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Energy Audit of 220/66 kV Substation

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Abstract

This paper highlights on the study of an electrical substation through energy audit on a regular basis and also focuses on the importance of the performance analysis of the substation. To analyze the performance of the substation based on different parameters under various operating conditions, a 220/66 kV substation is identified and detailed study is carried out. Based on the observations, it was found that the substation installed capacity was very large in comparison to the supply which was transferred to different loads connected to the substation. Through this observation, it was found that the substation was under loaded and underutilized during maximum time period of its operation. Due to this, the efficiency of operation of the substation is reduced. The second most observation was the level of voltage of the incoming line was high during the operating hours. The line reactors at the receiving and sending end of the substation are kept in ON position to maintain the level of voltage. One of the incoming lines of 220 kV is kept in OFF position when the condition of the loads is off peak. The energy audit study focuses station capacity optimization, power quality improvement, loading pattern and operation of substation. Based on the study, recommendations are suggested.

Keywords: Energy audit, station capacity, substation efficiency, performance analysis, power quality.

Introduction

For any nation, the standard of living, productivity, prosperity and strength is affected by electrical power which is the most important and critical component. For this reason electrical power requirement has increased rapidly but the capacity of power generation has not been able to match the demand which creates shortage of electrical power. The reason for this is the increase in power generation is happening slowly and pilferage of power during transmission and distribution, shortage of non renewable sources for power generation, very less utilization of renewable energy sources, power wastage due to less awareness about conservation of energy etc. These reasons along with poor power quality have increased the power shortages, which if not looked upon the situation will go out of control.

To tackle the shortage of power the following techniques can be adopted:

- By increasing the capacities of generation of power
- The quality of the supply power needs to be maintained which is reliable and absence of harmonics.
- The power factor, frequency and allowable voltage need to be maintained.
- Performance analysis of an electrical installation needs to be done based on which energy conservation techniques can be implemented to improve the efficiency of energy.

From the following techniques mentioned above, the last technique mentioned is very simple, effective, most economical and environment friendly. The usage of electrical power should be done proper manner, hence there is necessary to plan the usage the energy and minimization of wastage of energy. Hence for this purpose, an energy management tool called energy audit which is an effective and scientific method is adopted.

With the above mentioned objectives, energy audit of 220/66 kV substation is carried to analyze the performance parameters during transmission and distribution.

Substation Technical details

The following are the technical details of substation:

- 220 kV CTV 203 – Bay
- 220 kV line 89 DE isolator
- 220 kV line 89 – T, 89 – D, 89 – C, 89 – B and 89 – A isolator
- 220 kV bus coupler's circuit breaker
- 220 kV bus – 1 pt and bus – 2 pt.
- Bus 220 kV PT transformer
- 220 kV PT 89A isolator bus 1, 220 kV PT transformer, 89 B and 89 C isolator
- 220 kV transformer HV circuit breaker
- 220 kV transformer HV NCT
- 220 kV 100 MVA transformer
- 66 kV line

220 kV CTV 203 – Bay: Make – ABB; Rated voltage – 127 V; Rated insulation level – 245/ 460/ 1050 kV; Rated frequency – 50 Hz; Total thermal burden – 400 VA; Class of insulation – A.

220 kV line isolator: Make - GR Power Switchgear; Voltage Rating – 220 kV; Current Rating – 1250 A; Control Voltage – 220 V DC

220 KV Bus Coupler Circuit Breaker: Make – ABB; Voltage Rating – 245 kV; Normal Current – 1250 A; Frequency – 50 Hz; Lightning impulse withstand voltage – 1050 kV; Short time breaking current – 40 kA; Line charging breaking current – 1254 A

Transformer: Make: ABB, Frequency – 50 Hz; Current – 500 A, Insulation to ground – 125 kV; Step voltage 1588 V; control voltage – 110 V; nominal power – 60/80/100 MVA; nominal voltage – HV 220kV, LV 66 kV, TV 11 kV; nominal current - HV-157.46-209.95-262.43, LV-524.86-699.82-874.79, TV-1049.73-1399.81-1743.37

The substation is fed through two 220 kV lines. The installed capacity of the two transformers is 100 MVA each. The two incoming lines are connected to two 220 kV bus which are coupled through bus couplers normally. An extra provision is also made for an extra line if in case there is any requirement. At present there five 66 kV outgoing lines and also provision is there for extra 66 kV lines for installation as per the requirement of load. The length of the existing 66 kV lines is between the ranges of 2 kms to 40 kms. Figure 1 shows the single line diagram of substation.

