THE ONTARIO RELIABILITY OUTLOOK

DECEMBER

2009

ieso

Power to Ontario. On Demand.

COVER: The Archetype Sustainable House is a prototype home demonstrating smart energy management systems. These systems enable consumers to monitor and schedule the operation of equipment such as dishwashers, electric vehicles and pool pumps during lower price periods.

Photo taken at Kortright Centre for Conservation. Screenshot courtesy of dx2EcoSense™

ABOVE: Prince Wind Farm in Sault Ste. Marie, with 189 MW generating capacity, is one of the largest wind farms in Ontario.

Credit: Brookfield Renewable Power

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As Canada's largest commercial solar farm, First Light Solar Park near Kingston spans 90 acres and has a generating capacity of 9 MW.

Credit: SkyPower Corp and SunEdison Canada

EXECUTIVE SUMMARY

A new vision is emerging for the provision and consumption of electricity in the province. Ontario's electricity system is rapidly becoming more participatory, distributed, and sustainable, challenging the industry to respond and innovate.

The Green Energy Act (GEA) is accelerating the development of renewable resources – placing the province among the leaders in green energy. This cleaner supply mix will be complemented by a more engaged consumer base, one that provides new and more sophisticated forms of demand response. Reliability, efficiency and sustainability are enhanced in this new paradigm through the stronger interplay between supply and demand.

The IESO's 2009 Ontario Reliability Outlook examines the sweeping task of renewing the province's electricity infrastructure: describing the challenges of transmission, integration and reliability; as well as the changing dynamics of a system in transformation.

Delivering Sustainable, Reliable Power

With increasing amounts of new supply coming online and strong performance from existing generators, the province's reliability outlook continues to improve steadily. This new supply has taken the form of renewable or cleaner forms of energy, which are beginning to deliver tangible benefits:

- Wind-powered generation connected to the IESO-controlled grid increased to almost 1,100 MW, with an average yearly capacity factor of 28 per cent over the past 12 months.
- Approximately 4,700 MW of gas-fired generation has been added to the IESO-controlled grid since 2003. Gas generation capacity now represents 24 per cent of the supply mix and exceeds coal capacity.
- Reliance on coal-fired generation continues to diminish with lower demand and natural gas prices. By the end of October, total greenhouse gases from coal and gas-fired generation were approximately 40 per cent less than they were in the same period in 2008.

By the end of next year, Ontario's new gas supply will have been in service for at least two peak operating seasons – setting the stage for the closure of two coal units at Nanticoke and another two at Lambton in late 2010. With these closures, the province's coal-fired generation capacity will be reduced by 40 per cent from 2003 levels, on track for the complete phase-out of coal by the end of 2014.

Even though the supply picture looks positive for the next few years, a viable plan for resources beyond 2014 needs to emerge in the not too distant future, as many of the available options require long lead times to implement. Decisions about nuclear refurbishment and/or new-build are pending. Renewable projects under the Feed-in Tariff (FIT) program could start to come into effect by the end of 2010, with a significant increase in variable capacity in the years to follow. The outcomes in these two areas will have a profound impact on the way the province's electricity system will be managed in the decades to come.

The GEA: Making it Work

The achievements to date provide the foundation for the ongoing transformation of Ontario's electricity system. The GEA and the accompanying FIT program will accelerate the growth of the province's renewable generation capabilities. Transmission, distribution and integration issues need to be addressed to achieve this program's full potential.

Transmission

Earlier this fall, Hydro One was instructed by the Minister of Energy and Infrastructure to immediately commence work on 20 transmission projects, as well as other station work and distribution projects. These new facilities will increase the transfer capability of the transmission network, allowing it to accommodate output from renewable generation located in many of Ontario's remote, yet resource-rich locations. This move recognizes that longer lead-times are required for new transmission infrastructure than for generation projects.

Previous Outlooks have highlighted the impact of extended regulatory approvals, environmental reviews and land acquisition processes on in service dates. To that end, the GEA also introduced a new renewable energy approval process which consolidates two existing processes into one. This approach will be critical to the timely implementation of new renewable contracts.

The IESO remains concerned, however, that ongoing delays to key transmission projects such as the Bruce-Milton line, could impede the rapid integration of new generation facilities. This concern also extends to approvals for future major transmission projects. Specific initiatives to streamline existing – yet important – approval processes will help with the construction of new transmission infrastructure in time to connect new renewable generation.

