Amr Amin
2205 Lower Mall
Vancouver, BC V6T 1Z4

April 6, 2012

Dr. William Dunford
Electrical and Computer Engineering
The University of British Columbia
3043 – 2332 Main Mall
Vancouver, BC V6T 1Z4

Dear Dr. Dunford:

Subject: Formal Report Assignment for EECE 492

In response to your request for a formal report as the final assignment for the Electrical and Computer Engineering 492 course, I have prepared the enclosed report entitled "An Evaluation of the Smart Metering Program".

This report compares the features of old electricity meters and smart meters, describes how the smart metering program works, discusses the advantages and disadvantages of the smart metering program, and analyzes the program from an economic standpoint.

If you require further information concerning the report, please feel free to contact me at amramin@interchange.ubc.ca.

Respectfully submitted,

Amr Amin

Enclosure

AN EVALUATION OF THE SMART METERING PROGRAM

Prepared by: Amr Amin

Date submitted: April 6, 2012

EECE 492 – Distributed Energy Systems Management

The University of British Columbia

ABSTRACT

"An Evaluation of the Smart Metering Program"

Prepared by: Amr Amin

Our electricity grid has changed little over the past 50-100 years and has not kept pace with the advancements in technology. An important upgrade to the grid is now taking place. Old electricity meters are being replaced with modern digital devices known as "smart meters".

This report compares the features of old electricity meters and smart meters, describes how the smart metering program works, discusses the advantages and disadvantages of the smart metering program, and analyzes the program from an economic standpoint. The main case study used throughout the report is the smart metering program in the province of British Columbia.

The advantages of the smart metering program include two-way communication between the meter and the utility, improved power-outage-detection techniques, customer tools for conservation, and electricity theft detection. The disadvantages of the program include the transition process, the difficulty in ensuring the security of data, and the electromagnetic radiation produced by the smart meters. The smart metering program is worthwhile from an economic standpoint since its net present value is $520million.

TABLE OF CONTENTS

LIST OF ILLUSTRATIONS

1.**0 INTRODUCTION**

Our electricity grid has changed little over the past 50-100 years and has not kept pace with the advancements in technology. An important upgrade to the grid is now taking place. Old electricity meters are being replaced with modern digital devices known as “smart meters”. The introduction of smart meters will offer improved safety and reliability across the grid, and will pave the way for renewable energy sources such as wind and solar power.

This report presents an evaluation of the smart metering program. The objectives of this report are to: compare the features of old electricity meters with those of smart meters, describe how the smart metering program works, discuss the advantages and disadvantages of the smart metering program, and analyze the program from an economic standpoint. The main case study that will be used throughout the report is the smart metering program in the province of British Columbia.

One of the most common misconceptions associated with smart meters is that they form what is known as a “smart grid”. It is important to emphasize that smart meters are only a subset of the smart grid concept. The vision of the smart grid is to introduce improved communication, monitoring, and control across the electricity grid by means of computational power.

This report divides into the following primary sections: Old Electricity Meters vs. Smart Meters, How the Smart Metering Program Works, Advantages of the Smart Metering Program, Disadvantages of the Smart Metering Program, and Conclusions.

2.0 OLD ELECTRICITY METERS VS. SMART METERS

There are several differences between old electricity meters and smart meters, and this should come as no surprise considering that many of the old meters have not been changed for almost 50 years. Although the old electricity meters have a long lifetime, their features are limited. Table 1 below compares the features of the old electricity meters and smart meters:

	
Old Meter	**Smart Meter**
• Captures only electricity consumption	• Captures voltage, power quality measurements, hourly electricity consumption data
• No communication capability	• Integrated two-way communication between the meter and BC Hydro, and the meter and the premise
• No outage detection	• Automated outage detection and notification – "last gasp" and "first breath"
• No tamper detection	• Automated meter tamper alarms and support for theft detection and other analytics
• Manual on-site meter reading • Manual meter connects and disconnects	• Automated and on-demand meter readings • Remote meter connect and disconnects • Disconnect policy remains the same
• Estimated cost and consumption feedback provided through bi-monthly bills only	• Customer cost and consumption feedback provided in near real-time via multiple choices

