. A waterway that travels the shortest distance possible between the upper reservoir, powerhouse, and lower reservoir is optimal. A shorter waterway is preferred to minimize both construction costs and friction losses in the system. The water conduit system should further be designed to minimize friction losses in both pumping and generating modes.

4. Head

Low head projects generally require larger conduits, which are cost prohibitive. High head projects (typically over 2,500 feet) require more complex multistage pump/turbine units, and eliminate the ability to regulate the units in generating mode. High head projects are typically more cost effective, because based on the power equation, the product of the total volume of water stored by the total head is proportional to the total energy stored; therefore a project with a higher head would require smaller reservoirs and have smaller electrical-mechanical provide an equivalent amount of energy.

5. Flow Rates

The basic criterion used during planning is the desired generating capacity, and based on this and available head. For a given head, projects with higher design flow rates require larger waterway conduits and pump/turbine units. As part of the project planning process, it is important to perform a cost-benefit analysis to look at different flow rates/plant sizing capacity that will provide the greatest overall benefit. Another important consideration regarding design flow rates are the desire to minimize the head losses in the waterways. Smaller flow rates, and associated smaller conduit diameters, typically have higher head losses versus larger conduits; however larger conduits are typically more expensive to construct because they require more civil works.

3.1 Working

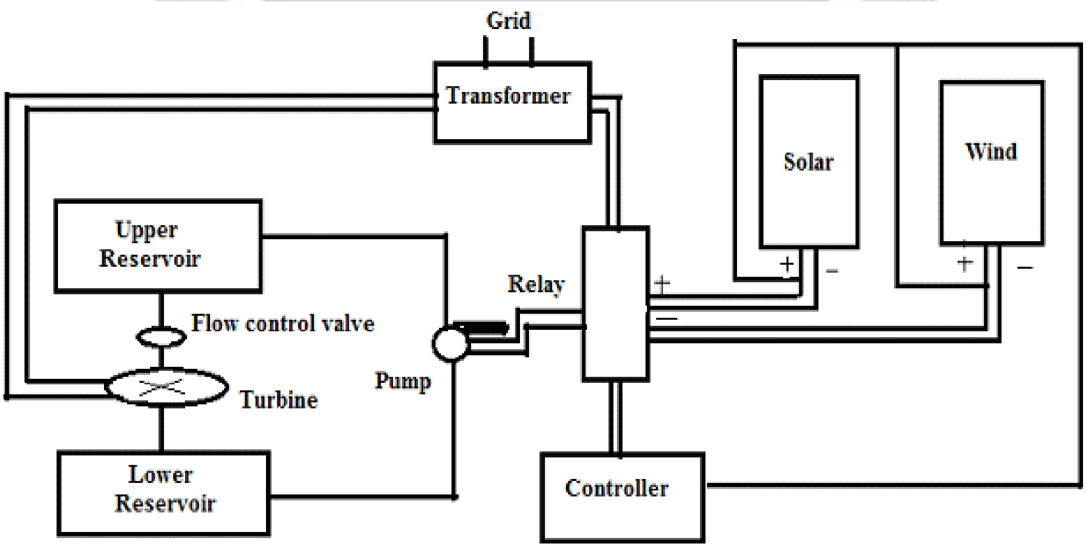

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Figure 2: Block Diagram of Pumped Storage Power Plant

The pumped storage hydro power plant, which uses a combination of pumped water and natural stream flow to produce energy, is better solution for hydro power. The general structure of a pumped storage system is shown in figure 2. Pumped storage hydro power plant is modified use of conventional hydro power technology to store and manage energy or electricity. In PHEP two modes is conduct one is generating mode and another is pumping mode.

In generating mode, the water is stored in upper reservoir, the force of falling water pushing against the turbine blades causes turbine to spin, generator is connected to the turbine by shafts and possibly gear so when the turbine spin it causes the generator to spin also convert mechanical energy from turbine into electrical energy. By using transmission line electricity is conduct from hydro power plant. After that in pumping mode, water is stored in lower reservoirs is pumped from lower reservoir to higher reservoir, for pumping requiring external supply is given from solar and wind energy and excess of energy is given to grid. This process is occurred continuously by using the renewable energy sources without affecting the environment.

4. ADVANTAGES AND DISADVANTAGES

4.1 Pros

- The advantages are the very long lifetime, huge installed capacity and practically unlimited cycle lifetime. By storing electricity, PHS facilities can protect the power system from an outage.

- Coupled with advanced power electronics, PHS systems can also reduce harmonic distortions and eliminate voltage sags and surges.

- These systems could be an alternative for the high cost peak generation units. Low operation and maintenance costs and high reliability are also important.

- Currently, pumped hydro has the lowest levelizes cost of electricity from the electrical energy storage technologies.

4.2 Cons

- Their main drawback is the PHS system s geographical restrictions. These are dictated by the need for relatively large water reservoirs and large elevation variations between lower and upper reservoirs to provide sufficient capacity.

- The construction of a plant typically takes many years. Although the operation and maintaince costs are low, there is a high upfront capital investment in civil construction. This can only be returned over decades of operation.

- Environmental impacts are also serious concerns and have caused cancellations of proposed projects. The construction of conventional PHS systems often involves the damming of a river to create the reservoir.

- The blocking of the natural flow could disrupt the aquatic ecosystem, change the landscape and endanger wildlife. There are some technical solutions for those problems such as fish deterrent systems, oxygen injection systems and turbulence minimization. The potential impacts of the applications are site-specific and must be evaluated on a case by case basis

5. CONCLUSIONS

pumped hydroelectric energy storage (PHES) systems is conducted, focusing on the existing technologies, practices operation and maintenance, environmental aspects, and economics of using PHES systems to store energy produced by wind and solar photovoltaic power plants. It has been agreed by the scientific community that massive electricity storage is the critical technology for the renewable power, if it is to become a major source of base load despicable power. Among all existing storage technologies, PHES is the most suitable technology for small autonomous island grids and massive energy storage both technological maturity and economical compatibility over the lifespan of the project.

To make a pump whose efficiency above 80% and is consumes power below 40% as turbine generation. The main purpose of PHES is to utilize excess energy from the grid during off peak hours or the excess energy produced by wind farms or solar photovoltaic power plants to pump the water from the lower reservoir to the higher reservoir and then release the water from the higher reservoir to the lower through the hydraulic turbines to produce energy during peak load hours. In this way, the wastage of energy from either of the three sources can be minimized and the excess energy can be optimally utilized.

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