# Design of MicroGrid Modeled Distribution Feeder through Power Audit Recommendations

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***Abstract*—Energy saving is one of the major concerns in the present era. The project highlights the necessity of Power Audit in the residential feeders and the need of local MicroGrid design. The present study deals with Power Audit Analysis of 132 residential houses and 10 commercial buildings, connected to the 250 Kva distribution transformer feeders. The Detailed Power Audit is carried out for 10 houses connected to the feeder and preliminary audit is carried out for 122 houses. Recommendations are proposed further with Micro Grid for reducing the dependency of at least 20% loads of houses on Main Grid and for encouraging people to generate their own power. The suggested implementation tested with ETAP simulation and concluded with the improvement of energy efficiency of Residential houses and thereby reducing the energy wastage.**

***Keywords—Distribution System, Energy Audit and MicroGrid***

## I. INTRODUCTION

Global energy demand is set to grow by 37% by 2040 [1] in our central scenario, but the development path for a growing world population and economy is less energy-intensive than it used to be. In our central scenario, growth in global demand slows markedly, from above 2% per year over the last two decades to 1% per year after 2025; this is a result both of price and policy effects, and a structural shift in the global economy towards services and lighter industrial sectors.

During the fiscal year 2014-15, the electricity generated in Indian utility sector [2] is 1,030.785 billion KWh with a short fall of requirement by 38.138 billion KWh (-3.6%) against the 5.1% deficit anticipated. The peak load met was 141,180 MW with a short fall of requirement by 7,006 MW (-4.7%) against the 2.0% deficit anticipated. The 17th electric power survey of India report claims that the electrical energy demand for 2016–17 is expected to be at least 1,392 Tera Watt Hours, with a peak electric demand of 218 GW and the electrical energy demand for 2021–22 is expected to be at least 1,915 Tera Watt Hours, with a peak electric demand of 298 GW.

To satisfy the energy needs of the State, Tamil Nadu Generation and Distribution Corporation Limited has installed capacity of 11884.44 MW which includes State projects, Central share and Independent Power. Other than this, the State has installations in renewable energy sources like wind mill, solar, biomass and cogeneration up to 8219.67 MW. The present demand and generation gap is to be 20 %, due to the lag in addition of new generation and less awareness about the energy saving initiative.

To meet this increasing demand we have to increase the generation of power by installing new generating stations but increasing the generation of power without looking into the aspect of energy conservation is like filling up the bucket, without arresting the leakage. One unit of Energy saved is equivalent to two units generated. One best possible solution is to reduce the global, national and local demand through Effective Energy Audit Analysis and implementation of suitable recommendation. The review of energy audit and proposed work is presented in chapter two.

## II. REVIEW OF ENERGY AUDIT WORK

Different authors presented energy audit analysis and recommendations for residential house, library, commercial buildings, industries, institutions and power plants, which are consolidated and discussed here. Jian Zhang etal., [3] conducted an in-depth study on how to reduce energy consumption in China with the objective to finding out problems of energy audit and energy management in Jilin province. Loganthurai eral., [4] conducted audit in the engineering institution and provided solution to reduce 20% gap between the demand and generation, if all the Engineering colleges. Vyas Pareshkumar etal., [5] presented energy conservation opportunities for process industries consume a substantial amount of energy. Anna Pellegrino etal., [6] presented a testing method to assess day lighting in classrooms based on performance indicators drawn from literature. The results obtained from the study showed some critical situations. Zhuxian Yao etal., [7] presented statistical energy use characteristics of hotel buildings in Shanghai. Building information and energy consumption data had been collected by field survey of 45 star hotels. Bonacinaa etal., [8] developed a tool to stimulate cost-effective deep renovations. Cosimo Marinoscia etal., [9] presented a preliminary energy audit of the historical building and results of the energy analysis show an energy saving of about 15% . Xinxin Liang etal., [10] carried out the study to investigate property's energy consumption from the view of passive energy saving, and then use the results to determine the best energy saving plan.

To support the initiative to reduce demand and create awareness to the general public Dr. M.G.R Educational & Research Institute, Chennai has taken initiative in the year 2014 called. **'MGR Vision 10 MW'** under the leadership of Dr. L Ramesh to save 10 MW in 10 years. The contributed research works under the pilot project-1 were published in Scopus publications [11-15] and the reports are published by the Research Forum GREEN9 (Energy Efficiency Research Group).

