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Optimal Power Flow Analysis for 23MW Microgrid using ETAP

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Abstract:- Recent advancements in the micro grid are aiding the power system in case of reliability and cost efficiency. Since the micro grid is an interconnection of various renewable resources, the system to be analysed consists of biogas as a renewable resource. In this project an electrical system is analysed for efficient power usage (between electrical grid and bio gas generation) and cost minimisation during peak hours. Efficient usage of power and cost minimization is attained using optimal power flow analysis. This project analyses the micro grid considering grid constraints such as Real and Reactive power loss minimization, bus voltage security. The aim is to compare the existing system and proposed system and their differences in cost during peak hours. The software used for analysis is ETAP.

Keywords:- *Optimal power flow; Micro grid; Grid constraint; peak hour Cost; ETAP.*

I. INTRODUCTION

This paper deals with the analysis of optimal power flow for the electrical system of 23MW gas district cooling plant(GDC). For the past few years, the power shortage keeps on increasing which leads to large duration of peak hour [9], because of the usage of power at peak hour, there will be increase in cost[8]. In this paper the solution is attained by optimized operation of the power system considering various constraints to reduce the losses and maintain the bus voltage to meet the demand [1]. Optimal power flow analysis is used to optimize the steady-state performance of a power system in terms of an objective function under certain constraints. If a system is optimized, it will reduce the installation and operating cost, which leads to improvement in overall performance, stability, reliability. Now-a-days electrical engineers using many software tools for analysis and monitoring the power system. For the efficient operation of the power system, the power flow analysis is indispensable. Many papers were dealt with various power system [2][3]. Powerful computer-based software's were employed in the power system for fast computation. The software used for analyzing the microgrid is ETAP (Electrical Transient and Analysis Program). ETAP is employed in transmission side and in industrial analysis [10]. The analysis through the ETAP software provides user friendly environment and the fast computation of the analysis [5]. This software is used for simulation studies and is a most common analysis platform for design, operation of industrial power systems. This software decreases the computation time, also it leads to Real-Time Intelligent Energy Management System. A Microgrid is a small-scale power grid that can operate independently or combined with the area's main electrical grid. Microgrid integrates various renewable resources. The objective of a microgrid is to make the generation near the load and to provide reliable power flow. The microgrid and the utility grid is interconnected via Point of Common Coupling (PCC). The Micro-grid is operated in two different modes which are Islanded mode and Grid-connected mode. The Islanded mode is used when the supply from the grid is shut down. The main factors to be considered are voltage and frequency stability. In grid-connected mode, the factors to be considered are the minimization of cost of energy imported from the PCC, to improve the power factor and to optimize the voltage profile.

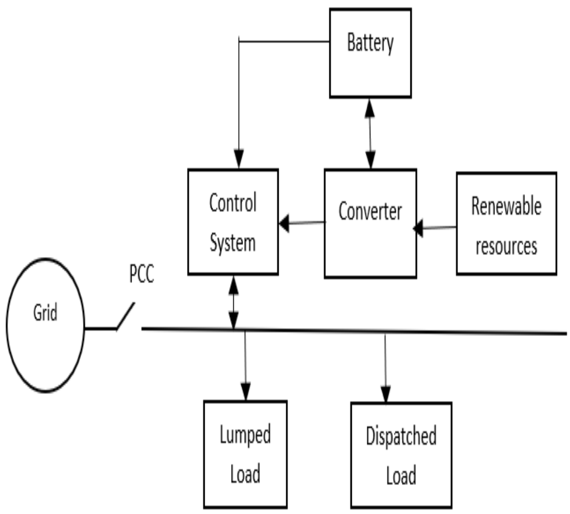

Fig 1:- Typical microgrid block diagram

In ETAP, the various analysis supported such as Load flow analysis, Short circuit analysis, Harmonic Analysis, Optimal power flow Analysis and Stability Analysis.

II. ELECTRICAL SYSTEM DESCRIPTION

The single line diagram of the existing system is a 23MW rated air cooling system consists of 66 buses, two 10MVA transformers, eight 2.5MVA transformers, an 11.5MW generator, two 4.5MW generators. This system uses air cooling pumps as their loads. The transformers include tap Changing facilities for maintaining the bus voltage profile. The generators rated 3MW are kept OFF during off-peak hours. During peak hours, 3.5MW power is supplied to the grid.

