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Research Article

Load Management Strategy in Smart Micro Grid

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Abstract

The smart load management, an aspect in smart micro-grids, is prototyped. The load management algorithm classifies the loads as primary, secondary and scheduled ones. A prioritizing algorithm, based on the mentioned classification, manages the loads in such a way that the primary loads are given the highest priority. In a three feeders case study environment, the availability of electrical power and the load requirements, are observed continuously to prevent overloading of feeders and tripping/shedding of loads. This is done by shifting the loads amongst the feeders based on the availability of power. This eliminated consumer irritation and in bigger picture it provides efficient utilization of the available power.

Keywords: *Smart Micro Grid, Load Management, Load Shifting, Consumer Choice, Load Scheduling, Proteous Software, Arduino UNO, Arduino Mega.*

Introduction

Smart micro grid is the upgradation of the ordinary grid station into smarter one and makes it automatic and decision making with the help of intelligent devices which is not in the case of ordinary grid station. The concept is enforced by an increasing demand of sustained and controlled electrical power. Analyst's calculations show that energy consumption is increasing every day. According to the UN data, incoming four decades population of our world will be double. Therefore, to meet the energy crisis, better power systems are needed.

The U.S.A department of energy developed the concept of a smart grid. San Diego was the place where the U.S.A installed the first smart grid (San Diego, 2006). The analyst's observed the effectiveness and technical feasibility of installing smart grid concept or smart grid technologies.

The concept of smart grid passed through evolution. In the start, smart grid technologies were created using simple pieces of equipment, metering, electric control and monitoring system. In 1980s, the automated meters were used to monitor load while in 1990 advanced metering infrastructure was used (Staff, 2006)

American Recovery and Reinvestment Act (ARRA) in the US is one of the biggest projects in the world. America has invested almost $9 million in this project. This concept is also working successfully in Austin. This project was started in 2003 and its main aim was to replace old meters with smart meters that will work through a wireless mesh network (Betsy Loeff, March 2008). In Colorado, the first smart grid project was completed in 2008. In this project, the smart meter had used as a gateway to the home automation network. This system controls all devices and sockets (Betsy Loeff, March 2008). German Power Company has planted a project named 'MoMa' in Mannheim city. This project is based on broadband power line technique (Ali, 2011). Canada has planted a large smart grid project in Ontario, named Hydro-1. This project is serving almost 1.3 million customers in the area of Ontario. This initiative has won an award from the utility planning network (Leccese F, May 2012) (Galvin R, Yeager K., July 2008) (John, Jeff , November 17, 2009).

Upgradation of current system with the load management strategy in smart micro grid done with the help of software simulation as well as hardware prototype which reduces overloading problem and equally distribute the load among all the feeders. Proposed strategy manages the load according to the load priority, time preferences and availability of power along with the consideration of over voltage, over load, short circuit and under voltage.

The paper is organized as follows: Section II includes Description of Load Management Strategy. Section III includes Software Simulation. Section IV incudes Hardware Simulation. Section V includes Result and Discussion. Section VI includes Concluding Remarks and Section VII includes References.

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Description of Load Management strategy

Load managing and load scheduling is the important feature of the smart micro grid. There are many strategies developed for smart grid power utilization but one such study conducted is the load management and load scheduling in smart micro grid is done with the help of Virtual environment Proteous and Hardware Prototype. Strategy illustrate the utilization of power in effective manner by classification of loads in Primary, Secondary and Schedule ones. Description of loads are given below.

Primary Load

Primary load is load's which are necessary for survival of consumer, i.e. Light in night time, Fan during summer, Heater during winter etc.

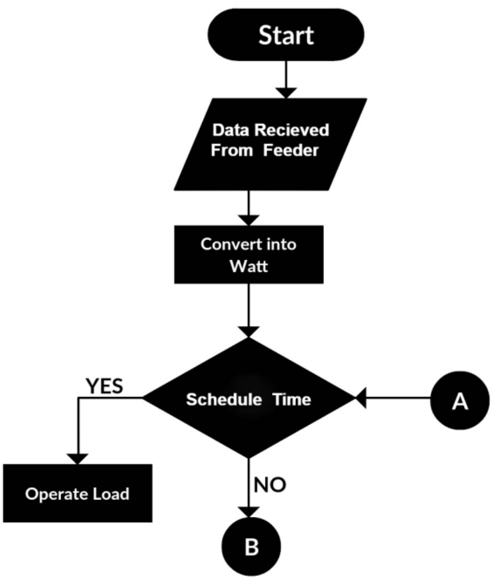
Secondary Load

Secondary load is load's which are optional by consumer i.e. Television, Oven, etc.

