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Analysis for Residential Electricity Consumption in A Community Micro-grid System

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Abstract: *For residential electricity users, the greatest electricity consumption is generally due to use of various electric appliances, like lighting devices, air conditioners, washing machines etc., for each user. With increasing use of electricity by these users, traditional fuel-type power generations may not able to provide sufficient electricity due to a lacking system upgrade. Furthermore, electricity users are not able to take initiative in participating in demand regulation under the single-direction power flow situation. This may force residential electricity users to face the risk of power outage. To overcome the problem, an application of the micro-grid is thus introduced, integrated into electric grid to provide sustainable energy sources for electricity supporting services to multiple electricity customers within a community. In this paper we proposed a model which generate the electricity by suing solar and thermal and provided to micro grid for fulfill the domestic user electricity demand.*

Keywords: Renewable energy, photovoltaic system, solar system, hybrid, simulation, modeling, grid power.

Introduction

Energy resources will play an important role in the world's future. The energy resources have been split into three categories: fossil fuels, renewable resources, and nuclear resources. Renewable energy sources (RES) are also often called alternative sources of energy. RES that use domestic resources have the potential to provide energy services with zero or almost zero emissions of both air pollutants and greenhouse gases. RES are biomass, hydropower, geothermal, solar, wind, and marine energies. The renewable are the primary energy resources. Renewable energy is a clean or inexhaustible energy like hydrogen energy and nuclear energy. RES occur naturally in the environment and, therefore, should never run out. They also produce lower or negligible levels of greenhouse gases and other pollutants when compared with the fossil energy sources they replace. RES are derived from those natural, mechanical, thermal, and growth processes that repeat themselves within our lifetime and may be relied upon to produce predictable quantities of energy when required. RES reduced environmental effects compared to fossil fuels.

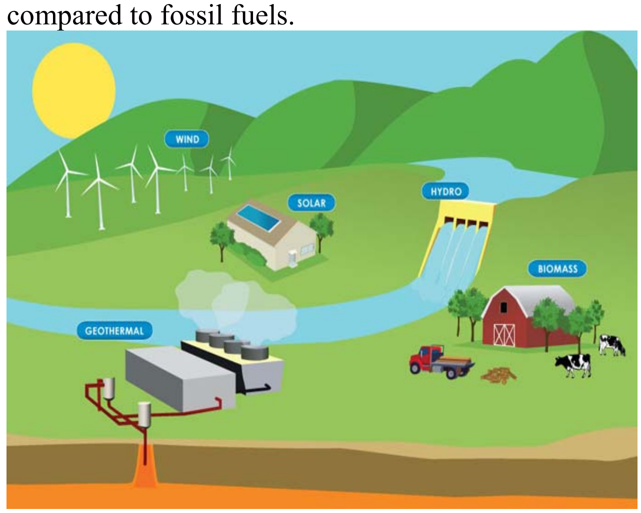

Fig 1: Energy resources.

The exponential increase in global energy demand is the main cause of rapid depletion of fossil fuels and increased greenhouse gas emissions of conventional generators (CGs). To overcome these problems, the world has taken initiatives to deploy renewable energy resources (RERs) on a large scale, in order of GW, since a decade. The RERs, such as solar, wind, biomass, hydro, and tidal power are one of the most important sources in providing clean energy and mitigating greenhouse gas (GHG) emissions for sustainable development. United Nations Sustainable Development and Paris Climate Agreement goals also promote installation of RERs. RERs, micro CGs, and energy storage systems (ESSs) are often described as distributed energy resources (DERs) in the literature. DERs are on-site generation sources in distribution system. Hence, no transmission equipment is required for power transfer to load ends. In DERs, the RERs, particularly solar and wind energy are volatile and intermittent energy sources. Therefore, ESSs and micro CGs are needed to overcome these uncertainties. The integration of DERs into distribution network requires the optimal sizing, control, and scheduling of these energy resources. A microgrid (MG) embodies these issues by integrating DERs into power grid, together with an ability to operate in an islanded mode during main grid failure. Hence, it helps in achieving objectives of efficient transformation of the passive network into an active one, bidirectional and controlled power flow management, reliable and continuous supply, power quality enhancement, and clean environment [18].