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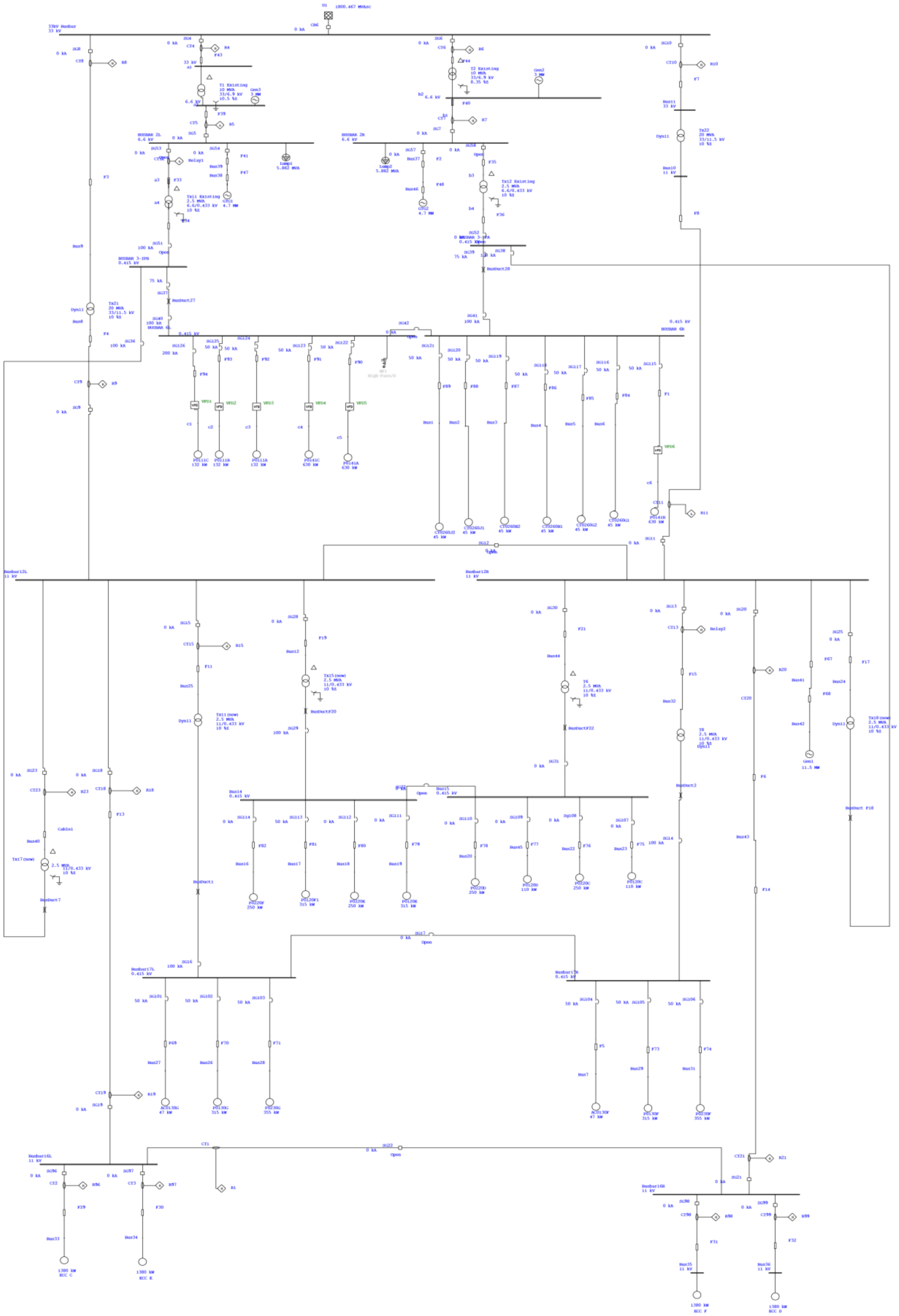

Fig 2:- One line diagram of the 23MW Gas Cooling District Plant

The generators produce 26.5MW of power during peak hours and 20MW during off-peak hours.

The proposed system consists of two added generators of 3MW each along with the existing system.

