Chapter 1

Introductory Chapter: Demand Response Incentive Program (DRIP) with Advanced Metering and ECHONET

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Additional information is available at the end of the chapter

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1. Introduction

The rollout of smart meters plays an important role for the world transition to a low-carbon economy and helps in facing some of the long-term challenges for ensuring an affordable, secure, and sustainable energy supply. Smart meters have the potential to transform consumers' relationship with energy bringing considerable benefits and also for energy industry. A smart metering solution generally delivers a range of applications using an infrastructure comprising networked meters, communication networks, and data collection and management systems. Recently, smart metering and infrastructure using advanced metering infrastructure [1] has become one of the hottest topics within electric power utilities. Smart metering and infrastructure is not a tool to capture customer energy consumption every month or two, but an integrated hardware and software architecture is capable of capturing real-time consumption, demand, voltage, current, and other information. In other words, the system functionality of smart metering and infrastructure goes far beyond just obtaining a monthly meter reading. Establishing bidirectional communication and smart metering technologies that can record customers' load profiles, the smart metering and infrastructure provides utilities with system-wide sensing and measuring capability [2–4].

When establishing smart meters, many areas should be considered, the most important are dynamic tariffs, smart grids, and feed-in tariffs. The dynamic tariffs permit the utilities to charge many rates at different day and focus as "spot market" for business customers. The smart grids are precisely balancing the supply and load for in order to earn the optimum benefit of intermittent RES. The feed-in tariffs authorize the utilities to measure and reward electricity generated on-site by microgeneration technologies. This contains photovoltaic panels (PVs), microcombined heat and power, and small-scale wind turbines. Smart meters offer several additional features of interest to the utility market in comparison with traditional mechanical and electromechanical meters, and smart meters include the following:

- High reliability and hardness
- High accuracy
- Anti-tampering function
- Automation in reading
- Support of nonlinear and low-power factor loads
- Self-calibrated
- Security
- Applying with different programs using advanced billing (time-of-use, prepay, etc.)

Whether the measurements can be gas, water, heat, or electricity, some or all of these features apply and are making the smart meters the solution of choice in both new and existing markets.

- The smart meter can measure the amount of electricity at customer sides. The differences between a smart meter and tradition mechanical meter are that the smart meter automatically can remotely transmit total electric usage to company Power using via radio signal for the customers.
- The smart meters are considered as a part of integrated program that will pay for itself through reduced theft of electricity, operational efficiencies, and energy savings.
- Several technologies are currently in use to achieve automated meter reading of electronic meters or to retrofit existing mechanical/electromechanical meters.

Electronic meters can read and communicate automatically through different mechanisms such as:

- Short-range infrared
- Short and long radio frequency range
- Broadband
- Telephone line data modem
- Short to medium power line carrier range
- RS-485 serial port

The automated reading advantages that they can be obtained using communicating with a handheld device (RF, infrared—up to several hundred feet away). This of course cannot eliminate the need for operators who visit locations, and in such case, the readings are accurate and speed up the process. The smart meters data flow can be given in **Figure 1**.

The communications systems applied in transmission, or telemetry, of data, and control will send signals between the meter interface units and the central office. Such communications

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can take the shape of telephone, power line carrier, radio frequency, or cable television. These system components involved in the communications system depend on the communication media used.

There are two new billing technologies that are made possible by the implementation of electronic meters: time-of-use and prepay.

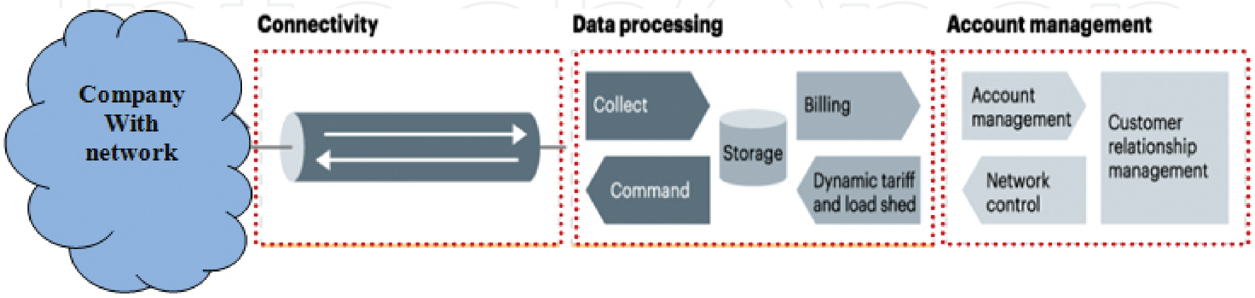

Figure 1. The smart meters data flow.