This work is the pilot study work -2 and presents the restructuring of 250kVA Distribution Transformer feeder with Micro Grid through efficient Energy Audit and Management.

## III. Data Observation

### *A. Observation of Existing Parameters*

The preliminary power audit started to collect all the required information from the 133 residential houses. Only the selected sample representations are presented here, due to the page limitations.

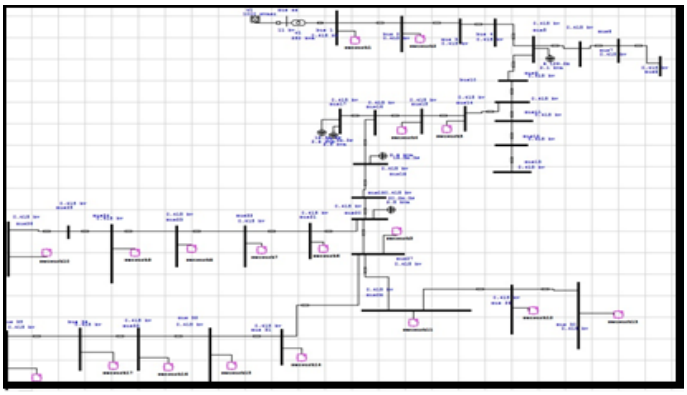

Fig. 1. Existing Test Feeder in ETAP

The ETAP single line diagram of the existing 11KV distribution feeder is represented in figure 1. It is the radial feeder with 36 buses connected with 3 phase and single phase supply. The length of the feeder is 1.5 km.

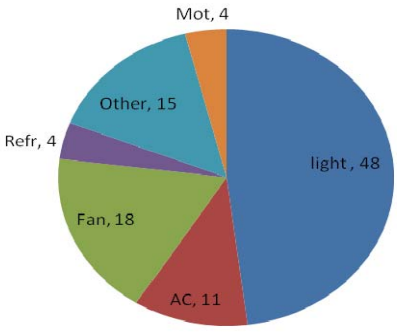


Fig. 2. Power Utilization of Houses

The pie chart representation for the utilization of power is represented in figure 2. It shows that the lighting prefers the most important component for saving power.

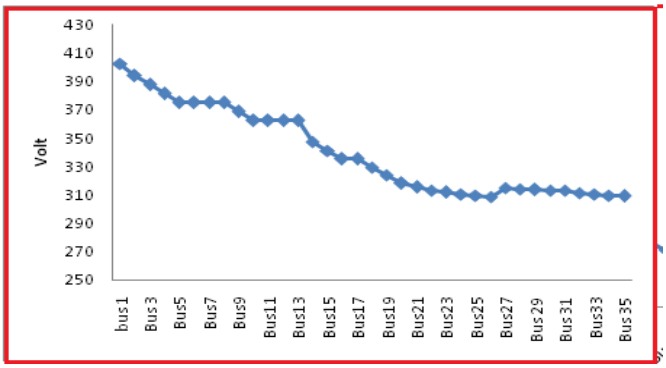


Fig. 3. Bus Voltage of Existing Test Feeder in ETAP

The voltage obtained through ETAP simulation for the 35 buses in the feeder, when connected all the existing loads are represented in the figure 3. It clearly demonstrates that, the existing system is very week and the tail end voltage ends with 310volts.

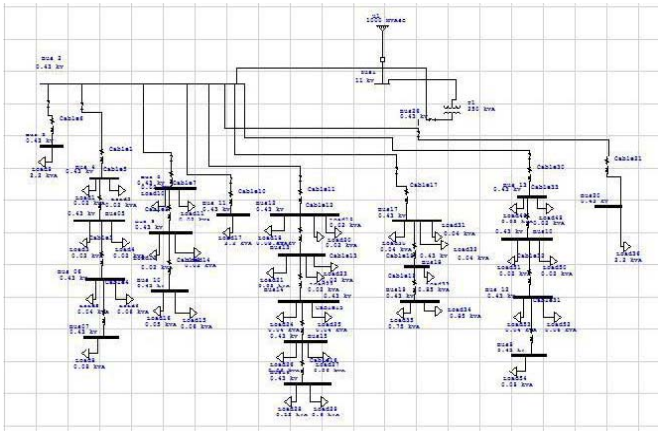

Fig. 4. Triple Bed Room Single Line Diagram in ETAP

The sample representation of triple bed room house power distribution ETAP single line diagram presented in figure.

