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PROSPECTS OF SMART METERING SYSTEM IN BANGLADESH: COST BENEFIT ANALYSIS

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A thesis/project
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CERTIFICATE OF APPROVAL

The thesis entitled as "**Prospects of Smart Metering System in Bangladesh: Cost Benefit Analysis**" submitted by **Md. Mohibul Hassan**, bearing Matric ID. **ET163002** and **Mahmudul Alam**, bearing Matric ID. **ET163019** of session **Spring 2021**, to the Department of Electrical and Electronic Engineering, International Islamic University Chittagong, has been accepted as satisfactory in partial fulfilment of the requirements for the degree of Bachelor of Science in Engineering and approved for the examination held on 3~~17~~ September~~August~~, **2021**.

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DECLARATION

It is hereby declared that this work has been done by us and no portion of the work contained in this thesis/project has been submitted elsewhere for the award of any degree or diploma.

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Md. Mohibul Hassan

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Mahmudul Alam

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We are beholden to a number of people, who supported us to carry out our thesis work properly and to complete it successfully.
~~this work of this thesis work to complete it successfully.~~
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Md. Mohibul Hassan
Mahmudul Alam

ABSTRACT

One of the most significant parts of smart grids is Smart Metering System. They felicitate the information exchange between the service providers and the consumers, resulting in efficient management in the electricity supply.

Implementation of Smart Meter system is only possible if the people, government and the investors are highly interested to implement this technology. Many Western countries like Great Britain (GB) and Canada have conducted Cost Benefit Analysis (CBA) before starting installation of Smart Meters. The aim of this study is to replace ~~usual~~ traditional (~~Prepaid~~ electro-mechanical and pre-paid) meters with Smart Metering System in accordance with its cost benefit analysis. So the main focus is to put emphasis on the cost benefit analysis and probability of this thesis work in this field of digitalizing the meter system across the country. The most important fact to analyze before the installation of Smart Meters is to find out the advantages of such technology as well as the cost behind the setup of such meter. For example, the degradation of CO_2 emission, the installation and maintenance expenses, financial savings from the Time-of-Use (ToU) etc.

Bangladesh is still relying on the prepaid meters whereas the modern world is trying to implement a smarter technology rather than prepaid meters. The question that comes from mind is that whether installing Smart Meter in our region is affordable or not. The establishment cost of installing ~~S~~mart meter may be high but in general, the roll-out offers a 1.36 benefit-to-cost ratio (BCR), which reflects the costs and benefits of lifetime. In order to investigate this study, Chittagong Municipality Area was chosen to find out the total consumers of this region and how can the prepaid meters be replaced with the Smart Meters within an approximate minimal expense. From the very beginning of installing the Smart Metering System the required costs were being calculated approximately which includes operational cost, maintenance cost, meter cost, In-home display cost, Data Communications Company (DCC) cost etc. The total cost of this project is set to be nearly $300.9M. The energy savings and power consumption cost are also discussed in the later part.

Keywords: Smart Meter, Cost Benefit Analysis, Time-of-Use, Energy Saving, Implementation

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LIST OF ABBREVIATIONS

BCR	Benefit-to-cost ratio
BDT	Bangladeshi taka
CBA	Cost Benefit Analysis
CBR	Cost Benefit ratio
CDMA	Code Division Multiple Access
CML	Customer Minutes Lost
DCC	Data and communications Company
DNO	Data network operator
DSL	Digital Subscriber Line
ELP	Early Learning project
GB	Great Britain
GPRS	General Packet Radio Service
GSM	Global System for Mobile
IHD	In home display
IT	Information and technology
KWH	Kilowatt hours
LTE	Long Term Evolution
MOD	Monthly Operational Data
PDB	Power Development Board
PLC	Power Line Communication
PPM	Prepaid Meter
SMETS1	Smart Metering Equipment Technical Specification Standard 1
SMETS2	Smart Metering Equipment Technical Specification Standard 2

Chapter 1

INTRODUCTION

1.1 **Motivation**

In Smart Metering system, the billing process is seamless, the electricity usage in real time is tracked down easily and the billing errors is reduced in a significant manner thus the consumers can also observe it sitting at their home. It is for the very first time that consumers are emerged as the umbilical point in power sector. The benefit of tracking the real time usage of their electricity consumption has enabled them to save energy and possess capital savings. In fact, more researches are taking place in order to make it easier for the consumers to save electricity and reduce carbon emission. More analytical processes are being generated to aid consumers to differentiate energy consumption of their own with the similar consumers. Thus it may help the consumers to reduce their energy bills and use the energy according to their usage.

In order to keep pace with the advance world, the effectiveness of Smart Meter is beggar description. Smart Meter is a form of blessing in the power sector to fulfill the requirements to reform power sector in a disciplined manner. For building a sturdy ~~ad~~ smart power sector, as well as a growing digital energy ecosystem - Smart Meter has become an essential influence.

Smart Meter has secondary benefits too. It is not only significant in energy savings but also day metering time is enabled by Smart Meters. It shall help to enhance renewable power across the country. Moreover, Smart Meters omit the task of patrolling for meter reading and reduce the carbon footprint as well.

What really became the motivation to implement this study is the variety of space Smart Meter produces to ease the life of billions as well as bringing revolutionary changes in the energy saving. In Smart Metering system it is not necessary to submit meter readings. The suppliers have access to readings that Smart Meters generate automatically thus consumers do not have any burden to submit it monthly. The burden of standing in a queue or in the rain demolishes.

The In-home display associated with the Smart Meter exactly shows how much energy is used and also provides the associated cost. It encourages and motivates the consumers to use energy at a balanced rate according to the needs of the consumers which enables the energy savings. Recent reports show that already 5-20% energy savings are stored due to the implementation of Smart Metering system. That shows Smart Meter bears a great impact in budgeting.

Smart Meter offers billings automatically and most importantly it provides the bill according to consumer's use of electricity. Suppose, if a consumer is under prepaid billing system and somehow forgets to submit a reading the supplier needs to check how much energy is used by the consumer over the billing period. The estimation is probably done by the suppliers on the basis of the previous usage of the consumer or how much the consumer is intended to use. Most often the supplier's estimation is inappropriate. It is because they do not have vast knowledge regarding the usage of the consumers. On the other hand, Smart Metering system eliminates all of these inconveniences as it doesn't produce ghost billing system and also avoids the consumers to witness huge billing at the end of their tariff because the opportunity is there for the consumers to map their usage of power according to their intention.

The In-home display clearly shows how much energy is used by the consumers at any given time as well as it shows any sudden spikes that occur due to a faulty section. So it allows the consumers to deal with the faulty section immediately and safely. From different analogy being analyzed it is estimated that within 2030 there will be 24% decrease in the emissions from homes and businesses [1].

It is 2021 and we are moving towards a smart future where Smart Meter offers a variety of advantages including exclusive tariff plans which ease the abnormal billings carried by the consumers and enables the consumers with a set of choice to use energy at a reasonable tariff plan. Smart Meter provides a consumer with the ability to switch between prepay mode and credit mode. Thus the supplier doesn't need to install a new meter for this switching purpose.

According to the Power Division Ministry of Bangladesh's website the annual report for the fiscal year 2019-20, it has been reported that there is distribution loss near about 8.73% and total loss about 11.23%. Here distribution losses mainly occur on contracting out meter reading and billing, energy theft. Per day energy generation in Bangladesh is now average 12,000MW. Thus, a 6-7% power loss account for a massive loss per annum.

The impact of Smart Meter that motivated to implement the study are listed as follows-

- Offers more detailed information to the consumers and the suppliers compared to the recent metering system used across the country.
- Accurate meter readings are obtained.
- Alleviate energy consumption.
- Provides support to the renewable energy technologies.
- Helps to create better tariff plan comprising with electricity pricing solutions.
- Different companies that provide utilities of this metering system are aided by the system and assist them to grow their business purpose.

This study motivated us to work on the issues stated above and encouraged us to help the government to find a solution on this point by installing Smart Meter across the country in order to step into smart world.

1.2 **Literature review**

A prepaid meter allows consumers to save electricity, thus saving money as well. For the necessity of saving, prepaid meter was introduced. On the other hand, a Smart Meter is the most accurate way of measuring electricity which lacks any severe inconvenience. This study comprises with the instalment of Smart Meter in Bangladesh. Also emphasis has been given upon the Cost Benefit Analysis on the installation of Smart Meters. Moreover, the interferences are also being analysed in this study.

Italy is considered to be the first country to introduce Smart Meter installation project across the country. ENEL has installed about 32 million meters in the last decade. Eventually ENEL started its project in 2001 named as 'Telgestore" [8]. For the purpose of backbone communication PLC technology was used and for the last mile connectivity GSM was linked up. Other developed countries were amazed and influenced with this project. Soon they began to deploy Smart Meter projects in their own region.

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In April, 2004 the very first and biggest Smart Meter project of Canada began its journey [2]. In spite of the introduction of this project, the Cost Benefit Analysis was not being analysed properly though the expenditure was high. But United Kingdom put importance on the Cost Benefit Analysis of its Smart Meter installation project in 2008 [3].

Smart Metering system is undoubtedly one of the most emerging technologies. Canada has installed 4.8 million Smart Meters in Ontario to make it a smarter city and it has benefited them by providing actual consumption information and many more, decreasing the emissions of carbon, avoided visiting sites frequently [4].