The water in rivers and streams can be captured and turned into hydropower, also called hydroelectric power. Hydropower is also inexpensive, and like many other renewable energy sources, it does not produce air pollution. Large scale hydropower provides about one-quarter of the world's total electricity supply, virtually all of Norway's electricity and more than 40% of the electricity used in developing countries. The technically usable world potential of large-scale hydro is estimated to be over 2200 GW, of which only about 25% is currently exploited. There are two small-scale hydropower systems: micro hydropower systems (MHP) with capacities below 100 kW and small hydropower systems (SHP) with capacity between 101 kW and 1 MW. Large-scale hydropower supplies 20 percent of global electricity. In the developing countries, considerable potential still exists, but large hydropower projects may face financial, environmental, and social constraints (UNDP, 2000). The two small-scale hydropower systems, which are being discussed in this section are the sites with capacities below 100 kW (referred to as micro hydropower systems) and sites with capacity between 101 kW and 1 MW (referred to as small hydropower systems). Micro hydropower (MHP) systems which uses cross flow turbines and pelton wheels can provide both direct mechanical energy (for crop processing) and electrical energy. However, due to design constraints, turbines up to a capacity of 30 kW are suitable for extracting mechanical energy. Of the total installed capacity of about 12 MW of MHP systems, half is used solely for crop processing. The most popular of the MHP systems is the peltric set, which is an integrated pelton turbine and electricity generation unit with an average capacity of 1 kW. MHP systems are sometimes described as those having capacities below 100 kW, mini hydropower plants are those ranging from 100 to 1,000 kW and small hydropower (SHP) plants are those that produce from 1 to 30 MW. Small hydropower is one of the most valuable energies to be offered to the rural community's electrification. Small hydroelectricity growth can decrease the gap of decentralized production for private sector and municipal activity production.

As an energy source, geothermal energy has come of age. Geothermal is a type of thermal energy generated and stored within the Earth. It has been used throughout history for bathing, heating and cooking. Geothermal energy is created by radioactive decay, with temperatures reaching 4,000˚C at the core of the Earth. While geothermal energy is available worldwide, there is an important factor called the geothermal gradient that indicates whether a region is a favored place for enactment. It measures the rate at which the temperature increases as the depth of the Earth increases. The geothermal gradient is not the only tool used to measure the accessibility of geothermal energy. The permeability of rocks, which determines the rate of flowing heat to the surface, is considered to be another important measure in the availability of geothermal energy. Geothermal energy has a major advantage compared to wind and solar energy in that it is available 24 hours a day through the year.

A solar PV module is composed of many solar cells connected in a series and parallel combination to fulfil the system requirements of voltage and current rating. Series connection defines the PV module output voltage while parallel connection of the cells determines what the PV module output current is. For understanding the operation characteristics of a solar PV, Fig 2 below shows an example of solar photovoltaic system [13].

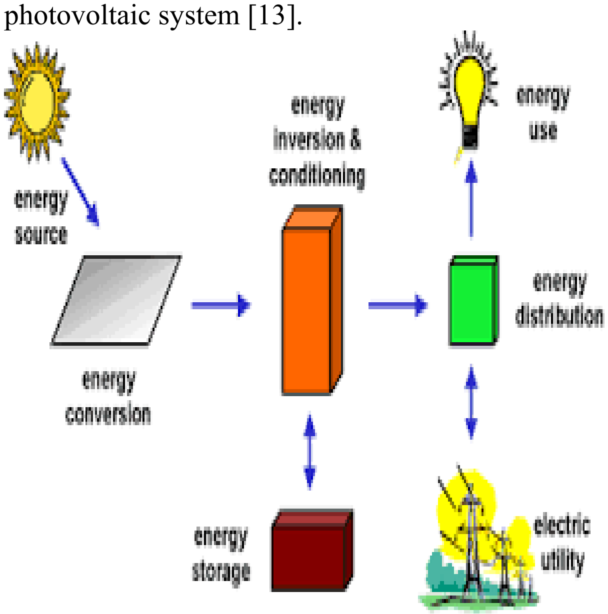

Fig 2: Solar Photovoltaic System Architecture.

The potential energy of falling water, captured and converted to mechanical energy by waterwheels, powered the start of the industrial revolution. Wherever sufficient head, or change in elevation, could be found, rivers and streams were dammed and mills were built. Water under pressure flows through a turbine causes it to spin. The Turbine is connected to a generator, which produces. In India the potential of small hydro power is estimated about 10,000 MW. A total of 183.45 MW small Hydro projects have been installed in India by the end of March 1999. Small Hydro Power projects of 3 MW capacities have been also installed individually and 148 MW project is under construction. Small Hydro Power is a reliable, mature and proven technology. It is non-polluting, and does not involve setting up of large dams or problems of deforestation, submergence and rehabilitation. India has an estimated potential of 10,000 MW. Hilly regions of India, particularly the Himalayan belts, are endowed with rich hydel resources with tremendous potential.