1.1. Time-of-use

The TOU pricing can also be used as an involuntary way for consumers to adjust the electricity consumption in different time axis in accordance with the cost of electricity. Time-of-use defines as the different tariffs for the use of the utility at different hours of the day or day of the week. This technology helps the utilities to shape the demand in order to optimize the utilization of the available capacity throughout the day.

1.2. Prepay

- The technology of prepay is applied to reduce the financial cost of payment of the utilities. The user is permitted to purchase certain amounts of the service ahead of time and receives credits that are charged on smart or magnetic cards. The meter coupled with a card reader and acts as a gate controlling the delivery of the electricity service.

Automatic meter reading system (AMR) is the remote collection of consumption data from customers' utility such as electric meters using radio frequency, telephony, power line, or satellite communication technologies, and processes the data to generate the bill.

For their advanced metering infrastructure (AMI), utilities require an economical solution to enable fast and secure communications to smart meters, to allow new market-driven billing structures to be implemented.

- Now there are different kinds of communication and protocol types that used smart metering. A combination of GPRS and power line carrier communication is used in many countries such as Italy, Denmark, and Finland. These European examples of the PLC technology are used between the smart meters and data concentrators, and GPRS is used between the concentrator and gateway to the data management system.

2. Demand response

Demand response is the process of scheduling the loads to reduce the electric energy consumption and or the maximum demand. It is basically optimizing the processes and loads to improve the system load factor [5].

The concept of the demand response is traditionally used as load management methods for changes in the equipment and consumption patterns on the customer side.

The load management methods can be applied by an industry or a utility. Typical actions can be given such as load shedding and restoring, load shifting, achieving energy efficient programs and equipment, energy storage, cogeneration and nonconventional energy sources, and reactive power control.

The load management methods provide customers with the option to avoid or curtail central electricity during the peak hours. Some mechanisms for load management programs are given in [6, 7].

The major benefits of demand response is the reduction in maximum demand, reduction in power loss, better equipment utilization, and saving through reduced maximum demand charges. Such a program of load shifting to the off-period is to reduce the demand in the peak period by shifting some appliances and equipment to the off-peak periods. It is important to focus about the costs arise that showed it can be possible to take features of incentives and favorable pricing gained by utilities in order to encourage consumers to use energy during off-peak period. In this case, it enables the utility to change load patterns.

Demand response is considered as an essential tool for the electric utility in facing the growing demand for electricity. Demand response is a subset of wider category of consumers for energy solutions known as demand-side management (DSM). Beside the demand response, DSM includes energy efficiency programs and conservation. Demand response defines as changes in the electric usage by end uses from their regular consumption patterns in response to changes in the price of electricity over time, or it can be incentive payments designed to produce lower electricity use at times of high wholesale market prices [8].

Classification of the demand response programs as follows:

- Demand response based on real-time pricing (RTP), critical-peak pricing (CPP), and time-of-use (TOU) tariffs that facilitate customers time-varying rates that reflect the value and cost of electricity in different time periods.
- Demand response based on incentive programs can help in participating customers to reduce their loads at times requested by the program sponsor, issued either by a grid reliability problem or by high electricity prices.

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To encourage reduction in peak demand, many utilities have already implemented time-of-use rates (TOU) or have plans for introducing such rates [9, 10].

The purpose of utilizing these programs is to reduce the load curve during the peak periods. However, some utilities applied these programs mandatory during the peak periods. During the day, the programs can be applied successful in case of having the customers peak demands.

2.1. Time-of-use-tariff

- Time-of-use defines as various tariffs for the use of the same utility at different intervals of hours per day or day of the week. This technology helps the utility companies to shape the demand in order to optimize the utilization of the available capacity through the day.
- With high rates, it can charge during the peak hours and incentive the user to make a more rational efficient use of the resources.
- Smart meters can incorporate inexpensive real-time clock (RTC) and calendar (RTCC) circuitry to keep track of utility usage in real time.

2.2. Interruptible load tariffs

These incentive rates for the customers, which they get if they interrupt or reduce the power demand during the system peak period or emergency condition. Large industrial consumers can use interruptible tariffs. The implementation of interruptible tariff structure involves unbundling electric service and offers the customers a range of rate reliability choices. Load contract with utility is signed for an interruptible to reduce their demand as and when requested by the utility.

2.3. Dynamic pricing (dispatchable rates)

Different prices during different time periods so-called retail prices for energy consumed offer and reflect the fact that power generation costs and wholesale power purchase costs vary during different time periods. There are different types such as dynamic versions of time-of-use pricing, critical peak pricing, and real-time pricing.