The aim of the European Union ~~is~~ was to replace their 80% of electricity meters with Smart Meters within 2020. The Smart Metering system and smart grid is capable of reducing emission to 9%. EU countries conveyed Cost Benefit Analysis depending on the guidelines provided by the European Commission. Similarly for gas, another assessment was carried out on Smart Meters [5].

The Power, Energy and Mineral Resources ministry of Bangladesh stated that, they are determined to bring the entire power consumers under prepaid metering as the generation capacity has now reached 24,421 MW [6].

France is aiming to install 35 million Smart Meters by 2020. The project is set to be implemented for around 30 million consumers. The approximate cost for the project is set to be €5 billion. It should be noted that almost 80% of those meters will be built in France. Moreover 30,000 meters have already been circulated for the pilot project. The purpose behind this procedure is to reduce the carbon emission and to save the electricity bills between 5 to 15% [7].

In the United States, about 49 million Smart Meters have been installed. For home area network (HAN) PLC technology is used and for last mile connectivity with BPL, 2G/3G cellular is used [9].

In all, it can be observed that major countries have adopted the energy saving invention named as Smart Meter system. Thus these countries have begun their planning on installation and optimization of this technology and to reach their desired outcomes by implementing last long plans surrounding it.

Obviously it is not an easy task to cover the whole country under Smart Meter system as Bangladesh is still a developing country and the research are still an ongoing process~~.~~. ~~Moreover it is very much costly as a project and reliable on electricity saving at the same time.~~ Though it is a costly project to be implemented, it is reliable in saving electricity. This study based on the pros and cons of the installation the Smart Meter in Bangladesh and also to take a look at its progress in the near future.

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1.3 **Objective**

At present there are two types of metering system in Bangladesh, one is traditional credit meter another one is prepaid meter. In traditional credit meter system consumer often complain about ghost billing system. Sometimes utility companies failed to collect their revenue in time. For solving all this issue Government is currently installing new prepaid metering system. For a sustainable and eco-friendly energy supply system every developed country has introduced Smart grid. Smart Meter is one of the core point of Smart grids. Smart Meter has more benefit over prepaid meter. ~~Smart Meter not only helps in the distribution sector but also can provide benefit on generation sector~~.

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This study aims to discuss about the following objectives-

- To put emphasis on the impact of Smart Metering system installation.
- To describe the Cost Benefit Analysis of Smart Metering system in brief.
- To study different cases related to the installation of Smart Meter.
- To realize the importance of energy saving by implementing Smart Meters.

This study puts emphasis on the significance of Smart Meter implementation across the country and to discuss about the CBA behind this metering system to be installed. ~~Moreover~~Moreover, the necessary steps and measures are discussed briefly to put light on the impact of Smart Meter system in the lives of the people of this country.

1.4 **Organization of the thesis**

This book is organized in five chapters which are given as follows:

- Chapter-1 introduces the reader with the objective and the motivation behind our work, also representing a brief summary of some related works which have been done by previous groups.
- Chaper-2 describes about the basic features of Smart Meter and present scenario of Bangladesh Smart Metering network
- Chapter-3 tells about the methodology in this work.
- Chapter-4 describes about the result we have obtained from the Cost Benefit Analysis in Chittagong municipality area.
- Chapter-5 concludes with some prospects for future work.

Chapter 2

Smart Metering System

2.1 **Definitions of Smart Meter and Metering Network**

A Smart Meter is an electronic device that measures and collects data and bring intelligence to the edge of the grid. Smart Meter typically record and provides information to utility provider with predetermined time interval. The Smart Meter system is quite sophisticated and reliable as it is embellished with advanced equipment. Smart Meters enable ~~two way~~two-way communication between the meter and the central system.

A diagram for Smart Metering network are shown in **Figure 1**

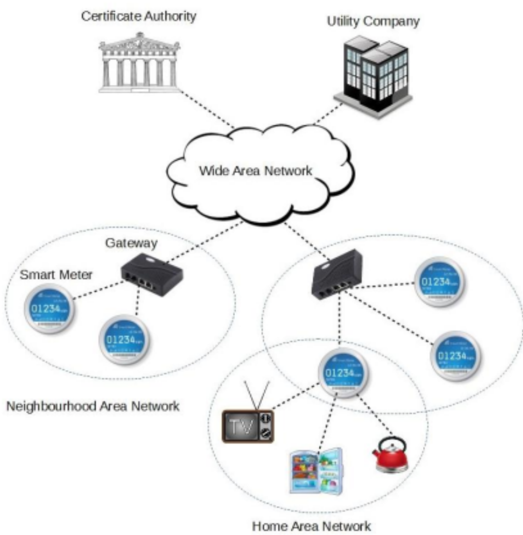

Figure 1: Smart Metering Network Architecture

Smart Meter can constantly measure energy along with monitoring their own performance and environment. Smart Meters can provide proper communication ports in order to respond to requests for collecting necessary data, to commands issued by the central access server to switch on or off or in case of any manipulation [10].

For example, Smart Meter will report if there any power outage occurs with the help of his backup supply and they can also report if there is any internal memory problem or if the terminal cover is removed. In these cases, supplier can easily identify the problem by analysing the data provided by the Smart Meter. And they can also send someone for solving the problem. Comparison of Smart Meter with traditional meters shown in **Table 1.**

Table 1: Comparison of Smart Meter with traditional meters

Property	Electro-Mechanical meter	Prepaid meter	Smart Meter
Accuracy	Low	High	Very high
Theft detection	Low	Possible at node level	Possible at network level
Communication	Manual reading	One way communication	Two way communication
Control	No	Limited	Full
Consumer participation	Nil	Less	High
Time wise reading	No	After a fix interval	According to requirement
Day to day billing info	Not possible	Not possible	Possible

There are three types of Smart Meter: SMETS1 meters, SMETS2 meters and advanced meters in the non-domestic sector. In domestic sector the latest version of Smart Meter used is SMETS2.

According to the Govt. of UK the Smart Metering Equipment Technical Specifications (SMETS) [11] are given below:

Physical requirements

Electric Smart Metering Equipment (ESME) shall have this following components

I. a clock;

II. a Data Sore;

III. an Electricity Meter containing one measuring element;

IV. a HAN interface;

V. a Load switch;

VI. a Random Number Generator;

VII. a User Interface; and

VIII. where installed with a Communications Hub provided by the Data and Communications Company

Functional Requirements

Clock

The Clock forming part of ESME shall be capable of operating so as to be accurate to within 10 seconds of the UTC date and time under normal operating conditions.

Communications

When any command addresses to ESME is received via any Communications Link ESME shall be capable of:

I. using the Security Credentials ESME holds, Authenticating to a Trusted Source the Command

II. verifying that the sender of the command is Authorized to execute the Command

III. verifying the integrity of the Command

Display of information

ESME shall be capable of displaying the following information on its user interface:

I. the payment mode currently in operation, being Prepayment Mode or Credit Mode

II. the Tariff TOU Register Matrix, the Tariff TOU Block Register Matrix and the Tariff Block Counter Matrix

III. the active import Register

IV. the active export Register

V. the Meter Balance

VI. the Debt to Clear

VII. the customer identification Number

VIII. whether Emergency Credit is available for activation

IX. the Emergency Credit Balance where Emergency credit is activated

X. any low credit condition

XI. the supply state

XII. any standing charge

XIII. the local time

XIV. the contact details

XV. the Active Tariff Price

XVI. the Event log and Power event log

Recording

ESME must be capable of recording Active Energy Imported and Exported data. Consumption and cost of consumption data should be recorded by ESME.

Security

ESME shall be designed in that way to ensure that there will be no breaching of Personal Data at any circumstances. It shall capable of preventing unauthorised access that could compromise the Confidentiality.

These are the requirement to install metering equipment in Great Britain.

Now we will explain our reader Smart Metering scheme that is used in England. The case study is as follows:

"A Smart Meter works by measuring the current flow and voltage at regular intervals and then adding this up to calculate the power used in a half hour period. This information sent to consumer In-Home Display and to supplier. Different communications technologies may be used in different parts of the country to allow the wide Area Network to send data to and from the company providing the communications.

The information from your meter goes first into a communications hub that is usually built into the electricity meter, and then through radio waves to the communications company. In the case of the SMETS2 meters it is the Data and Communications Company (DCC). From there it is sent on to the various DCC Services users who have a need for the data.

From the DCC, the Smart Meter messages can be sent to various Service Users depending on the messages content. Electricity and gas suppliers and distribution network operators will all have a keen interest in the data from Smart Meters. They will use it for the following reasons:

- Suppliers
    - Meter readings - for billing purposes
    - Half Hourly readings - for additional services or sophisticated products
    - Maintenance messages about the health of the meter - such as memory problems
    - Firmware messages - to update the software in the meter
    - Configuration messages - to set up new products
    - Pay as You Go messages - to top up PAYG credit
    - Tamper messages - to detect theft and security attacks
    - Export meter readings - to measure how much electricity your solar cells or wind turbine is passing back to the network for load management and to credit the customer, depending on the commercial arrangement.

- Distribution Network Operators
    - Power outage messages - to know when and where outages occur
    - Meter readings - for network billing to suppliers
    - Half Hourly readings - for network load planning
    - Voltage, Current and Power Factor readings - for network operation and planning.
    - Export meter readings - for network operation and planning.

- Other Authorized Parties
    - Meters readings - to analyze and show you your energy usage
    - Half Hourly readings - to analyze and show you your particular energy profile shape [12]."

