

# SMART METERING & INFRASTRUCTURE PROGRAM BUSINESS CASE

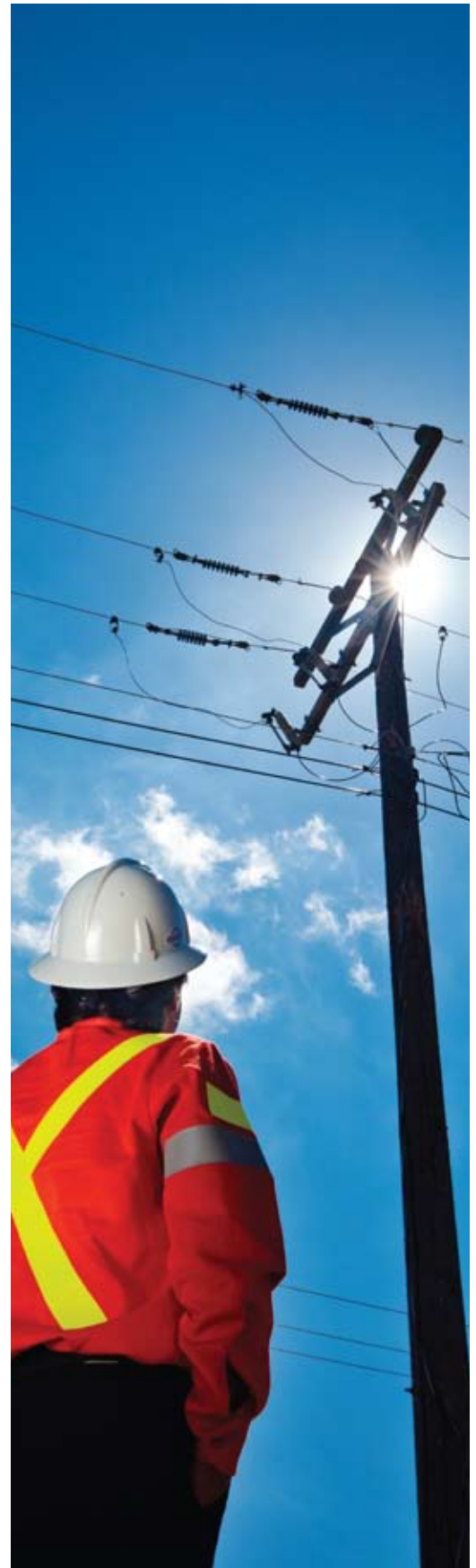


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## EXECUTIVE SUMMARY

In 2011, BC Hydro will begin implementation of the Smart Metering Program. The Smart Metering Program will pay for itself through reduced theft of electricity, energy savings, and operating efficiencies.

BC Hydro's Smart Metering Program is an important foundational step in the modernization of BC Hydro's electricity system. The program involves replacing existing customer meters, now becoming obsolete, with a comprehensive smart metering system. This system includes the technology and telecommunications infrastructure needed for BC Hydro to continue to manage the electricity system in a reliable, safe and cost-effective manner.

### Substantial Benefits to Customers

The Smart Metering Program will:

- **Improve safety and reliability** through faster and precise outage notification and a reduction in the damage caused by illegal electricity diversions.
- **Enhance customer service** by reporting electricity use more accurately, eliminating estimated bills, simplifying the process of opening and closing an account when moving, and reducing the need for onsite visits by field crews.
- **Reduce electricity theft** that currently amounts to approximately \$100 million a year in lost revenue—costs that are borne by all legitimate BC Hydro customers.
- **Improve operational efficiency and reduce wasted electricity** through voltage optimization. Lower operating costs are passed on to all customers in rates.
- **Support greater customer choice and control** by offering optional in-home feedback tools that provide direct and timely information to customers about their electricity consumption.
- **Help modernize British Columbia's electricity system** by replacing nearly obsolete meters, and creating the foundation for supporting new uses of electricity such as electric vehicles, customer generation and microgrids.

### Implementation to be Prudent and On Budget

Smart meter installation will be on time and on budget. Installation of smart meters will begin in 2011 and **will be complete by the end of 2012** with other elements of the program implemented through 2014.

**Security, privacy and safety** features in smart metering infrastructure will include encryption of data similar to that used by online banking systems, and mandatory criteria was included in all procurement processes to ensure only proven technologies were considered.

BC Hydro will **maintain existing rate structures** throughout the meter installation process. Any new rate structures will be subject to public consultation and review by the independent British Columbia Utilities Commission.

The BC Utilities Commission will review the prudence of BC Hydro's decisions and actions in relation to the implementation of the program.

### Benefits for BC Hydro Customers Exceed Costs

The Smart Metering Program business case shows that the benefits exceed the cost by \$520 million in today's dollars. These benefits are attributed to four primary areas including:

- **Operating Efficiencies**—More efficient use of distribution assets and streamlining of business processes, reducing operating and future capital expenses;
- **Energy Savings**—Lower electricity use through improved system control, operational efficiencies and providing customers with new options to better manage their electricity consumption;

- **Revenue Protection**—Includes both recovery of revenue (e.g. back-billing) and prevention of future potential revenue loss (e.g. reduced theft); and
- **Capacity Savings**—Lower electricity use at certain key periods, which reduces peak demand and capacity constraints.

Almost 80 per cent of the quantified benefits delivered through the Smart Metering Program result from BC Hydro activities. If customers take advantage of the conservation tools to be implemented by the Smart Metering Program, the overall benefits increase significantly.

### Positive Net Present Value

The Smart Metering Program business case has a net present value (NPV) of \$520 million through F2033. The NPV remains positive even if all costs are incurred but only the BC Hydro operational efficiencies are realized. The NPV also remains positive if all benefits are achieved at the low end of the estimated benefit range.

The following table summarizes the key financial components of the Smart Metering Program business case, resulting in the positive NPV of \$520 million.

#### BUSINESS CASE SUMMARY IN NOMINAL AND PRESENT VALUE

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)
<b>Total Net Value for the period F2006 to F2033</b>	<b>\$2,983</b>	<b>\$520</b>

### Rate Analysis

Net benefits will flow into lower rates for customers, reducing them below what they would otherwise be in the absence of BC Hydro's investment in the program.

#### KEY TIMELINE FOR CUSTOMERS

Stage	Timeframe	Key Activities
<b>Program Information</b>	<b>Underway and throughout the program</b>	Customers have access—through the BC Hydro website, bill inserts, and community events—to information about the Smart Metering Program, the smart metering system that will be installed, how it works, and other topics of customer interest.  Customers can share their feedback, concerns, and interest directly through calling, email, community events, and customer research.
<b>Installation of Smart Meters</b>	<b>Mid 2011 through 2012</b>	Customers receive information packages before smart meters are installed in their community <sup>1</sup> .
<b>In-home Feedback Tools</b>	<b>2012 through 2014</b>	Customers receive information highlighting new options available to support their energy conservation efforts.  Customers receive a rebate for a basic in-home display device that can be redeemed at select stores.  Customers will have access to information about their electricity use, up to the previous day, through a secure Power Smart website.

<sup>1</sup> Smart meter installation will begin simultaneously in communities throughout the province.

## INTRODUCTION

BC Hydro was created 50 years ago to plan, build and deliver a clean, reliable supply of electricity to homes and businesses throughout our growing province. Investments in dams, generating stations and transmission and distribution networks ensured a stable supply of electricity for generations of British Columbians that followed.

Thanks to this visionary planning and investment, BC Hydro has been reliably meeting our province's growing energy needs for the last 50 years. However, vitally important elements of our electricity system infrastructure are reaching an age when significant investment is required to keep our system reliable.

At the same time that our electricity system is aging, demand for power is growing. The latest forecasts show demand for electricity in British Columbia growing by as much as 40 per cent over the next 20 years. That's the equivalent of adding five more cities the size of Vancouver to our system.

### The Need for Smart Metering

Home electronics, consumer products, and manufacturing automation are just a few examples of how technology has advanced, leading to more electricity use than ever before.

The electricity system that supplies the energy to support this demand hasn't kept pace. For example, meters—the devices that measure how much electricity customers are using—have not fundamentally changed since the 1950s. In fact, the electro-mechanical meter is becoming obsolete and will soon no longer be manufactured.



Customers are using more technology than ever before.

Today, BC Hydro's meters provide a one-way flow of information (from the customer to the utility) that is very basic and not timely. For example, residential and commercial customers might be surprised to learn that BC Hydro does not know of outages until, and unless, customers call to tell us the power is out.

The electricity system must be updated to ensure that BC Hydro can continue to provide customers with safe and reliable electricity.

Modernizing British Columbia's electricity system will also ensure that advances in technology can be accommodated. Without new investment in technology and systems the 20<sup>th</sup> century electricity system will be unable to support 21<sup>st</sup> century innovations such as solar panels, electric vehicles and increased customer service options.

Utilities around the world are upgrading their electricity systems and adopting smart meters to enhance customer service, improve reliability and make their operations more efficient. By 2015, 250 million smart meters will be installed worldwide<sup>2</sup>.

In short, investing in smart metering infrastructure is as important as renewing and reinvesting in our dams and generating facilities.

Over the next three years, BC Hydro will be investing \$2 billion per year to build and renew dams, generating facilities, and transmission and distribution networks to ensure a safe and reliable supply of power continues to flow to B.C.'s homes and businesses. A key component of this investment is the Smart Metering Program.

## WHAT IS THE SMART METERING PROGRAM?

Smart meters are part of an integrated program that will pay for itself through reduced theft of electricity, energy savings, and operational efficiencies. This means that over the long term the Smart Metering Program will reduce customer rates below what they would otherwise be in the absence of BC Hydro's investment in the program.

BC Hydro's Smart Metering Program is an important foundational step in the modernization of BC Hydro's electricity system. It involves replacing existing customer meters with smart meters and upgrading the technology and telecommunications infrastructure that allows BC Hydro to manage the electricity system in a reliable, safe and cost-effective manner.

The program consists of:

- Smart meters are digital meters that allow two-way communications between a customer's meter and BC Hydro through a secure connection that captures the amount of electricity consumed and when. For more information about smart meter safety, security, and privacy, see Appendix 1.
- Optional in-home feedback tools to provide up-to-date energy consumption and price information directly to residential and commercial customers providing them with more choices to actively manage their electricity use.
- Systems and infrastructure to reduce electricity theft that will help to create safer communities and mitigate rate impacts borne by legitimate customers .
- Advanced telecommunications infrastructure to allow BC Hydro to more accurately measure the actual flow of electricity through the system and support advanced electricity system management and customer applications.
- Information technology systems to integrate meter reading data into BC Hydro's customer billing, load forecasting and outage management systems.

The broad scope of the Smart Metering Program is described further in Appendix 2.

Smart meter installation will begin in 2011 and will be complete by the end of 2012. Customers will be notified in advance when the meter exchange will take place in their community. While customers do not need to be home for the meter exchange, they do need to ensure technicians have access to their current meter. There will be a brief service interruption during the meter exchange, which takes only minutes. Once smart meters are installed, customers will have the option of adopting in-home feedback tools. For example:

- Customers can choose to take advantage of incentives to purchase an in-home display device that provides near real-time information about their energy use; and
- All customers will have access to a secure website that provides prior day consumption data and other tools to analyze electricity use.



Your new smart meter will replace the existing meter on the outside of your home or in your meter bank if you live in a multi-dwelling unit. If you choose an optional in-home display, the smart meter can send real-time consumption and price information directly to you.

<sup>2</sup> Pike Research, November 2009

## BENEFITS

BC Hydro's Smart Metering Program delivers substantial benefits to customers. Specifically, the program will:

- Improve safety and reliability;
- Enhance customer service;
- Reduce electricity theft;
- Improve operational efficiency and reduce wasted electricity;
- Support greater customer choice and control; and
- Help modernize British Columbia's electricity system.

### Improve Safety and Reliability

Keeping customers' power on requires BC Hydro to dispatch crews day and night, under all types of weather conditions to search for, assess, and repair faults on the electricity system. The current metering infrastructure does not provide any residential customer outage information to BC Hydro. In fact, BC Hydro is not aware of outages until customers call in to inform us that the power is out.