Schedule Load

Schedule load are the load which operate on the basis of power availability and time scheduling. These loads consumed much energy as compared to the previous ones and increased the electricity bill. i.e. Electric Iron, Pump motor etc.

A monitoring system is installed which continuously measure the power consumption and send command to perform required operation during running mode. Strategy is implemented on three feeder's which are at small distance with each other. These feeders are wirelessly controlled by the main feeder. High Priority is set for primary, Secondary load is at less priority then primary and schedule load are at least priority among all loads. Fig.1 Show the Flow chart of proposed strategy in smart micro grid.



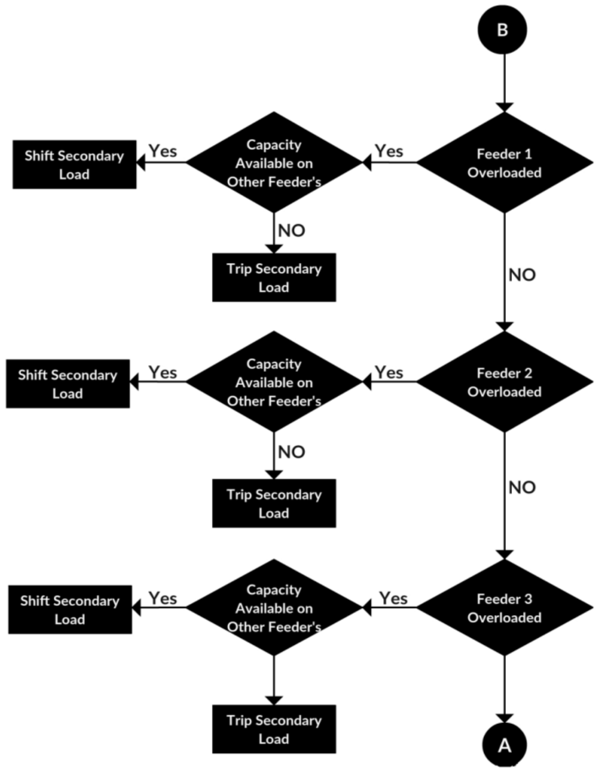


Figure 1 Flow Chart of Load Management Strategy

Software simulation of proposed strategy in smart micro grid is done on the Proteous software and divided into two parts.

- Simulation of feeder
- Simulation of grid

The data of every feeder sent to main feeder and main feeder respond according to the logics which we are done in programming. The arduino software is used as programming platform. Each feeder has three types of loads classified as:

- Primary Load
- Secondary Load
- Schedule Load

Feeders Simulation

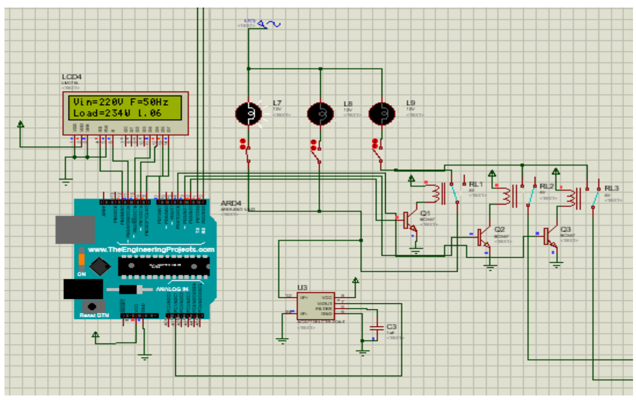


Figure 2 Feeders Simulation

In feeder's simulation 220V supply is connected with loads parallel to each other and each load is controlled by switch. A current sensor is connected in series with load to measure current of feeders. Input of the sensor is current while output is analogue signal from 0 to 5V and its value is in between 0-1023 according to load current. when load is on current is draw from load which is sense by current sensor. Output pin of current sensor is connected with arduino where logical programming calibrates the sensor for exact value of current. After calculation of current, power is obtained by multiplying the current with voltage. On feeder side three parameters voltage, current, and power is displayed at Liquid Crystal Display (LCD). Fig.2 shows feeders simulation.