2.2 The hardware structure of Smart Meter

In functional block diagram of a Smart Meter includes signal acquisition, signal conditioning, Analogue to digital Conversation (ADC), computation and communication [13]. Here is a visual representation of functional block diagram of a Smart Meter shown in **Figure 2.**

Figure 2: Functional block diagram of a Smart Meter

Voltage and current sensors are used by the Smart Meter for collecting the input signals. Signal conditioning, ADC and calculations are done by the micro controller unit (MCU). There are some additional components are required for other operations like communication, time and measurements, and data backup and storage.

A Smart Meter basically consist of following hardware components:

- Voltage and current sensing unit.
- Power supply
- Energy measurement unit
- Microcontroller
- Real time clock
- Communicating system

Figure 3 shows a typical hardware structure of a Smart Meter.

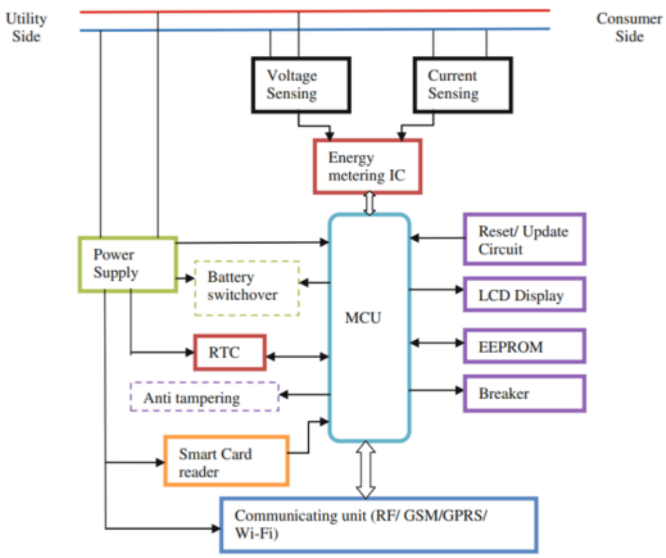

Figure 3: Hardware structure of a modern Smart Meter

2.2.1 The voltage sensing unit

For voltage measurement there is mainly used Step down transformer and resistor divider network. Transformer often have a limited operating range, have an intrinsic phase shift that varies with frequency and relatively expensive. In digital meters' resistor divider network mainly used due to low cost. **Figure 4** shows the configuration of a resistor divider type voltage sensor.

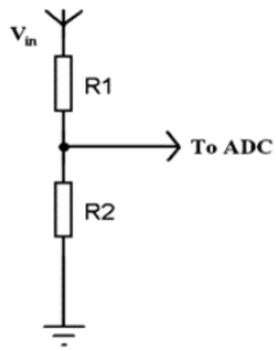

Figure 4: Resistor divider configuration

$$Vo = \frac{R2}{R1 + R2} Vin$$

Where

Vo is the output voltage

Vin is the input voltage

The values of R1 and R2 should be chosen that the main voltages divided down in such way that it would be fit for energy measurement chip. The Ac voltage applied to R1 and R2 should be ground. Output is taken from the middle point of the divider and delivered to ADC. Normally R1 and R2 are in kΩ scale. R1 is much greater than R2 ($R1 \geq 500R2$).

2.2.2 The Current sensing unit

In Smart Meter four types of current sensors used in Smart Meters. They are:

- Hall effect- based linear current sensors
- Current Resistor

- Shunt Resistor
- Rogowski coils

(A) **Hall effect-based linear current sensors**

A Hall Effect current sensor allows non-contact detection of direct and alternating currents, using a hall element, a magnet-electric converting element. It consists of a chip and a copper conduction path located near the surface of the die. The current flowing through the copper conduction path generates a magnetic field. This magnetic field is captured by Hall IC and converted into a potential voltage [14]. **Figure 5** shows an example of ACS 712 Hall IC which is available in market.

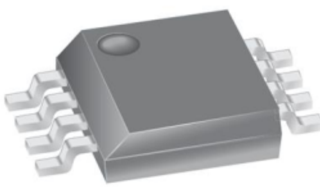

Figure 5: ACS 712 Hall IC (Courtesy of Allegro Microsystems, Inc.)

(B) **Current Transformers**

Current transformers produce a secondary current which is proportional to the primary current. Magnetic properties of CTs are highly linear over wide range of primary current and temperature. The primary is connected in series with the device [15]. **Figure 6** shows the through-hole type current transformers which are widely used in metering applications.

Figure 6: Single Phase 30 Amp. Current Transformer

(C) Shunt resistors

Shunt resistors widely used in metering applications for its lower cost than other types of current sensors. These sensors put series with the load current path. Their typically very low with the range of 100µΩ – 500mΩ. The power loss is proportional to the square of the current. So very small resistance should be selected to minimize the heat dissipation [13]. **Figure 7** ~~F~~represents how shunt resistors works in Smart meter.

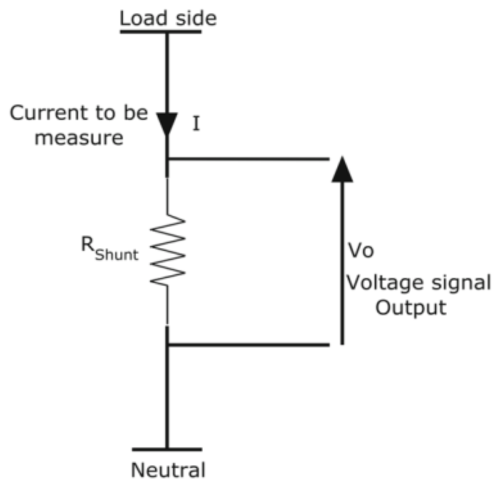

Figure 7: Shunt diagram of a shunt resistor

(D) Rogowski coil sensors

In 1902 Rogowski coil introduced in the electrical industry. It used to measure the magnetic fields, but these could not measure current because lack of power generated was not enough to drive electromechanical equipment. Now a day it can provide wide range of measurement with the help of improved microprocessor based system. They can deliver an output voltage which is proportional to the rate of change of current. They are saturation free as there is no iron in these coils. They have many advantages over conventional CTs, which include [16]

- High measurement accuracy
- Wide measurement range
- Wide frequency range
- Can withstand unlimited short circuit currents
- Small in size and waits

- Low production cost

The voltage signal Rogowski coil produced it is not directly proportional to the current flow. The relationship between the output voltage and the current flow is stated below

$$V = k\frac{dI}{dt}$$

Where;

V is the output voltage

I is the current to be measured

t is the time and

k is a constant

Current signal can be achieved from dI/dt signal. Rearranging the terms in

$$Vdt = kdI$$

$$\int Vdt = \int kdI$$

$$I = \frac{1}{k}\int Vdt$$

Figure 8 ~~Figure~~ represents a commercially available Rogowski coils

Figure 8: Commercially available Rogowski coils (Courtesy of Taehwatrans Co. Ltd.)

2.2.3 Power supply

Power supply unit vary from Smart Meter designer to designer. However, a Smart Meter unit typically consists of step down transformers, rectifiers, AC-DC converters, DC-DC converters and regulators. **Figure 9** shows power supply schematic for a Smart Meter.

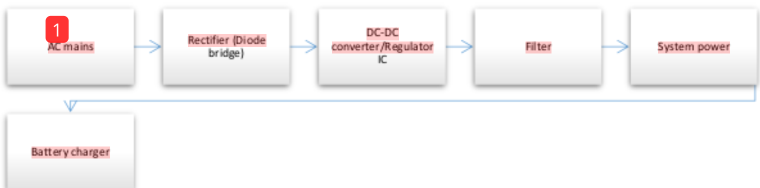

Figure 9: A typical power supply in A Smart Meter

Before designing a power supply, it should be taken into consideration that the energy chip, MCU, LCD, battery charger and communication unit required power. Figure shows the block diagram of typical power supply unit used in Smart Meters. At first AC line voltage is rectified through a diode bridge. Sometimes AC voltage is stepped down before the rectification. After regulation the unregulated voltage output is fed to a regulator IC. DC-DC converter consist of an inductor, a capacitor, and an electric switch. The electric switch used in this converter can be MOSFET, Power transistor or IGBT. Instead of DC-DC converter, a regulator can be used. After that the output is filtered and supplied to the system power.

2.2.4 Energy measurement unit

Energy measurement unit could be a standard energy measurement chip or the system MCU itself. Signal conditioning, ADC and calculation are done in the energy measurement unit. Energy measurement chips have digital signal processor (DSP) to perform all the process. These chips can provide active, reactive, and apparent energy information as data or frequency (pulse) output. There are some other things can be done such as RMS voltage, RMS current, frequency, temperature, tampering detection, power management, line SAG detection and communication. Microhip, Teridian, STMicroelectronics and NXP are well known energy measurement chips manufactures.

2.2.5 Microcontroller

Microcontroller is known as the core of the meter. All functions in the Smart Meter are performed by microcontroller. Here are the following functions controlled by microcontroller

- Communication with the energy measurement chip
- Calculations based on the data received
- Display all parameters, tariff and cost
- Smart card reading
- Tamper detection
- Data management with EEPROM
- Communication with other communication devices
- Power management

Some Smart Meters have energy measurement IC in single MCU. In these types of meters all tasks including the energy measurement and routine arithmetic operations are done in single MCU. In this case multi-tasking or high degree of parallelism is needed [13].