Due to this lack of detailed and specific outage information, field crews engage in significant travel to identify the location and cause of an outage, increasing personal risk as well as delaying restoration times. During storm season, the outages are frequently at multiple locations and the risk is even higher due to the need to drive and fly under adverse conditions.

In addition, theft of electricity is occurring in increasingly dangerous ways, posing major safety risks to the general public, first responders and BC Hydro employees through the threat of fire and electrocution. For example, in Surrey, approximately 50 per cent of marijuana growing operations inspected by the fire department involved diversion of electricity from BC Hydro distribution lines. Theft also causes strain on the distribution infrastructure resulting in an estimated 100 premature transformer failures a year.

The Smart Metering Program will deploy new technologies, better analysis and notification tools, and automated decision-making that will result in improved public and employee safety and shorter outage restoration times. Benefits include:

- **Faster outage notification**—Real-time outage notification provided automatically by smart meters will serve to pinpoint problems quickly and specifically, reducing the amount of travel required under adverse conditions and accelerating the restoration process.
- **Reliable restoration notification**—Allowing field crews to quickly confirm the outage has been addressed instead of driving along the electricity lines to look for secondary outage problems.
- **Reduced risk and fewer outages from electricity diversions**—By helping identify potential electricity diversions in a more consistent and automated way, the Smart Metering Program will reduce safety risks and customer outages that are caused by premature transformer failures.



Power line technician during a Campbell River snowstorm.



Smart meters will decrease illegal electricity diversion (shown here), keeping neighbourhoods safe from fires like the one that destroyed this house.

*Photo credit: Vancouver Fire and Rescue Services and Vancouver Police Department*



## Enhance Customer Service

Smart meters capture more accurate and detailed electricity use information, which will result in enhanced customer service including:

- **More accurate meter readings**—Anomalies in reported electricity use can be reconciled quickly and accurately with the use of hourly meter data rather than bi-monthly meter reads or estimated bills.
- **Elimination of estimated billing**—With smart meters in place, customer bills will be generated from actual electricity use, not from estimated readings based on profiles.
- **More streamlined moving procedures**—With automated meter reads available on request, customers can receive an accurate, up-to-date final bill and will no longer have to deal with transferring bill amounts when they move into or move out of a home or business.
- **Better informed customer service representatives**—BC Hydro call centre employees will have substantially more accurate information available to address customer questions related to their bills, electricity use, or opportunities for energy savings.
- **Increased privacy and convenience**—Customers will no longer need to provide meter readers with regular access.
- **Reduced onsite visits**—Automated meter reading, automated connection services, and more information available for problem solving, will reduce the need for BC Hydro to send crews to customer homes and businesses resulting in direct savings that will be passed on to customers.



Call centre agents will have more accurate information available to address customer questions related to their bills, electricity use, or opportunities for energy savings.

## Reduce Electricity Theft

Legitimate customers bear the cost of electricity theft, which has grown significantly from approximately 500 GWh in 2006 to an estimate of at least 850 GWh today—that's enough power to supply 77,000 homes for a year and amounts to approximately \$100 million a year in energy cost.

Although BC Hydro has identified over 2,600 electricity thefts over the past five years, identifying and confirming theft is a time-consuming, inefficient and expensive manual process. While BC Hydro cannot reasonably expect to eliminate all electricity theft, augmenting the current manual process with new technology will substantially reduce current levels of theft by:

- **Theft detection**—New distribution system meters (different from those to be installed at customer homes or businesses) located at key points on BC Hydro's system will measure electricity supplied to specific areas. Combined with software tools to enable electricity balancing analysis, distribution system meters will help BC Hydro identify electricity theft more accurately and address it more quickly.
- **Tamper detection**—Smart meters have a tamper detection feature that automatically notifies BC Hydro if they have been removed from the wall or otherwise manipulated.



Electricity theft results in higher rates for legitimate customers.

Reducing electricity theft delivers tangible financial benefits through increased revenue, revenue recovery (e.g. back-billing), and reduced cost of energy.

## Improve Operational Efficiency and Reduce Wasted Electricity

Currently, BC Hydro transmits more electricity than needed by customers to ensure there is acceptable power quality delivered to every customer. Reducing wasted electricity benefits all customers through lower operating costs.

The amount of excess energy required can be substantially reduced with better monitoring and control over the distribution system including:

- **Voltage optimization**—Use voltage information collected from smart meters to make existing electricity control devices (voltage regulators, capacitor banks, and transformers) along the distribution system more efficient. Simply put, less electricity will be required to be transmitted to maintain expected power quality, resulting in less electricity having to be generated or purchased, which in turn, lowers costs.
- **Efficiencies in meter reading, meter sampling, distribution system maintenance, outage management, and load research**—Will significantly reduce operating costs.

## Support Greater Customer Choice and Control

Today, customers have few tools to manage their electricity use because the current meters do not capture enough information. Without specific and timely information, it is difficult for customers to take advantage of new service options or make informed decisions to actively manage electricity in their own circumstances.

Research has shown that electricity is typically not something customers regularly think about, and that increasing customer awareness by enabling them to view their own consumption in a timely manner can achieve electricity savings of up to 15 per cent. See Appendix 3 for more information related to research.

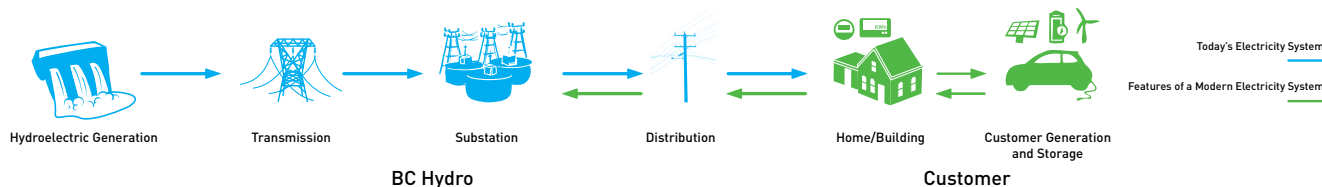
More information and control will help customers to save money—and help to achieve BC Hydro’s goal of meeting two-thirds of incremental electricity demand through conservation by 2020.

The Smart Metering Program will enable customers to have greater choice and control of their energy use through:

- **Optional in-home feedback tools**—BC Hydro will provide incentives for customers to adopt market available in-home displays, programmable thermostats, and energy management software products.
- **Power Smart website**—Customers will also have the option of accessing their own secure consumption information through BC Hydro’s expanded Power Smart website.
- **Rate Options**—Smart meters capture information that will enable BC Hydro to design new rate structures that encourage conservation during peak periods, such as voluntary time-of-use. The design of these rates will involve consultation with customers and will be subject to review and approval by the BC Utilities Commission.



Optional in-home feedback tools will provide customers with more choices and control.



## Help Modernize BC Hydro's Electricity System

BC Hydro's electricity system, including the current base of electromechanical meters, has changed very little over the past 50 years. These older style meters are becoming obsolete, as meter vendors switch to producing smart meters.

Upgrading to a smart metering system is a key foundational step in modernizing BC Hydro's overall electricity system. Additional measurement points throughout the electricity system combined with the ability to measure electricity to and from a customer site will enable:

- **Support for new customer applications**—Advanced telecommunications infrastructure will support advanced electricity system functions and emerging applications like customer generation and microgrids.
- **Support for large-scale clean energy initiatives**—Implementation of smart metering and network operations functions will help BC Hydro to manage new uses for the electricity system such as electric vehicles, electrification of public transportation, community-based generation, and integration of renewable fuel sources. For example, with a more modern electricity system, customers who invest in solar panels, or other clean sources of electricity, could sell excess power back to BC Hydro, or draw electricity from their electric vehicles during a power outage.



With a more modern electricity system, customers who invest in solar panels, or other clean sources of electricity, could sell excess power back to BC Hydro.

## FINANCIAL ANALYSIS

The Smart Metering Program business case, originally developed beginning in 2006, was most recently updated in December 2010 and reflects updated benefit assumptions as well as increased cost certainty as a result of the procurement activity during 2010. This section summarizes the benefits, costs, and net present value included in the business case.

### Quantified Benefits

The Smart Metering Program business case includes approximately \$1.6 billion in quantified benefits (present value), to be realized over 20 years. These benefits are attributed to four primary areas including:

- **Operational Efficiencies**—More efficient use of distribution assets and streamlining of business processes, thereby reducing operational and future capital expenses;
- **Energy Savings**—Lower electricity use through improved distribution system control, efficiencies and reduced consumption by customers;
- **Revenue Protection**—Includes both recovery of revenue and prevention of future potential revenue loss through reduced theft; and
- **Capacity Savings**—Lower electricity use at certain key periods, which reduces peak demand and capacity constraints.

Almost 80 per cent of the quantified benefits delivered through the Smart Metering Program result from operational efficiencies within BC Hydro. If customers take advantage of the conservation tools offered through the program, the overall benefits increase significantly. Additional information regarding each specific benefit stream, including key assumptions, is provided in Appendix 4.

In addition to the quantified benefits, the Smart Metering Program will deliver numerous other benefits that have not been quantified in this business case or cannot be monetized. A summary of these additional benefits can be found in Appendix 5.

The operational savings delivered by the Smart Metering Program will benefit all BC Hydro customers. As a publically-owned cost-recovery utility, all benefits realized by BC Hydro are passed on to customers and will be reflected in rates. In addition, customers will not be billed separately for the cost of the new smart meters.

TABLE 1: PROGRAM BENEFITS AS OF DECEMBER 2010—IN PRESENT VALUE

Type of Benefit	Description	Expected Benefit (\$ Million)	Sensitivity Range <sup>3</sup> (\$ Million)
<b>Operational Efficiencies, Avoided Capital</b>	Meter Reading Automation	\$222	\$182–\$247
	Meter Sampling	\$61	\$56–\$66
	Remote Re-connect Automation	\$47	\$42–\$52
	Distribution Asset Optimization	\$15	\$12–\$25
	Outage Management Efficiencies	\$10	\$5–\$15
	Continuous Optimization and Load Research	\$6	\$2–\$10
	Call Center & Billing	(\$2)	(\$4)–\$0
<b>Energy Savings</b>	Voltage Optimization—Commercial Customer Sites	\$108	\$48–\$148
	Voltage Optimization—Distribution System	\$100	\$85–\$150
<b>Revenue Protection</b>	Theft Detection	\$732	\$632–\$832
<b>Derived from BC Hydro Operational Efficiencies (~80%)</b>		<b>\$1,299</b>	<b>\$1,060–\$1,545</b>
<b>Capacity Savings</b>	Voluntary Time-of-use Rates	\$110	\$30–\$250
<b>Energy Savings</b>	Conservation Tools (in-home feedback tools)	\$220	\$170–\$270
<b>Increased Customer Conservation (~20%)</b>		<b>\$330</b>	<b>\$200–\$520</b>
<b>Total Quantified Benefits</b>		<b>\$1,629</b>	<b>\$1,260–\$2,065</b>

### Benefits Realization

The Smart Metering Program is a large and complex project designed to deliver significant benefits from across several business groups at BC Hydro. The benefits described in this business case pay for the investment in the program. BC Hydro is implementing a formal benefit realization framework, base-lined with the benefit streams identified in this business case, to ensure accountability and transparency in the measurement and reporting of the benefits over time.

<sup>3</sup> Sensitivity ranges identified for each benefit bracket the probable benefit outcomes. The ranges are based on an assessment of the upside and downside in variability associated with the key drivers behind each benefit.

