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Impartial amalgam Power Generation-Elimination of Dump Load with Pumped stockpiling Hydro plant

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Abstract— **Among developing burden request and a dangerous atmospheric deviation, a situation benevolent kind of vitality answers for secure the earth for the future ages has turned into an essential. Other than hydro control, a few vitality sources like breeze and sun powered vitality is exceptionally potential sources to gather our vitality requests. Frameworks which utilizes at least two sustainable power sources is prevalent than the single source framework as far as cost, effectiveness and unwavering quality. Independent Wind/sun oriented crossover age framework offers a solid and better answer for circulated age for remote zones and areas where control from network isn't accessible. Normal vitality based power age frameworks are constantly outfitted with capacity batteries to give consistent yield independent of the regular vitality variety. There are odds of battery getting cheated. For the Standalone sort of age establishment of dump stack is important to keep the cheating by appropriate usage of dump control. Disposal of dump stack by including a Pumped Storage Hydro plant is outlined here. The plant won't just scatter the overabundance wind vitality yet in addition partakes in control age when requested for. The demonstrating and reenactment is finished utilizing MATLAB/SIMULINK programming.**

Index Terms— **Buck-Boost DC-DC Converter, Dump Load, Hybrid Power Generation, Modes of Operation, Pumped Storage Hydro plant (PSH), Solar Power Generation, Wind Power Generation.**

I. INTRODUCTION

Nowadays, the world pays growing attention to renewable energy sources. The reason is they are clean and inexhaustible, and interdisciplinary research is continuously developed in order to sustain the improvement of existing conversion technologies and the development of new ones. The rising consumption rate of fossil fuels and the pollution problem associated with them has attracted a wide scale attention towards renewable energy sources. An integrated system of two or more renewable energy sources is more effective as compared to single source system in terms of cost, efficiency and reliability. Wisely selected renewable power sources help in reducing the necessitate for fossil fuel. Other than hydro power, many such energy sources like wind and solar energy can be used as the sole producers of power. Apart from this reason there are areas which are remote where the electricity which is being generated from the main grid cannot be transmitted due to the high cost of transmission and losses. Diesel generators are normally used to supply power to such areas where grid connection is not available [3]. However due to the usage of fuel the usage of these are not advisable as they produce pollutant gases and the price of the diesel is on the rise. The availability of renewable sources like wind, solar, hydro, etc. effectively contributes to the consideration of development of the stand-alone hybrid generation systems (HGS's).

The system on which the work is done is standalone wind power generation system. The generation system is feeding a standalone load. As mentioned before it can be any type of areas which are far away from the conventional generation centers. And also feeding such areas from the conventional generation centers would demand lengthier transmission lines and also the transmission losses which demand for more expenses. Hence the idea of standalone generation is equipped [6]. Along with the wind generation, the area should be provided with some method of unnecessary generation so that the loads will never experience a cut off of power. Hence in the particular system being studied diesel generators are added along with the wind generation system.

The system which is being concentrated in the thesis work is the hybrid system which is feeding a standalone community as load. The dominant producer of energy in the same is wind. Similar system is explained in [1] Standalone hybrid system is mainly composed of natural energy sources (i.e., wind power and solar power), and a storage battery. In most cases a diesel engine generator may be incorporated into the system for redundancy. The dump power, which is defined as the surplus portion obtained after deducting load from generated power, is used as charging power for storage battery [1]. In the course of battery charging, an advanced technique to prevent battery overcharge is required. Dump load usually a resistor load, which functions to consume dump power, is usually connected in parallel with the battery or ac output point. Few techniques to prevent battery overcharging were widely used. A master slave control technology is used in the work [1] to enunciate the control of the whole power regulation. PLL technique is used for the purpose of synchronization. The dump power produced in the unit is first used to charge the battery and whatever is there in excess is dissipated in the resistor banks as explained before. In [3] the battery is installed adjacent to the wind power generation system, and a solid-state controls the switching of dump load. Another technique is that surplus power is consumed by a hydrogen generator instead of conventional battery. The dump load is applied to the system when hydrogen tank is full. These techniques but always demand installation of dump load. Also, for the status transmission of the voltage and current of the battery, the system requires a high-speed line, or otherwise a high-tech dump load control method, is necessary.