Geothermal energy for electricity generation has been produced commercially since 1913, and for four decades on the scale of hundreds of MW both for electricity generation and direct use. The utilization has increased rapidly during the last three decades. In 2000, geothermal resources have been identified in over 80 countries and there are quantified records of geothermal utilization in 58 countries in the world. Table 9 shows the status of geothermal energy. In Tuscany, Italy, a geothermal plant has been operating since the early 1900s. There are also geothermal power stations in the USA, New Zealand, and Iceland. In Southampton (UK) there is a district heating scheme based on geothermal energy. Hot water is pumped up from about 1,800 meters below ground. Direct application of geothermal energy can involve a wide variety of end uses, such as space heating and cooling, industry, greenhouses, fish farming, and health.

The rest of this paper is organized as follows in the first section we describe an introduction of different types of energy sources, applications of solar and thermal energies. In section II we discuss about the literature review about simulation-based electricity analysis scheme. In section III we discuss about proposed and experimental work for Development of a Modelling and Simulation Method for Residential Electricity Consumption, and finally in section IV we conclude the about our paper.

II. Related Work

[1] In this paper, author aimed to develop a simulation-based electricity analysis scheme for a real community microgrid configuration using a proposed modeling methodology, simulation mechanisms, and a power balancing control strategy under the MATLAB environment. Simulation results of this paper considering different weather conditions reported the observed performance of electricity analysis. Calculations of electricity bills depending on two electricity rates are also discussed. It also represented the benefits of electricity bill reduction when electricity users accepted the power supply from community microgrid systems. This paper also presented an effective simulation mechanism under the MATLAB/Simulink environment for the electricity analysis in C-ugrid systems, and it can flexibly be modified so as to comply with different simulation requirements when faced with various system topologies.

[2] In this paper, author presents the potential role of thermal power generation in a future power system with high shares of variable generation while considering different sources of demand side flexibility such as heat pumps and heat storages in district heating, demand response from industries and electric vehicles. The research in this paper is carried out using a generation planning model combined with a unit commitment and economic dispatch model. The results from the planning model show a strong shift away from combined cycle gas turbines to open cycle gas turbines and gas engines as the share of wind power and solar photovoltaic increases. Demand side flexibility measures pushed this trend further. The results from the unit commitment and economic dispatch model of this paper demonstrate that the flexibility measures decrease the ramping frequency of thermal units, while the ramp rates of thermal units remain largely unchanged or increased. This indicates that the flexibility measures can cover smaller ramps in the net load more cost-effectively but that thermal power plants are still valuable for larger ramps. Impacts on emissions and electricity prices are also explored.

[3] In this paper, author presents a status review of the technical issues that may appear under the community grid scenario. Building upon the surveyed issues, this paper also reviews and discusses approaches to solutions, which are required in order to make the community grid highly renewable and sustainable. To achieve the de-carbonization of grid network and empowering energy citizens, a way of penetrating high renewable in the low voltage distribution network through the development of community grid is presented here. This will allow multiple integration of µGens and other DGs in a sustainable way. With all of improvements in DER based integrated energy system development and integration, maintaining the grid stability, improved power quality and efficient energy management with high penetration of renewable from a large number of micro-generation systems in the distribution network are still a matter of great concern. Therefore, a concept of community grid structure in the form of virtual microgrid embedded in the distribution network is presented in this paper. A major goal of this proposed community grid structure is to increase renewable energy usage by facilitating the consumer transition to active prosumers, and giving them a scenario to develop the solution using their existing setup.

[5] In this paper, author proposed a DSM scheme for electricity expenses and peak to average ratio (PAR) reduction using two well-known heuristic approaches, the cuckoo search algorithm (CSA) and strawberry algorithm (SA).This paper also proposed a smart home decides to buy or sell electricity from/to the commercial grid for minimizing electricity costs and PAR with earning maximization. It makes a decision on the basis of electricity prices, demand and generation from its own microgrid. The

microgrid consists of a wind turbine and solar panel. Electricity generation from the solar panel and wind turbine is intermittent in nature. Therefore, an energy storage system (ESS) is also considered for stable and reliable power system operation. Author also tested their proposed scheme on a set of different case studies. The simulation results of this paper confirm author's proposed scheme in terms of electricity cost and PAR reduction with profit maximization.