TABLE 2: SMART METERING PROGRAM BUDGET

\$ millions

Initiation Phase (Completed F2007)			1.4
Identification Phase (Completed F2008)			8.9
Definition Phase (Completed F2011)			38.8
<b>Implementation Phase (F2011–F2014)</b>			
Smart Metering System			
	Architecture and Design	8.6	
	Assets: Smart Meters, Telecommunications, Software	256.0	
	Deployment Activities	126.5	
<b>Sub-Total: Smart Metering System</b>			<b>391.1</b>
Solution Integration (Information Technology)			
	Architecture and Design	3.2	
	Assets: Meter Data Management System and Other Applications	7.9	
	Implementation Activities	49.8	
<b>Sub-Total: Solution Integration (Information Technology)</b>			<b>60.9</b>
Theft Detection			
	Architecture and Design	2.6	
	Assets: Distribution System Meters, Application Software	62.7	
	Deployment Activities	45.2	
<b>Sub-Total: Theft Detection</b>			<b>110.5</b>
Conservation Tools			
	Architecture and Design	2.4	
	Assets: In-Home Displays, Website, Software Supporting Rates	18.4	
	Rebate Program	42.0	
<b>Sub-Total: Conservation Tools</b>			<b>62.8</b>
Grid Modernization Infrastructure Upgrades			
	Architecture and Design	1.9	
	Assets: Advanced Telecom Devices and Applications	33.0	
	Deployment Activities	19.3	
<b>Sub-Total: Grid Modernization Infrastructure Upgrades</b>			<b>54.2</b>
Program Delivery Activities			
	Project Management and Controls	22.2	
	Safety, Security, Privacy Governance	1.1	
	Finance and Regulatory	2.4	
	Customer Research, Engagement and Outreach	8.6	
	Contract Management	2.7	
<b>Sub-Total: Program Delivery Activities</b>			<b>37.0</b>
<b>Sub-Total: Implementation Phase</b>			<b>716.5</b>
Interest During Construction			
			14.4
Contingency			
			60.0
<b>Sub-Total</b>			<b>840.0</b>
Reserve Subject to Board Control			90.0
<b>Total: Program Authorized Amount</b>			<b>930.0</b>

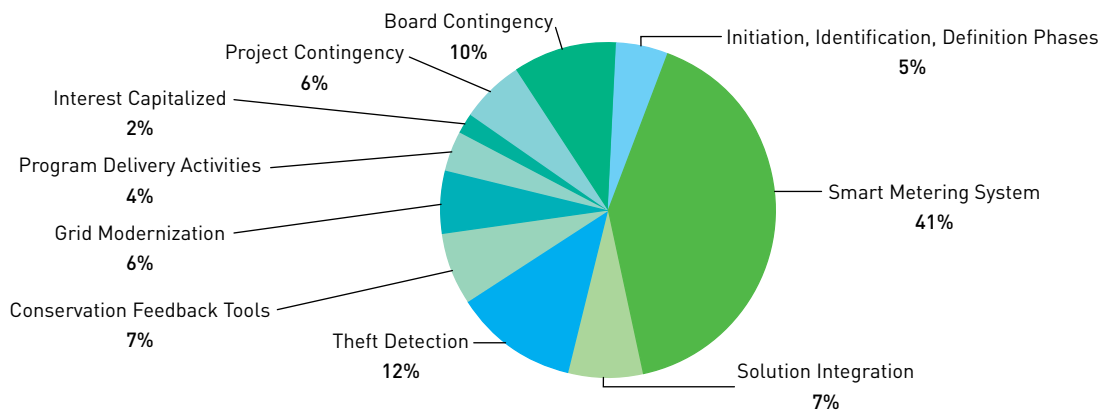


FIGURE 1: BUDGET COMPONENTS BY PERCENTAGE WITH SPECIFIC FOCUS ON THE IMPLEMENTATION PHASE

### Program Costs

The total Authorized Amount for the Smart Metering Program is \$930 million (nominal value) including contingency. The budget was developed using BC Hydro’s standard project planning methodology, and is organized into four major phases (see Glossary for definition of phases):

- **Initiation Phase**—Completed in F2007
- **Identification Phase**—Completed in F2008
- **Definition Phase**—Completed in F2011
- **Implementation Phase**—Scheduled to be fully completed in F2014, with the installation of customer meters on track for the December 2012 date as legislated by the Province of British Columbia.

### Net Present Value

The Smart Metering Program business case shows a net present value (NPV) of \$520 million through F2033. The NPV remains positive even if all costs are incurred and only the BC Hydro operational efficiencies are realized. The NPV also remains positive if all benefits are achieved at the low end of the estimated benefit range. A more detailed discussion of the business case analysis can be found in Appendix 6.

The positive NPV of the Smart Metering Program will benefit all BC Hydro customers. These net benefits will flow, over time, into lower rates for customers, reducing them below what they would otherwise be in the absence of BC Hydro’s investment in the program. See Appendix 7 for a discussion of the Smart Metering Program rate analysis.

## RISKS

BC Hydro has put in place a Risk Management process to identify, assess, and mitigate risks that could significantly impact the Smart Metering Program. Appendix 8 provides a summary of the key risks and mitigation strategies. The procurement process employed by the program has also played a significant role in mitigating technology, cost, and schedule risk. More information about how BC Hydro has managed risk through procurement can be found in Appendix 9.

## LESSONS LEARNED FROM OTHER JURISDICTIONS

BC Hydro has also managed risk through learning from others. By adopting smart meters after learning from the experience of other utilities, BC Hydro has the advantage of knowing what factors contribute to successful implementation and benefit realization. Some of these key learnings are included in Table 3.

TABLE 3: SUMMARY OF LESSONS LEARNED FROM OTHER JURISDICTIONS

Program Element	Experience of other utilities	Our approach
<b>Technology</b>	Some utilities were adopters of early smart metering technology which had limited capabilities and ultimately had to be replaced.	BC Hydro is taking advantage of the fact that metering technology has stabilized, and technology standards are now more open, robust and secure. BC Hydro is actively involved in numerous industry standards and policy groups as outlined in Appendix 10. BC Hydro has also included mandatory criteria in procurement packages to ensure only proven and scalable technology would be considered.
<b>Meter Accuracy</b>	In some jurisdictions, questions were raised about meter accuracy. Ultimately, it was determined that events such as heat waves occurring at the same time as meter installation were the main factors in perceived inaccuracies. Testing has confirmed smart meters are more accurate than electro-mechanical meters.	BC Hydro is governed by the testing requirements established by Measurement Canada, a federal agency. The installed base of meters in Canada has a very high degree of accuracy due to regular random testing.
<b>Rates</b>	Several utilities have chosen to implement time-of-use rates at the same time as smart meter installation, resulting in higher bills for customers.	BC Hydro will maintain existing rate structures at the same time as meter installation. BC Hydro will engage customers in the design of any new rate structures and any new or modified rates will be subject to review and approval by the BC Utilities Commission.
<b>Customer Choice and Support</b>	Some utilities provided few in-home feedback options and provided limited transactional information through their call centre, not offering customers adequate meter installation information or support for conservation efforts.	BC Hydro will offer incentives for customers to adopt conservation tools such as in-home displays that will provide near real-time feedback, and a secure web page that provides next day consumption data, with tools to help analyze patterns. Trained call centre agents will be available to answer specific customer questions during the meter installation period, and to provide advice on how to maximize conservation savings through the use of new in-home feedback tools when they become available.
<b>Security and Privacy</b>	In some cases, privacy and security considerations were implemented as an afterthought.	Privacy, security and safety features were key evaluation criteria in all procurement processes related to the Smart Metering Program. Privacy-by-Design and Security-by-Design processes are used for all design, development, and implementation activities. BC Hydro also has active and ongoing involvement with industry standards and policy groups, including those focused on security, privacy and safety standards.

## KEY TIMELINE FOR CUSTOMERS

A key lesson learned from other smart meter initiatives is the importance of communication with customers. Accordingly, BC Hydro has developed a proactive approach to ensure open and frequent customer engagement. The following table provides highlights from the Smart Metering Program’s customer engagement approach.

TABLE 4: KEY TIMELINE FOR CUSTOMERS

Stage	Timeframe	Key Activities
<b>Program Information</b>	<b>Underway and throughout the program</b>	Customers have access—through the BC Hydro website, bill inserts, and community events—to information about the Smart Metering Program, the smart metering system that will be installed, how it works, and other topics of customer interest.  Customers can share their feedback, concerns, and interest directly through calling, email, community events, and customer research.
<b>Installation of Smart Meters</b>	<b>Mid 2011 through 2012</b>	Customers receive information packages before smart meters are installed in their community <sup>4</sup> .
<b>In-home Feedback Tools</b>	<b>2012 through 2014</b>	Customers receive information highlighting new options available to support their energy conservation efforts.  Customers receive a rebate for a basic in-home display device that can be redeemed at select stores.  Customers will have access to information about their electricity use, up to the previous day, through a secure Power Smart website.

<sup>4</sup> Smart meter installation will begin simultaneously in communities throughout the province.



## APPENDIX 1: SMART METER SECURITY, PRIVACY AND SAFETY

Security, privacy and safety have been considered key priorities throughout the development of the Smart Metering Program. The program redefines many of the existing business processes—and introduces new ones—requiring that security, privacy and safety are embedded in each and every aspect. The basic principles of Security-by-Design, Privacy-by-Design and Safety-by-Design have been incorporated throughout the planning of the program. Each of these disciplines are also intrinsically linked; for example, ensuring a security objective is achieved also enhances safety and privacy.

### Procurement

Security, privacy and safety requirements are included throughout all of the Smart Metering Program Requests for Proposals (RFPs). Examples of specific requirements include:

- Ensuring vendors are provided with all BC Hydro safety standards and Smart Metering Program security and privacy specifications.
- BC Hydro's Safety-by-Design Practice referenced as a specification. Examples include the metering system specifications explicitly referencing:
  - Applicable American National Standards Institute (ANSI) and Institute of Electrical and Electronics Engineers (IEEE) safety standards; and
  - Generation Project and Service Delivery Practices: Safety-by-Design.
- In RFPs, proponents are required to describe their safety programs and how they propose to comply with BC Hydro safety principles.
- Vendors are required to document, in detail, how their solutions to smart metering security standards demonstrate security best practices.
- Security penetration testing is a mandatory deliverable before implementation of each component of the solution.
- Field Operations Safety and Work Methods staff members participated in vendor evaluation sessions where worker safety practices were thoroughly reviewed. This involvement will continue for future procurements associated with smart metering field devices and related work methods.
- Enhanced meter safety and security design criteria was included in the metering system RFP.

### Security in the Smart Meter and Smart Metering System

There are a number of security and safety features within the smart meters themselves, including:

- Use of the end-to-end 128-bit Advanced Encryption Standard (AES) algorithm, which is the same as typical online banking systems;
- Use of an asymmetric key algorithm, which ensures the smart meter cannot read any information it generates once that information has been encrypted. This also means that a specific smart meter can not access or read any data generated by another smart meter; and
- Limited historical data is stored on the smart meters mitigating any exposure of a customer's private data. Additionally, BC Hydro has privacy requirements in place to ensure that employees protect the privacy of customers in accordance with the *Freedom of Information and Protection of Privacy Act*.

There are also security and safety features inherent in the smart metering system:

- Home Area Network (HAN) components, such as in-home display devices, utilize a secure communication system that works only for the local network (i.e. the specific home). Nearby in-home display devices will not be able to access information from another device.

- The smart metering deployment architecture is designed to use different access keys for each localized area to ensure the overall system remains secure—essentially, the smart metering system is broken up into many isolated units. Gaining access to one isolated unit does not provide access to the whole. In other words, devices with a localized area key do not have access to the entire network and no one device is capable of accessing the entire electricity system.
- When a customer moves to a home with an existing smart meter, BC Hydro will ensure that all current in-home device connections are cleared so that usage information from the previous home owner stays private.
- Field tools, used to configure smart meters when remote configuration is not possible, are managed through a secure isolated network. Access to field tools will be limited to necessary staff members using unique passwords. Field tools also carry limited customer meter data and will be purged after each use.

### Smart Meter Privacy

- The Smart Metering Program has been focused on privacy concerns since its inception. BC Hydro's Freedom of Information Coordination Office (FOICO) has been central in the discussion of privacy-related issues and participated in all aspects of the requirements and RFP phases of the project.
- In addition to FOICO, resources with expertise in privacy are assigned to the Smart Metering Program to assess and ensure that privacy requirements are met through the life of the program.
- A Privacy Impact Assessment (PIA) is completed for the entire Smart Metering Program, each individual release, and specific security or privacy sensitive components. In all, more than thirty PIAs are anticipated and each PIA will require FOICO sign-off to ensure privacy requirements are effectively managed throughout the program.
- Security and privacy frameworks are being developed for each release of the program to ensure that BC Hydro standards for security and privacy meet or exceed compliance requirements and future expectations.

