OPERATIONS CAPITAL

1.0 INTRODUCTION

Operations Capital funds enhancements and replacements to the facilities required to operate the Hydro One Transmission system within the requirements established by the reliability authorities, operating agreements and the market rules. The process to develop capital investments for Operations assets is discussed in Exhibit A, Tab 12, Schedule 4.

The planned investments enable Hydro One Transmission to meet its regulatory obligations as a transmission owner and operator and align with Hydro One Transmission's vision as a leading transmission company by employing "best in breed" commercially available operations systems and equipment that provide adequate monitoring and control to maintain system and customer reliability at required levels, and maintain public and worker safety.

Operations capital investments are required to sustain assets that are at their end of life or need major refurbishment and to implement, enhance and modify the physical infrastructure, systems and tools necessary for transmission operations. These investments deliver improvements to transmission system performance in the form of reduced outage duration, improved system utilization and improved information to asset managers and customers.

Failure to sustain the Network Operating systems and tools would lead to increased business and operational risk as they become less reliable and require more maintenance over time. Network Operating system and/or tool failures may negatively impact customer service, system reliability and regulatory compliance.

The Operations Capital program for the test years is divided into two categories:

- Grid Operations Control Facilities, which funds enhancements to, and replacement of, the computer tools and systems that support the transmission operating functions at the Ontario Grid Control Centre (OGCC) and the back-up centre.
- Operating Infrastructure, which funds enhancements or modifications to the physical infrastructure outside of the control centres, required for the operation of the transmission system.

The required funding for the test years, along with the spending levels for the bridge and historic years is provided in Table 1 for each of these categories.

Table 1

Operations Capital ($ Millions)

Description	**Historic**			**Bridge**	**Test**	
	2007	**2008**	**2009**	**2010**	**2011**	**2012**
Grid Operations Control Facilities	2.0	16.8	11.3	8.8	22.6	18.5
Operating Infrastructure	2.7	6.3	8.7	1.4	21.7	38.9
Total	**4.7**	**23.1**	**20.0**	**10.1**	**44.3**	**57.4**

Planned spending in 2011 is $44.3 million as compared to the 2010 level of $10.1 million. This increase is required to provide a Wide Area Network for protection and control of the grid as well as to address OGCC and Back-up Centre building space needs, as discussed in Sections 4.3.3 and 3.3 respectively. Planned spending in 2012 of $57.4 million is a 30% increase over the 2011 level resulting from the higher necessary spending levels for the Wide Area Network Project.

A brief description of the primary systems used to manage Hydro One Transmission's system is provided in Section 2.0 below. This is followed by the description and details of, and the year-to-year changes in, the two individual Operations Capital investment categories.

2.0 DESCRIPTION OF THE SYSTEMS AND TOOLS

Hydro One Transmission operates and controls the entire Hydro One Transmission system from the OGCC. Backup facilities are also provided at a separate location in the event that the OGCC is unavailable. A suite of centralized systems and tools, supported by province wide telecommunication and station control infrastructure is used to carry out the monitoring and control of the transmission assets and system, the planning and scheduling of transmission equipment outages, and the provision of transmission system performance information. Hydro One Transmission continually assesses and implements technologies to improve the performance and efficiency of its transmission operating function. The operating function faces growing challenges:

- The efficient scheduling and real time management of an increasing number of equipment outages required to support the growing Sustainment and Development work programs
- Challenges associated with adjusting to the changing conditions of aging assets that require closer management of operating limits and equipment de-ratings. This results in increasing workload to plan and manage equipment outages.
- New impacts on transmission operation resulting from the connection of large amounts of renewable generation directly tapped to transmission lines or connected to the distribution systems. Many of these require controls and monitoring to manage system impacts, performance and customer requirements.