[6] In this paper, author proposed design considerations to transform the Malta College of Arts, Science and Technology (MCAST) current and future planned electrical network system into an efficient micro-grid. During this study, consumption of electrical loads and photovoltaic (PV) generation has been monitored by author in real-time to define the micro-grid concept. These measurements provide the values to integrate a combined 63kWp PV system together with intelligent loads such as heating, ventilation and air conditioning systems, and lighting, highlighting the integration capabilities. The future enlargement of the MCAST micro-grid is also considered and recommendations are given on the infrastructure to complete an integral campus wide transformation. Eventually the 3DMgrid would be a blueprint for future micro-grids for training purposes. This paper also results real measurements obtained by main 400 V feeders within a realistic MCAST Pilot Micro Grid campus. The analysis of this paper is used to design the micro grid requirements and plan future expansion within the campus as well as energy storage systems and increase renewable energy and electrical energy systems. In addition, the demand and consumption curves of a real micro grid are also parameterized by the author, which is susceptible to serve as a test bench for other studies in this field.

[7] In this paper, author proposed a novel method for the microgrid energy management problem by introducing a nonlinear, continuous-time, rolling horizon formulation. The method is linearization-free and gives a global optimal solution with closed loop controls. It allows for the modelling of switches. They also formulated the energy management problem as a deterministic optimal control problem (OCP). They also solved (OCP) with two classical approaches, the direct method and Bellman's Dynamic Programming Principle (DPP).In both cases, author has used the optimal control toolbox Bocop for the numerical simulations. For the DPP approach, they implemented a semi-Lagrangian scheme adapted to handle the optimization of switching times for the on/off modes of the diesel generator. The DPP approach allows for accurate modelling and is computationally cheap. It finds the global optimum in less than one second, a CPU time similar to the time needed with a Mixed Integer Linear Programming approach used in previous works. They achieved this result by introducing a 'trick' based on the Pontryagin Maximum Principle. The trick reduces the computation time by several orders and improves the precision of the solution. For validation purposes, authors have performed simulations on datasets from an actual isolated microgrid located in northern Chile.

[9] The main objective of this paper is to provide a comprehensive literature review to identify, classify, evaluate and analyze the performance of different methodologies, models and energy systems for isolated areas. Therefore, effective information could be provided to support decision making toward to appropriate energy models and systems for isolated areas with different scales and demands. This paper has also reviewed the forecasting techniques of energy demand and renewable energy (RE) resources, energy models, application of hybrid RE systems (HRESs), and management of energy planning for two most representative isolated areas: islands and remote villages. The uncertainty analysis of energy systems of isolated areas is also discussed. It is evident that the indigenous RE resources show great potentials for the energy system of isolated areas, especially the solar and wind resources. The various combinations of photovoltaic (PV), wind,

diesel and batteries have been proven more competitive. Also, it is necessary to develop sophisticated models that are more applicable to isolated areas and that consider the distinctive characteristics, practical needs and uncertainties of isolated areas. In this paper, various forecasting techniques for both energy demand and RE were identified and classified. The developed approaches suitable for isolated areas based on conventional forecasting techniques were surveyed. The evolution of modeling approaches was also explored, and the applicability of these models for isolated areas was analyzed. The roles of RE and HRES in isolated areas were evaluated, and the application of various configuration of HRESs for different isolated areas were investigated. The management including policy effect on energy planning of isolated areas were discussed with two typical representatives: islands and remote villages.

[10] In this paper, author investigates the economic adoption of microgrids, focusing especially on community-scale systems. Feasibility analysis results in the case study countries Portugal and Japan, as well as sensitivity analyses to various grades of change in demand factors such as customer mix, demand characteristics, and the uncertainty of end-use demand, are presented. The result of this paper shows that the characteristics of the demand are at the heart of microgrids financial attractiveness. High values of HPR and HEC unlock energy efficiency opportunities linked to CHP, while high load factors allow DG to more appropriately run within their operational constraints. Also, generally, community microgrids form more attractive investments than single microgrids, and can be specifically designed for optimal financial performances. Single microgrids are sensitive to demand oscillations, while community microgrids are more resilient, taking various levels of variability while still running economically. This paper also explores the sensitivity of unsubsidized such investments to various grades of change in demand factors such as the customer mix, the demand characteristics (heat-power ratio – HPR, heat-electric coincidence – HEC, and electric and thermal load factors – Lfe and LFth, respectively), and the uncertainty of the end-user demand.