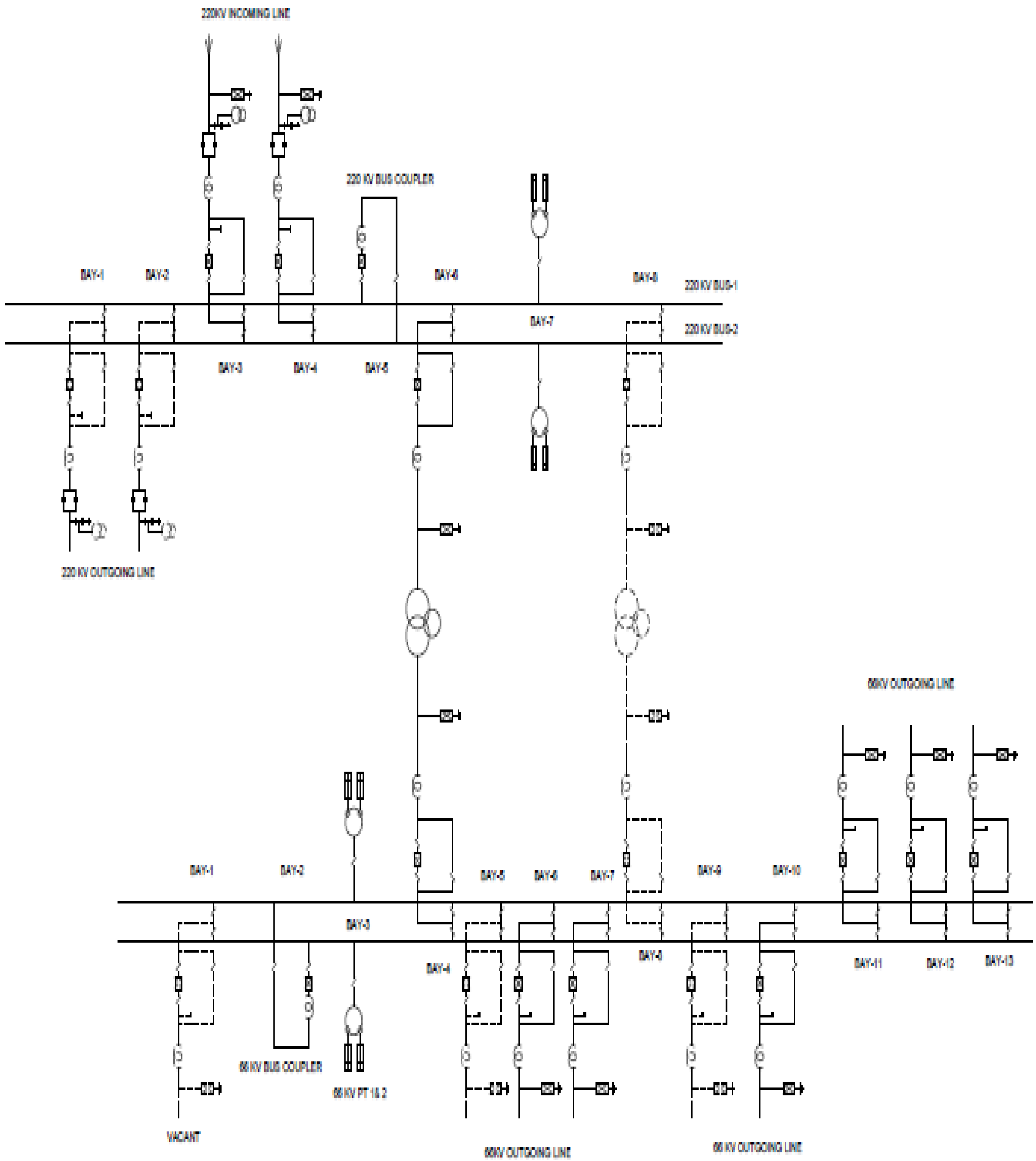
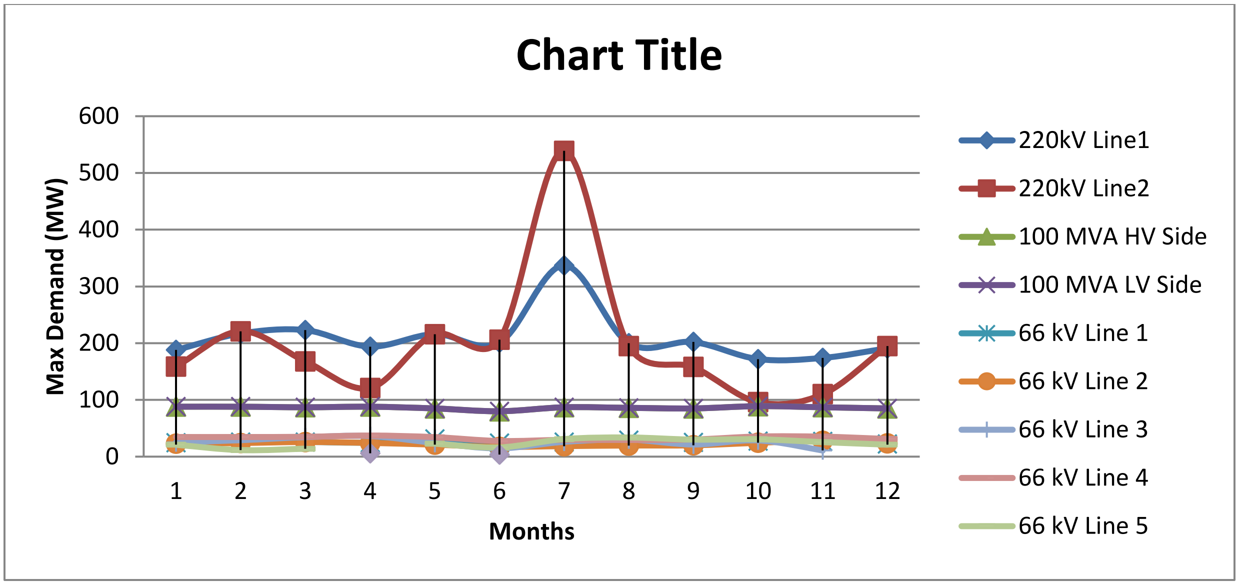