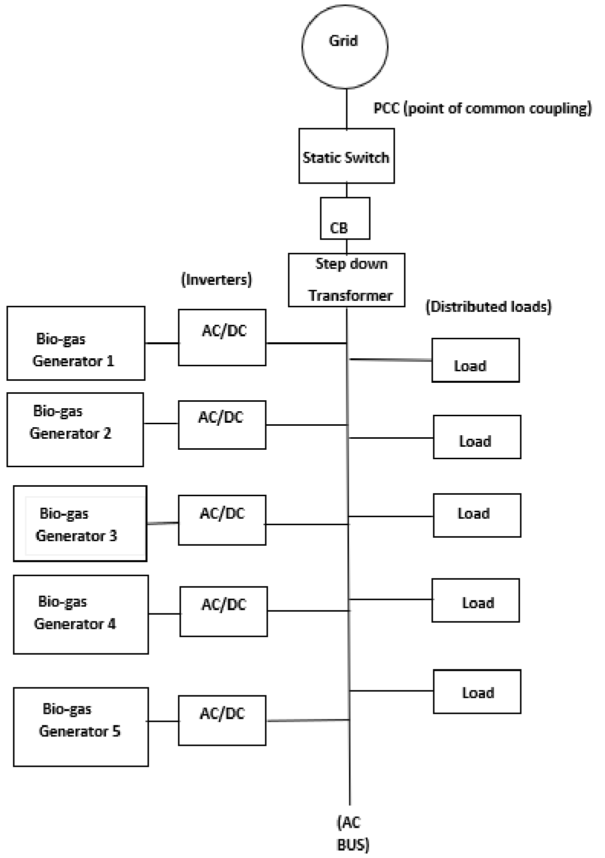

Fig 3:- Block diagram of proposed system

III. EXISTING SYSTEM

SUMMARY OF TOTAL GENERATION, LOADING & DEMAND

	MW	Mvar	MVA	% PF
Source (Swing Buses):	2.570	0.119	2.572	99.89 Lagging
Source (Non-Swing Buses):	20.000	11.580	23.111	86.54 Lagging
Total Demand:	22.570	11.699	25.422	88.78 Lagging
Total Motor Load:	22.092	11.839	25.064	88.14 Lagging
Total Static Load:	0.000	0.000	0.000	
Total Constant I Load:	0.000	0.000	0.000	
Total Generic Load:	0.000	0.000	0.000	
Apparent Losses:	0.478	-0.140		

Fig 4:- Summary of existing system

Fig.4. represents the total load of the system is 22.57MW. The power imported from the utility grid is 2.57MW; the power generated by the biogas generation is 20MW. The generator GTG1 and GTG2 with the capacity of 4.7MW connected to the bus BUSBAR2L and BUSBAR2R respectively of 6.6kV generates 95.7% of its rated capacity. The generator GEN1 of capacity 11.5MW connected to bus BUSBAR12R of 11kV generates 95.6% of its rated capacity. As per IEEE standard, an 11kV bus should be maintained at a power factor of 85%. The system buses are maintained as per the IEEE standard's recommendation. The transformers installed have the tap changing facility to maintain the bus voltage within the safer limit. The overall losses of the system are around 0.48MW. During peak hour, the cost of the power imported from the PCC is approximately rupees 15 per unit. So, the total cost charged by the utility grid is 39 thousand rupees. The cost laid on the biogas generation is approximately 90 thousand rupees. Hence the overall cost of the existing system at peak hours is around 130 thousand rupees.

IV. PROPOSED SYSTEM (OPTIMAL POWER FLOW ANALYSIS)

The optimal power flow analysis is employed in analyzing the proposed system. Optimal power flow plays a wide role in power system operation. It is strongly influenced by power system due to its competitive nature in industry. OPF is used to optimize the steady-state performance of a power system in terms of an objective function under certain constraints.

An optimized system will reduce the installation and operating cost, which leads to improvement in overall performance, stability, reliability. It mainly aims to optimize the selected objective functions such as active real and reactive power loss, fuel cost through the optimal adjustments of power system constraints and power system control variables, it ensures the system constraints are not violated. The optimal power flow analysis has various methodologies, the well-known techniques like Newton method, Linear Programming method, Gradient method, Quadratic Programming method and interior-point method. Optimal flow analysis is performed using various algorithm depending upon the size of the system [6][7]. The optimal power flow is used in many applications of the power system, operational planning, and real-time control etc.,

Some of the main objectives of optimal power flow can be identified as below:

It minimizes the real and reactive power losses, minimizes the generator fuel cost, maximum power transfer is achieved, load shedding is minimized, reduces transmission losses, power exchange with other systems can be optimized (utilities, power grid, onsite generator), System performance is improved, system energy cost is minimized. Optimal power flow is computed only with the constraints assumed. In this project, three main constraints which are mandatory for any power system is assumed. Maintain bus voltage security, Minimization of real power loss, Minimization of reactive power loss. The other constraints offered by the ETAP are listed below:

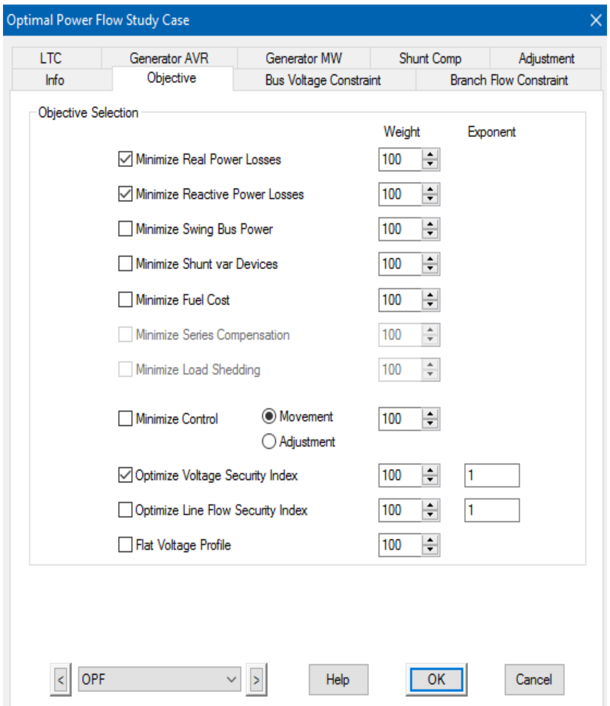

Fig 5:- optimal power flow analysis constraints in ETAP

Optimal Settings

Generator/Power Grid

ID	%Voltage	Operating MW	Operating Mvar	Delta MW	Delta Mvar
Gen1	95.87	11.000	-1.354	0.000	-1.354
Gen2	95.77	3.000	1.500	0.000	1.500
Gen3	95.75	3.000	1.500	0.000	1.500
GTG1	96.26	4.500	-0.068	0.000	-0.068
GTG2	96.21	4.500	-0.453	0.000	-0.453
U1	97.62	-3.439	10.741	-3.439	10.741

Fig 6:- Preferable operating conditions during peak hours

Fig.6 represents the preferred operating conditions during peak hours obtained from the optimal power flow analysis. To reduce the cost at peak hours, two generators rated 3MW is added. This generation schedule is recommended for the better operation of the system in case of minimization of losses, regulating the bus voltages, and also maintaining the bus power factor as per the standard defines. The bus voltage is regulated by varying the reactive power at the bus which is to be regulated. When the voltage decreases below the specified limit the bus demands the reactive power to compensate the drop. The operating limits of the bus voltage are given in fig 6.

Alert Summary Report

% Alert Settings	Critical	Marginal
Loading		
Bus	100.0	95.0
Cable	100.0	95.0
Reactor	100.0	95.0
Line	100.0	95.0
Transformer	100.0	95.0
Panel	100.0	95.0
Protective Device	100.0	95.0
Generator	105.0	95.0
Inverter/Charger	100.0	95.0
Bus Voltage		
OverVoltage	105.0	102.0
UnderVoltage	95.0	98.0
Generator Excitation		
OverExcited (Q Max.)	105.0	95.0
UnderExcited (Q Min.)		

Fig 7:- The voltage limits considered for the safer operation of the system

When the system operation is maintained as per the schedule recommended the result obtained is shown in Fig.8.

SUMMARY OF TOTAL GENERATION, LOADING & DEMAND

	MW	Mvar	MVA	% PF
Source (Swing Buses):	-3.439	10.741	11.278	-99.98 PF Leading
Source (Non-Swing Buses):	26.000	1.126	26.024	99.91 PF Lagging
Total Demand:	22.165	10.486	24.520	89.02 PF Lagging
Total Line Charging:	0.000	-0.039		
Apparent Losses:	0.396	1.380		
System Mismatch:	0.000	0.000		

Fig 8:- The result of the system after the optimal power flow during peak hours

The swing bus power is represented in negative because the excess power generated by the system is fed back to the utility grid.