2.2.6 Real Time Clock

For keeping track of the current time all Smart Meters need an essential hardware component called Real time clock. It can provide time, date and alarm signals. Most Smart Meters have separately worked RTC accessed by MCU. There are also some other types of Smart Meter where RTC found built in. Smart Meter connected to the network and synchronized with actual time to avoid time drifts. The drift has been as 60 min per year [17].

2.2.7 Communicating Systems

Smart Metering system can consist with a HAN, a neighborhood Area Network (NAN) and a WAN. Smart Meters are the key element in this networking system which allows all the communication.

By using HAN, Smart Meter can establish communication with in-home display, other smart appliances. In HAN the communication protocol can be used with a wired or wireless media. Zig-bee, Z-wave, Wi-Fi and power line communication are widely used in HANs. The communication between Smart Meter and the server is done by WAN. GSM, GPRS, 3G, and WiMAx communication technologies can be used to connect the meter to the WAN.

2.3 Present scenario of Bangladesh's Metering System

At present, in Bangladesh there are mainly two types of metering system, one is conventional post-paid metering system another one is prepaid metering system. Prepaid meter users have to pay first before they use the energy. At present, Bangladesh has around more than 30 lac prepaid meters. Government is trying to replace all conventional meter with prepaid meter. Because it helps them to manage their resources and reduce wastage of energy.

From the Annual report of Power Division Ministry of Bangladesh for the fiscal year 2019-2020, we have learnt that there is almost 8-9% of generated power is lost due to non-technical losses.

There are 32 million consumers throughout the country using post-paid metering system. In this system 'meter readers' take readings of meter on a monthly basis and then billing process is carried out. Compared to this, prepaid metering system is much more helpful to the utility provider.

At present there is a significant number of prepaid meter installed. In prepaid meters, there is no hassle for meter reading or billings as like Post-paid metering system. In digital prepaid metering system consumer can easily pay their bill. For this reason, collecting bills are more simplified in this system. Here is a picture shows the scenario how it becomes more simplified with a prepaid meter. **Figure 10** shows the scenario how it becomes more simplified with a prepaid meter.

Figure 10: A digital prepaid meter being recharged by a consumer

The more advanced technology that follows prepaid meter is Smart Meter. Here ‘S~~s~~mart’ stands for two-way communication system and programmable capabilities. At present there are only few number of Smart Meter which are available in industrial sector.

Dhaka Electric Supply Company (DESCO) in an attempt to introduce intelligent metering keeping in line with Smart Meter concept conducted a pilot project to introduce prepaid meters with limited feature for residential customers. So it is clear to say that there is no Smart Meter in our distribution system. In current metering system there is no penalty for exceeding the sanctioned load across the country. DESCO is deploying energy meters on a small scale with instantaneous load monitoring capability and applying penalty. But we can adopt more user-friendly approach by means of Smart Meter. It will turn off the supply if there is any break of sanctioned load and will not turn back on until the operating load is reduced below the sanctioned load limit.

Electrical current flow & voltage at regular intervals is measured by a Smart Meter. Then these data ~~is~~are added to calculate the power used in 30 minutes period. The same procedure is maintained at regular intervals for the gas. This information can be easily provided to the household in a LCD display & also to the supplier. There is a variety of range of technologies for the communication interconnected to a Smart Meter. In different countries different technologies are implemented on the contrary of its available resources and technologies to send data to and from the company providing the communications. Besides measuring the energy these Smart Meters are also engaged in monitoring its own performance & surrounding atmosphere.

For example, when error occurs the meter shall indicate this and report the error to the provider immediately. Thus the supplier shall instantly take action and send a technician in order to fix the problem by contacting the customer.

The information from the meter goes first into a communications hub that is usually built into the electricity meter, and then through radio waves to the communications company. In the case of the SMETS2 meters it is the Data and Communication Company (DCC). From there it is sent on to the various DCC Services users who have a need for the data.

The power demand in Bangladesh is increasing with the passage of time. In order to cope with the increasing power demand new technologies and advanced generation power distribution is highly required. Thus to meet with the requirement these newly custom technologies are being introduced in a rapid manner by not analyzing the capability to restore it under standard capacity in the country. The customer needs to be provided with the best possible technology in the best possible resources available. It will not only secure the distribution of power system significantly but also will provide the sustainable system which is necessarily required. **Figure 11** shows the Grid map of Bangladesh.

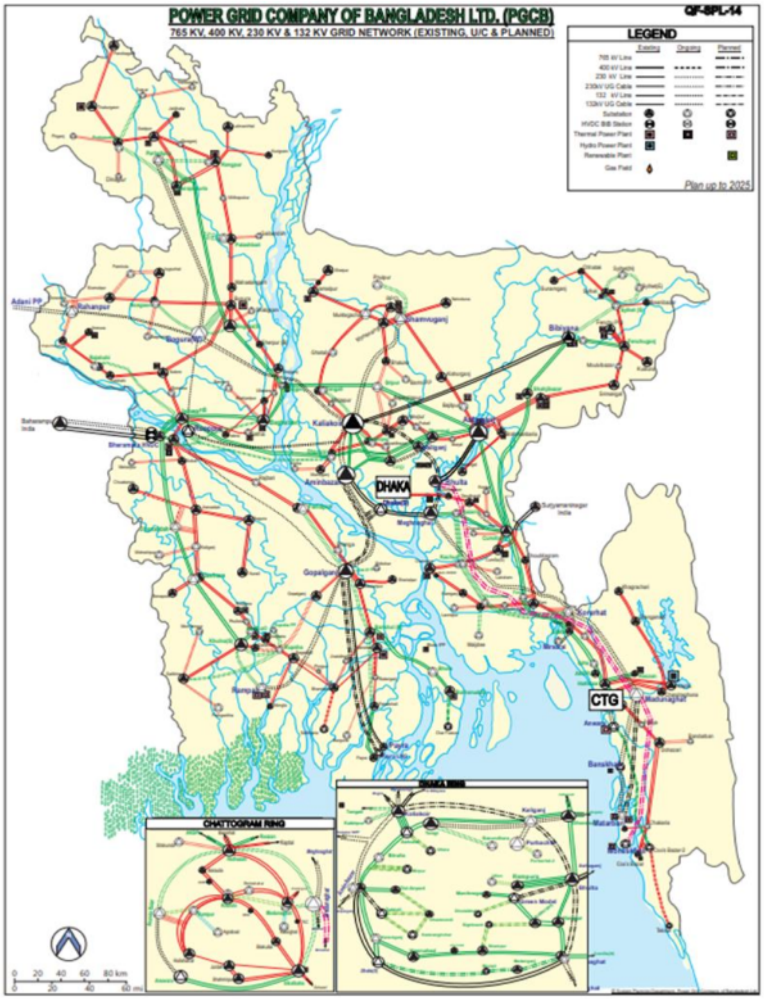

Figure 11: Grid map of Bangladesh

Some of the requirements that should be kept in mind while introducing smart grid system within the country ----

- Implementation of Smart Metering infrastructure.
- Selecting the most appropriate communication infrastructure.
- Distributed energy resources must be utilized properly
- Customer's satisfaction – for making them accepting the new technology gradually.
- Roadmap policies.
- The cost effective management should be followed strictly.
- The financial investment must be planned.
- Political willingness is an important catalyst in this regard.

Smart Meter system is a system which requires high cost and investment. As a developing country like Bangladesh it is not possible to bear the total expenses. In this regard a pilot project can be taken into account jointly by Bangladesh and any other foreign investor. And if the project gets the desired appreciation as well as the success, the government can further move a step forward in establishing smart grid across the country. In this regard the policy makers can invite online tender notice and set up a committee to evaluate the decisions related to implementing this technology and its related costs. Most of the countries have already built Smart Meter system under its smart grid technology. But it is also true that some of this countries lack the policy and regulations. The biggest challenges for Bangladesh will also be to set up the policies and regulations regarding smart grid technology. Bangladesh Energy Regulatory Commission (BERS) should come forward in this regard to introduce the required polices & regulations in order to meet the demand of smart grid system.

Chapter 3

Methodology

3.1 Methodology

The methodological approach of Cost-Benefit Analysis in utilities and transportation was proposed by Jules Dupuit in 1840s [18]. The methodological approach of CBA on smart grids projects conducted by Electrical Power Research Institute (EPRI) in 2010 [19]. Based on this framework the measurable benefits could be calculated. According to this approach, the European Commission developed the guidelines for CBA of smart grid projects [20] and Smart Metering development [3].

For any decision making of Smart Meter roll-outs member countries are required to conduct CBA, according to the Third Energy Package of EU. After completing CBA, 16 member states (>80%) have made the decision on roll-outs by 2020 or earlier; Poland and Romania had positive CBAs, but an official decision is pending; while 7 states (Belgium, Lithuania, Czech Republic, Portugal, Germany, Latvia, and Slovakia) had negative or inconclusive CBAs [21].

