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ETAP-Based Power Flow Analysis of Hydro-power plant

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Abstract: The technical investigation and analysis of micro hydro plants to create a local rural grid is presented in this work. To this end, 10 MW micro hydro plants located in the kokan region of dodamarg district have been selected. Every crucial aspect needed to create the power flow analysis model has been suitably taken into account. ETAP is used to do a load flow assessment for both peak and off-peak hours under both contingency and non-contingency scenarios, employing a unique power system network model for each units. Simulation findings for both clusters demonstrate that the establishment of a local grid facilitates the use of excess power during off-peak hours, something that is not feasible when micro hydro plants operate independently.

I. Introduction:

Particularly in remote locations where it is not technically or financially possible to expand the national grid, micro hydro plants are emerging as one of the dependable sources to meet energy demand. The majority of these plants are run in stand-alone mode. A common issue with these plants is that they generate very little electricity during off-peak hours, which leads to a low plant factor. The problem of plant efficiency loss due to underutilisation of power generation during off-peak hours can also be resolved using a Micro-Grid, also known as a local grid. This encourages increased commercial activity to support sustainable rural development and may also create opportunities for additional cottage and business industries in rural areas.

II. Construction & Commissioning

The Hydropower plant consists of a two 5 MW turbine-generator units, the 10 MVA station transformer, and the 25 MVA main transformer are installed in accordance with technical specifications and are appropriately integrated into the civil structures, supervision is required.
Switchyard construction: The two switchyards (6.6 kV/33 kV and 33 kV/220 kV) will be built in accordance with the electrical design, and all related switchgear, busbars, and protection equipment will be installed.
Wet commissioning: To evaluate the units' performance, mechanical soundness, and power production, water will be pumped through the turbines up to a maximum discharge of 32 cum.
Grid synchronisation: The 220 kV state grid will be used to synchronise the generators. To guarantee a steady connection, this entails precisely adjusting the generator's voltage, frequency, and phase angle with the grid. Testing will confirm how well the transformers operate when under load.

III. Methodology:

1. Analysis of feasibility
Estimating the energy potential: Compute: Verify the project's results using the established design parameters. The following formula provides the power produced by a hydroelectric plant: **$P=\eta \cdot \rho \cdot g\cdot Q\cdot H_{net}$**.
At a maximum discharge of 32 m^{3}/s and a gross head of 50 meters, the study will calculate the net head (H_{net}) by deducting head losses. To verify if two 5 MW units are suitable for the location, a preliminary power estimate can be made.
Site examinations: In addition to ensuring that the water supply can sustain the 32 cumecs flow rate during the production season and provide a dependable lower flow for off-peak operation, surveys must verify that the 50-meter head is continuously available.

2. Detailed project design:
Water conveyance and intake: The canal, forebay, penstock, and intake structure must all be built to securely manage the 32 m^{3}/s maximum discharge capacity. Particularly during times of heavy flow, a garbage rack and desilting basin will be sized to keep debris from harming the turbines.Stronghold: The powerhouse will have a layout that makes maintenance and safe operation easier, and it will be large enough to house two 5 MW turbine-generator units.
Turbine and generator selection**:** Based on a medium head of 50 meters and the specified discharge, Francis turbines are likely the most efficient choice for this installation. Two separate 5 MW turbine-generator units will be selected to match the project's capacity.
Electrical system design:
Generator output: The two 5 MW generators will likely produce power at a standard medium voltage, such as 6.6 kV.
Station service transformer: A 33 kV/6.6 kV transformer with a 10 MVA capacity is needed to step down power from the local 33 kV grid to power the plant's auxiliary systems at 6.6 kV. This also provides backup power for the station.

Step-up transformer: The power generated at 6.6 kV will need to be stepped up to the transmission voltage for evacuation to the grid. A 220 kV/33 kV transformer with a capacity of 25 MVA is specified for grid connection. This indicates that the 33 kV output from the generators is further transformed to the higher voltage (220 kV) for long-distance transmission.

Fig 1) Three phase alternator

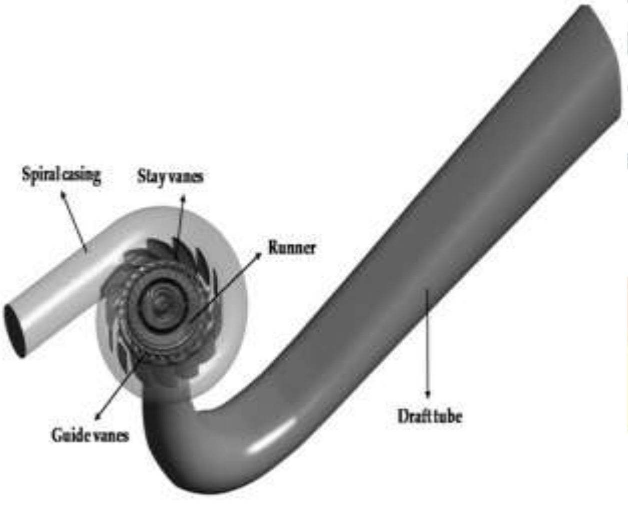

Fig 2) Fransis turbine

Fig. 3) 33 KV / 6.6 Kv transformer

Fig. 4) BUS-BAR

IV. ANALYSIS OF LOAD FLOW :

The Gauss Seidel method is used in ETAP to conduct load flow analysis in Hydropower plant. While operating the model, the slack bus can draw more power if necessary and provide whatever amount of extra power that the system load requests. This is how it has been set up for analysis.

TABLE 1: CONTINGENCY ALERTS DURING LOAD FLOW STUDY

Simulation Case	Condition
All plants running with peak load	Normal
All plants running with offpeak load	Slack Bus drawing power from network
One plant NOT in operation (fault condition)	Over load, Over excited
Two plants NOT in operation (fault condition)	Over load, Over excited

V. GRID CONNECTION

A microprocessor-based grid synchronizable digital electronic load controller is used to guarantee grid connectivity. It allows micro hydro plants to be connected in both automated and manual modes, and it controls the system's frequency by rerouting excess electricity. For power import/export, it has a frequency controlling unit, a voltage regulating unit, a synchronising unit, a signal and measuring unit, a protection unit, and switchgear. Medium voltage overhead transmission systems operating at 11 kV are used for local grid transmission.

VI. RESTRICTIONS AND CHALLENGES

While establishing a local grid from linked cluster-based micro hydro plants has various benefits over isolated mode, operation of a micro hydro plant, there are still certain technological difficulties and restrictions. There will undoubtedly be problems with low voltage and frequency or loadshedding to address the lack of available power in the local grid in the event of forced or scheduled outages of a large plant within the cluster. The primary technological constraint that may be seen during the actual implementation of the local grid scheme is the aforementioned issue. To guarantee that the local grid operates satisfactorily, these problems could be reduced or eliminated with rigorous technological design considerations.

VII. CONCLUSION

In ETAP, a unique power system model is made for every generation units. For every units, a load flow analysis is carried out under various system situations, both with and without contingencies. It It is observed that the utilisation of off-peak power, which is currently not feasible in the current stand-alone system, is the primary technical significance of such a local grid connection. The suggested networked system may be especially helpful in this particular field.

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