During peak hours the system is able to feed the utility grid and make the profit instead of the paying higher to the grid at that peak hours. The amount of power injected into the utility grid is 3.439MW. Since the source for biogas is abundant, it is cost efficient to generate power exceeding the load. Hence the overall cost of the proposed system at peak hours is 66 thousand rupees.

V. COMPARATIVE RESULTS

PARAMETERS	EXISITING SYSTEM	PROPOSED SYSTEM
SWING BUS (UTILITYGRID) IN MW	2.57	-3.44
NON-SWING BUS (GENERATORS) IN MW	20	26
LOSS(MW)	0.478	0.396
COST(Rs.)	1,30,000	66,000

Table1. The comparative results of the existing system and the proposed system

With the help of the ETAP, the above results have obtained. The reason behind each result is explained individually.

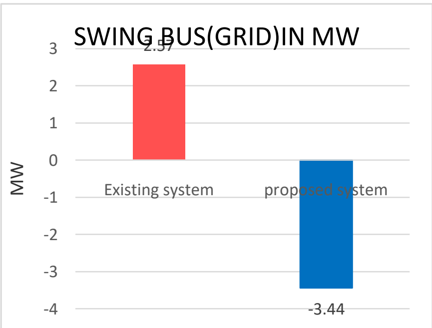

Fig 9:- The power exchanged at the point of common coupling

Due to increasing power demand, the supplier can't meet out the user demand. Thus, during peak hours to reduce the demand, the supplier charges high than compared to the normal operating hours. The system analyzed in this paper is the full-time operating system. In order to avoid peak hour charges and also to aid the utility during peak hours, the generation is made higher than the demand of the plant. This is achieved by adding two more generators which are rated 3MW each. The excess power is given to the main grid.

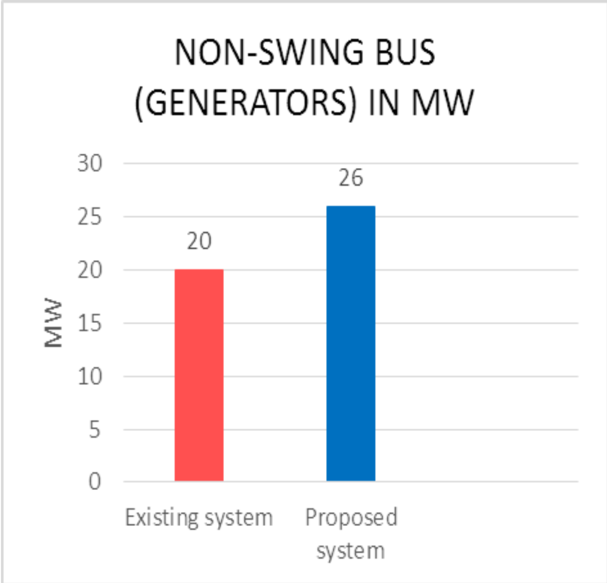

Fig 10:- Bio-gas generation

Fig.10 represents the generator buses connected in the system. The existing system has the total generation capacity as 20MW and the proposed system with 26MW. Since the load is supplied with near by generation the transmission loss of power is controlled.

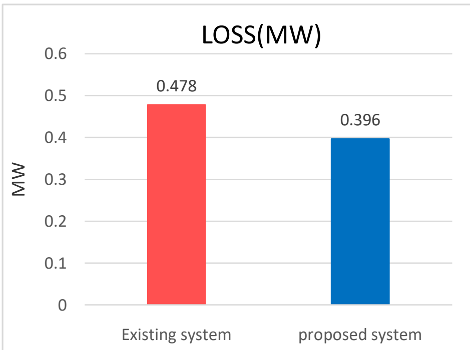

Fig 11:- Loss comparison

The reduction in the system losses is attained by the setting up constraints in the optimal power flow analysis as objectives. Using this analysis, the system chooses the best path for the power to flow. The three major constraints considered are to maintain the bus voltage, to minimize the real and reactive power losses. With these constraints, the analysis provides the best path for the power flow.