### Smart Meters and Radio Frequency Safety

Smart meters will use radio frequency to communicate data to and from BC Hydro. The health effects of the frequencies employed have been thoroughly investigated by BC Hydro. In addition, many reputable health authorities such as the World Health Organization and Health Canada have conducted thorough reviews of all the different types of studies and research on electromagnetic fields and health. These health authorities have examined the scientific weight-of-evidence and have determined that when all of the epidemiological and experimental studies are considered together, the consensus is that there is no cause-effect relationship between exposure to electromagnetic fields and human health.

Specific to radio frequency exposure to the public, proposed Field Area Network devices must be certified by Industry Canada and in compliance with Health Canada's Limits of Exposure to Radio Frequency Electromagnetic Energy in the Frequency Range from 3 kHz to 300 GHz [Safety Code 6]. BC Hydro will continue to monitor research related to radio frequency. General information and resources related to electromagnetic fields can be found on BC Hydro's website at:

[bchydro.com/safety/electric\\_magnetic\\_fields/magnetic\\_fields\\_and\\_health.html](http://bchydro.com/safety/electric_magnetic_fields/magnetic_fields_and_health.html).

BC Hydro will collaborate with customers who are concerned about radio frequency with the objective of identifying solutions that can be mutually supported.

There are three key factors that contribute to radio frequency safety: duration of the signal, signal strength and distance from the signal.

#### 1. Signal Duration

While the period during which a smart meter transmits data back to BC Hydro will vary depending on the specific metering system used, transmission is expected to last for only a few minutes per day.

## 2. Signal Strength

The signal strength emitted by a smart meter is considerably less than visible light and exposure common to everyday living, such as laptops, cell phones and handheld radios. For example, if you are standing adjacent to the smart meter and it is transmitting continually for those few minutes, exposure is between 60 times and 600 times below the acceptable level identified in Safety Code 6.

## 3. Distance from the Signal

Smart meters will be located in the same place as the existing meter on the outside of a customer's home, or in a meter bank in multi dwelling units such as town homes, condominiums or apartment buildings.

Standing 3 metres (10 feet) away from the meter while it is transmitting, exposure drops to 60,000 times to 600,000 times below the Safety Code 6 acceptable level. Excluding the built in safety factor in Health Canada's Safety Code 6, standing adjacent to a smart meter device, the radio frequency radiation is 60 times less than the Safety Code 6 acceptable level. This is assuming the smart meter device is transmitting 100 per cent of the time, which it does not.

Some customers have expressed concerns about the potential effect of radio frequencies on their unique personal health condition. Individuals who have concerns or questions are invited to contact us at [smartmeters@bchydro.com](mailto:smartmeters@bchydro.com).

The following table compares the radio frequency generated by items common to everyday life.

### DEVICE RELATIVE POWER DENSITY IN MICROWATTS PER SQUARE CENTIMETRE ( $\mu\text{W}/\text{cm}^2$ )

Distance from the Signal	Signal Strength
FM radio or TV broadcast station signal	0.005 microwatts
<b>Smart meter device at 3 metres (10 feet)</b>	<b>0.01 microwatts*</b>
Cyber cafe (Wi-Fi)	10–20 microwatts
Laptop computer	10–20 microwatts
Cell phone held up to head	30–10,000 microwatts
Hand-held radio at head	500–42,000 microwatts
Microwave oven, 5 cm (2 inches) from door	5,000 microwatts
Summer sunlight at earth's surface	100,000 microwatts

\*Adjacent to meter <10 microwatts

## Design and Operation of Equipment

BC Hydro's Safety-by-Design practice addresses the design and operation of new and existing equipment throughout the system including:

- Safe placement of equipment in energized locations (e.g. collectors requiring a power source);
- Safe operation of equipment (e.g. vehicles used for deployment); and
- Designing new components (e.g. integration of distribution system meters) from a safety perspective.

An important component of the Smart Metering Program since 2008 has been the engagement of other utilities and research bodies throughout North America (e.g. Pacific Gas & Electric) to understand their safety challenges and experiences. BC Hydro is an active member of several industry groups where the focus is safety, security, and privacy standards.

BC Hydro has anticipated a possible risk of violence related to electricity theft from drug operations during the installation of smart meters. Measures to protect both employees and the public include:

- The establishment of a police coordination program;
- The development of policies to ensure employees do not engage in unsafe situations; and
- Violence risk assessment training for all installation technicians.

### Internal Procedures

Internal procedures have been reviewed from a safety, security and privacy perspective. An outcome of this review is the development of enhanced and new training programs to reinforce safety awareness and safe work practices. Examples include:

- A Safety-by-Design Project Hazard Matrix will be implemented for all planned technologies and the physical placement of meters, telecommunications components and system meters.
- Standards design work is underway with the Distribution Engineering Standards department for the safe and secure placement of telecommunications components.
- Meter installer training programs will be reviewed by the BC Hydro Work Methods department and scrutinized for compliance with safe work practices.
- Mandatory safety requirements and qualifications for meter installation proponents include compliance with WorkSafeBC and the *Safety Standards Act*, with a specific focus on vehicle safety, and provision for safety audits of the installation work.
- Project team members are trained in, and will adhere to, applicable BC Hydro safe work practices in our field and laboratory environments.

### Industry Standards Development

BC Hydro is participating in the National Electric Energy Testing Research and Applications Center (NEETRAC), testing and developing meter service connect/disconnect standards with respect to performance and safety. As part of BC Hydro's metering system procurement process vendors must provide formal documentation related to their compliance with the testing requirements and acceptance criteria of NEETRAC. Further, BC Hydro is working as a member of an American National Standards Institute committee on advancing service connect/disconnect standards. BC Hydro's commitment to service switch safety will enhance the safety of both customers and workers.

## APPENDIX 2: PROGRAM SCOPE

For the past four years, BC Hydro has been defining the scope and approach for the Smart Metering Program. Key activities include:

- Developing a detailed set of specific functional, operational and technical requirements captured in a set of comprehensive use cases described later in this section.
- Actively participating in technology and industry standards groups focused on smart metering and the emerging smart grid sectors to ensure BC Hydro business needs are captured in industry standards.
- Monitoring the progress and results from utilities who were early implementers of smart metering projects—including Pacific Gas & Electric, Southern California Edison, San Diego Gas & Electric, Duke Power, ENEL (Italy), and in Ontario—Hydro One, Toronto Hydro—and incorporating their “lessons learned” into BC Hydro’s project planning.
- Tracking the market evolution of metering technologies, software products, and in-home energy management offerings to ensure BC Hydro’s solution choices are based on proven, secure technologies.

The activities listed above resulted in the final Smart Metering Program scope which includes the following six major components. Each will be managed and implemented as part of a single, integrated program:

**Smart Metering System**—Captures and communicates consumption data and meter events, such as outages, to both the customer and BC Hydro;

**Solution Integration**—Designs, develops, and implements the software components, business processes, and ongoing support structures required to enable smart metering capabilities;

**Theft Detection**—Enables BC Hydro to better localize sources of electricity diversion;

**Conservation Tools**—Provide information enabling customers to make informed and timely decisions in relation to their electricity consumption;

**Grid Modernization Infrastructure Upgrades**—Provide the smart meter operations centre, and advanced technology and telecommunications infrastructure, to help improve the reliability and security of the electricity system; and

**Program Delivery Activities**—Provide the overall project management activities and responsibilities designed to ensure a quality implementation of each solution component included in the program scope.

Following is a more detailed description of each scope component.

### Smart Metering System

Included as part of the Smart Metering System<sup>5</sup> are:

- **Smart Meters**—Digital meters—capable of two-way communications—with the ability to measure the incoming and outgoing flow of electricity from a specific location such as a customer’s home or business. The two-way communication capability enables smart meters to provide use data to both customers and BC Hydro—in different formats. When paired with an in-home display, the smart meter can send real-time consumption and price information directly to the customer. Real-time customer use information will be transmitted through the Home Area Network directly to the customer and will not be available to BC Hydro. Smart meters will capture and store use on an hourly basis and transmit the data back to BC Hydro, through the Field Area Network and Wide Area Network, during short intervals (couple of minutes) at prescheduled times during the day.
- **Metering Telecommunications**—Consisting of two parts—the Field Area Network (localized to meters in the field) and the Wide Area Network connections (enterprise wide focus)—this communications infrastructure provides the physical devices required to enable two-way transmission of data between smart meters and BC Hydro. There are several different ways this field-based communications infrastructure can be implemented, depending on the metering system selected.
- **Automated Data Collection System**—This software application is designed to aggregate meter usage and event data from smart meters and manage the Field Area Network communications infrastructure. This software is provided by the metering system vendor.

<sup>5</sup> BC Hydro is currently in an active procurement process to select the Metering System vendor.

## Solution Integration

In addition to the overall smart metering system, the Smart Metering Program is responsible for the business environment that supports smart metering including implementation of new business software applications, changes to existing information systems, enhanced data warehouse and analytics capabilities, and all of the business transformation activities that will help BC Hydro adapt to the new technologies and systems. Specific elements of scope include:

- **Meter Data Management System**—A software application that stores, validates, edits and analyses meter reading data prior to releasing it for integration into other BC Hydro operational systems such as customer billing, load forecasting and outage management.
- **Interfaces and Integration**—This systems integration work involves modifying existing applications to handle the enhanced automated meter reading information, and building interfaces between new and existing enterprise applications to support BC Hydro's end-to-end business processes.
- **Business Transformation**—The major elements of business transformation work involve development of new and modified business processes, design of organizational and job changes, rollout of training and knowledge management programs, employee engagement to facilitate cultural change, and effective transition to business operations for ongoing work.

## Theft Detection

BC Hydro currently does not have the measurement devices and analytical tools to quickly and accurately identify where theft of electricity is occurring. A comprehensive theft detection solution, based on electricity balancing analysis, will be implemented as part of the program. Scope elements include:

- **Distribution System Meters**—New meters (different from those to be installed at customer homes or businesses) will be installed at key points on BC Hydro's system to measure electricity supplied to localized areas.
- **Theft Analytics**—A suite of software tools that support enhanced electricity network modeling methods, as well as the business rules required to analyze measurement data captured from new distribution system and smart meters.

## Conservation Tools

Smart meters will enable customers to take advantage of new tools to save energy and money. These include:

- **In-home Display**—Customers will have the choice of whether or not they wish to acquire in-home display devices. BC Hydro will provide financial incentives to enable customers to acquire a basic market available in-home display device from their local retailer. In-home displays will be enabled through the Home Area Network, a communication channel between the smart meter and the customer's home or business. This secure channel, an attribute of the smart metering system, enables customers to view their consumption either on a real-time or accumulated basis, represented in both cost and kilowatt-hours.
- **Power Smart Website**—BC Hydro's existing secure Power Smart website will be expanded to include new interactive and informative applications—based on the hourly data captured from smart meters—designed to help customers better understand and model their energy use. Today, residential customer meters are read every two months, which provides little practical information for customers to determine which, if any, conservation actions they should pursue.
- **Rate Options**—The smart metering system infrastructure will enable BC Hydro to design new rate structures that encourage conservation during peak periods. While the implementation of new rates is enabled by the Wide Area Network, Field Area Network and web interface, the design and implementation of new rate structures is a separate initiative. Key functional and data requirements to support rate options will be enabled by the new smart metering system and the Meter Data Management System. The design of these rate options will involve consultation with customers and key stakeholders, and will be subject to full review and approval by the BC Utilities Commission.

## Grid Modernization Infrastructure Upgrades

This program scope element involves two key components; the specific requirements of each will depend on the metering technology selected:

- **Advanced Telecommunications Infrastructure**—Involves the design and installation of additional secure and reliable Wide Area Network telecommunications infrastructure to support advanced electricity system functions and emerging customer applications like customer generation and microgrids.
- **Advanced Operational Support**—Involves the implementation of a smart metering and network operations function to support real-time operations of the metering system. This support function will likely be implemented as an extension of BC Hydro’s distribution operations centre so that all real-time system and telecommunications operations can be managed seamlessly and efficiently.