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II. SYSTEM TOPOLOGY

The basic feature of the basic system referred should be

1) Dispersed installation various sources of power which are parallel connected
2) Elimination of dump load by using a unique dump power control
3) No need for dedicated high-speed line for battery current/voltage status data transmission
4) When load increases additional power sources can be parallel connected so that the capacity can be easily expanded.

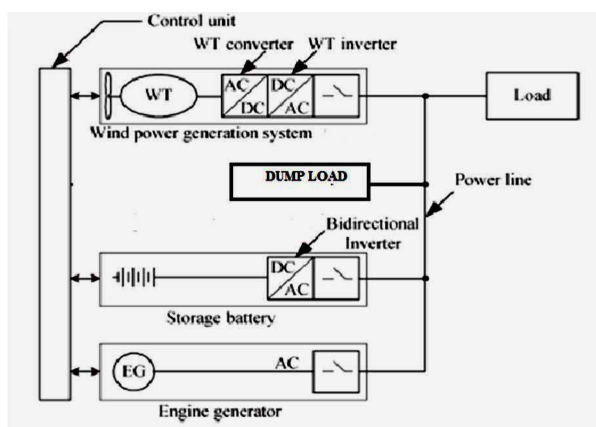

Fig.1. System configuration

Fig. 1 shows the standalone hybrid wind power generation system composed of four power sources: a wind power generation system (with a converter and inverter), a pumped storage hydro plant (which is the dump load), storage battery (with a bidirectional inverter), and diesel engine generator; and a control unit. The control unit controls the operation by sending suitable operation commands to individual power sources and monitor power status. Once an ON command is sent to each source it takes up the master role and delivers the power demanded; however manual control of inverter operating conditions is also possible. The inverters enable redundant parallel operation, making a reliable, stable power supply possible.

The different operating stages in the system are as below:

Stage 1) The remaining battery capacity is sufficient: diesel generator operation stops. And all inverters operate in parallel.

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Power surplus and deficit is optimally adjusted through battery charging or discharging.
Stage 2) The remaining battery capacity is insufficient: the engine generator along with the parallel operating inverters. When power generated by wind is insufficient to meet load demand, EG compensates for the deficiency. EG charges the battery through the bidirectional inverter. This inverter regulates charging power for the battery following a command from the control unit.
If a condition arises when the wind is in excess then the power after being stored in the battery has to be fed to the dump load, i.e., the pumped storage hydro plant.

III. PUMPED STORAGE HYDRO PLANT

A type of hydroelectric energy storage used by electric power systems is Pumped-storage hydroelectricity (PSH) which has a role in load balancing. Energy is stored in the form of potential energy of water, pumped from a lower elevation reservoir to a higher elevation. Pumps are run at off-peak time when the cost of electricity is low. When electrical demand is high, the stored water is released through turbines to produce electric power. But the pumping process in the pumped storage system makes it a consumer of electricity. Though there are losses it improves revenue by taking part in generation during peak demand. Pumped storage is the largest-capacity form of grid energy storage available. As reports from EPRI, Power Research Institute reports, more that 99% of bulk storage capacity around world is by PSH.

A. General Structure Of PSH

The structure of a pumped storage system is shown in Fig.2. Water pipes are used to connect the upper and lower reservoir. The upper sections of these pipes are water tunnels. The tunnel may be short depending on design and geographic features and it has its own tunnel. If upper reservoir is far away from the lower one and power house, long water tunnels are required and one single common water tunnel is then used for all penstocks.