2.1 Grid Operation and Control Facilities

The primary systems used in the monitoring and control of the transmission system are:

- **The Network Management System ("NMS")** is the transmission network monitoring and control tool which performs the following functions: data acquisition, supervisory control, real-time and study mode network analysis, and training simulation. It provides the real time voltage and loading on the transmission system as well as monitoring and control of the status of the switches and breakers connecting the equipment to the integrated network for the purpose of safe and reliable operation of the transmission system. The NMS also provides predictive assessment tools which help in providing situational awareness to the operator.
- **Operations Support Tools** enable the integration of outage management, utility work protection code and electronic logging functions, each of which is described below:
    a. **Network Outage Management System ("NOMS")** is the transmission outage management tool that is used for planning, scheduling, assessing and executing transmission equipment outages and for transmitting outage requests, via a direct communication link, to the Independent Electricity System Operator (IESO) for approval.
    b. The **Utility Work Protection Code System** is used by Hydro One Transmission to establish conditions which, when combined with appropriate work practices, procedures and work methods will provide employees with a safe work area. This electronic work permit forms system contains the necessary information to support the development of required Work Protection documentation.
    c. **Electronic Logging** is the records system for the control room daily activity. It has automated features to capture operations using the NMS, including operator actions such as opening and closing breakers, and automatic operations resulting

from power system faults. The staff also manually record all other pertinent information to create the chronological record of the daily activity. Electronic logging provides system data for asset management and system planning.

- The **Transmission and Station Operating Diagrams** are used by field crews and by the OGCC to provide detailed information on the configuration of the transmission system and the connectivity of the transmission station equipment. This information is essential in ensuring the safe and reliable operation of the transmission system.
- The **OGCC Integrated Voice System** is designed to allow OGCC Operations to effectively manage voice communications between the OGCC, IESO, transmission connected customers and field staff. This system provides the interface to multiple communication media, such as the public telephone network, public cell phone network and Hydro One Transmission's provincial mobile radio system.
- The **OGCC Emergency Services Information System** provides verified up-to-date contact numbers for all emergency response services (e.g. police, fire, ambulance, ministry of environment, gas utilities, etc.) across the Province. This system is designed to enable OGCC staff to quickly and effectively contact emergency personnel.

2.2 Operating Infrastructure

The Operating Infrastructure comprises the systems and telecommunications required to connect the OGCC and Back-up centre to the transmission stations, to support real time field operations and to fulfill Hydro One's obligations for real time telemetry under the Market Rules and Transmission System Code. Specifically, the Operating Infrastructure includes:

- **Gateway Systems** that connect legacy station control systems at the approximately 460 transmission switchyards to modern systems used at the OGCC and Back-up

Centres and to the systems at the IESO. There are 110 gateway systems located at 37 sites, referred to as Hub Sites, across the province. The station control systems themselves, also generally referred to as Remote Terminal Units (RTUs), are considered part of the station asset and not Operating Infrastructure.

- The **Wide Area Telecommunications Network** that ensures multiple independent paths, including by satellite, to all stations that are of critical importance to the operation of the grid and restoration following any major disturbance event. This network also carries real time data that Hydro One is obliged to provide to Transmission Connected Customers from the OGCC or Back-up Centre to local points of presence for these customers.
- The **Fault Locating Systems** which are new systems being deployed to promptly identify the location of failures on transmission circuits. This will save cost and time for restoring circuits to service.
- The **Provincial Mobile Radio System** is the means by which both the OGCC and the field operations centres maintain continuous contact with field crews. It is designed to be reliable in the event of a widespread blackout and capable of accessing all remote locations where field crews would be dispatched to provide crews with an assured means of communication in case of emergency.
- **Underground Cable Monitors** which are probes that monitor the surface temperature and soil temperature gradients in order to ensure the healthy and optimum operation of cables which are critical to the supply of large downtown load centres.
- **Geomagnetically Induced Current Monitors** which detect currents flowing through the transmission system induced by the earth's magnetic field during solar disturbances. These currents can disrupt protection systems and cause outages.
- **Weather Stations** to acquire location specific weather data required for determining accurate operating limits on equipment, or other key condition information of vital

importance to grid operation such as accumulation of insulator contamination and ice build up.

3.0 GRID OPERATIONS CONTROL FACILITIES

3.1 Overview

Grid Operations Control Facilities provide critical capabilities to support transmission operations at OGCC and the back-up centre. This program funds enhancements to, and capital sustainment of, the computer tools and systems to maintain equipment performance at appropriate levels, thereby maintaining the overall reliability and service quality while satisfying all regulatory requirements.

Computer and network systems are short lived assets typically requiring renewal every five years. Grid Operations Control Facilities requiring upgrade are at the end of their normal life cycle and are subject to reduced reliability and increased support and maintenance requirements.

The Operations Capital projects for the Grid Operations Control Facilities are provided in Table 2 below.