## Program Delivery Activities

Included in the scope of the Smart Metering Program are the overall program delivery activities and services which ensure all of the technical aspects of the project are successfully implemented, and accepted by BC Hydro’s customers and stakeholders. These activities include:

- **Project Management and Controls**—Includes the personnel and support tools to manage and report on the overall delivery of all aspects of the Smart Metering Program, including scope, schedule, budget, quality, issues resolution, environment management, and transition to operations.
- **Security, Privacy and Safety**—This independent team ensures appropriate governance and compliance for all the physical security, cyber security, data privacy, and employee, vendor and contractor safety aspects of the program. Security, privacy and safety have been fundamental drivers of the program.
- **Finance & Regulatory**—This team provides financial oversight and regulatory support to the project team.
- **Customer Research, Engagement and Outreach**—Includes the resources required to support the Smart Metering Program with respect to research, community engagement, customer communications, employee engagement, and media.
- **Contract Management**—Includes the personnel and processes required to manage procurement and tendering activities, as well as manage contractual commitments and any contract issues that may emerge.

## Use Cases

Use cases provide a starting point to inform the scope of complex, cross functional projects, and define the subsequent procurement requirements. Use case methodology is an industry-leading approach to matching functional needs to the appropriate technology and systems.

BC Hydro examined use cases from other utilities across North America involved in smart metering systems. From there the approach was expanded to create 17 individual use cases based on BC Hydro’s unique business needs and context. For example, BC Hydro’s requirements included enhanced customer service options and theft detection. The inclusion of these requirements improved program benefits and contributed to a stronger business case.

Organized into four main categories the use cases include: Customer Service, Distribution System Optimization, Home Area Network and in-home feedback, and network and meter management. Based on business scenarios the use cases capture the current and long-term (over 20 years) functional, operational and technical requirements for BC Hydro.

Category	Use Cases	Description
<b>Customer Service</b>	<ul style="list-style-type: none"> <li>Customer Contact</li> <li>Collect Interval Data</li> <li>Remote Connect or Disconnect</li> <li>Pre-pay Services</li> <li>Bill an Account</li> </ul>	<p>These use cases describe the functional requirements and business processes required to achieve enhanced customer services through improved communications, more accurate account billing, automated meter data collection, remote connect and disconnect services, and new service offerings such as pre-paid options. Customer Service Representatives will be better equipped to handle all customer requests regarding account enquiries, billing and payments, as well as help customers to monitor and adjust their energy consumption.</p>
<b>Distribution System Optimization</b>	<ul style="list-style-type: none"> <li>Extending or Reconfiguring the Distribution System</li> <li>Analyzing Meter Data for Load Research, Planning and Rates</li> <li>Detection of Tampering or Theft</li> <li>Distribution System Optimization and Automation</li> <li>Outage Detection and Restoration</li> <li>Customer Generation</li> </ul>	<p>These use cases describe the functional requirements, business processes, and operational aspects required to optimize the distribution system with respect to implementation of a new smart metering system. This includes the impact on BC Hydro's network design and engineering processes to incorporate new features and capabilities.</p> <p>Current and historical data captured through the Meter Data Management System includes accumulated energy consumption, demand profiles, aggregated time-of-use information, voltage information, and metering events (e.g. tamper flags). This more detailed and timely information supports several distribution system business processes including outage detection and analysis, theft identification and mitigation, and customer generation.</p>
<b>Home Area Network</b>	<ul style="list-style-type: none"> <li>Home Area Networks</li> <li>Providing Demand Side Management Capabilities</li> <li>Plug-in Hybrid Vehicles</li> </ul>	<p>These use cases describe the functional and technical requirements, and the business processes required to enable a Home Area Network using new smart meters and various in-home feedback tools. This may include providing pro-active notifications to customers if they choose, and the ability to accommodate electric vehicles on the distribution network.</p> <p>As customers, especially industrial and commercial customers, become more interested in direct load control, they can use demand response capabilities included in the Smart Metering Program to configure, manage, monitor and settle various load programs.</p>
<b>Network and Meter Management</b>	<ul style="list-style-type: none"> <li>Meter Lifecycle Management</li> <li>Management and Recovery of the System</li> <li>Installation and Configuration of the System</li> </ul>	<p>These use cases describe the requirements to configure, manage, recover and maintain the various metering units within the product lifecycle. A typical life cycle of a smart meter is described, including the installation, replacement, and remote troubleshooting methods involved.</p> <p>Described within these use cases is the initial installation and configuration of the smart metering system including meter procurement, quality assurance testing, logistics and installation.</p>



## APPENDIX 3: RESEARCH

In addition to applying lessons learned from other utilities, BC Hydro has reviewed research findings, conducted customer research, and field tested theft detection devices to assist in shaping the delivery of the Smart Metering Program. Key results are included below.

### Research on Energy Conservation Effectiveness of In-home Feedback

BC Hydro has estimated that customers who use in-home feedback tools will realize an average 4 per cent energy savings. This estimate is considered to be conservative, based on various research findings, as outlined below.

Research in relation to the effectiveness of in-home feedback tools includes both academic research related to behaviour change and actual pilots and trials that have been conducted worldwide. This research has informed the savings assumption above, as well as the overall approach BC Hydro will be taking related to in-home feedback. Key research findings have found that saving from direct and indirect feedback can range from 3–15 per cent and 0–10 per cent respectively<sup>6</sup>.

Specific industry initiatives have also provided a point of reference for potential energy conservation for the Smart Metering Program. For example, customer energy conservation has been reported as follows:

- Pacific Gas & Electric states an average 6.5 per cent reduction in energy use when using an in-home display<sup>7</sup>,
- Southern California Edison reports a 6.5 per cent reduction in energy use when using Home Area Network devices and a 2 per cent reduction in energy when using historical online feedback<sup>8</sup>, and
- Commonwealth Edison reported a 2 per cent reduction in energy use when customers subscribed to monthly online reports<sup>9</sup>.

### Research on Customer Participation for In-home Feedback

Customer participation will depend on several factors, including the cost of in-home feedback tools, their overall appeal and simplicity of use, the marketing campaign that supports their distribution, and their effectiveness in helping customers save electricity. Also reported in Southern California Edison and Pacific Gas & Electric's application filing to the California Public Utilities Commission were their assumptions on participation. Southern California Edison assumes a 10 per cent penetration with 1 per cent growth per year for their online web pages while Pacific Gas & Electric assumes a 21 per cent penetration by 2030 for customer-purchased in-home displays.

BC Hydro qualitative focus group research, conducted with customers and employees, found there was strong interest in electricity feedback mechanisms. Based on focus groups completed in 2010, customers were optimistic that increased awareness via in-home feedback tools will help them conserve energy and save money. In general, most participants expressed interest in the program. In addition, it was found that 83 per cent of BC Hydro customers have at least one computer and 86 per cent had internet connectivity at home<sup>10</sup>. Given these statistics, the potential use of a secure online feedback website should be widespread.

### Conservation Research Initiative

Important feedback was also derived from the Conservation Research Initiative, a program launched by BC Hydro in 2006. The goal of the Conservation Research Initiative was to examine how individual British Columbians could make a difference and help meet the growing demand for electricity in BC by conserving electricity in their homes.


<sup>6</sup>The Effectiveness Of Feedback On Energy Consumption; Sarah Darby, Environmental Change Institute, Oxford University, April 2006; Residential Electricity Use Feedback: A Research Synthesis and Economic Framework; EPRI (Electric Power Research Institute), February 2009; Impact Of Informational Feedback On Energy Consumption—A Survey Of The Experimental Evidence; Ahmad Faruqui, Sanem Sergici and Ahmed Sharif, May 2009

<sup>7</sup>Application filed to CPUC December 12, 2007 App No 07-12-009

<sup>8</sup>Application filed to CPUC July 31, 2007 App No 07-07-026

<sup>9</sup>Pilot findings: <http://usweatherizing.com/blog/?p=923>

<sup>10</sup>Residential Customers Needs Survey F10 (February 2010)



This study was conducted in more than 1,800 residential homes across six communities: Vancouver, Burnaby, North Vancouver, West Vancouver, Campbell River and Fort St. John. The study tested time-of-use rates and smart meters to help BC Hydro better understand how adjusting the price of electricity at different times of the day influences electricity use by residential customers.

The results of the Conservation Research Initiative are summarized below:

- Overall consumption was reduced by 7.6 per cent.
- Energy use during peak hours was reduced by 11.5 per cent.
- 63 per cent of participants saved money by conserving and shifting their consumption to off-peak hours.

### Theft Detection Pilots

Since 2005, BC Hydro has implemented four theft detection pilots using distribution system meters to conduct energy inventory balances with customer smart meters. All of these pilots have successfully demonstrated that the energy inventory balance approach, conducted at either the primary or secondary voltage level, can readily identify localized areas of the electricity system where theft is occurring. In total these pilots, which are still operational, covered over 800 homes, and resulted in the identification and termination of 22 electricity thefts. Where thefts have been identified and shut down quickly, there has been little recurrence. Further details regarding the theft pilots can not be released for security reasons. These theft detection pilots identified key requirements for the design of a scalable solution including the following three major components in addition to the basic smart metering system: distribution system meters; theft analytics software; and new investigation techniques and processes.

## APPENDIX 4: QUANTIFIED BENEFITS AND KEY ASSUMPTIONS

This section provides a summary of the key sensitivities and assumptions for each benefit stream included in the Smart Metering Program business case.

Benefit Description	Present Value (PV) Millions (M)	Key Business Case Assumptions	Sensitivity Millions (M)
<p><b>Meter Reading Automation</b> Accenture Business Services for Utilities currently provides manual meter reading services. BC Hydro supplies the infrastructure including vehicles, facilities, meter reading software and hand-held equipment.</p> <p>This benefit represents a reduction in manual meter reading services, supporting infrastructure, and green house gas emission costs, based on an assumed Field Area Network coverage for 95 per cent of customers.</p>	<p><b>\$222 M</b></p> <p>Range is: \$182 M–\$247 M</p>	<p>A Field Area Network will provide communications infrastructure to at least 95 per cent of customers.</p> <p>Costs to read the remaining 5 per cent of customers are estimated at 3 times higher than current costs.</p>	<p>Each per cent point over 95 per cent coverage adds \$6 M to the PV.</p>
<p><b>Meter Sampling</b> BC Hydro has ongoing processes to ensure customer meters are maintained and operated within the accuracy requirements mandated by Measurement Canada. Each year, a statistical sample of meter groups is removed and tested for accuracy. If a sample group does not meet the accuracy standards, that entire group of meters is removed from service. An average of 40,000 meters are replaced annually under this program. Smart meters will eliminate the need to sample and test meters for some period of time.</p>	<p><b>\$61 M</b></p> <p>Range is: \$56 M–\$66 M</p>	<p>This benefit results from reduced operating costs for sampling processes and reduced capital expenditures to replace failed meter groups over a planned seven-year period following installation of smart meters.</p> <p>Health of meters in service will be monitored during the seven year suspension of sampling.</p> <p>Estimate of 1 per cent of meters replaced annually, based on increased accuracy of electronic smart meters.</p>	<p>Each per cent change in the meter failure rate results in a \$3.4 M change in PV.</p>
<p><b>Remote Re-connect Automation</b> Today, meter reconnections and disconnections are completed onsite by a meter technician or power line technician. The remote on/off switch provided within smart meters enables all connection related services to be completed remotely, safely and securely.</p> <p>This benefit is due to reducing the need for manual connects/disconnects for non-payment, and the associated vehicle expenses.</p>	<p><b>\$47 M</b></p> <p>Range is: \$42 M–\$52 M</p>	<p>BC Hydro's policies and procedures for when service can and will be disconnected are not changed for this business case.</p> <p>Remote on/off switch will be included in all meters where it is technically feasible.</p>	<p>Each percentage point over 95 per cent coverage adds \$0.23 M to the PV.</p>