Figure1: Single line diagram of 220/ 66 kV substation

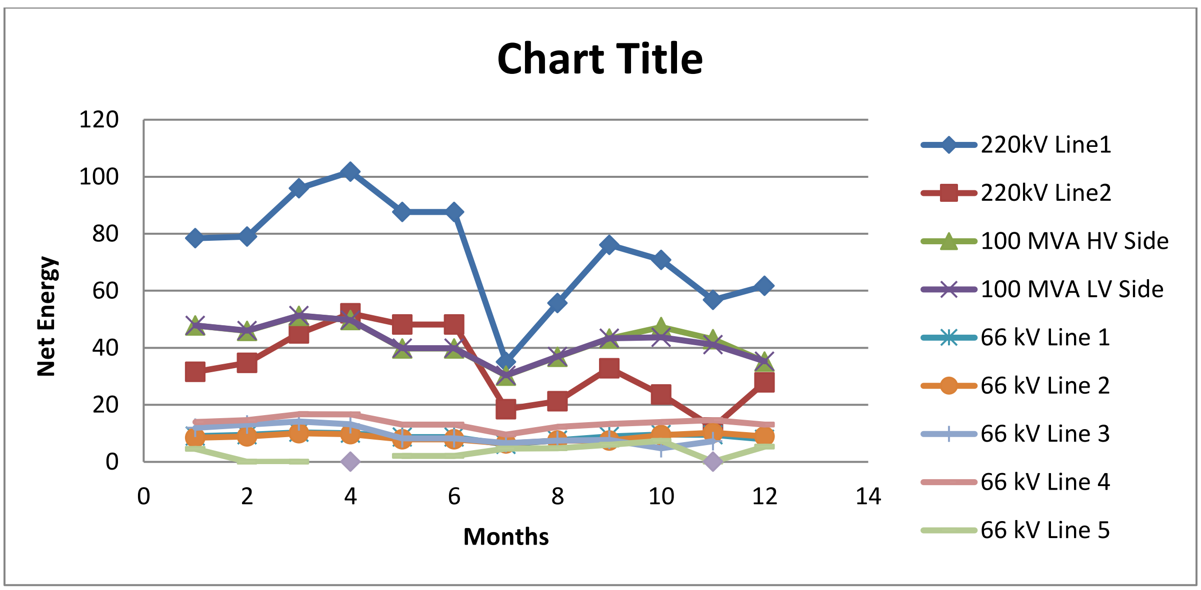
Performance Analysis

Details of the substation are collected manually and automatically on hourly basis. Some data are collected through automatic data logger and some data are collected manually.

The collection of data included readings of the meter of 220 kV and 66 kV lines, peak load and interruption line, peak load on transformer, MVAR of transformer, battery status etc. Variation of the maximum demand and net energy for every month is plotted in the graph shown below.



Graph 1: Maximum demand for a year



1: Maximum demand for a year

From graph 1 it is observed that the maximum demand across both the line 220 and 60 kV slightly mismatches. Graph 2 helps in understanding the net energy consumed by the loads meeting the maximum demand. Net energy calculated by the difference between energy supplied and energy demand. Through the data collected the station efficiency is calculated to match the transformer efficiency. The efficiency of the station is calculated directly with the help of input and output data.