3. Proposed program

Different terms in use in the demand side related to each other but with slightly different focuses. These definitions are as follows:

- Demand-side management (DSM): The activities of the utility influence use of the customer for electricity. This includes the planning, implementation, and monitoring of many activities. Such activities are designed to incentive consumers to change the consumer patterns of usage.

- Demand response (DR): This type of program used as mechanisms to manage the demand response to supply conditions in signal communication.
- Demand-side participation: In the competitive electricity market, a set of strategies can be applied via customers to contribute to economic, system security, and environmental benefits.

The demand response program is a potential resource for satisfying the nation's energy needs. If the peak demand for energy is lowered, the demand response programs will reduce constructing new plants and avoiding the expensive generation units. The Federal Energy Regulatory Commission (FERC or Commission) staff reports—*A National Assessment of Demand Response Potential* (National Assessment), submitted to Congress in June 2009—current demand response programs tap less than a quarter of the total market potential for demand response [11]. The running programs have missed a potential portion of the cost-effective demand response significant, and for this reason, the action needs to be taken to either create new programs or apply existing ones with cost-effective.

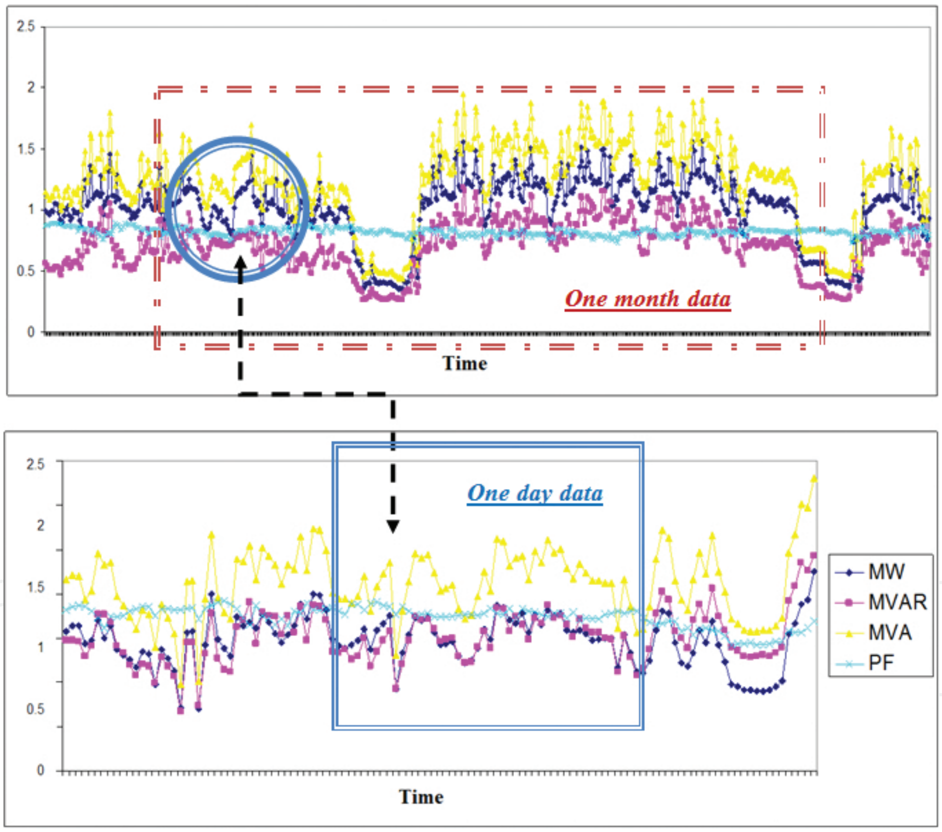

Figure 2. The load curve used for calculating the base power in case of nonavailability of the recorded data.

The program of **DRIP**: Demand response incentive program submitted to the electricity company (EC) is a response to a voluntary to motivate participants to reduce the load at peak periods between one o'clock noon until five o'clock pm during working days (Saturday to Wednesday), from the first of June until the end of September, the peak in the electricity

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company. The program is an incentive rates for the customers, which they get a return if they reduce the power demand during the system peak period. The electricity company (EC) will pay for the customers an incentive which depends on the level of reduction in demand power each month during the peak periods. One of the main objectives of the program (**DRIP**) is to raise the efficiency of energy demand and further secure the electrical grid. The participants can be in cooperation with the electricity company to achieve the program of **DRIP** to reduce loads through redistribution of electrical loads, the use of reserve generation, the use of storage cooling, shifting electrical loads, etc. **Figure 2** shows the load curve used for calculating the base power in case of nonavailability of the recorded data.