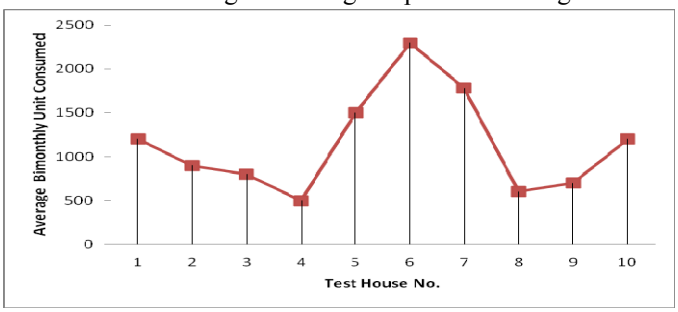


Fig. 5. Average tarrif Analysis

The average unit consumed by the identified ten houses for power audit is represented in figure 5. The observation indicates that, minimum of 500 units and maximum of 2300 units consumed averagely in bimonthly plan. It indicates that good saving can be recommended for these houses.

### B. *Real Time Measured Reading*

The team conducted several online measurement study of voltage and current with the secondary of the transformer. The load profile is identified with the help of collected real time data's.

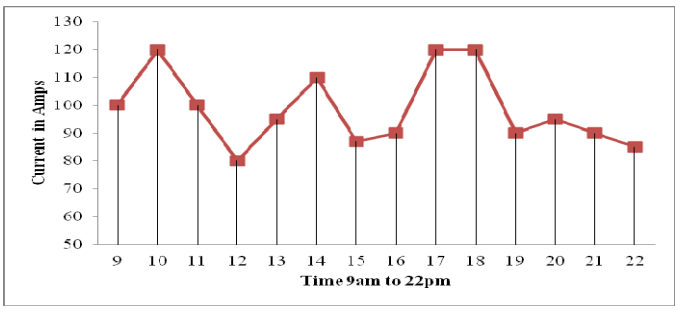


Fig. 6. Real Time Load Current

The sample data collected a period from 9AM to 22PM is represented in the figure 6. It observed that, 12th hour with minimum load and 17th hour with maximum load.

## IV. Recommendations With Microgrid

The recommendations which are give after a audit can be taken as a best suggestion for the betterment of energy saving , especially the best suggestion you choose the better result you get. Mostly recommendations are based on the average of both practical and theoretical value. Auditing provide clear and reliable information on potential investment and saving the electricity in long term benefits, by calculating net present values cash flow and the resulting discounted saving over time. This enhances considerably the quality and value of the recommendations. Recommendations are divided into various categories like investment, benefits and quality. The investment is classified in to mminimum iinvestment, medium investment and maximum investment. The benefits are classified in to mminimum and maximum benefits recommendation. The quality is classified in to hhigh and low quality recommendation.

### A. ***General Recommendation for 132 houses***

The detailed recommendation study conducted for audited ten houses and presented the final savings outcome of one triple bedroom, due to the page limitation. The same procedure adopted for all the other 122 houses and presented here the collective combined recommendation for 132 houses with unit saving comparison.

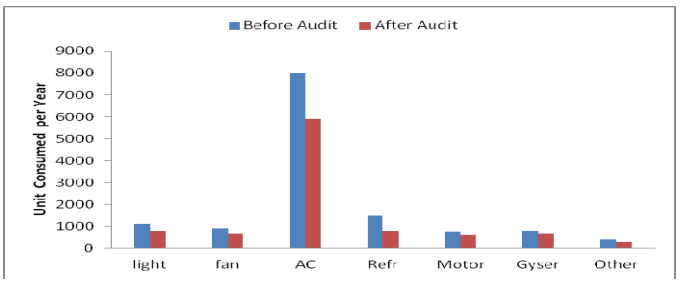


Fig. 7. Real Time Load Current

The final comparison of the unit consumed by the equipment for one year in three bedroom house is indicated in figure 7 and it shows the 27% savings after the recommendation of audit.