Integration

Integrating renewable energy supplies will require maximizing the flexibility within each and every resource. In anticipation of large amounts of variable generation connected to the transmission grid and distribution systems, the IESO is developing new ways to help it balance supply and demand. These efforts include new tools such as centralized wind forecasting that will provide a more accurate and reliable view of wind's contribution to the system.

Other approaches are also needed. Storage technologies – from flywheels to pumped storage and batteries – are being demonstrated in various pilot projects around the world, offering reliability services such as balancing short-term volatility and managing both minimum and peak-load requirements.

With levels of renewable generation increasing in virtually all jurisdictions across North America, Ontario and its neighbours need to take advantage of broader regional diversity to create an added level of flexibility and efficiency to system operations.

Load control (response from the demand side) represents a largely untapped resource that could play a central role in counterbalancing the variability of wind. With the introduction of smart grid capabilities carrying information back and forth between system operators (or local distribution companies) and consumers – the possibility of adjusting demand to help manage the rapidly changing availability of supply is becoming attainable.

In the future, batteries from electric cars may act as storage – charging up when wind resources are high and demand is low – and potentially injecting electricity back into the system if and when it's needed. Developing and coordinating new demand resources with clear price signals, dynamic demand response programs, automated energy management tools and consumer education needs to be an increasing priority for the industry.

Getting the Price Right

As the province reaches its smart meter targets, increasing numbers of consumers adopt energy management systems and electric cars begin to penetrate the market, electricity prices will potentially have an even greater impact on system reliability. Consumers on Time-of-Use (TOU) prices will more likely avoid heavy energy consumption during on-peak periods and owners of electric vehicles will likewise look for the most economic price options to recharge their cars.

Ontario is well-positioned for increased price-responsiveness. Most residential and small business consumers will be paying TOU rates by 2011; and larger business and institutional consumers currently pay hourly prices. As a result, the IESO and its partners have recognized the need to improve the accuracy of price signals.

On the supply side, generator contracts are being structured to incent producers to react to market prices and curtail output during periods of oversupply. On the demand side, further refinements will need to be considered to the Global Adjustment (which in part accounts for additional costs of contracted and regulated supply) to provide consumers with greater incentives to shift consumption to off-peak periods.

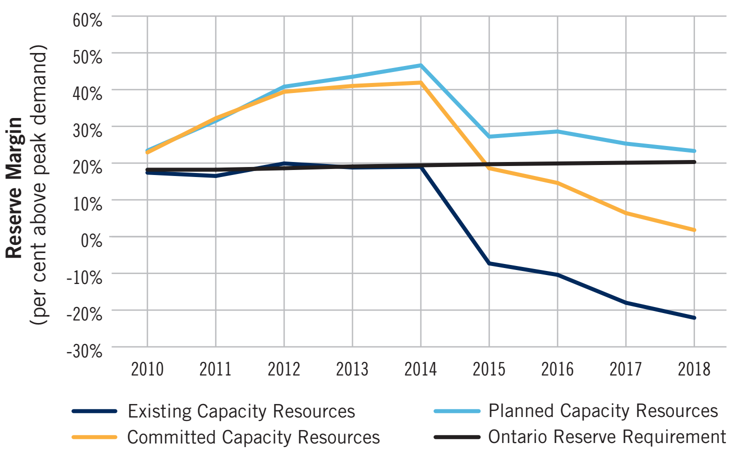
Ensuring Resource Adequacy

While new resources and limited demand growth are contributing to a positive reliability outlook over the next five years, the year 2015 marks the beginning of a new period of resource management for the industry. In the years following the phase out of coal-fired generation, meeting resource adequacy requirements will entail the successful coordination and implementation of a number of different initiatives to address the ongoing management of the province's aging nuclear fleet.

There is uncertainty around the available nuclear capacity beyond 2014 as decisions (including timing) about unit refurbishment or replacement have not been finalized. Nor has it been determined whether some units of the former coal fleet will be re-powered on alternate, cleaner fuels. These complex decisions are the responsibility of the asset owners and the Ontario Power Authority (OPA) which is charged with ensuring the necessary resources are in place to meet resource adequacy requirements. The OPA is exploring a variety of options and developing future resource scenarios to satisfy Ontario electricity demand, including sufficient reserve, to deal with supply uncertainties.