The procedures of the **DRIP** program involve changes to load consumption pattern on the customers' side. To achieve the program, the following three methods should be satisfied:

3.1. Remote load control method

The program can be achieved by using the control of electric load (load redistribution or stand-by electricity generation). This can be done through switching load off at this time or through the use of on-site generation for part of the load.

3.2. Obligated reduced power

The customers should introduce application form to indicate the level of electricity demand they will consume (in MW) during the delivery period. This is the obligated level

3.3. Payment procedure

Payment will be made after the meter has been read and some calculations. The payment calculation can be classified as:

a. *A—Power reduced payment (PRP)*

b. *B—Demand incentive payment (DIP)*

c. *C—Violation payment (VP)*

Figure 1 shows the load curve used for calculating the base power in case of nonavailability of the recorded data.

4. Outage detection

In the smart meters scenario, the utilities are familiar by the power outages at customer location (obligated level). Using the smart meters data and obligated level of contracts, you can easily identify the level of reduction and amount of outage as being less or large. So, with smart grid, the smart meter can detect power outage and inform back in real time, providing the outage location and lot more technical data than what the service personnel typically had.

5. Service connect/disconnect

The smart meters have the capability to connect a customer service or disconnect avoiding many of problems for the utilities and customers. The customers should precisely identify the controlled load under switching with the utility during the obligated contracted period. This facility greatly improves customer satisfaction, by being able to respond to a request 'online', without having to set up appointment for field visit.

6. Peak demand reduction

The utilities bear maximum costs in estimating and meeting the peak demand of consumers, using peaking plants and providing very higher amount than estimated peak. Smart grid using smart meters can offer many methods to flatten the peak demand, such as:

a. Issue an awareness of the increasing demand

b. Implement incentive rate for reducing the peak usage compared to off-peak

c. Implement active ***DRIP*** to tune specific energy devices (reducing load settings) into 'load shedding'

d. Increase insight into consumer use patterns to the Utility

6.1. Support for *DRIP* rates

a. AMI enables two-way flow of information between the meters and the utility, enabling active monitoring of energy usage, and convey and help implement ***DRIP*** rates. Smart grid strives to flatten the peak demand, and implementing ***DRIP*** rates is a good way to reduce peak demand. In some utilities, critical peak rates can be up to 100 times the off-peak rates, leading the consumer to be 'more aware' of the difference in 'energy supply' conditions.

7. Commercial energy management system (CEMS)

Commercial energy management system (CEMS) is a system for cleverly managing the various types of energy used in the industry. Installing CEMS makes data on electric power generation and utility usage visible on monitors and other screens, facilitating "control" of CEMS compatible machines and loads. By making the electricity used by load more "visible," each member of company will become more aware of saving energy, and wasteful use of electricity will be eliminated and energy costs will thus be reduced. And when you would reduce reduction, you will be able to "control" energy use by switching off or some of CEMS compatible loads with a single action, thus avoiding energy wastage. The management process can be done by actually study well the loads and period of peaks. **Figure 3** shows the ECHONET is a communication protocol design.

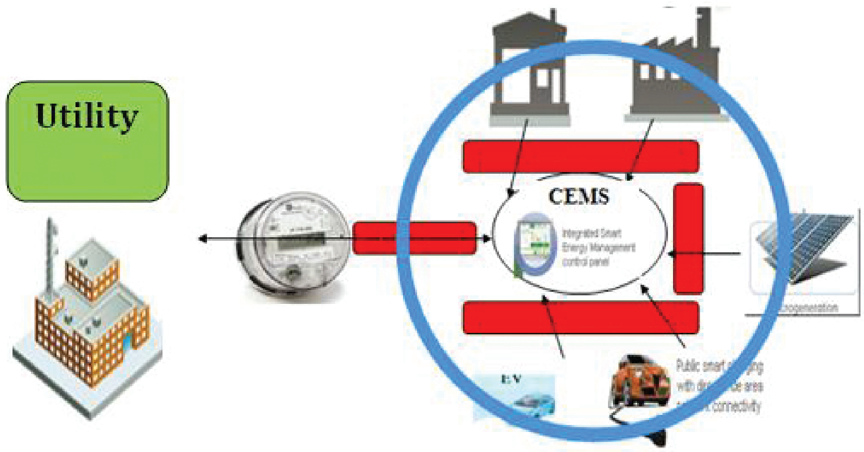

Figure 3. ECHONET is a communication protocol design.