Grid Simulation

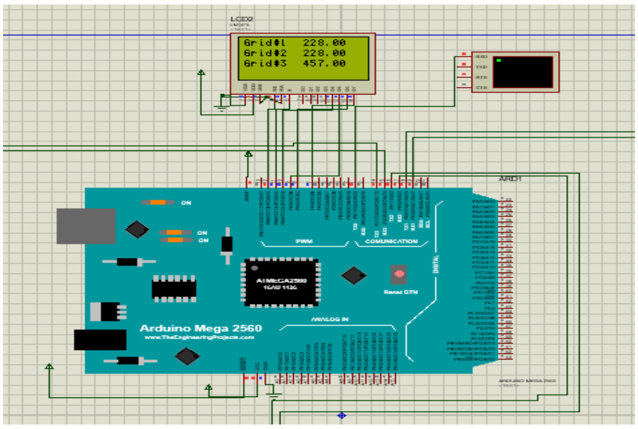


Figure 3 Grid Simulation

Loads of each feeder managed according to availability of power by grid. Running wattage of each feeder are displayed at Grid side using LCD.Fig.3 shows the simulation of grid.

Complete Simulation

Complete simulation consists of both feeders and grid simulation combined. Fig.4 shows the complete simulation.

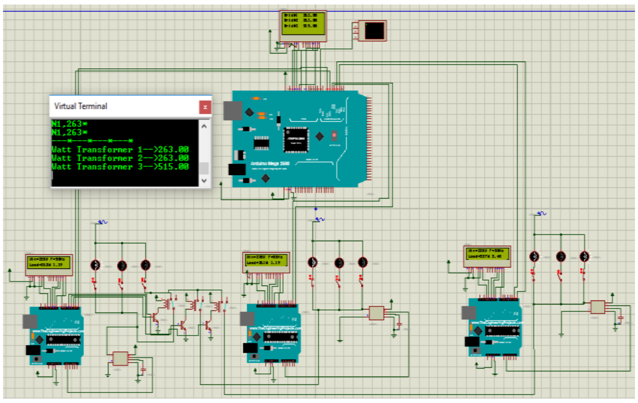


Figure 4 Complete Simulation

Hardware Simulation

Hardware implementation of proposed strategy is done in following steps:

Implementation of Grid Transformer

Shell type transformers are used to limit the output to 250 VA because decision is taken at low level. Actually, these transformer takes 220V at input and provide 220V at output with power rating of 250 VA each. Fig.5 shows grid transformer implementation.

Figure 5 Implementation of Grid Transformer

Implementation of Grid Control Circuitry

Grid circuitry consist of arduino mega,20x4 LCD, HC-11 wireless module etc. Control circuitry operate the relays as per signal of main controller and shift the loads among feeders. Data of each feeder is displayed on liquid crystal display.Fig.6 shows Grid control circuitry implementation.

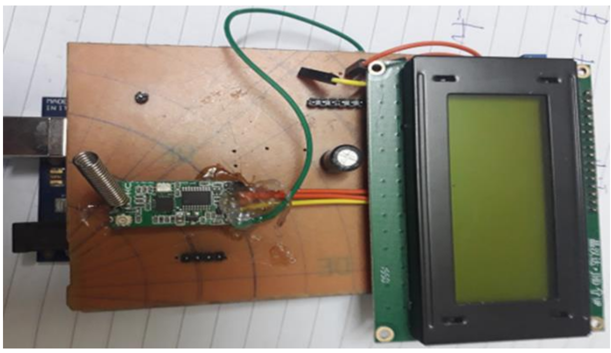


Figure 6 Implementation of Grid Control Circuitry

Implementation of Feeder Control Circuitry

Feeder control circuitry consists of different relays and Integrated Circuits (IC). It has five electromagnetic relays which is used to switched load's as per requirement. Each feeder contains one relay for primary, one for secondary and three for schedule load. To operate these relays an IC uln2803 consists of transistor having eight outputs is used. Fig.7 shows feeder control circuitry implementation.

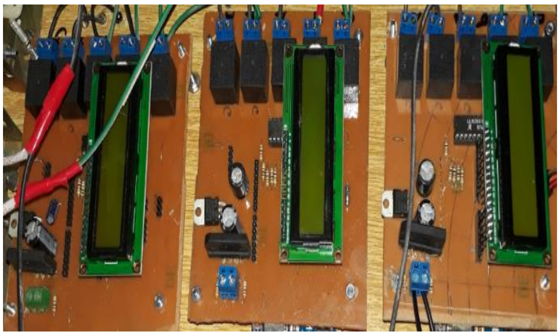


Figure 7 Implementation of Feeder Control Circuitry

Implementation of Load Unit

Load unit consist of three types of loads for each feeder. Switches are used to operate load's manually. Fig.8 shows the implementation of load unit.