Table 1: Features of the Old Electricity Meters and the Smart Meters [1]

One of the key characteristics of old electricity meters is that they are usually electro-mechanical. Electro-mechanical devices contain magnetic disks which rotate at a speed proportional to electrical power. The main drawback associated with these devices is that they can only capture the total electricity consumption. There are two ways in which a customer can monitor their electricity consumption using an old electricity meter. The first method involves reading the meter directly. The second involves waiting for the utility to deliver the bi-monthly bill (which is also prepared by a manual on-site reading of the meter by a utility employee). In both cases, the meter reading reveals only the total consumption, and not the consumption over certain time intervals.

The smart meters are digital devices, and use digital signal processing to capture voltage, power quality and hourly electricity consumption data. Even though some of the more recent old meters are in fact, also digital, they do not possess many of the features that the smart meters possess. The term "smart meter" is derived from the intelligence of these modern devices. The communication capability of a smart meter allows it to automatically send consumption data to the utility for billing purposes, and allows customers to monitor their consumption in near real-time through various methods.

3.0 HOW THE SMART METERING PROGRAM WORKS

Smart meters record electricity consumption on an hourly basis. The recorded data is stored within the meter's memory, in the form of a data log. These data logs are then sent to the utility three times per day via wireless communication. Communication is achieved through a Zigbee module on the customer end, and 900MHz radio frequency on the utility end. Figure 1 below shows a system overview of the smart metering program:

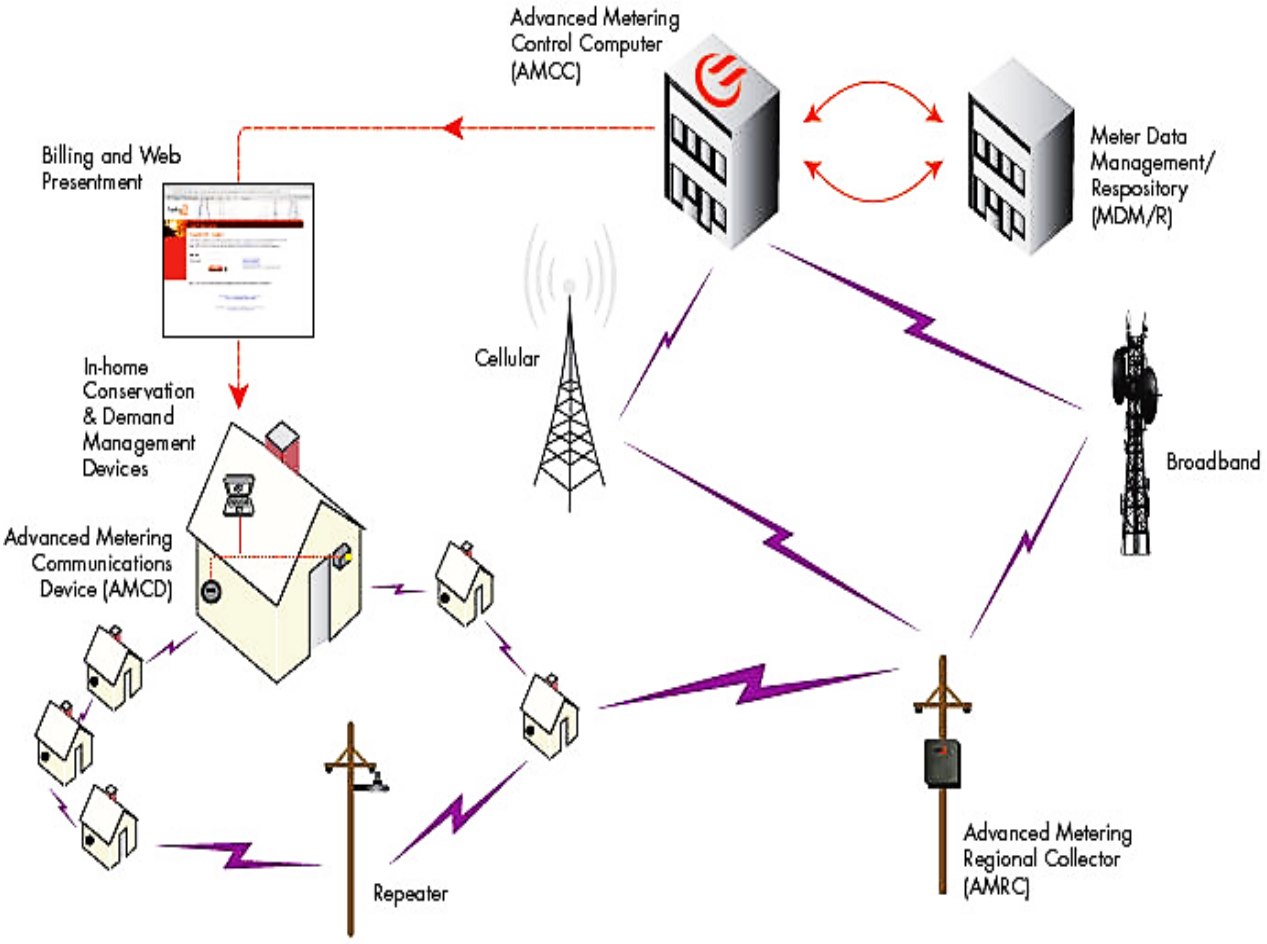

Figure 1: Smart Metering System Overview [2]

Data is securely routed between the individual smart meters in a neighborhood until it reaches a common collector. If an obstacle impedes the transmission of data, the self-healing network will route the data through a different meter or collector. This mesh network allows data to be transmitted in a reliable and cost-effective manner. The common collector then sends this data to the utility using existing infrastructure such as cellular and broadband. Communication between the smart meter and the utility averages only 15 minutes per day, and the data is highly encrypted to ensure its security.

4.0 ADVANTAGES OF THE SMART METERING PROGRAM

This section discusses some of the advantages of the smart metering program, which include two-way communication between the meter and the utility, improved power-outage-detection techniques, customer tools for conservation, and electricity theft detection.

4.1 Two-way Communication

One of the most important features of smart meters is that they allow two-way communication between the meter and the utility. Not only will smart meters measure the electricity consumed by the customer, but they will also be able to measure the electricity produced by the customer. This paves the way for renewable energy sources such as solar and wind power. Customers may also be able to sell electricity back to the utility in the future, however, it is important to emphasize that the current infrastructure does not support this.

4.2 Improved Power-Outage-Detection Techniques

The only way the utility can find out about a power outage in an area where only old electricity meters are installed, is through a phone call. This means that the utility is only informed about outages once customers call in to report them. This is one of the most significant drawbacks of the old electricity meters.

Smart meters on the other hand, are able to detect power outages immediately and send a notification signal to the utility. This means that power outages can be pinpointed, and the restoration process can be completed faster. The smart meter contains an internal battery which allows it to operate when power is lost. This is known as the “last gasp” feature.

4.3 Customer Tools for Conservation

The data that is recorded hourly by the smart meter is sent to the utility 3 times per day. This data is then securely stored in the utility's system and made available to customers through an online, password-protected account. This allows customers to more closely monitor their electricity consumption. Figure 2 below shows how the secure, online account is updated:

Figure 2: Secure, Online Account [3]

In addition to the secure, online account, customers can purchase Energy Monitoring Units (EMU). These allow customers to monitor consumption in near real-time. There are two radio modules in the smart meter, one that communicates with the utility and one that communicates with other devices such as EMUs. The latter is disabled as a default setting, but can be enabled by contacting the utility. Conservation tools can help customers save up to 15%. Figure 3 below shows an Energy Monitoring Unit produced by Rainforest Automation ©:

Figure 3: Energy Monitoring Unit [4]

4.4 Electricity Theft Detection

Electricity theft is a major concern for utilities. It is estimated that around $100million worth of electricity is stolen each year. Smart meters will help prevent electricity theft by keeping track of electricity flow. If the sum of the electricity consumption measured by smart meters in a geographical area does not match the electricity being supplied to that area, the utility will be able to identify and investigate this discrepancy.