The basic necessary advises suggested to improve the savings without the investment is presented below. Implementing the below advice with help the customer for energy saving of 5%, if implemented effectively. Clean a fans blade periodically which improves the performance life of the fan. Keep refrigerator away from the wall to allow air to circulate around the Refrigerator. Avoid frequent closing and opening of refrigerator door. Allow heated food stuff to cool down to normal temperature before Refrigerating. Defrost regularly to keep freezers working their best. Use washing machine to its full capacity. Avoid ironing one or two clothes daily and adopt large scale iron. Turn off your computers when not in use, a computer that runs 24 hours a day for instance, uses more power than an energy efficient refrigerator. If your computer must be left on, turn off the monitor this device alone uses more than half the systems energy. Avoid water leakage in taps/joints.

The sample suggestion for triple bedroom fans is recommended with choice of replacement, where ten houses requested for super fan, seven houses requested for orbit fan and 20 houses requested for any one five star rated fan.

TABLE I. FAN Unit Consumption with PayBack Period

| S.No | No. of Cust. demand | Fans to Replac. | Fan Types | Unit consumed /year | Pay Back Period |
|---|---|---|---|---|---|
| **1.** | 10 | 20 | Super | 2016 | 6 |
| **2.** | 7 | 14 | BL 30 | 1785.6 | 8 |
| **3.** | 20 | 40 | 5 Rated | 5760 | 5 |

The table 1 represents the unit consumed per year with their payback period. The existing unit consumed per day by the 37 triple bed room houses for fan is 88 units and 78 units per day after the suggested recommendation.

The sample suggestion for double bedroom lighting is recommended with choice of replacement, where 23 houses present lighting is good and recommendation needed for 20 houses out of 43 double bedroom houses.

TABLE II. Lighting Recommented Lumens

| Room | Present Arrangement | Required lumens | Restructured Arrangement |
|---|---|---|---|
| Bed Room 1 | 2 Tubelights 56000 lum | 4400 | 3 LED , 16w 4800 lumens |
| Bed Room 2 | 2 Tube lights 5600 lumens | 3406 | 2 LED Tubelight 3200 lumens |
| Hall | 4 tube light 11200 lumen | 6355 | 4 LED 6400 lumen |
| Kitchen | 1 tube light 2800 lumen | 3300 | 2 LED 3200 lumen |
| Balcony | 1 CFL 200 lumen | 600 | 1 more CFL 400 lumen |
| Bathroom | 1 Tubelight 2600 lumen | 808 | 10 watt LED 800 lumen |

The table 2 represents the required lumens of lighting and recommended lumens with suggested LED lighting. The present lighting arrangement consumes 19036.8 unit / year and the restructured lighting arrangement by all the houses consumes 10339.2 unit / year. The money to be invested for restructuring is Rs 187000 with the payback period of 4.3 years.

The recommendations for the Air Conditioner, with all the bedrooms are presented here. The analysis study indicates that, 53 air conditioners from the 116 houses are using AC for average of 10 hour per day. It is suggested to replace them by the five star one.

TABLE III. AC RECOMMENDATIONS

| Recommendation for AC | | |
|---|---|---|
| Existing AC .. | 363600 unit/year | Rs 181899/year |
| 5 * rated godrej split AC .. | 263304 unit/year | Rs 1316520/year |
| Investment is Rs 1908000 .. | Payback Period is 3.8 years | |
| Unit Cons. /year before rec. 940240 unit | Unit Cons. /year after rec. 839944 unit | Savings Unit 100296 |

The table 3 represents the recommended AC with suggested units and saving units. It is recoded that 60 houses with three star, and 22 houses with five star and 50 houses without star rated refrigerators. It is suggested to replace all the non star refrigerators to five star rated 200watts LG brand. The observation from the survey on geyser indicates that, 23 geysers are installed before 10 years, 27 geysers are installed 12 years back and 40 geysers are installed for past 15 years. Since 40 geysers are around 15 years old, it is suggested to replace 40 geysers by Usha 15L SWH Aqua Genie Geyser of 2000 watt.