Figure 8 Implementation of Load Unit

Implementation of Complete Hardware

Complete hardware consists of plug, transformers, current sensors, load unit, stepdown transformer, liquid crystal display, arduino uno, arduino mega, relays etc. Plug provide main supply from socket. Transformer are used to limit the power requirement. Current sensors acs712 are used to measure current for each feeder. A 220/12v step down transformer and voltage regulator 7805 is used to turn on the LCD and Arduino after rectification through bridge rectifier. All these components are combined at a single board. Fig.9 shows complete hardware implementation.

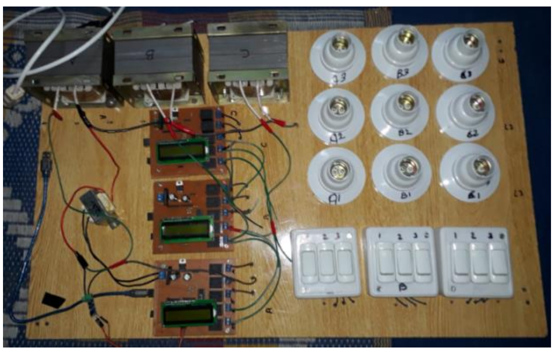


Figure 9 Implementation of Complete Hardware

Result and Discussion

Proposed strategy is performed on practically on Hardware prototype and different result obtained which are shown below:

Load management strategy among feeders without schedule Load

Case 01

When one feeder will be overloaded it will check the availability of power on nearest feeder, if power available it will shift secondary load on that feeder, otherwise it will move to next case. Fig.10 shows hardware result of case 01 and Fig.11 shows real time arduino plotter result of case 01.

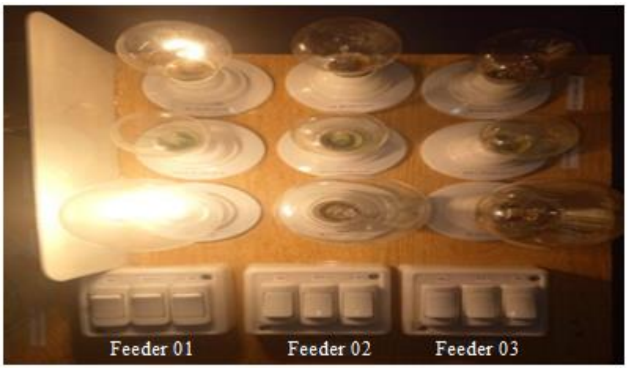


Figure 10 Hardware Result Case 01

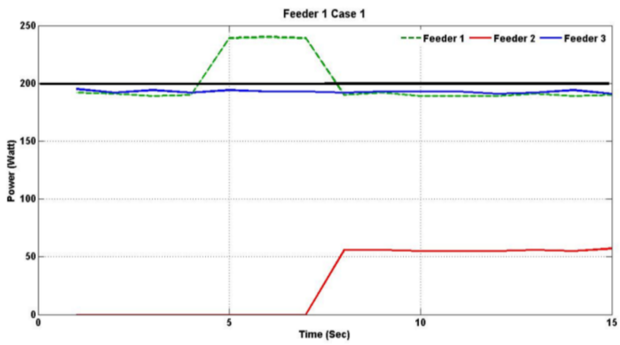


Figure 11 Real time arduino plotter result of case 01

Case 02

When one feeder will be overloaded and power is not available with nearest feeder it will check power availability next to nearest feeder, if power available it will shift secondary load on that feeder, otherwise it will move to next case. Fig.12 shows hardware result of case 02 and Fig.13 shows real time arduino plotter result of case 02.