<p><b>Distribution Asset Optimization</b> Capital expenditures related to growth of the distribution system—driven by load growth, reliability improvements, customer connections and station expansion—are approximately \$500 M per year for the foreseeable future.</p> <p>Smart Metering Program benefits from improved availability of assets and system performance data and information results in conservative capital budget savings of 0.3 to 0.5 per cent per year following implementation of all Smart Metering Program assets.</p>	<p><b>\$15 M</b></p> <p>Range is: \$12 M–\$25 M</p>	<p>Does not include any distribution asset optimization benefits resulting from theft detection and reduction. Only includes incremental benefits due to new distribution system meters and smart meters.</p>	<p>Each 0.1 per cent change in the distribution system capital budget impact related to smart metering results in a \$4.7 M PV change.</p>
<p><b>Outage Management Efficiencies</b> Today, BC Hydro is only made aware of customer (residential/commercial) outages when they call 1 888 POWERON.</p> <p>Smart meters will provide automated outage notification, specific outage location information, and confirm when power has been restored.</p> <p>Smart Metering Program related benefits include improved time to restore outages, reduced visits to false outages, more rapid identification and restoration of embedded outages, and improved customer satisfaction.</p>	<p><b>\$10 M</b></p> <p>Range is: \$5 M–\$15 M</p>	<p>Includes outage management improvements from both trouble-based outages (e.g. single customer calls) and storm-based outages (i.e. wide-spread outages due to a specific event).</p>	<p>Due to the high variability of outages from year to year, this benefit is based on an average, over the term of the business case.</p>
<p><b>Continuous Optimization and Load Research</b> BC Hydro's Continuous Optimization Program targets operational savings in the commercial sector. The program provides consulting services to help identify actions to reduce energy use in buildings. With smart meters, the program will no longer have to retrofit the existing meter and install additional hardware on the customer's site to capture interval meter reading data.</p> <p>Smart meters will provide Load Research with load profile information in a more timely and accurate form, avoiding capital and operational costs.</p>	<p><b>\$6 M</b></p> <p>Range is: \$2 M–\$10 M</p>	<p>Estimated savings in meter upgrades of \$1,800 per Continuous Optimization site, plus savings of additional hardware and installation costs of \$2,980 per site.</p> <p>Estimated annual operational savings for Load Research of \$290 K, plus one-time capital savings of \$2.2 M.</p>	<p>A 10 per cent change in the number of customers in the Continuous Optimization Program results in a change of \$0.2M PV.</p>

<p><b>Call Centre and Billing</b></p> <p>With smart meters, customer calls related to estimated bills and meter reading access arrangements will be substantially reduced. Also, call centre agents will have much more information available to help address questions regarding meter reads, billing, payments, and energy conservation.</p> <p>BC Hydro expects call volumes to increase as smart meters are being introduced and this cost has been factored in to the overall business case.</p>	<p><b>(\$2) M</b></p> <p>Range is: \$(4) M–\$0 M</p>	<p>Call volumes estimated based on inquiries related to current Power Smart programs.</p> <p>Approximately 48 per cent of billing errors will be eliminated.</p>	<p>A change of 48,000 calls results in a change of \$1 M in PV.</p> <p>Every 5 per cent change in billing exceptions changes the PV by \$0.5 M</p>
<p><b>Voltage Optimization</b></p> <p>Voltage optimization or Volt-VAR Optimization (VVO) technology helps reduce the amount of electricity that must be transmitted in order to ensure sufficient power quality at customer sites. Smart meters will enhance BC Hydro’s existing VVO program by providing significantly more measurement points along the distribution network, thus helping to manage voltage more effectively. Smart metering helps deliver VVO benefits for both the Distribution system and Customers:</p> <p><b>Customers</b>—Extend the VVO program to a Power Smart Program for eligible commercial customers.</p> <p><b>Distribution</b>—Enhance the effectiveness of the VVO program and enable the extension of the program to additional substations.</p>	<p>\$108 M</p> <p>Range is: \$48 M–\$148 M</p> <p>\$100 M</p> <p>Range is: \$85 M–\$150 M</p>	<p>At least 2,000 commercial customer sites have use characteristics that would benefit from voltage optimization.</p> <p>Benefit is net of the Demand Side Management Program costs to incent customers to install equipment.</p>	<p>Each increase/decrease of 10 per cent in GWh/yr in energy savings results in \$14 M increase/decrease in PV.</p> <p>For each 100 increase/decrease in the number of customer sites included into the VVO program, the PV increases/decreases by \$11 M.</p>

<p><b>Theft Detection</b></p> <p>The theft detection solution includes distribution system metering, business analytics, and an upgraded topology model to quickly and accurately identify where theft is occurring. This increased automation will shift BC Hydro from a reliance on public-generated tips to system-generated tips regarding suspected theft.</p> <p>Smart meters also have automated tamper alarms to alert BC Hydro.</p> <p>Benefits result from energy and capacity savings, additional revenue through prevention of theft, and back-billing to recover cost of stolen energy and investigation costs.</p>	<p><b>\$732 M</b></p> <p>Range is: \$632 M–\$832 M</p>	<p>Estimated consumption by marijuana growing operations is 1,300 GWh/yr through F2033 (paid and theft), of which theft increases from 500 GWh/yr in F2007 to 850 GWh/yr in F2012.</p> <p>Realization of theft benefits is estimated at an initial 75 per cent, declining to about 67 per cent by F2027.</p> <p>Theft detection requires analysis and in-field investigation; the business case includes an incremental operations and maintenance increase of \$10 M, declining to \$7 M by F2015.</p> <p>Total portion of theft attributed to meter tampering is 5 per cent, with the rest attributed to diversion directly from distribution lines.</p> <p>An average of 16 per cent of back-billing for theft is collectible.</p>	<p>An increase/decrease of 10 per cent in the amount of theft reduction achieved results in an increase/decrease of \$86 M PV.</p>
<p><b>Voluntary Time-of-Use Rates</b></p> <p>Reducing peak period demand for electricity can reduce the amount of capacity BC Hydro needs in the system, thus potentially deferring the need to build more generation, transmission, and distribution assets.</p> <p>The more detailed use information captured by smart meters enables BC Hydro to investigate different rate options including time-of-use.</p> <p>BC Hydro is in the early stages of rate design and will soon begin engaging with customers and stakeholders to receive feedback on different types of rates. No decisions have been made yet regarding specific rate designs and any final rate designs will be subject to approval by the BC Utilities Commission.</p>	<p><b>\$110 M</b></p> <p>Range is: \$30 M–\$250 M</p>	<p>The business case benefits assume new time-of-use rates would be voluntary.</p> <p>Customer enrolment in time-of-use rate programs is expected to start slowly and build through 2015 to 30 per cent.</p> <p>Benefits are net of costs to design and implement the new rate structures.</p> <p>Price elasticity is assumed at -0.10.</p>	<p>A change in the participation rate of 1 per cent change results in a \$5.2 M change in PV.</p> <p>The business case benefits translate to a 10 per cent shift from on-peak to off-peak usage by participating residential customers, on average.</p>

<p><b>Conservation Tools (in-home feedback)</b> Offering customers opportunities to monitor their electricity consumption in new ways can lead to increased awareness of energy consumption and therefore increased conservation behaviour. Customers will be offered two feedback options:</p> <ol style="list-style-type: none"> <li>1. Near real-time feedback delivered via an optional in-home display device; and/or</li> <li>2. Hourly data, provided within 24 hours, through the Power Smart website.</li> </ol>	<p><b>\$220 M</b></p> <p>Range is: \$170 M–\$270 M</p>	<p>BC Hydro will offer a rebate program to encourage customers to choose a basic, market available in-home display.</p> <p>Customer take-up of in-home display is assumed at 30 per cent.</p> <p>Energy savings from in-home displays are 4 per cent with eight year persistence.</p> <p>Website-based energy savings are 2 per cent, with 15 per cent penetration of residential customers.</p>	<p>An increase/decrease of 1 per cent in customer participation translates to approximately \$1.2 M in PV.</p>
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## APPENDIX 5: ADDITIONAL NON-QUANTIFIED BENEFITS

In addition to the quantified benefits identified in the business case, the Smart Metering Program will deliver numerous other benefits that have not been captured in the business case to date. The following table provides a summary of these additional benefits.

Type of Benefit	Additional Benefits
<b>Operational Efficiencies, Cost Savings and Other Benefits</b>	<p>Additional uses of metering (unrelated to theft detection) in distribution planning and operations, asset management, etc.</p> <p>Reduction of line losses unrelated to theft detection (e.g. street lights).</p> <p>Facilitation of screening process required to assess the impact of Distributed Generation and electric vehicles during planning.</p> <p>Increased data will significantly improve the precision and quality of load profiles.</p> <p>Reduce staffing needs, related facility space and office equipment.</p> <p>Reduction in carbon offset payment for emissions for the BC Hydro fleet vehicles used by Accenture Business Services for Utilities.</p> <p>Improved overall system efficiency through better ability to optimize supply and demand levels throughout the day.</p>
<b>Safety, Privacy and Security</b>	<p>Reduced employee and contractor exposure to potential accidents and injury due to reduction of time spent in the field.</p> <p>Improved public safety due to the reduction in electricity theft.</p> <p>Customer security and privacy will increase as meter readers will no longer be required to enter customer property to read, disconnect or reconnect meters.</p>
<b>Improved Customer Service and Convenience</b>	<p>Customer service representatives will have the ability to check current meter readings directly from the meter while the customer is on the phone to validate meter functionality, address billing complaints, and confirm whether an outage is on the customer side of the meter.</p> <p>Customers will no longer be required to unlock gates, keep dogs inside, provide keys for access, etc.</p> <p>On-demand meter reading when customers move in or out of premises will avoid adjusted billings between tenants, simplifying transactions for customers.</p> <p>Customers will have the option of signing up for automated outage notification.</p> <p>Customers can choose to receive rate related information through an in-home display.</p> <p>Customers who use the in-home feedback tools, whether it is a secure web page or in-home display, and conserve energy will benefit from lower bills.</p> <p>Better ongoing information for customers and quicker response to power outage situations will enable commercial customers to make better decisions and reduce down-time costs.</p> <p>Customers will benefit from faster service re-connection.</p> <p>Commercial customers will be better able to optimize commercial building systems, saving energy and money.</p>



<p><b>Environment</b></p>	<p>Facilitates conservation and energy efficiency.</p> <p>System efficiencies and increased automation within BC Hydro’s operations will deliver some greenhouse gas emission reductions. Support for the large scale integration of electric vehicles and electrification of the transportation system could deliver further green house gas emission reductions.</p> <p>Smart metering benefits will help to achieve the Province’s target to reduce the projected demand increase by at least 66 per cent through conservation.</p> <p>Supports BC Hydro’s ability to pursue all cost-effective Demand Side Management.</p>
<p><b>Socio-economic</b></p>	<p>Employment opportunities related to the installation of meters, and creation of more information-based jobs.</p> <p>Opportunities for local business to build on the system and create new products and services that support a green economy.</p> <p>Opportunities to build on the new smart metering infrastructure to create made-in-B.C. technology solutions that support a green economy.</p> <p>Smart meters are the first step in enabling the large scale accommodation of electric vehicles, customer self generation and microgrids that will help communities throughout British Columbia become more self sufficient.</p> <p>Enables significant energy savings that can be used for other economic purposes.</p>

## APPENDIX 6: BUSINESS CASE ANALYSIS

A business case documents the economic justification to support an investment decision, such as acquiring assets. Business cases are based on forecasts of incremental cash flows, both benefits and costs, over a time horizon that reflects the economic lives of the assets acquired. These cash flows are then discounted resulting in a net present value (NPV).

A business case does not include non-cash financial impacts, such as depreciation, amortization, or write downs of existing assets. These are accounting transactions, included in appropriate financial reports, and are not a factor in the economic rationale to make a business investment.

The Smart Metering Program business case model includes all the inputs and assumptions required to complete a comprehensive financial analysis of costs and benefits over a 20 year term following the installation of the meters (through F2033). The Smart Metering Program business case analysis reflects those cash flows that are incremental to cash flows without the program. For example, the business case model captures total annual cash flows for capital expenditures, avoided and deferred capital benefits, operating expenses and operating benefits. The NPV of the cash flows over the evaluation period is then calculated. A positive NPV supports the proposed investment decision.