The Seven steps of proposed CBA work done by [EPRI 2010] detailed in **Figure 12.**~~3.1~~

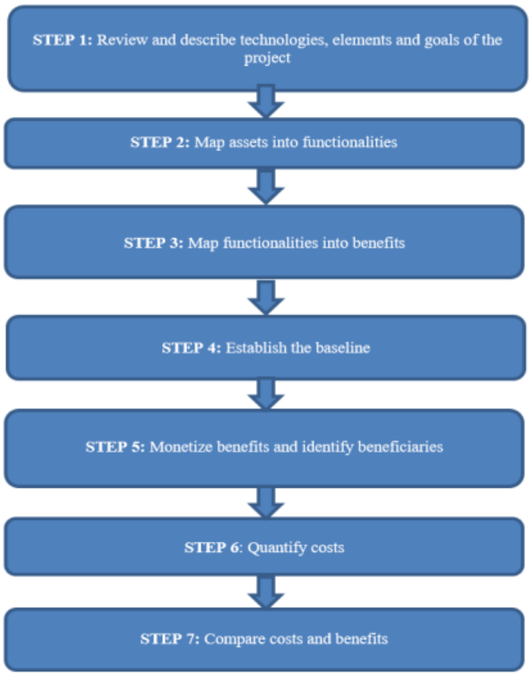

Figure 12: Seven steps of CBA

Scenarios for Smart Metering roll-out

The results of a CBA for a Smart Metering roll-out depend on implementation scenarios. It also helps enable Smart Grid functionalities as well as the number of implemented Smart Metering functionalities.

For completing~~performing~~ a Cost Benefit Analysis there are minimum two scenarios [3]

- Scenario 1: This scenario could be described as BaU - "Business as usual" without deployment of Smart Meters. Also in this scenario, it is assumed that no Smart Meters will be installed in the CBA time horizon. In other words, it is assumed that, for market reasons, meter operators do not need to install Smart Meters on top of conventional meters. It could be described ~~as~~ a "do nothing and nothing happen" scenario. ~~.This scenario could be labeled as 'Business as usual'- BaU: no roll-out of Smart Meters. In this scenario, it is also assumed that, no Smart Meters will be installed in the CBA time horizon. In other words, it is assumed that for market reasons meter operators no need to install Smart Meters over traditional meters. It might be addressed as "Do nothing and nothing happens" scenario.~~

- Scenario 2: In this scenario, roll-out of 80% of Smart Meters will be installed in described time period. Also in this scenario, Smart Meters are assumed to be equipped with the agreed minimum common functionalities.

3.1.1 Guidelines for CBA of Smart Metering deployment

According to the Guideline provided by EU, here is a guideline to perform a comprehensive CBA assessment of Smart Metering roll-outs [3]. The guidelines cover five main macro-steps:

1. Scenario definition should be completed in this step.
2. Define assumptions and boundary conditions to capture the variables impacting the investment
3. Completion of CBA
4. Perform a sensitivity analysis to analyze the influences of key variables on the estimations calculated in macro step 2
5. Asses qualitatively deployment merit, externalities and social impact

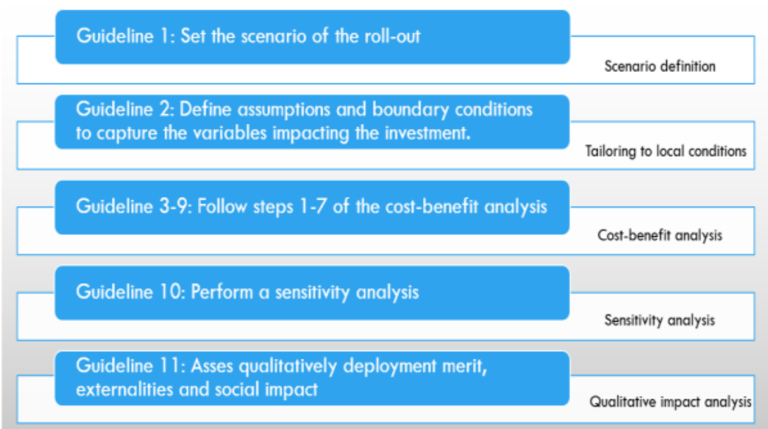

Figure 13: Five main macro-steps of guidelines

3.1.2 Guideline 1- Define the scenario

As described in previous section, we have chosen scenario 1 for the Smart Metering implementation. In this deployment scenario, no Smart Meters will be installed on the CBA time horizon. We also took other variables into account such as types of consumers and the density of supply. It is important to plan the smart metering implementation with the smart grid architecture in mind to maximize long-term benefits

3.1.3 Guideline 2- Define assumptions and set critical parameters

Frist of all we ~~identif~~recognisedy and list the main parameters. Than we communicated with an engineer of BPDB which is located in Khulsi. **Table 2** reports a representative list of variables/data we have collected potentially having an impact (positive or negative) on the investment.

Table 2: List of some variables to be define with local conditions phase

Variables	Unit
Energy consumption (Projected Variation)	%
Energy prices (Projected Variation)	%
Transmission and Distribution level (Electricity losses)	%
Non supplied minutes (Estimated)	Number of minutes
Lost load value supply value	$/kwh
Rate of discount	%
Costs of hardware (e.g. Smart Meter, GPS/PLC modem)	$
Amount of Smart Meters to be installed	Amount of Smart Meters
Smart Metering system (Installation Costs)	$
Life span of Smart Metering system	Number of years
Costs of Meter reading	$/year
Success rate of Telecommunication	%
Reduction of cost associated with technology growth	%
Schedule of implementation	Number of meter/year
Percentage of meters installed in rural vs. urban areas	%

Schedule of implementation

The implementation plan can have a significant impact on the results of the analysis. The implementation campaign we chose for this analysis is of the "concentrated" type, where the entire network or city covers the area. There is another type of installation called "scattered", here only the clients with the highest consumption in each network are considered for the implementation.

Electricity demand and prices

Saving energy is often one of the most important benefits of implementing Smart Metering. The demand for electricity depends on several parameters such as internal consumption, external consumption, electricity losses and the growth of electricity demand. ~~Though we have planned to implementation range will be Chittagong Municipality Area. For this reason,~~ We have collected information from BPDB Chittagong regional office, as we have planned to implement this project within the Chittagong Municipality Area. We have collected Monthly Operational Data (MOD) for the fiscal year 2017 to 2020 respectively. From MOD we got our necessary information/data such as domestic consumption, electricity losses, prepaid meter user, conventional meter user etc.

Implementation parameters

The CBA result can be strongly influenced by smart measurement architecture, design parameters, and technology. It is obvious that the price of Smart Meters and the operating costs of Smart Meters can vary significantly from country to country and depending on the technology. A recent study [22] found that the EU can range from $ 97 for household meters to $ 625 for industrial meters, and they made their calculations from an approximate cost of $165 per household meter (and $625 per industrial meter). In Ireland they carried out CBA for a national deployment of smart meters under the Energy Regulatory Commission (CER), the costs for PLC-based meters are $105 and $145 for mono-phase and poly-phase meters [CER 2011]. Installation costs for smart meters vary from country to country. Smart meter installation costs range from $67 in Ireland to $45 in the UK, from $88 in the Netherlands to $22 in Portugal [CER 2011].

Cost-Benefit Analysis

A brief overview of the seven steps required to complete the CBA is stated below. More details can be found in [CE, 2012b].

3.1.4 Guideline 3- Review and describe the technologies, elements and goals of the scenario (CBA step 1)

The first step in CBA is to give a main summary and correctly describe the elements that will be used in that analysis. The project objectives in the chosen scenario are clearly stated in this step. This might require the following information to be provided:

- The scope and dimension of the project
- The technical characteristics
- The local characteristics of the network
- The relevant stakeholders (i.e. their costs and benefits count)
- A clear statement of the project objective and the expected socio-economic impact

3.1.5 Guideline 4- Map assets into functionalities (CBA step 2)

In this step we have determined the assets such as Smart Meters, communications infrastructure that will be used in the selected scenario. Discover each asset individually and find out how it could be useful for any functionality. To enable benefits, different assets offer different types of functionality. For this reason, the analysis is likely to be incomplete if the assets used and the functionalities that the scenario enables are not clear.

3.1.6 Guideline 5- Map functionalities into benefits (CBA step 3)

In step 3 of CBA, we look at the individual functionalities. Let's find out how it could contribute to any of the benefits.

3.1.7 Guideline 6- Establish the baseline (CBA step 4)

In CBA step 4, we defined the "state of control" that would have occurred if the scenario had not occurred. When determining the initial situation, we would use it for the analysis with all other scenarios. Each CBA measure is based on the difference between costs and benefits.

3.1.8 Guideline 7- Monetize the benefits and identify the beneficiaries (CBA step 5)

To complete this step, we need data to quantify and monetize the benefits. To gather the necessary information, we went to the BPDB regional office. After collecting the data, we compare the most important assumptions and the level of estimation. We have clearly identified the beneficiaries as consumers, network operators, society and retailers that are associated with each benefit.

We follow some general recommendations from [3]

- The benefits must represent those that actually result from the scenario.
- Benefits must be significant, relevant to analysis, and transparent in quantification and monetization.
- The benefit calculation must be documented in a transparent and clear manner.
- Individual cost and benefit variables must be mutually exclusive.
- The level of uncertainty associated with the benefit estimate must be clearly stated and documented

3.1.9 Guideline 8- identify and quantify the costs (CBA step 6)

In this step we will identify and quantify the costs. Some costs can be easily measured as their prices are readily available in the market. Implementation costs are necessary to determine the return on investment. If the result is positive, it is helpful to take the necessary steps.

3.1.10 Guideline 9- Compare costs and benefits (CBA step 7)

When costs and benefits have been estimated, we compare them in this step 7. There are several ways to evaluate the profitability of the scenario. The methods we use include cumulative comparison, net present value, and cost-benefit ratio.