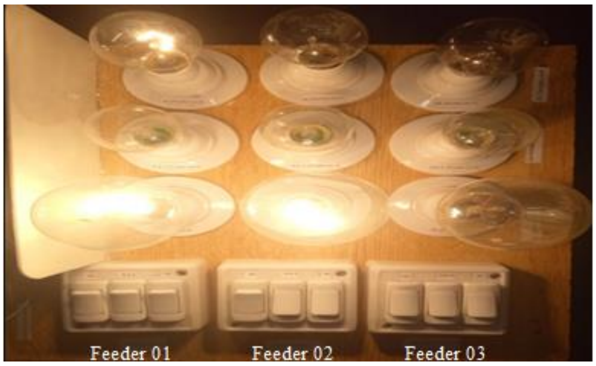


Figure 12 Hardware result of case 02

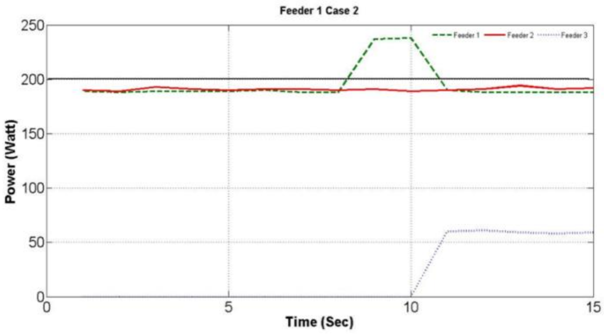


Figure 13 Real time arduino plotter result of case 02

Case 03

If power capacity is not available on any feeder it will trip the secondary load. Fig.14 shows hardware result of case 03 and Fig.14 shows real time arduino plotter result of case 03.

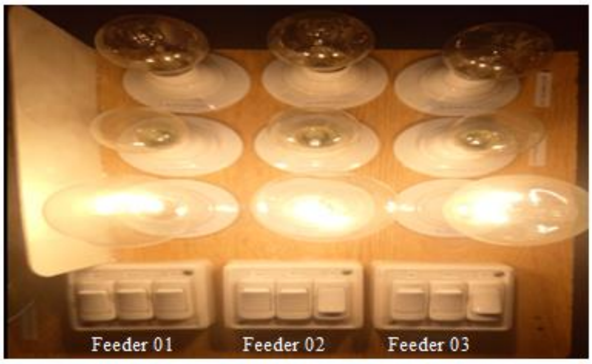


Figure 14 Hardware result case 03

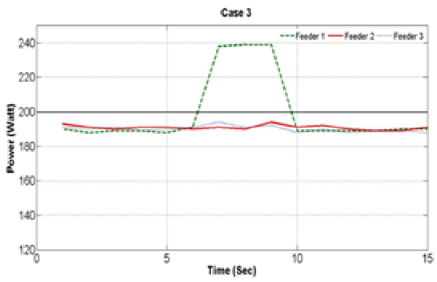


Figure 15 Real time arduino plotter result of case 03

Cases for Schedule Load

Case 01

During time of schedule load if capacity available on feeders then schedule load will be on in normal condition. Fig.16 shows hardware result of schedule load case 01 and Fig.17 shows real time arduino plotter result of schedule load case 01.

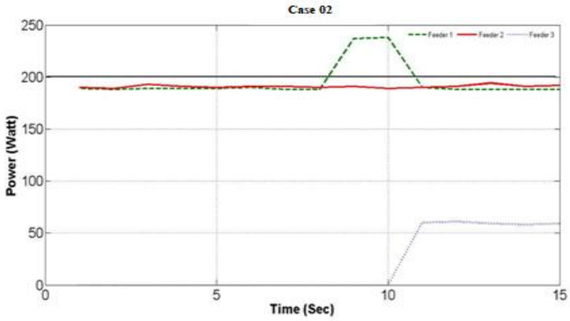


Figure 16 Hardware result schedule loads case 01

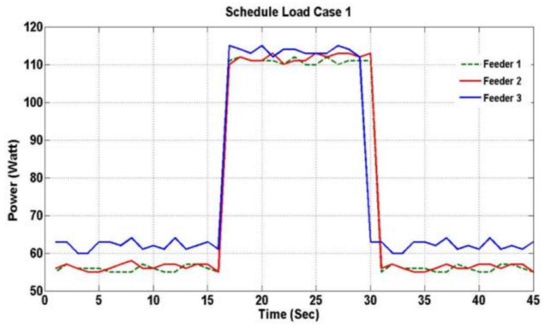


Figure 17 Arduino plotter result of schedule loads case 01

Case 02

If feeders are overloaded due to schedule load, then trip the secondary loads first then check if capacity is still not available due to primary load, then trip schedule loads as well because primary loads are at higher priority. Fig.18 shows hardware result of schedule load case 02 and Fig.19 shows real time arduino plotter result of schedule load case 02.