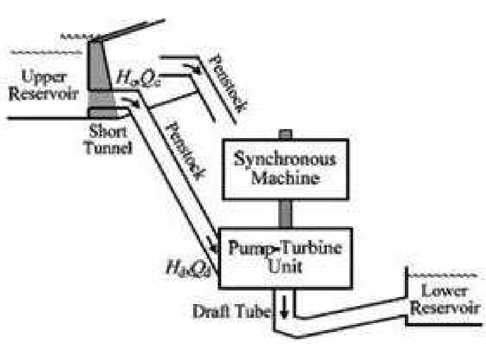

Fig.2. General Structure of a pumped storage hydro-plant

A multi-pole synchronous machine is made use in the PHS system. Usually a low speed machine is the preferred one vertically mounted multi-pole. Many pumped storage systems also employ reversible pump -turbine units, a single machine will be acting as the pump and generator in that case. In that case the phase sequence at the synchronous machine terminals is reversed to change the mode of operation from generating to pumping and vice versa .When the load demand is low, the generation capacity which is available in is used to pump water into the higher reservoir. When there is higher demand, through the turbine water is released to the reservoir downstream so as to generate electricity. Nearly all facilities use the height difference between two natural bodies of water or artificial reservoirs. Pure pumped-storage plants allow the water to be shifted between reservoirs.

B. Benefits of PSH:

PSH offers following advantages
a) As the only solution for efficiently storing large amounts of energy, pumped storage power plant act as a quick response for peak load energy supply
b) With approximately 80% efficiency pumped storage plants have the highest global cycle efficiency compared to other power plants.
c) Clean form of energy
d) Enable increased use of renewable energy sources
e) Most consistent method of storage.

Due to the before mentioned advantages PSH is being used to replace the dump load in the standalone system studied. Hence it acts as a dissipater of energy when wind is there in excess. When load demands more power and when wind is less the same energy from PSH can be used to produce the same.

IV. CONTROL TECHNIQUE

The concept of hybrid system is different. When the system is designed for smaller load they use just batteries. When small gensets have to be used they will be expensive to operate on. Due to this batteries are preferred for such systems. When the system for which the demand is met is larger with a higher kilowatt demand generally gensets driven by engine is made use. When the role of producer of power in a system is being shared wind turbines and diesel gensets, such systems are termed as a wind-diesel system. In these systems, the amount of wind power (wind penetration) is a decisive factor for the system design. The whole Standalone system involves may control loops inside the system. The main control technique of the fully integrated system is as below.
Step 1) Integration of the Wind generation with the required converters so as to deliver power to load.
Step 2) Interconnect the diesel system along with the wind system to meet the extra load power demand.
Step 3) Monitor the wind generation, Pw
Step 4) The load demand is also measured, P_D
Step 5) Check if the wind can meet the whole demand
Step 6) Initiate the supplementary source that is diesel generator if $P_W < P_D$ (Diesel generator is capable of feeding whole of the critical loads)
Step 7) The condition P_W + Pgen = P_D is constantly checked.
Step 8) Once PW exceeds the load demand the control logic initiate the pump in pumped storage plant).
Step 9) When PW drops again the PSH will contribute for generation first before the diesel generator actively participate.

At some cases the dump load that is the pump of PSH is also activated along so that it meets the minimum loading condition of the diesel generator. This explains the overall control strategy to be implemented for the whole integrated system. But other than this each of the generation system would demand implementing control schemes.

V. SIMULATION RESULTS

The models of each of the generation system ie, wind, diesel and PSH has to be done separately. A standalone load has to be assumed and modelled. All the generation systems has to be integrated and has to be checked for the different operation stages. The first part which was modelled in the system was the wind energy conversion system which converts the Wind Energy to the required electrical energy. The system consisted of a Wind Turbine and a synchronous machine. The energy conversion is from the wind energy to the electrical energy.
There are two types of generator which are being used for WECS .They are doubly fed induction generator (DFIG) and Permanent magnet synchronous generator (PMSG) . PMSG is a Direct Drive type generator; and don't require gear box. The aerodynamic torque is completely transmitted as the mechanical torque as there is no gearbox.