The table below provides a summary of the key financial modeling assumptions used in the Smart Metering Program business case model:

### KEY FINANCIAL MODELLING ASSUMPTIONS

Category	Assumption	Sensitivity
<b>Discount Rate and Inflation Rate</b>	The present value of all costs and benefits has been calculated using the nominal (i.e., with inflation) BC Hydro discount rate of 8 per cent <sup>11</sup> per year.	A variation of 0.25 per cent (+/-) in the discount rate changes the NPV in the business case by approximately \$30 M.
<b>Value of Energy</b>	Value of energy is the BC Hydro reference energy price based on the 2009 Clean Call for Power. This price is \$124 per MWh for F2010 and adjusted for inflation annually.	A 10 per cent change in the assumed value of energy results in a change in the NPV of about \$85 M.
<b>Value of Capacity</b>	Value of capacity is an estimate for the avoided cost of building generation, transmission and distribution assets. The capacity reference price is updated as part of the integrated resource planning process.  For capacity benefits associated with energy savings in this business case, the value of capacity is \$88 per kilowatt-year (as set in F2009 and adjusted for inflation annually).	A 10 per cent change in the assumed value of the capacity results in a change in the NPV of about \$28 M.

<sup>11</sup> BC Hydro's discount rate (Weighted Average Cost of Capital) for business cases is based on BC Hydro's deemed capital structure, the allowed rate of return on equity—both of which are approved by the British Columbia Utilities Commission—and the forecasted average cost of debt. The Weighted Average Cost of Capital for F2011 is presently set at 8 per cent, and includes a 2 per cent rate of inflation.

<b>Amortization period</b>	Amortization periods for smart metering assets acquired are based on the estimated economic life of each asset type, as follows: <ul style="list-style-type: none"> <li>Smart Meters: 20 years</li> <li>Telecommunications (Field Area Network): 20 years</li> <li>Telecommunications (Wide Area Network): 35 years</li> <li>Distribution System Meters: 15 years</li> <li>IT Hardware: 5 years</li> <li>IT Software: 10 years</li> </ul>	These amortization periods have no impact on the NPV of the business case. Assumed amortization periods do, however, affect customer rate impacts attributable to the Smart Metering Program.
<b>Asset Refresh</b>	Assets are typically replaced based on the estimated economic life of each asset type. Where the economic life of an asset falls within the timeframe of this business case, the asset refresh cost has been factored into the financial analysis.	No sensitivity analysis required.

### Business Case Summary

The following table provides a summary of the overall business case, including the key financial components resulting in the positive net present value (NPV) of \$520 million. For greater clarity—and because benefits have typically been discussed in terms of present value and costs in terms of nominal value—both nominal and present value figures are provided.

The ongoing operating and maintenance expenses for the Smart Metering Program include any incremental costs required to operate and maintain the new assets—such as meter maintenance, software application support, and telecommunications operations and maintenance.

The capital cost to replace Smart Metering Program assets during the period to F2033, based on the economic life of each asset type, has been included in the overall NPV. This capital cost is adjusted for the un-depreciated net book value of assets remaining in service at the end of F2033.

The following table provides a net present value (NPV) scenario analysis, beginning with the base case of \$520 million. The NPV remains positive even if all the benefits are achieved at the low end of the estimated benefit range. Conversely, if all benefits are achieved at the high end of the range, the NPV increases to \$956 million.

#### BUSINESS CASE SUMMARY IN NOMINAL AND PRESENT VALUE

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)
<b>Total Net Value for the period F2006 to F2033</b>	<b>\$2,983</b>	<b>\$520</b>

### Development of the Business Case

The Smart Metering Program business case has been updated and revised several times since the program was first initiated in 2006. Throughout the business case development process, BC Hydro has engaged a number of third party experts, including PricewaterhouseCoopers (PwC) and Enspira Solutions, to review and validate costs, benefits, approach and methodology. As a result of the continued evolution of the smart metering industry and related technologies, BC Hydro undertook a full refresh of the business case in 2010.

## APPENDIX 7: RATE ANALYSIS

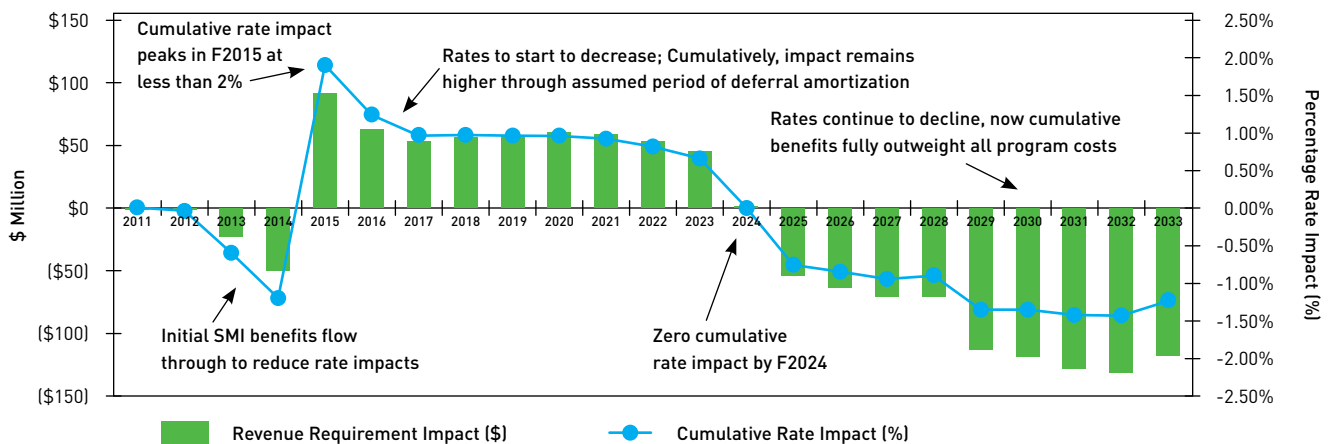
The Smart Metering Program pays for itself through reduced theft of electricity, energy savings, and operational efficiencies. Net benefits will flow to customers, reducing rates below what they would otherwise be in the absence of BC Hydro's investment in the program.

Similar to other capital projects, the Smart Metering Program has initial rate impacts which are reduced over time as the benefits accumulate. In order to better match the initial cost recovery to the timing of benefits realization, BC Hydro will seek BC Utilities Commission approval to "smooth" rate impacts.

The *Clean Energy Act* exempts the program from those sections of the *Utilities Commission Act* that specify BC Hydro's obligations to seek approvals from the BC Utilities Commission for capital projects. However, when BC Hydro seeks to recover Smart Metering Program expenditures in rates, the BC Utilities Commission will review the prudence of BC Hydro's decisions and actions in relation to the implementation of this program.

The estimated impact of the Smart Metering Program on BC Hydro's rates is based on the net cash flow benefits as presented in the business case, which are then incorporated into BC Hydro's regulatory accounting model to determine the incremental impact on BC Hydro's annual revenue requirements<sup>12</sup>.


The graph below illustrates the projected rate impact of the Smart Metering Program over the term of the business case, before considering potential rate smoothing proposals. Specifically, the graph shows the annual impact of the program on BC Hydro's revenue requirements, as well as the cumulative rate impact which ultimately results in a sustained rate decrease of over 1.25 per cent (below what rates would otherwise be in the absence of the Smart Metering Program).



The green bars on the graph show the annual dollar impact (in millions) of the Smart Metering Program on BC Hydro's overall revenue requirement. The blue line on the graph illustrates the cumulative impact on rates over the term of the business case. To help manage current rate pressures, \$75 million in benefits from the program will flow through to customers in F2012 through F2014—resulting in a cumulative rate decrease of just over 1 per cent by F2014.

Without the planned smoothing, in the first year following full implementation of the Smart Metering Program (F2015), there is an increase in BC Hydro's revenue requirement as the recovery of current—and previously deferred—costs starts. From F2016 through F2023, the additional revenue requirement due to the Smart Metering Program starts to drop.

<sup>12</sup> Revenue requirement refers to the total amount of money BC Hydro must collect from customers to pay all operating costs, energy costs, amortization, financing charges, and return on equity in a given year.



From F2024 on, the Smart Metering Program benefits reduce BC Hydro's annual revenue requirement, resulting in rates being reduced below what they would otherwise be without the program. Over the term of the business case, there is a total reduction in BC Hydro's revenue requirement of over \$400 million.

This \$400 million total reduction in BC Hydro's revenue requirement differs from the business case net present value of \$520 million because the revenue requirement includes accounting impacts of non-cash transactions from a regulatory point of view. For example, the revenue requirement factors in the financial impacts due to timing of regulatory cost recovery and recovery of the un-depreciated sunk cost of existing meters—a non-cash item.

## APPENDIX 8: KEY BUSINESS RISKS

### SUMMARY OF KEY RISKS AND MITIGATION STRATEGIES

Risk	Description	Mitigation Strategies
<b>Meter Supply Chain</b>	Risk of the market's inability to meet meter supply chain requirements, and interdependencies with other vendors.	<p>Procurement evaluation criteria considered the vendor's ability to meet the timeline.</p> <p>Incentive mechanisms are in place to align the related suppliers to deliver on time and on budget. Significant liquidated damages to be included in final contracts to ensure vendors meet their commitments.</p>
<b>Emerging Technology</b>	Risk of technology continuing to evolve resulting in stranded assets.	<p>All meter vendors under consideration in the procurement process have met minimum mandatory criteria which included having sizable deployments in other North American and European utilities, and based on proven technologies.</p> <p>Technology selection criteria were designed to meet current and expected future business needs.</p> <p>Procurement evaluation criteria included technology "future proofing" to ensure future business, technical and operational requirements were considered.</p> <p>Where technology risks may still exist, the successful vendor will be contractually committed to meeting BC Hydro's requirements by an agreed date. In addition, they will be required to provide full backward compatibility for selected products.</p>
<b>BC Hydro Resource Constraints</b>	Significant resource constraints internally for telecommunications, field crews, and technology personnel—skills and head count—could impact the schedule.	<p>The Smart Metering Program is a top corporate priority with broad executive oversight and commitment.</p> <p>Leverage meter and field contract labour market for peak resource requirements—including incentives for vendors to grow and create jobs in British Columbia.</p>
<b>Meter Deployment</b>	Unable to complete meter deployment by the end of 2012.	<p>Contract incentives are in place for solution integrator, meter system and meter deployment vendors to meet 2012 timeline.</p> <p>Use various strategies to deploy meters in multiple regions concurrently, including distributed warehouses.</p>

<p><b>Budget</b></p>	<p>Risk of exceeding project budget due to unforeseen costs or changes in scope.</p>	<p>Procurement approach designed to achieve cost certainty for at least 50 per cent of the project budget, including mechanisms like:</p> <ul style="list-style-type: none"> <li>• affordability ceilings</li> <li>• fixed price contracts</li> <li>• incentive mechanism shared with all vendors</li> </ul> <p>Rigorous control over scope elements implemented including:</p> <ul style="list-style-type: none"> <li>• formal change control process for any change in scope, timeline, or deliverables</li> <li>• project controls office in place to manage issues, risks, assumptions and changes</li> </ul> <p>Rigorous financial controls are being implemented including:</p> <ul style="list-style-type: none"> <li>• budget assigned to accountable managers and measured</li> <li>• financial performance tracking and forecasting tools</li> </ul>
<p><b>Safety/Security/ Customer Privacy</b></p>	<p>Risk of security or privacy breach impacting customers or system operations.</p>	<p>Safety, security and privacy were built into all procurement processes.</p> <p>Safety, security and privacy were built into end-to-end solution architecture and all business processes, which will be validated during solution acceptance testing.</p> <p>BC Hydro is an active participant in external standards setting groups, including committees focused on safety, security, and privacy.</p> <p>A dedicated smart metering safety, security and privacy office has been established.</p> <p>Formal penetration test plan including hiring external agencies to attempt to break into the system.</p>
<p><b>Customer Experience</b></p>	<p>Risk of limited customer awareness and public support of smart metering, and/or negative customer experience during meter deployment.</p>	<p>Customer research to discover baseline level of public awareness and to identify specific issues and concerns regarding meter deployment.</p> <p>Comprehensive Smart Metering Program communications plan developed and being implemented. Includes specific customer contact plans pre-, during, and post- meter deployment.</p> <p>Incorporating lessons learned from other utilities with respect to customer engagement.</p>

## APPENDIX 9: MANAGING RISK THROUGH PROCUREMENT

In 2008, BC Hydro initiated a procurement process for a single Solution Integration firm, which would in turn be responsible for selection and sub-contracting of the required technology components, meters, deployment services, and project implementation. Proposals submitted at that time were significantly over budget and did not achieve the risk transfer expected by BC Hydro.