8. Communication protocol

Smart electric energy meters digitally measure electricity usage and automatically send measured data to power companies. They can also communicate with CEMS controllers via ECHONET Lite and express electricity usage status in visible form, based on the meter readings used for billing [12].

9. ECHONET Lite: a communication protocol supporting CEMS

Shared communication protocols are necessary to achieve two-way communication between CEMS controllers and various home appliances, household devices, etc. This function is provided by the ECHONET Lite Specification. With CEMS controllers adopting ECHONET Lite and devices compatible with CEMS, it should become possible for different manufacturers' products to be connected together for use [12].

ECHONET is a communication protocol designed to create the "smart commercial" of the future. Today, with Wi-Fi and other wireless networks readily available in ordinary industry, there is a growing demand for load inside the factory to be controlled using smart phones or controllers, or for electricity usage to be monitored in order to avoid wasting energy [12].

To achieve this kind of low-energy, comfortable, safe and reassuring lifestyle, we first need to create a system of rules or a "communication protocol" that can be read by any manufacturer's equipment. This is where ECHONET comes in.

The ECHONET Lite specification, in particular, is a communication protocol compatible with the now ubiquitous Internet. It is designed for ease of use and is simpler than the ECHONET specification. The ECHONET Lite specification is already compatible with more than 100 types of device and is also being adopted by the smart electric energy meters that will be installed in all households in future. **Figure 4** shows the overall structure of the proposed idea [12-14].

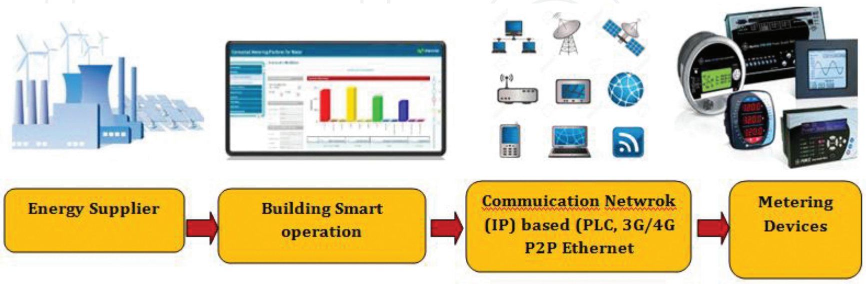

Figure 4. Flow chart for smart metering operations.

10. ECHONET lite system architecture

ECHONET Lite System Architecture This section specifies the ECHONET Lite system configuration and system architecture. **Figure 5** shows the system architecture. An ECHONET Lite system incorporates many devices with the same properties, security, management, etc. So, the major part that ECHONET Lite can manage is referred to as a domain. A domain will be specified as the range of controlled resources (company load, appliances and motors,

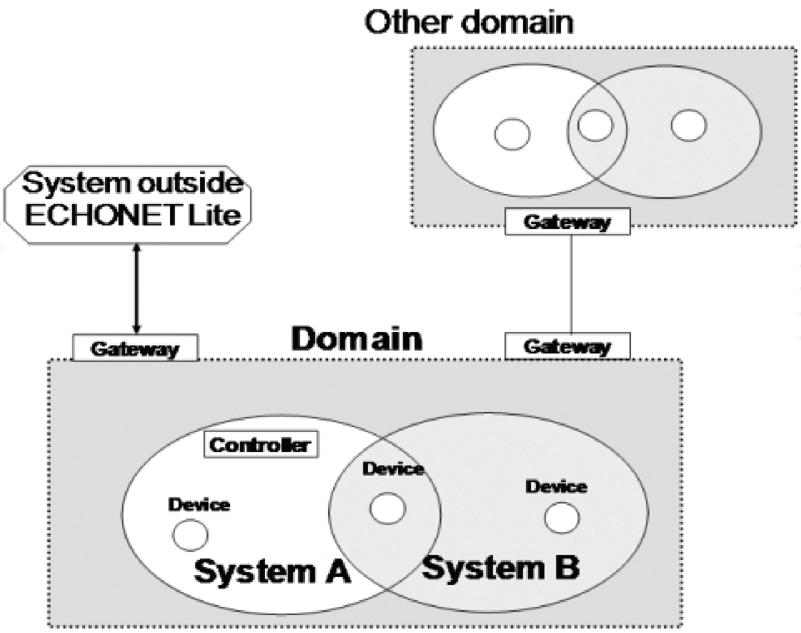

Figure 5. ECHONET Lite System Architecture [12].

sensors, controllers, control, etc.) present within the network range determined by ECHONET Lite. A system is defined as which performs communication and linked operations between devices and the controllers that control, monitor, and operate them and among devices themselves [12].

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