Results and Observations

The following observations are made from the data obtained during field visit and results are calculated:

1. The frequency range varies between 49 to 50.5 Hz.
2. The power factor of transformer is operated between 0.9 and above.
3. The input voltage varies between 194 kV to 223 kV.

4. Both the transformers are operated in parallel as each of them share equal load and they are kept in ON position continuously.
5. The output voltage varies between 64 to 67 kV.
6. The load on each of the transformer varies with a wide range of 23 to 75%. The maximum peak load on the transformer is about 85%.
7. The efficiency of the transformer is 98% which is calculated from the output and the losses. This efficiency is maintained with loading of transformer. The input power in MVA and the output power which is the actual station output but it's not the overall efficiency of the station directly varies with the percentage of loading. Therefore the overall efficiency of the station varies between ranges of 50 to 90%. The efficiency of transformer and station ideally does not match with each other.
8. There is no metering device to record the power factor of transformer, performance of tertiary transformer and consumption of power on basis. Installation of these automatic meters will help in analysis of performance more clearly.
9. The interruption of the line is mostly observed

Conclusions and recommendations

The following conclusions were made based on the observations and detailed performance analysis of the substation. Based on the conclusions, suitable recommendations were suggested for energy conservation and also improve the station efficiency.

1. Presently the loading on the transformer is between 23 to 75%, the transformer needs to be operated at 76.23% which is a derived condition for maximum efficiency. Generally the loading is near to 75% and below this value for the major duration for any give day. Generally to yield higher efficiency at higher percentage loading the transformers are designed which is followed as a usual practice.
    i. One of the transformers can be operated when the loading of station is in between the range of 40 to 55%. This will help in yielding the maximum efficiency, since under this condition the station would get loaded between the ranges of 70 to 90%.
    ii. Only one transformer can be operated when the loading on the station is below 40%. This would improve the efficiency of the operating transformer and would also the loss of power which could have occurred in the second transformer.
    iii. Both the transformers needs to be operated in parallel when the loading on the transformer is above 40% that is the loading on transformer would be more than 80%. Overloading of single transformer can be prevented.
2. Implementation of the above suggestions (mentioned in point no 1), the value of insulation resistance of the transformer which is kept in OFF position will be decreased. One of the two transformers can be kept in OFF position by switching alternatively and in a phased manner to overcome this limitation.
3. Instead of switching off the transformer, the circuit breaker of the 66 kV side of one transformer while connecting the primary side to 220 kV can be considered as alternative to the above suggestion (mentioned in point no 2). The load on one transformer can be transferred to another transformer which is in operation by implementing this. Due to this measure the no load losses suffered around 101.4 kW. These losses can be compensated if the efficiency of the transformer which is loaded improves by even small percentage.

    Due to this measure, an extremely small changeover time will be required during emergency due to the tripping of transformer to shift the load from loaded transformer to an idle transformer. This will improve the efficiency to a larger extent without affecting the reliability of the system.
4. The bus and line reactors are switched ON and also one of the incoming 220 kV line is being tripped for the purpose of controlling the incoming voltage due to Ferranti effect and light loading of the lines. This solution will cause additional power loss in the reactors and will also make the operation of the station hectic which will affect the efficiency of the system, economics and reliability. To overcome this limitation the total requirements of power can be drawn through this station. Thus utilization and loading of the station can be done to its full capacity.

5. There is no meter to record the performance of bus reactor which makes difficult to identify the reasons for the mismatch between the station and transformer efficiency. Hence it is assumed that loss in the station efficiency is not due to the transformers but due to loss in some other station equipments.
6. Presently there is no metering system to record the power factor, performance of tertiary transformer and performance of bus reactor. Hence there a metering system needs to be installed.
7. At present this station provides power to almost 5 stations. The remaining and additional capacity of the station can be diverted to the neighbouring stations and consumers. This can be considered as an alternative suggestion and feasible solution to optimize the increase in utilization of station capacity.
8. In the present scenario, the overcapacity of the station is mainly due to insufficient assessment of the power requirement of the consumers. Ten years back the prediction of power requirement was done for the growth of above 20%. Due to various reasons, the capacity of the station which was projected couldn't be realized even till date. For most of the period the station has been forcefully operated below 70% of its capacity. Hence it is suggested to reassess and study immediately the present and future requirements of the station so that the operation can be trimmed and utilized appropriately. The strategy of operation should be planned appropriately for the future requirement.

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