TABLE IV. OTHER RECOMMENDATIONS

| S.No | Item | Units/Year Bef. Audit | Units/Year Aft. Audit | Pay Back |
|---|---|---|---|---|
| 1 | Refrigerator | 259488 | 151488 | 1.7 |
| 2 | Geyser | 50400 | 28800 | 3.5 |

The observation from the above table 4, resulted with unit saving of 108000 for refrigerator and 21600 for geyser.

There are 69 separate motor in existing network of houses, in which most of the motors are over aged one. Operating over aged motor will result the following, resistive power will decrease, shaft get worn-out, coil will become weak, efficiency will decrease, overheating, sudden stopping of motor, noise production, draw heavy current and bearing problems. To overcome this, strong recommendations suggested by the authors to go for centralized motor pumping system arrangement. All the 69 motors installed in 69 houses are recommended to sell. All 69 motors are sold at Rs 1000 each. The money got after selling motors is Rs 69000. It is suggested to purchase seven 2HP submerged motor with cost Rs 112000, which will operate in a network to provide water to 69 houses. The invested money in buying 700 ft PVC water pipe for water supply is Rs 105000 and the total money invested is Rs 217000 with payback period of 1.8year.

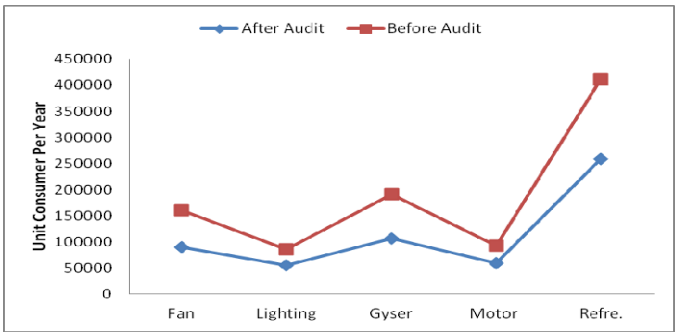


Fig. 8. Unit Consumed After and Before Audit

The figure 8 above represents the consolidative representation of all the major equipments in the house with the unit consumption per year after and before the audit. The unit consumed by AC after audit is 839944 and before audit is 940240. The considerable amount of savings is expected if the recommendations are implemented.

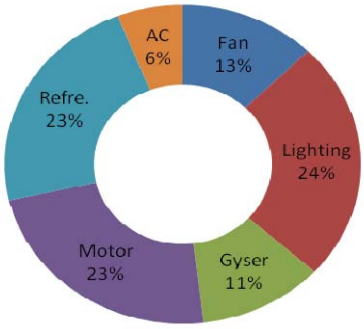


Fig. 9. Unit Savings Representations in Percentage

The pie chart in figure 9 represents the percentage of savings, when converted to 100% saving. It out lighted the ranking priority of implementation, lighting is given the first priority and followed by refrigerator. It is mandatory suggested to implement the recommendation in the network through ETAP simulation and counter check the outcome of savings.

### *B. Design of MicroGrid*

A micro grid is a local energy grid with control capability, which means it can disconnect from the traditional grid and operate autonomously. The authors have proposed installation of micro grid consist of solar panel and wind mills for 75 houses which are present in the same street. This area is chosen for micro grid installation, because these particular streets consist of cluster of residential houses.

TABLE V. CUSTOMER REQUEST FOR LOAD

| Type of House | No. of House | Requested load from Customer for MG (Watt) |
|---|---|---|
| SBH | 20 | 1960 |
| DBH | 30 | 4920 |
| TBH | 25 | 5750 |
| Total | 75 | 12360 |

The table 5 shows the type of houses and the customer request for minimum load capacity to run their house with renewable power. The recommended MG design data is presented below.