III. Proposed Work

With economic growth driving a gradual increase in electricity demand, electric power systems have recently introduced advanced grid or new energy technologies to satisfy these demands. In many advanced electric grid technologies, the microgrid (ugrid) system is one of most important applications, acting as a controllable localized electricity supplier for providing reliable energy to area demand facilities, promoting energy savings, minimizing carbon emissions, and reducing electricity bills for electricity users. The major components of ugrid systems include distributed/renewable energy resources, different types of energy storage systems (ESSs), grid-connected and islanding operation mechanisms, and various real-time monitoring and management/control methods. The main purpose in the following simulations can be used to observe the home user electricity consumption under the considered scenarios by the proposed modelling methodology and simulation mechanism. The smart home is able to make decisions at every hour to shift the load, purchase, sell or store electricity. In this case, a smart home imports electricity when rates are low and in ON-peak hours the load requirement is met by the microgrid, and the excess electricity is sold back to the commercial grid against high prices. The smart home earns maximum profit with this activity.

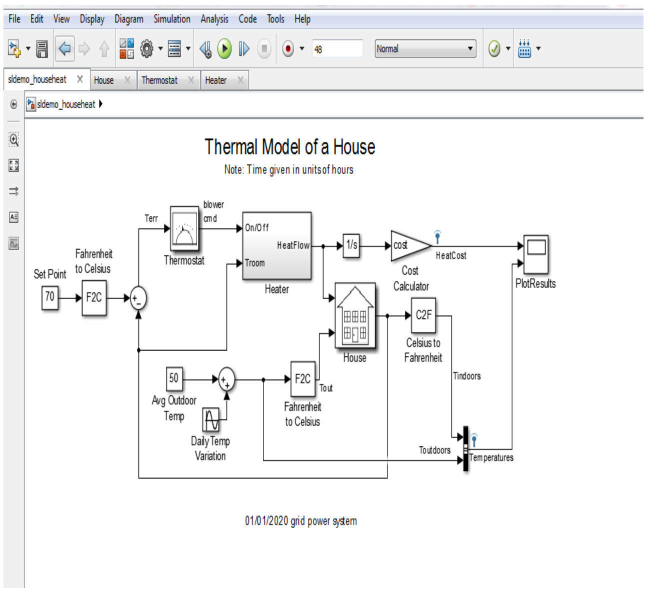

Fig 3: This figure shows Simulation model of a Domestic house.

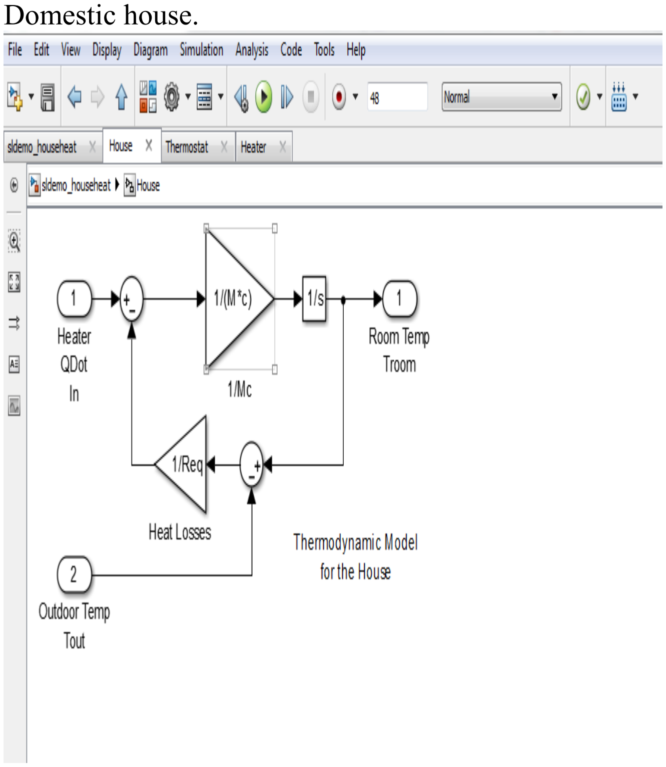

Fig 4: This figure shows the proposed thermodynamic model for the house.