3.1.11 Guideline 10- Perform a sensitivity analysis

There are some factors, such as economic, demographic, and geographic and energy economy factors that play an important role in determining the benefits for different regions. There are some variables such as reducing electricity costs and reducing electricity theft, as they are all country specific. There are some values that need to be forecast, such as the growth in electricity demand. Future development depends on a variety of factors, some of which may vary from region to region, so it is important to consider possible changes in key variables. To find out how these variables affected the profitability of a scenario, we performed a sensitivity analysis.

3.1.12 Guideline 11- Assess deployment merit

There are some advantages that qualitative analysis failed to capture. As part of this analysis, non-monetary effects on the electricity system and society were identified and evaluated. We found that the analysis of non-monetary impacts must be done very carefully, as the analysis is not based on quantitative factors.

Chapter 4

Result and Analysis

4.1 Result and Analysis

Installing Smart Metering will be a costly movement for government. So at first we have to ensure that installing Smart Meter will be beneficial more than the cost. And the Cost Benefit Analysis will be calculated ~~we will calculate the cost benefit analysis~~ in a small range. First we selected Chittagong municipality area for our pilot project. According to the MOD we got from PDB office which is located at Khulshi. There are total 12 divisions in Chittagong municipality area [23]. Here is the list given below in **Table 3.**

Table 3: Division wise consumer number in Chittagong Metro. Area

Name of the circle	Name of the division	Consumer
Ctg. Metro (East)	Patharghata	54,816
	Stadium	38,592
	Sholoshahar	70,100
	Kalurghat	68,753
	Baklia	84,237
	Madarbari	35,218
Ctg. Metro (West)	Agrabad	52,026
	Halishahar	47,535
	Khulsi	49,628
	Pahartali	80,215
	Rampur	54,969
	Newmooring	44,031
Total		680,120

In Chittagong Metro (East) and Chittagong Metro (West) total users respectively 351,716 and 328,404. So we got the total consumers in Chittagong Metro area is 680,120. There are two types of user in this region one is prepaid meter user and another is traditional credit meter user. We got another information about how many users are converted into prepaid meter user from credit meter user shown in **Table 4.**

Table 4: Prepaid meter user list in Chittagong Metro. Area

Name of the division	**Prepaid (%)**
Patharghata	**5**
Stadium	**90**
Sholoshahar	**70**
Kalurghat	**70**
Baklia	**70**
Madarbari	**99**
Agrabad	**98**
Halishahar	**0**
Khulsi	**97**
Pahartali	**98**
Rampur	**96**
Newmooring	**65**

According to the latest information provided by an Expert of BPDB he suggested to take the value (which >95%) as 100%. So we calculated how many prepaid meter users are located in Chittagong Metro area. Calculation of prepaid meter shown in **Table 5**.

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Table 5: Total Prepaid meter user

Name of division	Consumer	Prepaid (%)	Prepaid
Pathaorgata	54,816	5	2740
Stadium	38,562	90	34,732
Soloshahar	70,100	70	49,070
Kalurghat	68,753	70	48,127
Baklia	84,237	70	58,965
Madarbari	35,218	100	35,218
Agrabad	52,206	100	52,026
Halishahar	47,535	0	0
khulsi	49,628	100	49,628
Pahartali	80,215	100	80,215
Rampur	54,969	100	54,969
Newmooring	44,031	65	28,620
Total	**680120**		**494310**

So total prepaid meter user in Chittagong Metro is 494310 and traditional credit meter user is 185810.

In this analysis according to this information we will consider the total consumer is 680,000. Prepaid meter user is 495,000 and traditional meter user is 186,000

4.1.1 Smart Meter Types

There are three types of Smart Meter available: SMETS1 meters, SMETS2 meters and advanced meters. In this roll out we consider SMETS2 will be installed throughout the project.

4.1.2 Some General Assumptions

All the hypotheses we used in this analysis of the cost benefit indicated below.

4.1.3 Meter Lifespan

We assume all the meters will be installed in this project are manufactured in accordance with the Smart Metering Equipment Technical Specifications (SMTES) [11] which indicates that the lifespan of this type of meter is near about 15 years. We consulted with an Expert of BPD, who advised us to take count the lifespan of traditional meter lifespan is near about 20 years.

And we have taken the value of per unit cost of electricity is 6 taka which is equivalent to $0.07

The currency of $1=85 taka is considered in this document.

4.2 **Analysis of costs**

In analysis of cost we discussed about the considerable constituents of the costs of the roll-out Smart Meter program in Chittagong municipality area. Proportions of total costs shown in **Figure 14**.

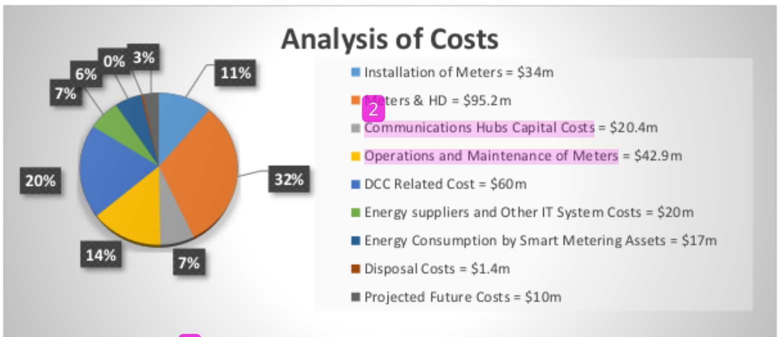

Figure 14: Distribution of total costs of the Smart Meter program

4.2.1 In-Premises Costs

In premises costs included with asset costs and installation costs. In premises cost mainly to find out total costs occur in consumer residence.

4.2.2 Installation costs

The installation cost of meter types will be different in every ~~countries~~country. For finding the installation cost of credit meter we have conducted with a local technician. Taking consideration of his suggestion we assume that in Bangladesh the installation cost of Traditional Credit meter is near about 200 or 300 BDT. So we have considered the value for cost per installation is $5. Prepaid meter installation is a new concept in Bangladesh comparatively credit meter system. The installation cost of prepaid meter is higher than the traditional credit meter. For evaluate the actual installation cost prepaid meter we have conducted an expert in Bangladesh Power Development Board (BPDB). The installation cost of prepaid meter we got from BPDB described in **Table 6**.

Table 6: Prepayment installation charge for customer by BPBD

No	Description	unit	Item Quantity	Unit Price	Total Price
1	Prepayment Meter Price (1 Phase)	Meter	1	5300	5300
2	PVC Ins. Single Core Cable	Meter	30	47	1410
3	GI wire 14 no.	Meter	20	5	100
4	Service Connector	Nos	2	180	360
5	Wedge Clamp with Cable Grip	Nos	1	100	100
6	Stain Clamp	Nos	1	50	50
7	Shackle Insulator	Nos	1	80	80
8	Meter Board	Nos	1	250	250
9	Assorted item	Job	1	95	95
	Consumer supplied materials charge				7745

According to this information the installation cost of per prepaid meter is 2445 taka. Smart Meter installation cost will be slightly higher than the prepaid meter.
Here is the price list of different types of meter installation cost shown in **Table 7**.

Table 7: Installation cost of different types meter

Installation type	Cost per installation		
	Smart Meter	Prepaid Meter	Traditional Credit Meter
Electric only	$50	$30	$5

According to the MOD of Chittagong metro area there is total user near about 680,000 [22]. As we want to install Smart Meter and the installation cost per Smart Meter is about $50, the total cost of installations ~~are~~is approximately $34M.

4.2.3 Asset costs

In asset costs we will try to figure out total costs for all the components of meter. In Smart Meter assets meter, In-Home Display and communication hub included for asset costs.

4.2.4 Meter Costs

It is obvious that Smart Meter has more capability than credit meter or prepaid meter. With the help of two-way communication system, it can send information to the central system. When it is required it can terminate the connection of home from supply line. So that the price of Smart Meter is higher than other two metering system. According to the table 4.4 we find the price of prepaid meter is $53. Smart electric meters cost somewhere around $100 to $500 as compared to the traditional meters, which have the pricing of around $10 to $30 [24]. **Table 8** shows the different cost of metering assets.

Table 8: Cost of different types of meter

Asset	Cost
Smart Meter – electric	$120
Traditional credit meter – electric	$10
Traditional prepaid meter – electric	$35

According to the MOD in Chittagong metro area total consumer is 680000 [22]. As per table information Smart Meter cost $120 and we will install Smart Meter for every consumer throughout the project. So overall cost associated with metering assets is approximately $81.6M.

4.2.5 Operations and Maintenance

We assume an annual operations and maintenance cost for Smart Meters of 2.5% of the purchase cost of the meter [25]. If the meter is defective we need to replace the meter This cost mainly related to replacing the faulty equipment. The total cost of meter purchase

includes Smart Meter cost, communication hub costs and In-Home Display costs. Smart Meter purchase cost is $81.6M, communication hub purchase cost $20.4m and In-Home Display purchase cost is $13.6M. After calculation, total cost of Smart Meter purchase is $114.6M. Per year operations and maintenance cost is approximately $2.87M.
The general cost associated with the operating and maintenance costs throughout the project is $42.9M.

4.2.6 Dual-Band Communications Hubs

In non-domestic premises a standard Smart Meter will communicate with In-Home display. This device will communicate with each other via Home Area Network (HAN). As for this analysis we considered STMES2 type Smart Meter, standard 2.4 GHz HAN solution will be suitable. Though some meters may not interact properly with 2.4 GHz signal because the location of the meters or building design may hinder the signal. For solving this problem, GB government made a solution by working with industry to implement an 868MHz solution facilitated by dual-band communication hubs. This dual-band communication hub is expected to solve all the problem.
The communications hub sitting immediately onto top of Smart Meter is responsible for receiving and sending all data. This data can be meter readings, commands or alerts. Each of dual band communication hub cost approximately $30 [25]. So the total cost will be $20.4M.