TABLE VI. MG DESIGN

| S.No | Micro grid design ( Theoretical Calculation) |
|---|---|
| 1 | Total connected load to micro grid is = 12.63 KW |
| 2 | Load Connected to the PV module = 8.84 kw( 70% of total load) |
| 3 | Usage of 9 hours per day = 79.56 kwh<br>Total pv panel energy need = 85.23*1.3<br>= 103.428 Kwh (110799 wh) |
| 4 | Panel generation factor for Chennai = 5.7<br>= 18145.263 watt hour |
| 5 | Theoretically for generation of 85.23 kwh of power we need 92 solar panels of 200 watts |
| 6 | Total power to be generated from the wind turbine is 3790 w of 4 wind turbine of 1kW each |
| 7 | Battery required 120 kwh, battery of 20 kwh in 6 numbers is to be used. |
| 8 | Inverter required for 45 numbers for 200 watt each |

The table 6 shows the basic requirement to install the MG with reference to the assumption calculation.

TABLE VII. PV PANEL DISTRIBUTION

| No. of House | Power Cons. (Whr/day) | PV Panel Energy Needed | No. of PV Panel Needed |
|---|---|---|---|
| 11 | 19800 | 257400 | 23 |
| 26 | 32724 | 42541 | 38 |
| 8 | 12402 | 16122 | 15 |
| 4 | 5004 | 6505 | 6 |
| 10 | 9468 | 12308 | 10 |
| Remaining 12 houses are supplied power from wind turbine which require 3.7 kw of power | | | |

The total required number of 92 PV panel is distributed according to the existing installation space constrains and the acceptance from the customers roof top. Five locations are identified to install the solar panel and two locations are identified for erection of wind turbine. This is represented in the above table 7.

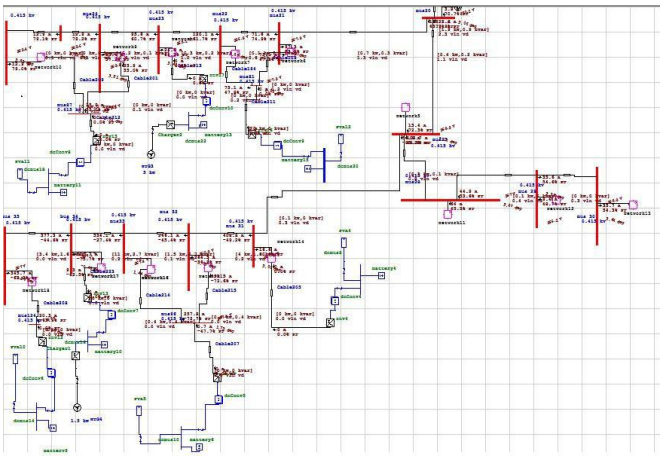

Fig. 10. MG Implementation in ETAP

The implementation of solar and wind in the existing system as suggested by the recomm. are presented in fig.

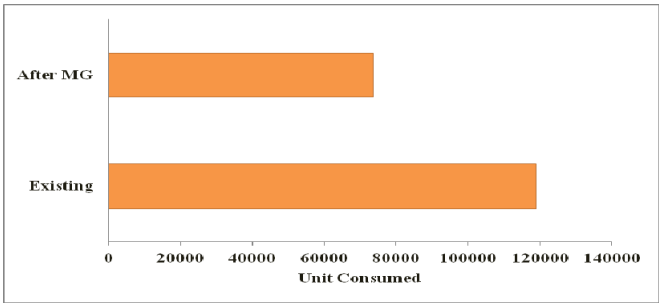


Fig. 11. Unit Consumed Before and After MG

The figure 11 represents the unit consumed in the existing system and the unit consumed after implementation of Micro Grid. The unit saved under full operation of MG is 45468. The calculated percentage of savings is 39%.

## V. IMPLEMENTATION IN ETAP

It is difficult for us to check practically, the suggested recommendation will provide effective performance. Before implementation in reality, the complete recommendations is implemented in ETAP simulation and tested for effectiveness of the proposed work. The simulation outcome of the major recommendation for 132 houses and MG implementations are presented in this section.