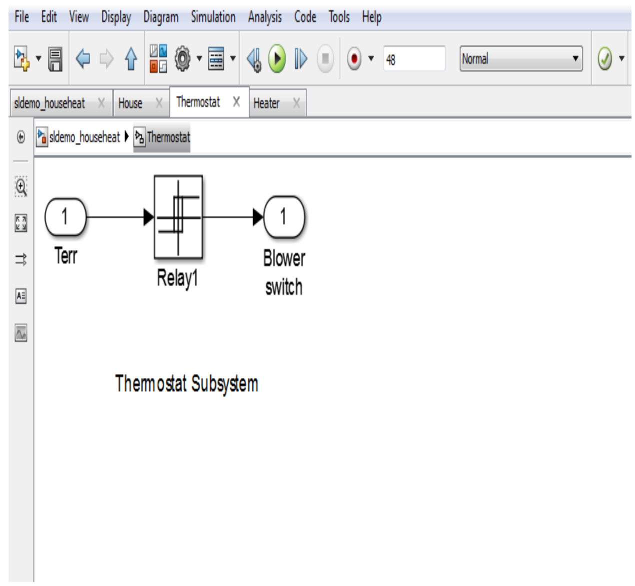

Fig 5: This figure shows the proposed thermostat subsystem.

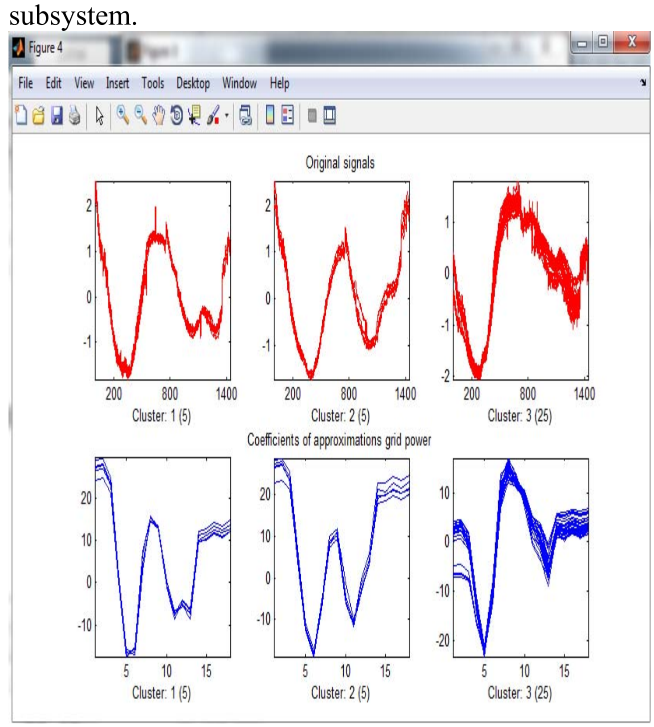

Fig 7: This figure shows the output signals for coefficients of approximations grid power.

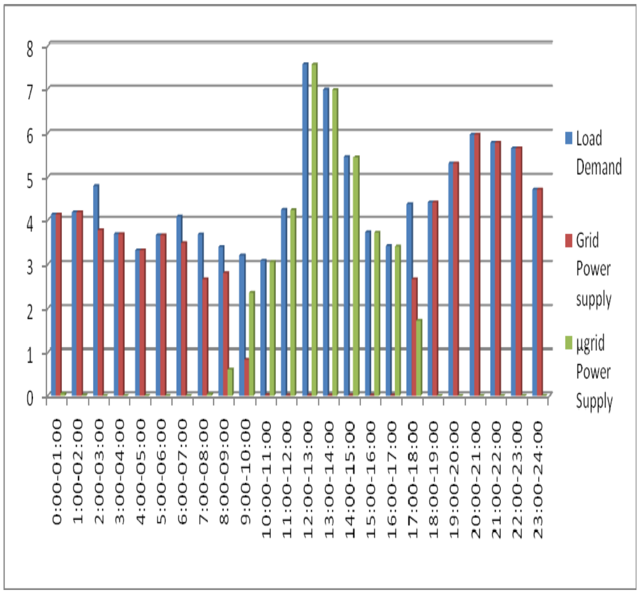

Fig 8: This figure shows the comparative analysis of load demand, grid power supply and µ grid power supply for 24 hours in Cloudy day.

VII. Conclusion

Understanding the use of electricity from different energy sources in a C-ugrid can be helpful for user demand management and system operation control. In this paper, a modeling and simulation methods for a C-ugrid system is developed to study electricity analysis of residential users. To study the performance of electricity analysis, proposed schemes that integrate solar and thermal modeling methodologies, implementation of real-time simulation. Two different weather scenarios, sunny and cloudy, are considered in simulations so as to observe the power supply capabilities among different energy sources to users in the C-ugrid.

The major contribution of this paper is to present an effective simulation mechanism under the MATLAB/Simulink environment.

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