ONTARIO REQUIRED RESERVE MARGINS (2010-2018)

Source: Independent Electricity System Operator, Ontario Power Authority



This graph shows Ontario's required reserve margins for the period 2010-2018 as well as the existing, committed and planned resources expected to meet these requirements. Required reserve margin is the percentage of resource capacity above peak demand required to maintain reliability.

- Existing capacity resources: Generation currently in service (some of which is subject to retirement over this period).
- Committed capacity resources: Existing capacity resources plus OPA contracted/government-directed capacity not yet in service (e.g. Oakville, York Region, Bruce A Units 1 & 2)
- Planned capacity resources: Existing, committed capacity resources plus all OPA planning options for future capacity to meet target reserve requirements (e.g. conversion of coal units to biomass and potential renewable FIT generation assuming the realization of transmission enhancements).

Halton Hills Generating Station is a natural gas-fired combined cycle facility with a capacity of 632 MW. It is expected to be in service in summer 2010.

Credit: TransCanada PipeLines Limited

A SECTOR IN TRANSFORMATION

While Ontario's electricity sector has achieved many successes over the last few years as it works to create a more sustainable electricity service, the Green Energy Act (GEA) has raised the bar even higher. The province's electricity system is becoming even more diverse and broadly-based with a pivotal role for renewables and conservation in providing reliability. Investment in transmission expansion in conjunction with streamlined approvals are needed in order to support this new supply.

The Green Energy Act

The passage of the GEA this spring and its related investments and regulations will accelerate the development of renewable energy in Ontario and drive the expansion of transmission and distribution systems. It will do this in a number of ways:

Financial incentives: The introduction of stable prices through long-term contracts (Feed-in Tariffs) for renewable generation will assist proponents in securing financing and getting projects off the ground.

Broad participation in energy generation: The GEA actively targets renewable projects developed by homeowners, farmers, schools, and other groups through its microFIT program. Regulations have also been changed to allow municipalities and local distribution companies to own and operate renewable projects less than 10 MW.

Streamlined processes: The Renewable Energy Facilitation Office has been established to assist developers in navigating project requirements.

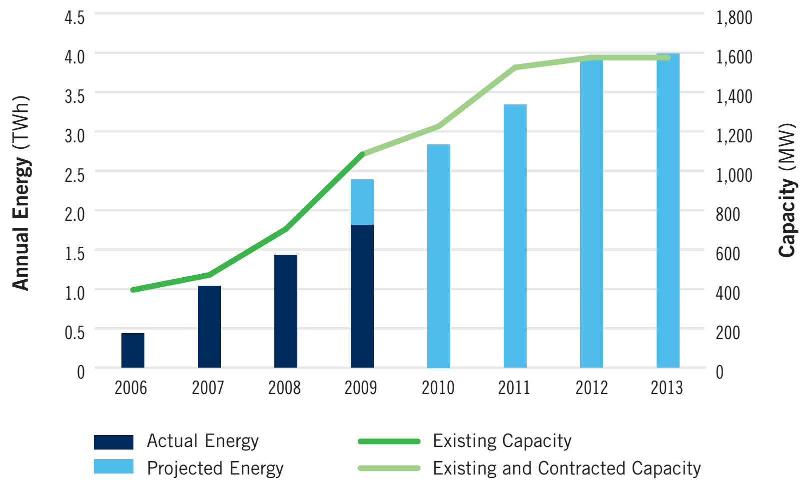
Modernizing electricity infrastructure for the digital age: Transmitters and distributors are now required to submit smart grid plans as part of their regulatory approvals processes – providing impetus and discipline for the coordinated development of smart grid infrastructure.

ONTARIO WIND ENERGY CAPACITY AND OUTPUT 2006-2013

While Ontario's wind output capacity has increased steadily over the last number of years, the need to manage the variability of this energy resource has also grown. While the highest hourly output for 2009 was 989 MW on October 31, the lowest was just 1 MW on August 13. Ontario wind output data is updated hourly on the IESO website at www.ieso.ca/windtracker

NOTES:

- Chart does not include wind capacity embedded in distribution systems (currently 68 MW)
- Actual data as of October 31, 2009



As a result, a new vision for the provincial electricity system has emerged – one that is largely clean and more interactive. Here are some achievements from the last few years:

Wind Ramps Up

Ontario continues to make great strides in developing a robust wind energy sector. There is currently almost 1,100 MW of wind capacity connected to the IESO-controlled grid, with another 492 MW anticipated over the next three years as projects under OPA Renewable Energy Supply 3 contracts come into service.