Table 2
Grid Operations Control Facilities
Capital Projects ($ Millions)

Description	Historic			Bridge	Test	
	2007	2008	2009	2010	2011	2012
Network Operations Buildings Expansion	0	0	0	0.5	12.1	11.0
NMS Upgrade & Enhancements	1.2	16.0	9.2	3.6	3.8	4.0
Transmission Operating Facilities Sustainment	.5	.4	.6	3.0	6.5	3.5
Operations Support Tools (NOMS, UWPC, Electronic Logging)	0	0.3	1.5	1.7	0	0
Miscellaneous	.3	.1	0	0.0	0.2	0
Total	**2.0**	**16.8**	**11.3**	**8.8**	**22.6**	**18.5**

3.2 Description of Investments

Table 3
Grid Operations Control Facilities
Capital Projects > $ 3 Million in Test Year 2011 or 2012 ($ Millions)

Ref #	Description	Cash Flow		Total Cost	Removal Cost	Capital Cost
		Test Years				
		2011	2012			
O1	Network Operations Buildings Expansion	12.1	11.0	23.1	0	23.1
O2	NMS Enhancements	3.8	4.0	7.8	0	7.8
O3	Transmission Operating Facilities Sustainment	6.5	3.5	10.0	0	10.0
	Other Projects/ Programs < $3M	0.2	0.0	0.2	0	0.2
	Total Cost	**22.6**	**18.5**	**41.1**	**0**	**41.1**
	Removal Cost	**0**	**0**	**0**		
	Capital Cost	**22.6**	**18.5**	**41.1**		

3.3 O1 Network Operations Buildings Expansion

This is a new investment required to ensure adequate building facilities, including back office, computer rooms and backup centre control rooms. The investment deals with both the primary control facility, the Ontario Grid Control Centre located in the Barrie area, and the back up control facility located in the Toronto area.

3.3.1 Ontario Grid Control Centre (Primary Control Facility)

Growing business requirements are driving increases both in staff numbers and expansion of the operating support systems. To date, all possible measures have been implemented

at the OGCC to use all available space. Office space has been optimized and computer hardware facilities have been expanded to maximum capability.

Moving staff to "overflow" locations or decentralizing various operating departments would increase costs due to the resulting lost staff time for travel, inefficiencies and space leasing costs. Experience since the consolidation of operations into the OGCC has demonstrated that it is most effective to accommodate operations staff and support facilities at one centre.

The best solution is to expand the OGCC facility either directly or by building a new facility adjacent to the original.

3.3.2 Backup Control Centre

The Backup Control Centre is required should an extreme contingency disable the OGCC. Existing Backup Control Centre computer rooms are currently stretched to capacity in terms of physical space, power supplies and environmental controls. As a result, full redundancy of all systems is not currently available and some systems are currently housed in substandard overflow locations, constituting a risk to the reliability of transmission operating facilities.

A review of the Back up Centre is in progress which is taking a broader assessment considering total life-cycle cost and the current and future operating needs of the existing back-up control centre facilities. Analysis shows that relocating to a new back-up centre with expansion capacity is the best option.

3.4 O2 NMS Enhancements

Additional tools are required to enable operators and outage planning staff to manage increasing workload required to execute the growing sustainment and development work programs.

During 2011 and 2012, new commercially available NMS applications will be implemented to provide better information on the status and condition of field equipment, better information on the power system and to automate routine tasks. As well, standard vendor supplied applications will replace custom applications thereby reducing ongoing support costs.

3.5 O3 Transmission Operating Facilities Sustainment

This investment provides capital sustainment of the computer tools and systems that support the Control Room and back office transmission operating functions at the OGCC and the back-up centre. Many of these systems have about a 5-year life.

During 2011 and 2012, the Control Room telephone system, NMS workstations and displays, and Control Room display wallboards will reach end of life and will require replacement.

The risk of not proceeding with these replacements will include increased support costs and increasing failures of systems essential for the smooth function of the control room.

3.6 Operations Support Tools

This capital investment provides for the replacement of the existing NOMS, Utility Work Protection Code (UWPC) Forms and Electronic Logging programs with an integrated

solution. The enhanced integrated system will bundle all of the transmission equipment outage planning tools in a complete solution and provide interfaces to asset management work program systems, thereby improving the outage planning process. The centralized system will also streamline the effort to ensure the accuracy of the work protection permits and switching orders – an important contribution to the provision of a safe working area to employees.