5.0 DISADVANTAGES OF THE SMART METERING PROGRAM

This section discusses the disadvantages of the smart metering program which include the transition process, the difficulty in ensuring the security of data, and the electromagnetic radiation produced by the smart meters. There have been quite a few public protests against the smart metering program due to these issues. In the Engineering discipline, it is not common to hear about the disadvantages of smart meters, and this may be influenced by the fact that the discipline advocates technology.

5.1 The Transition Process

The transition between old electricity meters and smart meters is not a simple process. There are more than a million electricity meters that need to be changed, and the financial costs of manufacturing and installing the smart meters are significant. Also, people simply don't like change. The utility will have to inform and educate the public about the program, and there will be many questions from the public that need to be answered.

5.2 Security of Data

The security of the data being communicated between the smart meter and the utility has raised privacy concerns. Although the data is encrypted and there are several firewalls in the system, it is not impossible for the system to be hacked. Not only would this create concerns for the utility, but customers may also be sensitive to the idea that someone else can monitor their electricity consumption.

5.3 Electromagnetic Radiation

The issue that creates most public concern and protest, as usual, is exposure to electromagnetic radiation produced by the smart meters. Since the smart meters will be communicating with the utility using wireless technology, customers will be concerned about how much radiation is being emitted by the meters. Although B.C. health authorities have confirmed that there is no known health risk associated with smart meters, it is difficult to convince the public.

6.0 ECONOMIC ANALYSIS

The feasibility of the smart metering program is dependent on its economic model. The program must also be economically worthwhile, for the utility to accept it. Table 2 below shows a summary of BC Hydro's business case for the smart metering program:

Business Case Summary	Nominal Value ($M)	Present Value ($M)
Gross Benefits attributable to Smart Metering Program, less costs related to the achievement of individual benefits	$4,658	$1,629
Less: Ongoing operating and maintenance expenses and incremental asset replacement capital	(745)	(330)
Less: Smart Metering Program Costs	(930)	(779)
Total Net Value for the period F2006 to F2033	**$2,983**	**$520**

Table 2: Business Case Summary in Nominal and Present Value [5]

The net present value (NPV) is a valuation criteria that shows how much value will be added to the company at the start of the analysis period if the project is accepted. The NPV of the smart metering program during the period F2006 to F2033 is $520million, which means that it is economically worthwhile for the utility. In fact, the program is expected to save BC Hydro around $70million during the next three years alone. The data shows that the benefits of the smart metering program outweigh its costs. It also shows that customers will not have to pay for a smart meter because the meter will pay for itself through its benefits.

7.0 CONCLUSIONS

This report presented an evaluation of the smart metering program. The report first compared the features of old electricity meters and smart meters. It then described how the smart metering program works, and discussed the advantages and disadvantages of the smart metering program. Finally, it analyzed the program from an economic standpoint.

The advantages of the smart metering program include two-way communication between the meter and the utility, improved power-outage-detection techniques, customer tools for conservation, and electricity theft detection. The disadvantages of the program include the transition process, the difficulty in ensuring the security of data, and the electromagnetic radiation produced by smart meters. The smart metering program is worthwhile from an economic standpoint since its net present value is $520million.

I personally believe that the benefits of the smart metering program outweigh its costs, and that it is an important upgrade to the electricity grid. The smart metering program will modernize the grid and pave the way for renewable energy sources such as wind and solar power. Not only will the increased availability of consumption data help customers reduce their energy usage, but it will also help the utility improve the safety and reliability of the grid.

REFERENCES

[1] *(2012, February 9). What Makes a Smart Meter Smart?* [Online]. Available: http://www.bchydro.com

[2] *(2012, February 10). Automated Meter Reading* [Online]. Available: http://www.hydroone.com

[3] *(2012, February 14). Smart Meters, Smarter Choices* [Online]. Available: http://www.bchydro.com

[4] *(2012, February 9). SWIFT™ Smart Energy Wireless Information Terminal* [Online]. Available: http://www.rainforestautomation.com

[5] *Smart Metering and Infrastructure Program Business Case,* BC Hydro, Vancouver, BC, 2010, pg. 2