Wind capacity in this province will increase significantly with the recent announcement of the OPA's first wave of applications to its Feed-in Tariff (FIT) program. Being "open" in nature, without fixed targets or ceilings, the FIT program sets a new standard for renewable energy procurement in North America. These applications – initially totalling 8,000 MW in potential new renewable capacity – will be reviewed by the OPA, with the support of LDCs and where necessary, the IESO, to determine each project's readiness to move forward and to conduct the related transmission and distribution assessments. With roughly 2,500 MW of new transmission capacity presently available, only some of those projects that are the most viable and "shovel-ready" will initially move forward. Ontario is undertaking an ambitious program of expansion and renewal of the province's transmission facilities to accommodate the remaining projects.

To support the increasing amounts of wind capacity, new wind integration methodologies were implemented for planning and outage approvals which have allowed the IESO to take advantage of wind's stronger performance in the winter and shoulder periods. Capacity factors this spring were encouraging, with the year's highest monthly average of 41 per cent taking place in April, contributing to total wind energy production of 2.24 TWh from November 2008 to October 2009.

This April, the North American Electric Reliability Corporation (NERC), the organization responsible for ensuring the reliability of the North American grid, recognized the IESO for its processes and practices in support of wind. These efforts include its connection assessment and approval processes, on-site testing of wind plant performance, wind forecasting methodology as well as its communications efforts to the broader public about wind energy issues.

The IESO's future centralized wind forecasting service will also support the growing penetration of wind energy in the province. By improving forecast accuracy and consistency, this service will allow IESO system operators to better understand when they can expect greater (or lower) levels of wind generation and manage all other resources accordingly.

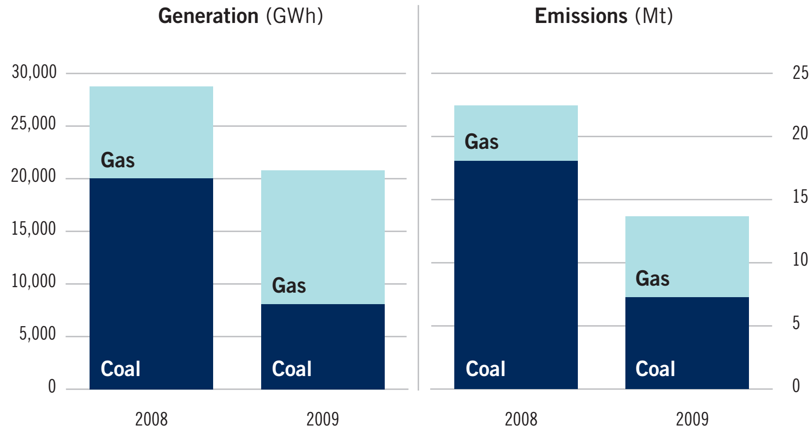
Natural Gas Performance

Twenty-four hundred megawatts of new natural gas resources are currently in development, adding to the 4,700 MW of gas-fired generation that has already been integrated into the supply mix since 2003. Halton Hills (632 MW), York Energy Centre (393 MW), Thorold Cogeneration Project (236 MW), the Greenfield South project (280 MW) in Mississauga and a 900 MW project in Oakville are expected to become operational within the next five years.

COAL LIMITATIONS AND GREENHOUSE GAS EMISSIONS (ESTIMATED)

2008 JAN–OCT VS. 2009 JAN–OCT

From the beginning of April until the end of October of this year, there were 673 hours (almost one month) when no coal-fired generation was required on the system. As a result, the province is expected to be well within this year's coal emissions target limit of 19.6 megatonnes (Mt).



The province's new gas-fired generation facilities have met IESO expectations in terms of operational performance. Over the last few years, both generators and system operators have learned a significant amount about the operational characteristics of gas-fired generation. This understanding will continue to grow as gas-fired generation becomes more established and facilitates the replacement of coal-fired generation in the province. By the end of next year, all of Ontario's new gas supply will have been in service for at least two peak operating seasons – an important milestone as these generators will have addressed initial start-up issues and a longer-term assessment about their operational performance can be made.