4.2.7 In-Home Display Costs

When consumer get a Smart Meter installed, a small box will also be provided consisting of a screen on it, known as an In-Home Display or IHD. The IHD shows the consumer on its current energy consumption like kWh (kilowatts, the unit used to measure energy use). It also shows the use of energy over time for the day, week, month and year. The average price of IHD close to around $20[19]. So the total cost of IHD installation will be $13.6M.

4.2.8 Financing of Assets

The cost of installation and the activities of smart measurement equipment discussed above are financed during the useful life of good at a cost of 4% cost of the capital.

4.2.9 DCC costs

The Company of Data and Communications (DCC) provides the shared communication platform required for secure data transmission and Smart Meter messages. The resulting costs estimates are classified in internal costs (DCC) and external (DCC service provider) costs.

4.2.10 DCC Internal costs

The internal costs of the DCC incurred directly by, or directly related to the DCC licensee, including the staff report, general expenses and the allowed margin and many of their smaller contacts.

4.2.11 DCC External Costs

External DCC costs that are charged to the DCC by fundamental external service providers of the supply of key parts of the smart measuring service, including the main contracts for the provision of data and communication services.

DCC related costs is near about 25% of total cost [25]. We assume the internal cost of DCC will be near about $60M.

4.2.12 Energy Suppliers and other IT System costs

This section acquires additional expenses that suppliers and industry should support to maximize their ability to understand the profit of the Smart Meter.

We assume the total cost of energy suppliers and other IT system costs near about $20M.

4.2.13 Other Costs

In other cost included with total energy Smart Meter uses itself, the disposal cost of the Smart Meter and some other cost may vary in the future. All this costs figured out in the next section.

4.2.14 Energy

All parts of Smart Meter consume energy. Smart Meter, communication hub and In-Home Display all need energy to run. There are more components in Smart Meter if we compare them with traditional meter. For this reason, they consume more power than credit meter. The forecast energy costs which is requires to establish a HAN in consumer premises also included in energy cost. According to the Green Book, Smart Meter annually consumes near about 18kwh [26].

So total energy consumption by Smart Meter over the appraisal period is approximately $17M.

4.2.15 Disposal

For environment purpose, we need to disposal Smart Meter after end of their lifespans. There is a cost related to the disposal of Smart Meter. We assume a cost of $2 per meter that is replaced.

After calculating we find out total costs of meter disposal amount is near about $1.4M.

4.2.16 Project future costs

While conducting the cost analysis we found that some costs are clear, there are several cost areas where there remains some uncertainty after the implementation started. There are some variable costs which could be changed in near future. In order to ensure the CBA is fully adaptive for uncertain costs, we have added them in future cost segment. In total, we include approximately $10M for potential future costs.

4.2.17 Total Costs

Summary of total costs shown in **Table 9.**

Table 9: Summary of total costs

ITEM	($M)
Installation of Meters	34
Meters & IHD	95.2
Communications Hubs Capital Costs	20.4
Operations and Maintenance of Meters	42.9
DCC Related Cost	60
Energy suppliers and Other IT System Costs	20
Energy Consumption by Smart Metering Assets	17
Disposal Costs	1.4
Projected Future Costs	10
Total costs	300.9

Total cost of the program is near about $300.9M.

4.3 Analysis of Benefits

In this section we discussed each of the major components of the benefits the roll-out delivers, covering customer benefits, supplier benefits, demand-shifting benefits, network benefits, environmental benefits and unquantified benefits. Total analysed benefits shown in **Figure 15**.

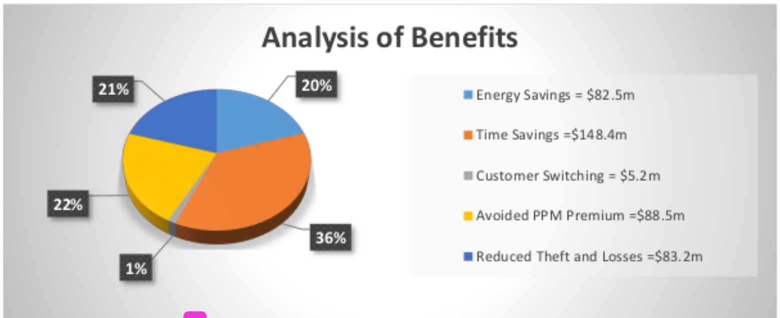

Figure 15: Distribution of total benefits of the Smart Meter program

4.3.1 Customer Benefits

Customer benefits mainly associated with energy savings, time savings. We have tried to figure out energy savings benefit with evidence base feedback. And time savings benefit calculated according to consumer behavior.

~~4.3.1~~4.3.2 Energy Savings

On the basis of consumer's energy consumption behavior, the Smart Meter roll-out offers significant advantages in the form of energy reductions. In-Home Displays help the consumers get the real time consumption data which assists the consumer to reduce energy consumption by taking necessary steps. There are four main points that helps to get energy savings benefits [27]:

- Direct feedback- real-time consumption data can easily have delivered to the customer through In-Home Displays. Thus it helps the consumer most to reduce the energy uses.
- Indirect feedback- accurate billing history is also helps the consumer to monetize their energy uses.
- Advice and guidance- when the installers offer applications and services they are required to put some advice that can help consumer to better choices.
- Motivational campaigns- campaigns are used to raise knowledge about the importance of energy and how consumer can use energy in an efficient way.

Evidence Base

Though in our country there is no pilot project run by the authorities. Before installing Smart Metering system many countries conducted pilot project and feedback trials. A recent review conducted by VaasaETT for the European Smart Metering Industry Group (ESMIG) [28]. This review study found that, across 130 electricity and gas pilots including 709 samples and involving 5.5 million residential consumers, they have an average reduction of 5.4% in electricity uses and 3.9% gas consumption. They have also found highest energy savings an average of 7.9% in electricity consumption and 9.6% in gas consumption.

There are some early learning projects run by the authorities of GB before installing the Smart Metering system. In 2011, Energy Demand Research Project (EDRP) was conducted to understand the response of GB Smart Meter consumers. This trials found energy reductions of 2% to 4% and the duration of the trials is taken count up to 2 years.

Assumptions

In 2015, GB government published the findings of the Early Learning Project (ELP) [29]. This project came with an independent report which summarized how GB consumers engage with their Smart Meter who received their Smart Meter between 2011 and 2013.Based on the available evidence, we assume that gross average reductions in demand per household will be:

- 3.0% for electricity

Calculating the Benefit

For finding out a per-meter figure for the amount of energy saved, we multiply the savings assumptions above by the amount of per capita consumption in given sourced from Monthly operational data of Chittagong Metro Area [20]. Total energy savings by using Smart Meter shown in **Table 10**.

Table 10: Calculation of total energy savings by Smart Meter

	Electricity
Per meter consumption (kWh)- A	3853
Average energy saving-B	3.0%
Per meter energy reduction (kWh) – C (A*B)	116
Projected number of Smart Meters installed – D	680000
Total energy reduction (MWh)- E(C*D)	78.888
Long-run variable cost of energy -F	0.07
Total value of energy reduction – G (E*F)	$5.5M

After calculating all the variables, we have found out that the total energy savings by the Smart Meter during the whole running project is approximately $82.5M.

~~4.3.2~~4.3.3 Time savings

By using Smart Meters consumers can reduce the amount of time spend interacting with the energy system. For example, smart customers are no longer required to submit meter readings and no longer topping up prepayment meters that do not require them to leave their home. Time saved by meter type shown in **Table 11**.

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Table 11: Time saved by meter type

Meter Type	Total minutes Saved per Year
Electric Credit	15
Electric PPM	10

Valuation Approach

A person working in Bangladesh typically earns around 26,000 BDT per month [30]. Per working day it will be 1181.81 taka. So in hourly basis it will be 147 taka. We applied the assumption of non-working value of time 82 taka which is equivalent to $0.96 [31]. Calculation of total value of time savings shown in **Table 12**.

Table 12: Total value of time savings

Source of time Savings	Credit	Prepayment
	Electricity	Electricity
Topping up prepayment meters	NA	$94.9M
Payment of credit meters	$53.5M	NA
Total	$148.4m	

According to this study the total consumer time savings benefit is approximately $148.4M.

~~4.3.3~~4.3.4 Supplier Benefits

In this section we have tried to figure out the benefits that related to the suppliers. There are some benefits could be achieved by the supplier by installing the Smart Meter such as avoided site visits, serving cost reduction compared to the prepayment meter, reduced theft, network benefits and some other benefits.

~~4.3.4~~4.3.5 Avoided Site visits

Energy suppliers are no longer need to send meter reading operatives to collect meter readings. Using data from an expert from BPDB he suggested us that the meter readings cost per meter budget is 10 taka per month. So per year cost of meter readings per meter is 120 taka. We have taken the value $1.41 for per meter. In Chittagong there are traditional credit meter user about 186,000. So total saved throughout the project is approximately $3.9M.

~~4.3.5~~4.3.6 Prepayment Cost to Serve

Smart Meters can achieve greatly savings in the costs that energy suppliers if we compare it with serving costs of prepayment meters (PPM).