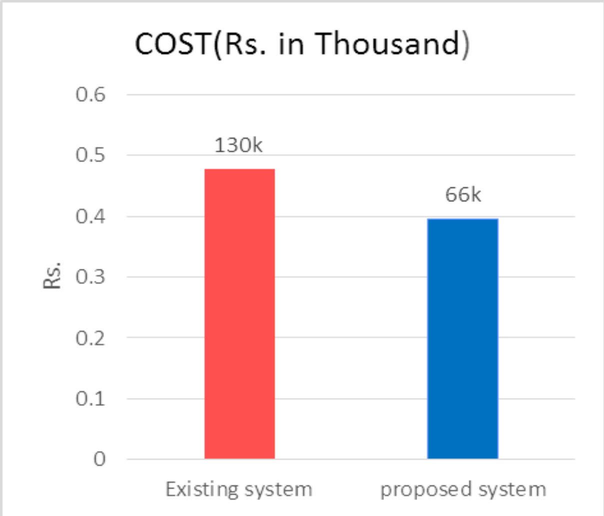

Fig 12:- Cost comparison

During peak hours the charge charged is Rs.15/kWh. During this hours the plant completely gets operated independently from the main grid. Since the generation planned is in excess of the power required by the plant, it is given to the grid where the plant gets paid by the utility. This makes this much cost reduction and also losses reduction aids the cost reduction parameter.

VI. CONCLUSION

In this project, an electrical system is analyzed for efficient power usage and cost minimization during peak hours. Generally, the cost charged by the utility during peak hours is far higher than the normal operating hours. Thus the analyzed system operates in a better way compared to the existing system in terms of power reliability, operating cost, losses by considering various constraints such as bus voltage security, Real, and Reactive power loss minimization. Analysis of a power system in ETAP is more user-friendly. In the project, the above crisis has been overcome by increasing the generation capacity of the plant only during the peak hour. Since power is distributed in an optimized manner the power losses were also minimized. The optimal power flow analysis is employed in dispatching the power generated optimally with maintained system parameter.

REFERENCES

[1]. Blair Hanna and Adel El-Shahat, Optimal Power Flow for Micro-grids, 2017 IEEE Global Humanitarian Technology Conference (GHTC), Pages: 1 – 3.

[2]. A.W.L.Lim; T.T.Teo; Muhammad Ramadan; T. Logenthiran; V. T. Phan, Optimum Long-Term Planning for Microgrid, TENCON 2017 - 2017 IEEE Region 10 Conference, Pages: 1457 – 1462.

[3]. Supachai Klungtong; Chow Chompoo-inwai, Power Flow Monitoring and Analysis for 24.6 MW at 6.9 kV Bus Diesel Power Plant(DPP) Using ETAP, 2016 International Conference on Smart Grid and Clean Energy Technologies (ICSGCE), Pages: 307 – 312.

[4]. Rana A.Jabbar Khan; Muhammad Junaid; Muhammad Mansoor Asgher, Analyses and monitoring of 132 kV grid using ETAP software, 2009 International Conference on Electrical and Electronics Engineering - ELECO 2009, Pages: I-113 - I-118.

[5]. Pallavi P. Bagul; Sonali M. Akolkar, Relay coordination in microgrid,2017 International Conference on Computing Methodologies and Communication (ICCMC), Pages: 784 – 789.

[6]. S. N. Chaphekar; Prashant R. Karad; A. A. Dharme,Optimal power flow for power management in Microgrid, 2016 IEEE 1st International Conference on Power Electronics, Intelligent Control and Energy Systems(ICPEICES), Pages: 1 – 5.

[7]. Yoash Levron; Josep M. Guerrero; Yuval Beck,Optimal Power Flow in Microgrids With Energy Storage, IEEE Transactions on Power Systems, 2013, Pages: 3226 – 3234.

[8]. Archana S. Talhar Belge; Sanjay B. Bodkhe, Use of solar energy for green building & reduction in the electricity bill of residential consumer, 2017 IEEE Region 10 Symposium (TENSYMP), Pages: 1 – 6.

[9]. Suresh Choudhary; Srijit Saha; Sheryl Jacob; Sai Ikshith; Mohini Kher, Reduction of electricity bill with standalone solar PV system, 2017 International Conference on Nascent Technologies in Engineering (ICNTE), Pages: 1 – 5.

[10]. Jyoti; Abhishek Arya; P. Arunachalam; L.Ramesh; V. Ganesan; Hudson Egbert, Energy usage analysis of industries with ETAP case study, 2017 International Conference on Circuit ,Power and Computing Technologies (ICCPCT), Pages: 1 – 7.