The value of Ontario's gas generation capability is demonstrated by the successful implementation of government-directed limits on coal emissions which took effect this year. Ontario Power Generation's (OPG) coal reduction strategy – which includes unit shutdowns for set periods – has resulted in lower output from coal plants and lower greenhouse gas emissions. Given favourable system conditions, the IESO has not needed to recall any of these units for reliability reasons. As a result, greenhouse gas emissions from Ontario's electricity sector are almost half what they were last year.

As outlined in previous Outlooks, the task of phasing out coal-fired generation by the end of 2014 is considerable, but moving forward. Four coal units – two at Nanticoke and two at Lambton, with a combined capacity of 1,950 MW – are slated to close in late 2010. Hydro One is adding seven shunt capacitors to the grid this year, with two static VAr compensators to be added by 2011 in order to compensate for the corresponding loss of voltage support from these units.

Earlier this year, OPG announced it was assessing the business case for the conversion of some of its remaining coal units to biomass, with a target for the first conversion to take place at the Atikokan Generating Station in 2012. Careful management of the off-coal schedule in the Northwest will be required at this facility, as well as the Thunder Bay plant as both facilities represent a significant portion of installed capacity in the area.

The Transmission Challenge

Renewing the province's supply mix is only part of the equation. The transmission infrastructure is similarly evolving to accommodate new and expanded forms of supply that can't be delivered using existing circuits.

Over the last few years, significant progress has been made in addressing a number of transmission and congestion concerns:

- Overloading in northern York Region is well on its way to being resolved with the completion of Holland TS and the announcement of the York Energy Centre in King Township scheduled to be in service in 2011.

- Proposed reinforcements along the north-south transmission corridor from Sudbury to Barrie (adding station equipment at Nobel SS, Porcupine TS and Kirkland Lake TS and making use of generation rejection) will increase transmission capability from 1,300 MW to 2,150 MW in 2010. These enhancements will also eliminate restrictions on existing generation and accommodate expanded generation along the Mattagami River.
- Reliability in the Greater Toronto Area (GTA) is improving significantly as a result of several new projects that are either in operation or coming into service in the next few years. These include the Sithe Goreway and Portlands generating facilities, the refurbishment of the Claireville TS, the expected completion of the Halton Hills generation facility in 2010 and a new 900 MW gas-fired facility in Oakville. All these projects will relieve the otherwise overtaxed electricity delivery system in the GTA.
- Ontario's intertie capacity has increased by 1,250 MW following the recent commissioning of a new interconnection with Quebec near Ottawa.

These achievements, for the most part, address current and intermediate concerns, but will not be sufficient to either accommodate greater levels of renewable generation or meet future needs throughout the nuclear refurbishment/replacement program.

RENEWING ONTARIO'S NUCLEAR BASELOAD CAPACITY

Ontario's nuclear fleet provides reliable, emission-free baseload generation to the province, with approximately 11,500 MW of operating capacity. While nuclear generation in Ontario is generally considered to be non-manoeuvrable, some units can provide limited levels of manoeuvrability during Surplus Baseload Generation (SBG) conditions. Bruce Power has been particularly responsive in providing manoeuvrability in these circumstances.

In the last few years, two Pickering units and two Bruce units have been restarted and placed back in service. None of the remaining units have been refurbished and all will reach their end of service life within 10 years. Discussions are underway to ensure that decisions surrounding nuclear new build, refurbishments and life-extension strategies are made on a timely basis. Projects of this magnitude have very long planning and development lead times, requiring thoughtful coordination to manage the required specialized equipment and skilled personnel to undertake the projects as well as manage the impacts of outages on the system.

The OPA has begun the process of determining the province's nuclear renewal program – by looking at the province's needs in the year 2015 and beyond and the required schedule and sequence to take old units offline and bring new or refurbished ones into service.

Here is an overview of the status of Ontario's nuclear generating units:

Bruce Generating Station: The refurbished Bruce A Units 1 and 2 are expected to be placed back in commercial service after refurbishment by 2011. The remaining Bruce A and B units are currently operating and will reach their end of service life toward the end of the next decade.