This capital investment is expected to be in-service by the end of 2010 and therefore it has no impact on the Operations Capital expenditures during the test years.

3.7 Miscellaneous Projects

The investment in Dynamic Transformer Ratings ($0.2 million total for 2011) continues funding of an existing project to investigate, verify and prove the accuracy of Dynamic Transformer Ratings (DTR). DTR has the potential to increase the efficiency of transformer usage under various operating conditions.

4.0 OPERATING INFRASTRUCTURE

4.1 Overview

This program funds enhancements, expansion and end of life replacement of the physical infrastructure required for the operation of the Transmission System.

Table 3
Operating Infrastructure Capital
($ Millions)

Description	Historic			Bridge	Test	
	2007	2008	2009	2010	2011	2012
Hub Site Management Program	0.1	5.3	5.3	1.0	2.9	4.3
Telemetry Expansion Program	0.2	0	0	0.1	3.4	3.5
Wide Area Network	0	0.3	0.1	0.3	11.0	26.1
Miscellaneous	2.4	0.7	3.3	0.0	4.4	5.1
Total	**2.7**	**6.3**	**8.7**	**1.4**	**21.7**	**38.9**

The spending level for this program is driven by the ongoing program requirements combined with discrete projects undertaken in any given year or period of years. The spend in 2010 is below trend due to an intentional slowing of some programs and delays to projects in order to re-assess their scope and priorities in the face of major emerging new requirements associated with the green energy initiatives such as distributed generation and Smart Grid and the future evolution of NERC Cyber Security requirements. The proposed plan is the result of that reassessment. The increase in 2011 and 2012 funding levels are mainly attributable to the telecommunication requirements for generation connections, smart grid, security (both cyber and physical) and enterprise efficiency and increasing the rate of the telemetry expansion program. The telecommunication requirements are expected to continue to grow over the next decade. While the funding between 2011 and 2013 for the initial telecommunication infrastructure build represents a one-time cost, relatively small ongoing incremental expansion costs will continue in future years. Combined with telemetry expansion, ongoing hub site management and end of life replacements, the future funding levels for Operating Infrastructure Capital will be higher than historic and likely in range of 60% above the 2008 to 2009 average spend.

4.2 Summary of Need

The key drivers for the expenditures in operating infrastructure are:

- Growth in the grid increasing the number of assets and system elements that need to be monitored and controlled
- New compliance requirements
- The need to provide improved open access to the grid for connection of generation
- The need to achieve improved efficiency and performance in order to execute expanded sustainment and development programs.
- Other challenges such as the need for improved physical security at stations

During the test years, and years following, there will be an unprecedented combination of all these factors requiring expansion to the operating infrastructure.

Operating Infrastructure is subject to demanding requirements for reliability, performance and cyber security and is architected and designed accordingly. It is essential that this infrastructure continue to operate during extreme events such as severe weather or a wide-spread blackout, that it be continuously monitored for, and impervious to, cyber attack and that it can handle the large volumes of data that need to be sent to the control centre during a system disturbance affecting multiple transmission stations.

4.3 Description of Investments

Table 4
Operating Infrastructure
Capital Projects > $ 3 Million in Test Year 2011 or 2012 ($ Millions)

Ref #	Description	Cash Flow		Total Cost	Removal Cost	Capital Cost
		Test Years				
		2011	2012			
O4	Hub Site Management Program	2.9	4.3	7.2	0	7.2
O5	Telemetry Expansion	3.4	3.5	6.9	0	6.9
O6	Wide Area Network	11.0	26.1	37.1	0	37.1
	Other Projects/ Programs < $3M	4.4	5.1	9.5	0	9.5
	Total Cost	**21.7**	**38.9**	**60.6**	**0**	**60.6**
	Removal Cost	**0**	**0**	**0**		
	Capital Cost	**21.7**	**38.9**	**60.6**		**60.6**

4.3.1 O4 Hub-Site Management Program

This program is needed to continuously expand the gateways systems located at 37 hub sites across the province to provide capacity for monitoring and control of new assets, stations and generators that are connecting to the system. As new asset are built, the additional telemetry required increases the utilization of the gateways. When a gateway approaches capacity, additional gateways and hub sites need to be added. After a period of about 5 years, the gateway boxes need to be replaced due to obsolescence. The hub site management program continually manages these factors optimally to ensure the capacity and reliability of the grid control infrastructure is in place to meet the needs of the development, load connection and generation connection programs.