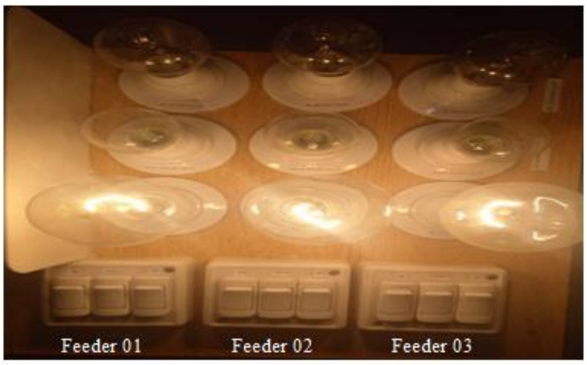


Figure 18 Hardware result of schedule loads case 02

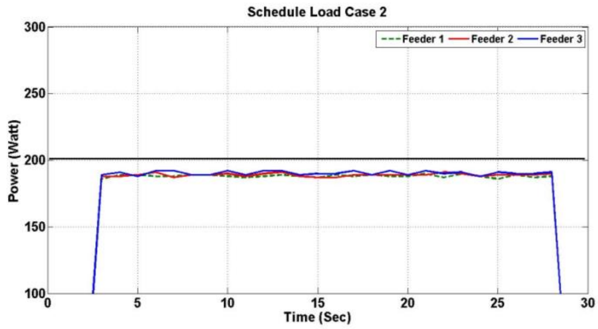


Figure 19 Real time arduino plotter result schedule loads case 02

Concluding Remarks

The aim of proposed and implemented strategy is to make a grid station more reliable, efficient by using intelligent devices. On many occasions, when a load on one feeder increases or decreases from the required range, options are leave to change the path of current by diverting load from one feeder to another feeder. Overload, under load, short circuit, problem was faced so need of such a smart micro grid occurs that has an ability to shift load from one feeder to another feeder. Different intelligent devices are used to make system automated and decision making. Beside automated operated system there is still problem of shifting loads among feeders automatically. In ordinary grid stations in Pakistan there is no technology that shift the load during period of overloading of feeders. Effort is made to cope with such problems.

It is very difficult to shift load from one feeder to another without smart micro grid system. It provides safety of components and in case of over or under load it has ability to shift or trip load according to condition. Proposed and implemented strategy deals with the load shifting from one feeder to another feeder at the time of overloading and tripping the load at time of power shortage which increase the demand of project, by National Transmission and Dispatch Company (NTDC), Water and Power Development Authority (WAPDA), and power distribution companies. Project cost effective and efficient and can be implemented at any area of Pakistan as well as in other countries.

References

San Diego (October 17, 2006), Smart Grid Study, Final Report. Publication No.061017_SD Smart Grid Study Final

Staff, F. E. R. C (2006), Assessment of demand response and advanced metering, Federal Energy Regulatory Commission, Docket AD-06-2-000

National Energy Technology Laboratory (August 2007). "NETL Modern Grid Initiative — Powering Our 21st-Century Economy" (PDF). United States Department of Energy Office of Electricity Delivery and Energy Reliability 17. Retrieved 2008-12-06.

Betsy Loeff (March 2008),. AMI Anatomy Core Technologies in Advanced Metering, Altimetric Newsletter. Automatic Meter Reading Association (Utilimetrics)

Betsy Loeff (March 2008), AMI Anatomy Core Technologies in Advanced Metering, Ultrimetrics Newsletter. Automatic Meter Reading Association (Utilimetrics)

Ali, Tausif, Ahmed Al Mansur, Zubaeer Bin Shams, S. M. Ferdous, and Md Ashraful Hoque (2011), An overview of smart grid technology in Bangladesh: Development and opportunities, In 2011 International Conference & Utility Exhibition on Power and Energy Systems, Issues and Prospects for Asia (ICUE), pp. 1-5. IEEE

Leccese F. (May 2012), An overwiev on IEEE Std 2030, In2012 11th International Conference on Environment and Electrical Engineering, (pp. 340-345). IEEE.

Galvin R, Yeager K. (July 2008), Perfect Power, How the MicroGrid Revolution Will Unleash Cleaner, Greener, More Abundant Energy. McGraw Hill Professional

John, Jeff (November 17, 2009), Honeywell's OpenADR Plans for SoCal Edison,"Greentechgrid. Retrieved January 25, 2012.

Costanzo, G.T., Kheir, J. and Zhu, G. (2011), Peak-load shaving in smart homes via online scheduling, IEEE International Symposium on Industrial Electronics (pp. 1347-1352). IEEE.