Darlington Generating Station: The competitive process to build new nuclear units at Darlington was suspended by the Ontario government in June 2009. In 2008, three of the existing Darlington units comprised the top performing CANDU units in the world.

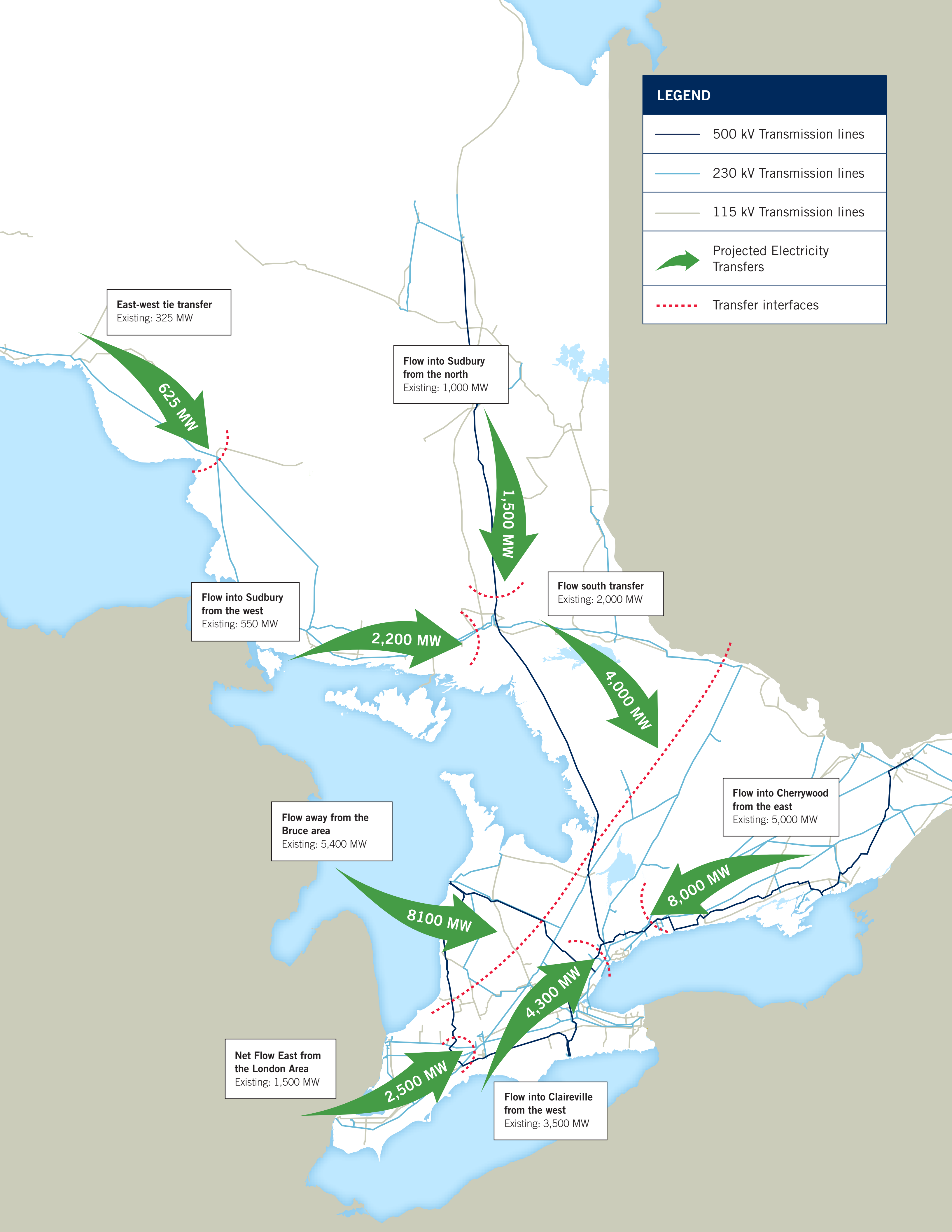
Pickering Generating Station: While two units at Pickering A were restarted and another two retired, the four Pickering B units will reach their end of service life within the next decade. The IESO has identified transmission requirements in the area regardless of whether these units continue to operate or are shut down.