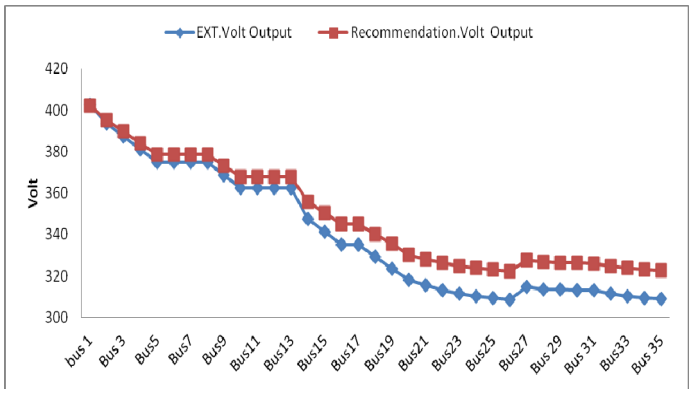


Fig. 12. Bus Volt. Profile After Recommendation

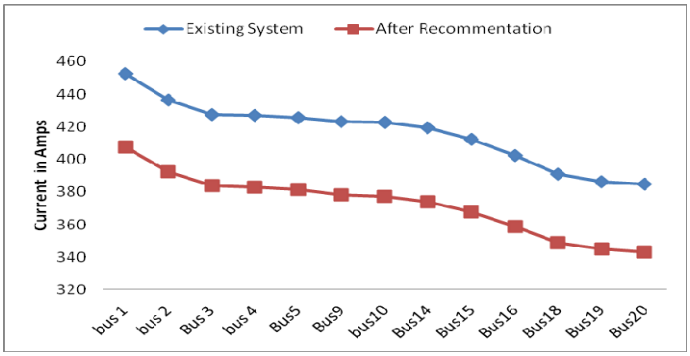


Fig. 13. Load Current Profile After Recommendation

The above 12 and 13 figures presented how the changes in the bus voltage and load current represented for improvement. The voltage graph indicates that the existing system performed very poor with the tail end voltage of 310 volts under connected load condition. It is good indication that the voltage performance is improved to 330 volts in the tail end, after all the suggested recommendations implemented. The current graph indicates that the proposed system performed well, with reduction in the load current of 40amphere.

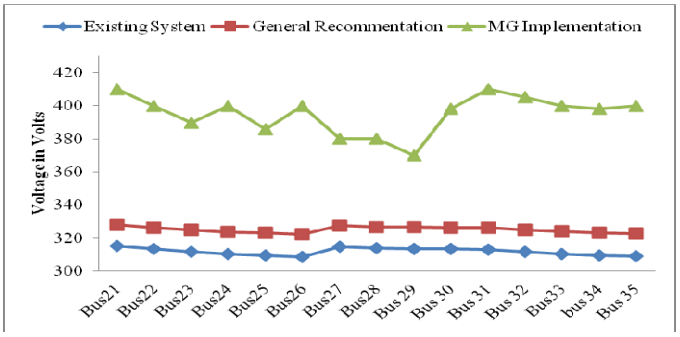


Fig. 14. Bus Voltage Profile after MG Recommendation

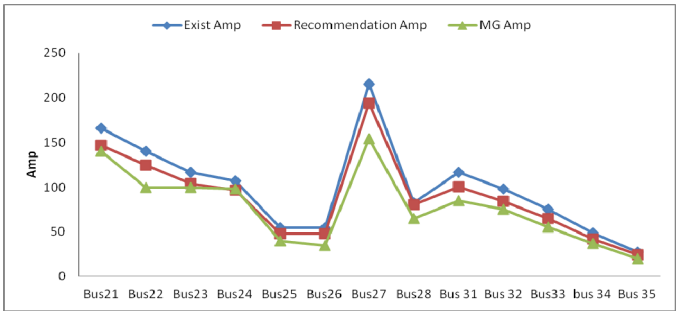


Fig. 15. Load Current Profile after MG Recommendation

The above 14 and 15 figures presented how the changes in the bus voltage and load current represented, when MG is connected to the existing system. The voltage profile improved well from 330 volts to 400 volts. The current graph indicates that the proposed system performed well, with reduction in the load current of 20amphere.

## VI. Conclusion

The power audit is conducted for 132 houses and concluded better recommendation to operate the existing system with MG. The following observations are made after the execution of the work, the increase in Voltage Potential with the introduction of Micro grid, the cost of solar panel/Wind mill will brought back to consumers through payback period, the supply frequency and reliability of power will be more with implementation of micro grid, introduction of micro grid in the existing system will bring much relief to the Utility. After Implementation of micro grid unit consumed per year will have the reduction of 61% (saving of 39% amount)

## *Acknowledgment*

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