This program was introduced in 2007 about 4 years after most of the gateways went into service for the creation of the OGCC. From 2007 to 2009 many gateway systems were upgraded to larger systems to address full capacity utilization problems of many systems. By 2011 it is projected that grid expansion and generation connections will require an increased rate of gateway expansion and hub site separations.

Additional detail for this program is provided in the Investment Summary Documents in Exhibit D2, Tab 2, Schedule 3.

4.3.2 O5 Telemetry Expansion Program

This program is required to eliminate unnecessary equipment outages and inefficient use of the time of field staff, and to better manage aging assets. This will contribute to improved grid reliability and also reduce impediments to accomplishing the growing sustainment and development work programs.

The key deliverables of this program are the splitting of critical bundled alarms and the addition of more detailed monitoring of station equipment. This will enable OGCC operators to make immediate determination of the cause of an alarm and the appropriate response and will eliminate the need for unnecessarily removing equipment from service and costly urgent field staff callout to the stations. The removal of any piece of equipment from service can place load supply at risk and will likely result in delaying other outages required to complete sustainment or development work. Delay or cancellation of outages can be very disruptive to the execution of work affecting both schedules and costs.

Additional detail for this program is provided in the Investment Summary Documents in Exhibit D2, Tab 2, Schedule 3.

4.3.3 O6 Telecom Wide Area Network

Hydro One projects a fourfold increase in requirement for telecom capacity over the next five years. This is to meet the needs of protection and control for new generation, smart grid, cyber security, enterprise systems and monitoring for physical site security.

The Telecom Wide Area Network project will install telecom facilities that will allow Hydro One to make optimum use of its existing extensive network of fibre optic cable installed onto its transmission lines to meet these requirements. Studies have shown that this investment will pay back in five years through reduced future telecom lease costs beyond the test years.

Additional detail for this program is provided in the Investment Summary Documents in Exhibit D2, Tab 2, Schedule 3.

4.3.4 Other Miscellaneous Projects

A number of other smaller projects totaling $4.4 million in 2011 and $5.1 million in 2012 make up the balance of the Operating Infrastructure expenditures. These projects are briefly described below:

Telecommunication Performance Improvement: This investment ($2.9 million total for 2011 and 2012) will fund improvements to Hydro One Transmission's grid control network to resolve telecommunication reliability and performance problems. There are a number of stations that improvements to reliability and redundancies are required due to telecom problems. It is particularly serious if the telecommunication fails as a result of power loss. This program addresses those by providing an alternate independent path or by addressing infrastructure problems which allow common mode failure issues.

Fault Locating: This program ($1.5 million total for 2011 and 2012) funds facilities required to accurately compute and promptly transmit the location of transmission line failures (faults) from the line terminal stations to the control room operators. Monitoring devices are now in place in most stations which have the ability to collect raw information that can be used to compute the fault location on transmission lines emanating from the station. This information is presently communicated verbally to the OGCC by protection and control staff once they have travelled to the station, interrogated the devices and performed the necessary calculations manually. This investment will allow for much faster determination of the location of the problem and faster restoration. It will also result in improved efficiency and reduced carbon footprint as the "windshield" time spent looking for a fault will be largely eliminated. Priority is given to long circuits in remote locations as these have both the longest travel times and the higher rates of faults. This investment receives information from the network connections installed at transmission stations as outlined on page 44 of Exhibit D1, Tab 3, Schedule 2.

Grid Control Network Sustainment: This program ($2.6 million total for 2011 and 2012) funds upgrades and end of life replacement of telecom equipment used in the Grid Control Network.

Real Time Data Service to Customers: This program ($1.0 million total for 2011 and 2012) funds maintenance, upgrades and enhancements to the Real Time Data Service. Hydro One is required under the Transmission System code to provide real time data to transmission connected customers. A system has been in operation from the OGCC and Back-up to provide this service and is well subscribed.

Weather Station Replacement: This project ($0.9 million total for 2011 and 2012) will fund end of life replacement of weather stations. Hydro One has a number of meteorological data collection systems at stations throughout the grid which provide

important data for determining real time equipment limits, track build up of contamination on insulators, and detecting ice accretion.

Underground Cable Monitoring: This project ($0.6 million total for 2011 and 2012) will complete the installation of monitors on underground cable supplying downtown Toronto. These monitors will help ensure the health of the cables while allowing the best possible operating limits.