In March 2010, BC Hydro decided to proceed with a “disaggregated” procurement approach to contract directly with proven industry vendors—ensuring BC Hydro retains direct control over the program while building business relationships that would extend over the economic life of the assets. Partnerships BC was engaged to provide expertise in structuring a comprehensive and open procurement process.

Specific project risk mitigation managed through procurement includes:

- **Minimum mandatory criteria:** a number of mandatory ‘pass/fail’ criteria were established to ensure only established, proven and scalable proponents are considered.
- **Affordability ceilings:** establishing the maximum value BC Hydro is prepared to pay for a product or service providing cost certainty.
- **Subject matter experts:** both internal and external subject matter experts have been involved to ensure a full understanding of proposed technologies.
- **Panel interviews:** because experienced professional resources are critical to the success of the project, panel interviews are conducted with key individuals proposed by vendors.
- **Fairness Advisor:** an independent and experienced Fairness Advisor participated in all procurement processes.
- **Due Diligence Committee:** a senior level independent advisory committee reviews procurement recommendations of the selection teams to ensure that the process was followed and the basis of recommendations is appropriately documented.

As of December 31, 2010, BC Hydro continues in active procurement or final contracting in four key procurement streams—Solutions Integrator, Metering System, Meter Data Management System and Meter Deployment Services. Announcements related to the successful proponents are expected in the near future.



## APPENDIX 10: TECHNOLOGY AND INDUSTRY STANDARDS GROUPS

BC Hydro has been active with industry in North America for several years to understand and influence the technology and standards that will impact the success of the Smart Metering Program. This work has included participation on a number of committees and collaboration with various industry associations as outlined below:

Industry Association	Purpose	BC Hydro Participation and Value
<b>Electric Power Research Institute (EPRI)</b>	To advance innovation, research and utility solutions.	Active participation on power delivery programs including smart grid applications.
<b>National Institute of Standards and Technology (NIST)</b>	To advance industry standards. Currently working on priority action plans related to smart grid development.	BC Hydro is closely following the NIST guidelines and standards for security including NISTIR 7628 and Federal Information Processing Standards.
<b>GridWise Alliance</b>	To advance smart grid business and technology solutions, including policy and legislation.	Membership has provided direct access to the latest industry advancements.
<b>National Electric Energy Testing Research and Applications Center (NEETRAC)</b>	To test and validate industry solutions, particularly safety for metering services.	Involved in defining and testing the latest smart metering functionalities and applications.
<b>Open Smart Grid (OpenSG)</b>	Address delivery of utility smart grid and smart metering requirements and related key industry technology issues.	BC Hydro is actively involved in OpenSG efforts including smart grid security and applying best practices for protecting the smart metering network and smart grid.
<b>Canadian Standards Association (CSA)</b>	To certify the safety of electrical equipment.	Assist in the evaluation of new smart grid components to meet safety standards.
<b>Canadian Electrical Association (CEA)</b>	To represent the Canadian utility industry. Currently addressing metering standards and acceptance with Measurement Canada.	Committee work to support acceptance of future metering solutions.
<b>Utilities Telecom Council (UTC)</b>	To advance telecom solutions and set standards.	Participation to establish efficient smart grid communication solutions.
<b>Canadian National Committee on Smart Grid Technology and Standards</b>	To address appropriate standardization for smart grid in Canada.	Participation to guide Canadian standards in a global context.
<b>Institute of Electrical and Electronics Engineers (IEEE)</b>	To address international technology issues and set standards.	Participation on a variety of technical committees related directly to BC Hydro's program.
<b>ZigBee Alliance</b>	To develop open industry standards for low-power wireless communications.	Active participation in the "Smart Energy Profile" working group, which defines data communication standards for smart meters and in-home devices over a Home Area Network.
<b>Health Canada</b>	Responsible for helping Canadians maintain and improve their health, while respecting individual choices and circumstances.	Ensuring compliance with the protection of customers and workers related to electricity including electromagnetic fields (EMF).
<b>SAP Lighthouse Council</b>	To foster collaboration between SAP, major utilities and industry vendors to integrate Advanced Metering Infrastructure with utility Enterprise technology.	Exposure to leading practices that achieve integration of end-to-end processes between the meter and the backend systems, and to reduce a company's total cost of ownership for Advanced Metering Infrastructure.

## GLOSSARY

### **Authorized Amount**

Requested funding for a project inclusive of all contingencies and based on a fixed scope and in-service date.

### **British Columbia Utilities Commission (BC Utilities Commission)**

An independent regulatory agency of the provincial government operating under and administering the *Utilities Commission Act*. The BC Utilities Commission's responsibility is the regulation of the energy utilities under its jurisdiction to ensure that the rates charged to utility customers for energy are fair, just and reasonable. The BC Utilities Commission is responsible for ensuring customers receive safe, reliable and non-discriminatory rates and shareholders receive a fair return.

### **Capacity**

The maximum sustainable amount of energy that can be produced or carried at an instant. For example, a car engine's horsepower rating is its energy capacity.

### **Capital Refresh of Assets**

The program assets are assumed to be replaced periodically based on the estimated economic life of each asset type.

### **Clean Energy Act**

A long-term vision for BC to become a clean energy leader. This Act guides government, BC Hydro and the British Columbia Utilities Commission in advancing the province's ambitious sustainable energy vision.

### **Contingency**

An amount provided in the estimate for a project having a fixed scope and in-service date to allow for potential costs which cannot be specifically identified at the time of estimate preparation but which experience shows will likely occur.

### **Customer Generation**

Allows customers to generate power on a smaller-scale in order to provide an alternative to, or an enhancement of, the traditional electrical power system. It can take the form of solar panels, wind power, biomass, etc.

### **Definition Phase**

Detailed investigation of the approved approach and preparation of a preliminary design, procurement, and Project Plan for Implementation Phase funding complete with business case. This phase also includes the securing of all key defining agreements.

### **Demand Side Management (DSM)**

Actions that modify customer demand for electricity, helping to defer the need for new energy and capacity supply additions.

### **Direct Labour Cost**

Labour cost without benefits or overhead loadings.

### **Distribution System**

The portion of the power system that converts energy to the right voltage and delivers power to homes and businesses across the province.

### **Electrical Distribution System Optimization (EDSO)**

Helps to reduce electricity usage and costs with no capital investment through matching voltage to equipment requirements.

### **Energy**

How much is consumed (or produced) over a period of time.

### **Field Area Network**

A secure two-way telecommunication network between customer meters, other end point devices, aggregation devices and network extenders.

### **Greenhouse Gas (GHG)**

Gases that are thought to contribute to global climate change, or the "greenhouse effect," including carbon dioxide (CO<sub>2</sub>), methane (CH<sub>4</sub>) and nitrous oxide (N<sub>2</sub>O).

### **Grid Modernization**

An automated, intelligent power delivery system that supports additional services and benefits to customers, the environment and the economy.

### **Gross Benefits**

The value of benefits before the deduction of related costs.

### **Home Area Network (HAN)**

A data communications system contained within a premise, such as a residence, that can connect devices (e.g. in-home display device) in the premise to the smart meter.

### **Identification Phase**

Review of conceptual alternatives, evaluation of feasibility, review of alternatives, and delivery of a project plan for Definition Phase funding. This phase ends with a decision on whether or not to proceed to the next phase.

### **In-home Display**

A device that can communicate with a smart meter to show how much energy is being consumed and at what cost.

### **In-home Feedback Tools**

Different ways through which customers can receive feedback about the electricity they are consuming, and the cost of that electricity, in their home, business or other location. In-home feedback can include an in-home display and/or secure websites, home energy management systems etc. that provide information about energy consumption.

### **Implementation Phase**

Includes detailed design, material and equipment procurement, construction, testing and commissioning into service. The phase ends with a Post-Expenditure Review and a Project Completion Report.

### **Initiation Phase**

Establishment of an initial project team, research and benchmarking. This phase ends with a decision to proceed on whether or not to proceed to the next phase.

### **Interest During Construction (IDC)**

When an asset is constructed, there is often a considerable period between the start of a project and its completion. Because the cost of an asset should include all costs incurred to prepare it for use, interest costs related to the construction are generally included in the cost of the asset that is capitalized.

### **Interval Data Recording (IDR)**

A record of energy consumptions, with reading made at regular interval throughout the day, every day.

### **Measurement Canada**

A federal agency responsible for ensuring the integrity and accuracy of measurement in the Canadian marketplace, including the accuracy of electricity meters.

### **Meter Data Management System**

The software applications and infrastructure required to support the integration of data from the smart metering system into other BC Hydro systems. The data is made available to the utility for a variety of business functions such as billing, energy diversion detection and outage tracking.

### **Microgrids**

Small networks of generating sources capable of operating independently from the electricity system. Microgrids can switch quickly between operating on and off the system, allowing communities to become more self-sufficient.

### **Net Benefits**

The value of the benefits after the reduction of related costs.

### **Net Present Value (NPV)**

The difference between the present value of benefits and the present value of costs (including capital, operating, maintenance and administration costs) for a given discount rate.

### **Nominal Growth/Price**

Growth or price measured in current dollars at the time the goods are produced; change includes the amount of inflation.

### **Ongoing Operating Expenses**

The incremental operating costs required to operate and maintain program assets, such as meter maintenance and telecommunications and software application operating costs.

### **Present Value**

Today's discounted value of future receipts or expenditures.

### **Price Elasticity**

The price responsiveness of consumption, expressed as the percentage change in quantity per a 1 per cent change in price. For example, an elasticity of -0.10 means that a 1 per cent increase in real price would lead to a 0.1 per cent decrease in consumption.

### **Project Costs**

The authorized amount for the Smart Metering Program is \$930 million (nominal), and this reflects the costs to put the program's assets required by regulation into operation.

### **Project Plan**

A document that sets out a strategy and course of action for meeting the project objectives.

## Revenue Requirement

A revenue requirement is the forecast cost of doing business for a period of time and must be approved by the British Columbia Utilities Commission. BC Hydro can collect its required revenue through tariffs—the rate charged to customers.

## Regulatory Account

Deferred amounts related to the Smart Metering Program will be recorded in the Smart Metering Program Regulatory Account. BC Hydro's accounting policies allow for the deferral of amounts that under Canadian generally accepted accounting principles would otherwise be recorded as expenses or income in the current accounting period. The deferred amounts are either recovered or refunded through future rate adjustments.

## Smart Grid

A smart grid delivers electricity from suppliers to consumers using digital communications to save energy, reduce costs and increase reliability and transparency. A smart grid is made possible by applying sensing, measurement and control devices with two-way communications, making it possible to dynamically respond to changes in system condition. A smart grid includes an intelligent monitoring system that keeps track of all electricity flowing in the system. It also has the capability of integrating clean, renewable electricity such as solar and wind.

## Smart Meter

Smart meters provide two-way communication between the customer's meter and BC Hydro, capturing the amount of power that is consumed and when.

## Smart Metering and Infrastructure Program

The Smart Metering and Infrastructure Program or Smart Metering Program plays a key role in modernizing BC Hydro's electricity system. It involves the introduction of new digital smart meters and the supporting infrastructure.

## Supervisory Control and Data Acquisition (SCADA)

Computer systems used to send and collect supervisory controls and monitor data through power lines.

## Volt-VAR Optimization (VVO)

Optimizes the energy delivery efficiency on distribution systems using real-time information, minimizing power loss.



Smart meters will allow BC Hydro to continue to manage the electricity system in a reliable, safe, and cost-effective manner.