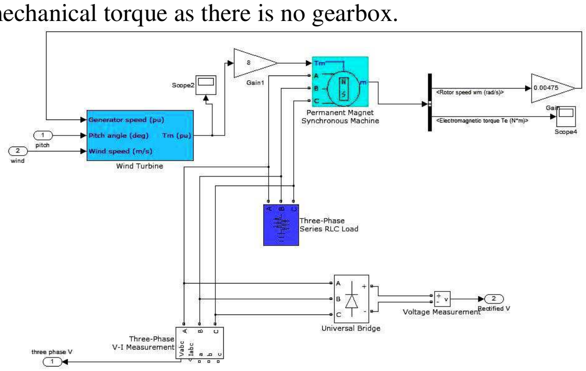

Fig.3. Simulink model for Wind Generation System

The diesel engine when modelled is considered as the speed feedback system. The operator gives a speed command by adjusting the governor system, the engine governor recognize the difference between the actual speed and the desired speed, which is same as the work of a sensor. It also regulates the fuel supply to maintain the engine speed within range. The general structure of the fuel actuator system is usually represented as a first order phase lag network, with a gain K_2 and time constant τ_2.

The output of the actuator is the fuel-flow $\Phi(s)$ and the input current is I(s)

$$\Phi(s) = \frac{K2K3}{1+s\tau 2} I(s) \quad (1)$$

Fuel Flow $\Phi(s)$ is then converted into mechanical torque T(s) after a time delay τ_1 and engine torque constant K_1.

$$T(s) = \Phi(s)\, K1\, e^{-\tau 1 s} \quad (2)$$

The power controller of diesel generator ensures the required power generation from diesel generator during no wind or low wind conditions in order to maintain voltage and frequency. The controller allows the diesel generator to run in two different modes; one is isochronous mode and the other is droop mode. During no wind conditions, the diesel generator runs on isochronous mode. In isochronous mode of operation, the governor produces required power in order to keep a constant system frequency. In low wind conditions, the diesel generator runs on droop mode.

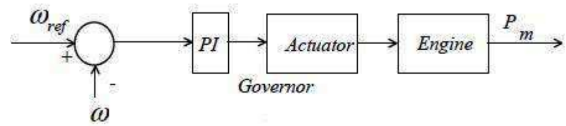

Fig.4. Isochronous Mode

The power control strategy of droop mode compares the reference power with the output power. The actuator controls the necessary fuel flow to produce the required power for the system. Initially the loop of the governor will run so as to settle the speed of the synchronous machine and after settling the speed it will run so as to chase the power deficit from the wind. The reference power given to the diesel generator would be the difference of the power demanded by the load and that being produced by the wind generation system. The controller of the diesel governor would try chasing this power in the droop mode.

The next stage of modelling is the pumped storage hydro plant. As mentioned before the method stores energy in the form of gravitational potential energy of water. Water is pumped from a lower elevation reservoir to a higher one. Electric power is used to run the pumps during the off-peak period when cost is low. When the demand of power is high the water from upper reservoir is released through turbines to produce electric power. Reversible turbine/generator assemblies act as pump and turbine. Fig.5 represents the hydrogenation scheme. In this the turbine is modeled using transfer functions. Along with the generation part the pumping system is also modeled. The complete generation system is integrated by MATLAB programming. The various generation scenarios were monitored and the power dispatched by each generation source was managed as per demand.

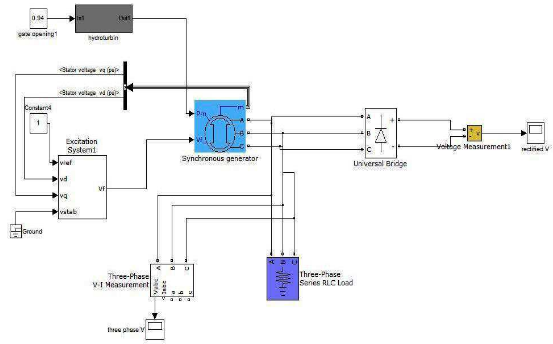

Fig.5. Simulink model for Hydro Generation System

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VI .CONCLUSION

The main approach of the work here the control of the different power generating sources according to the active power demand. The work is meant to control the dump power in stand-alone hybrid system by advanced technique other than providing dump load. The strategy being adopted for the dump load control is providing a PSH as a dump load in place of the normal resistors which are provided as dump load. The PSH acts as both dump load and also acts as storage. Hence when load demands for more power the PSH will act as an active producer of power.

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