The cost which is related to serving for a particular customer is comparatively higher in prepayment meter than traditional credit meter because:

- When it comes to buy and service prepayment meters are costly.
- To manage and accommodate the allocation of payments from customers to energy suppliers a specialized back-office administration is quested by the prepayment system.

Smart Meters bring about considerable cost savings to suppliers because:

- In Smart Meter prepayment and credit mode are enabled with remote switching. On the other hand, for traditional meter it requires visiting the site for switching purpose and replace a credit to prepayment meter.
- Providing a significant opportunity for consumers to get informed of their consumption of electricity and making a structural plan on how to utilize their spending patterns

According to the information from suppliers, the energy reduction cost can be achieved 33% less than the prepaid meter in cost to serve for electricity [32]. This means savings of $12 per year per electricity PPM customer.

As getting the information from MOD of the fiscal year 2019-2020 the PPM user in Chittagong Municipality Area is near about 494310.The present value of the prepayment cost to serve reduction benefit is approximately $5.9M. So the total benefit during the project is near about $88.5M.

~~4.3.6~~4.3.7 Reduce Theft and avoided losses

The implementation of Smart Metering will improve energy supplier's ability to detect and manage energy theft. Suppliers can get data from Smart Meter according to predetermined time interval which allows them to identify energy theft more easily. By getting this regular basis they can take proper step against energy theft. Utilizing these information suppliers could better their enforcement activity which will allow them reduce cost.

There are two types of losses – technical losses and another one is non-technical losses. Technical losses occur because of energy dissipated in the conductors, appliances used for the transmission line, distribution line and magnetic losses in transformers. The main reason for non-technical losses are related to meter reading, error in meter reading, faulty meter, lack of proper administration. In traditional meter sometimes consumer tempers the meter by mechanical jerks, using powerful magnets and some other techniques. But Smart Meter can prevent energy theft because it has a dedicated anti cheating unit which prevent energy theft and provide information to utility provider about the incident occurred.

Smart Meters facilitate some reduction in losses. The energy demand in Chittagong metro area per month is 222Mw [25]. Losses occur per month is near about 10% if we consider about 3% is the energy theft in this loss. By installing Smart Meter, we can reduce this loss. So per month reduction of theft energy will be near about 6.6Mw and for whole year it will be 79.2Mw. Throughout the project, the energy saved from theft will be 1188Mw. So it is equivalent to save near about $83.1M for whole project time.

~~4.3.7~~4.3.8 Network Benefits

Outage Detection and Management for Network Operators

Earlier Fault Notification

With traditional meter system DNOs rely on customers call for getting information about power outages. Sometimes it is difficult for utility provider get the proper information about the outage by phone call. Smart Meter can bring revolutionary change on this point. Because of the intelligent feature with the help of back up supply it can send information to the server about the problem occur in the consumer side. By getting the detailed information about the power outage utility provider now can take proper steps with more precisely.

Faster Restoration of supply

Outage notification from Smart Meters help DNOs to take proper step to restore the supply network rather than traditional metering system. After getting exact information utility provider can send their reinforcement to exact location for solving the outage problem. This will help them in reduce amount time for resolve the problem.

~~4.3.8~~4.3.9 Total Benefits

Summary of total benefits shown in **Table 13**.

Table 13: Summary of total benefits

ITEM	($M)
Energy Savings	82.5
Time Savings	148.4
Customer Switching	5.2
Avoided PPM Premium	88.5
Reduced Theft and Losses	83.2
Total Benefits	407.8

Chapter 5

CONCLUSIONS AND FUTURE WORK

5.1 Conclusions

After completing the Cost Benefit Analysis, ~~we found that~~ for 15 years from 2021 through 2036 we found that almost \$100M can be benefited from installing the Smart Metering System. The establishment cost of installing Smart Meter may be high but overall the roll-out in Chittagong Municipality Area delivers a **benefit-to-cost ratio (BCR) of 1.36**, reflecting lifetime costs and benefits. According to the analysis per household Smart Meter cost is \$440 and the benefit we get form the lifetime period - per Smart Meter is near about \$600. In the near future, Bangladesh government is planning to implement smart grid. Smart Meter plays a vital role in Smart grid. The advanced metering infrastructure (AMI) is such a system to be operated for real-time monitoring and control of electricity usage. The main benefits by adopting AMI are tremendous and great, and governments of many countries are preparing for the nation-wide implementation of various Smart Meters to collect the power consumption data from individual customer level ~~home appliances~~ and it can have the capability of data transmission to report the meter data which is power demand. Alternatively, a Smart Meter may connect with the home gate way with a dedicated function of data transmission. The first step in this process is to determine the system's ability to generate and deliver interval data. Hourly readings are the usual interval for asset management purposes. The next step is to ensure whether consumer gets enough power as per their demand. Some of the Smart Meters are equipped with a display for sending data on the amount of power consumed or the corresponding cost to the consumers. Therefore, the basic requirements for the power strip type Smart Meters in actual operating environments are that they should be low cost and have low communication load. Smart Meters have a pivotal role as they can measure and communicate detailed real-time energy usage technical data to the grid that is utility providers, which also facilitate remote power monitoring and control. In this connection one more aspect is data privacy. Smart grid privacy encompasses the privacy of information obtained from Smart Metering data, which may be systematically collected and analyzed. There are also multiple factors, including security and encryption, which define the suitable communication method. There are a number of essential functionalities meters that should be regardless of the type or quantity of their measurement. The Smart Meter is an important invention of the present time as it gives us a wide advantage and its effectiveness is much higher than the ordinary traditional meter. The following is a list of the functionalities that smart meter provides in the long run of smarter technology:

- It is able to effectively handle the threat of power loss in the distribution network.
- It provides an efficient billing system that can implement a multi-tariff rate depending on both "usage time" and "usage volume" during the day or period.
- It provides a usage profile that is specific to a particular user, making it more transparent to both the consumer and the service provider.
- It becomes easier to monitor and take the necessary actions required when generating alarms that, under certain conditions and disconnect the load from certain users.
- It performs efficient management of load shedding and load distribution at the network level.
- It monitors consumer behavior and helps to analyze load pattern so it is useful to easily measure any anomalies.
- It offers enhanced security and detects tampering on the distribution network.

Also Smart Meter provides some other efficacy such as: Reliable Power Supply, Islanding, Smart Metering Infrastructure, Security, Load Shifting and Switching, Electricity Market, Economic Benefit, Expansion Planning, Digitalization etc.

Developed countries have started to develop and implement smart grids since the introduction of this technology. Comparing with developed countries, especially in Europe and North America; Bangladesh is still far behind in all technical and economic aspects. They are putting a lot of effort into this sector and spending their manpower and their money to develop further. According to the "Power System Master Plan" of BPDB (Bangladesh Power Development Board) it was assumed that, transmission loss will be reduced to 3% by 2018 and distribution loss to 10% by 2019. But it may not be possible due to some obstacles such as corruption, insufficient technological support and political uncertainty. In that case, Smart Grid technology may be a good option. Since this is a technology, once implemented, the entire system is very easy to maintain and operate. As a result, fewer resources are required to run the nation's entire electric grid, resulting in huge savings in both money and labor. At the same time, the utilization of available resources is optimized as much as possible.

5.2 **Future work**

While conducting this work, a variety of interesting and significant research areas were revealed this may be pursued as future work.

A mixture of technologies can be implemented in the smart scheme. For communication system different types of metering network can be used. Such as Fiber Optics Network, DSL (Digital Subscriber Line), Power Line Communication, Mobile Network, GSM (Global System for mobile), LTE (Long Term Evolution) and CDMA (Code Division Multiple Access) are mainly used for Smart Metering Network. Research can be made on which combination of network will be more beneficial in the Smart Metering scheme.

Things that can be recommended for the improvement of future Smart Meter projects are as follows –

- Consumers play a pivotal role in this process. So it is obligatory to showcase the benefits and improvement of smart technologies before them which may enable them to accept this system without any anxiety or hesitation in their mind.
- Accurate and appropriate coordination is necessary to maintain the Smart Metering system. It enables to decrease the infrastructure costs and the peak demand which results in energy saving.
- Proper Time-of-Use (TOU) pricing is necessary.
- It is essential to seek consumers consent. As the Smart Meter system is a two-way communication system it enables both the consumer and utility provider to be aware of the billing system. Thus there lies satisfactory relationship between them which should be maintained properly.
- Cost Benefit Analysis is significant in Smart Metering system implementation or any other equivalent projects in order to analyze the advantages, related costs, risks and obstacles.
- The technological field and researches related to this field should be encouraged and provide necessary aid to carry out the innovative thinking.

The design, implementation, planning, operation, maintenance is a major issue in this regard. Only well trained & acknowledged engineers can implement this wonderful technology and maintain t properly. In Bangladesh it is a bigger challenge. Bangladesh must be formed with well-defined organogram to introduce the system properly in the country. Last but not the least it is a significant step to make the consumers aware of the Smart Meter system or we can say the necessity of whole smart grid system. The engineers and the investors in this regard need to come forward as they have the better knowledge related to this system. They can make people conscious in using the Smart Meter system and how important it is to meet up the demand of the countries power system. Also media and newspaper shall play a crucial role in this step. People are now well aware of the media facts & by watching this regularly in front of them they will be on the same page with the decision makers and will be acknowledging the benefits, supports and implementation necessity.

Lastly, to conclude, the objective of this thesis work was mainly to show the number of benefits can be gained by installing Smart Metering system compared to other metering network which is currently available.

Chapter 6

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