PROJECTED ELECTRICITY TRANSFERS TO BE ACCOMMODATED BY TRANSMISSION EXPANSION PROGRAM

TRANSMISSION HIGHLIGHTS

Here are some key transmission projects essential to Ontario's future reliability needs.

Cambridge and surrounding area	A solution is urgently required in this area as existing transmission infrastructure is unable to meet the IESO's criteria to restore power in the case of a contingency. Depending on future load growth in the Cambridge area, the amount of load interrupted in response to the loss of both 230kV circuits could violate IESO criteria for load supply security within five years. The installation of new transmission capacity would address immediate concerns and would establish the infrastructure needed for the future. Local generation is an alternative that would also address the immediate concerns in the Cambridge area.
Guelph	With existing transmission facilities in the Guelph area operating at close to capacity, there is limited capability available to supply additional load. Without remedial action, loading on some circuits is expected to exceed IESO standards in five years. Hydro One is proposing reinforcements at one or possibly two local transformer stations.
Bruce to Milton	Delays in regulatory approvals could push this important project beyond its target in service date of winter 2011/12. This new 500 kV double circuit line between the Bruce Nuclear Complex and Milton SS will help transfer production from the Bruce facility, 500 MW of existing renewable generators and an additional 1,200 MW of expected renewable resources. Bruce Power expects to return units 1 and 2 to service by mid-to-late 2011.
Milton to Greater Toronto Area	The expanded output from the Bruce and Southwest areas flowing toward the GTA would exceed the 4,000 MW capability of the existing four 500 kV circuits from Milton SS to Claireville TS (in the Northwest GTA), by as much as 500 MW. Plans to redirect some of this transfer, for example, through autotransformers at Milton SS would help alleviate the congestion.
Ontario-New York Ties at Niagara	Import capability through the Niagara intertie (or Queenston Flow West [QFW] Interface) is often limited by Lake Erie Circulation – flows of power that take alternate or parallel paths than those scheduled by system operators. Phase Angle Regulators at the Michigan interface are expected to be operational by spring 2010, allowing for greater control of the QFW Interface. Until there is a resolution of the dispute near Caledonia, the completion of a new 230 kV double circuit line between Allenburg TS near Niagara Falls and Middleport TS south of Hamilton, which would increase the transfer capability of this interface, is on hold.
Oshawa and surrounding area	Future load growth in the eastern GTA, including the Oshawa, Whitby and Ajax areas, will eventually lead to overloading of the auto-transformers at Cherrywood TS. The construction of a new transformer station, east of Oshawa, would relieve the loading at Cherrywood TS and enhance the reliability of supply to the area.



LEGEND
500 kV Transmission lines
230 kV Transmission lines
115 kV Transmission lines
Projected Electricity Transfers
Transfer interfaces
East-west tie transfer
Existing: 325 MW
625 MW
Flow into Sudbury from the north
Existing: 1,000 MW
1,500 MW
Flow into Sudbury from the west
Existing: 550 MW
2,200 MW
Flow south transfer
Existing: 2,000 MW
4,000 MW
Flow into Cherrywood from the east
Existing: 5,000 MW
8,000 MW
Flow away from the Bruce area
Existing: 5,400 MW
8100 MW
4,300 MW
Net Flow East from the London Area
Existing: 1,500 MW
2,500 MW
Flow into Claireville from the west
Existing: 3,500 MW

Delivering the Wind

Keeping pace with the development of new renewable projects is particularly challenging as transmission projects typically take longer to plan, obtain approvals for and build than the generation projects they support.

Hydro One has embarked on an investment plan for 20 major transmission projects and other station work as well as distribution projects to reinforce and expand infrastructure to transfer anticipated renewable supplies to load centres. Included in this program are "enabler lines" – transmission capacity built to connect renewable projects in these areas.

Given the relatively short time frames required for most renewable projects, streamlined approvals and regulatory requirements for the related transmission capabilities are critical. These processes, however, present the greatest risk to new transmission projects being built on time. Undue delays in property acquisitions, regulatory and environmental approvals could significantly impede the development of new renewable generation – and potentially impact costs. Appropriate reviews for transmission projects need to take place in a timely fashion to ensure that delivery infrastructure established to support renewable generation is in service when it's needed.

ONTARIO'S CHANGING DEMAND PROFILE

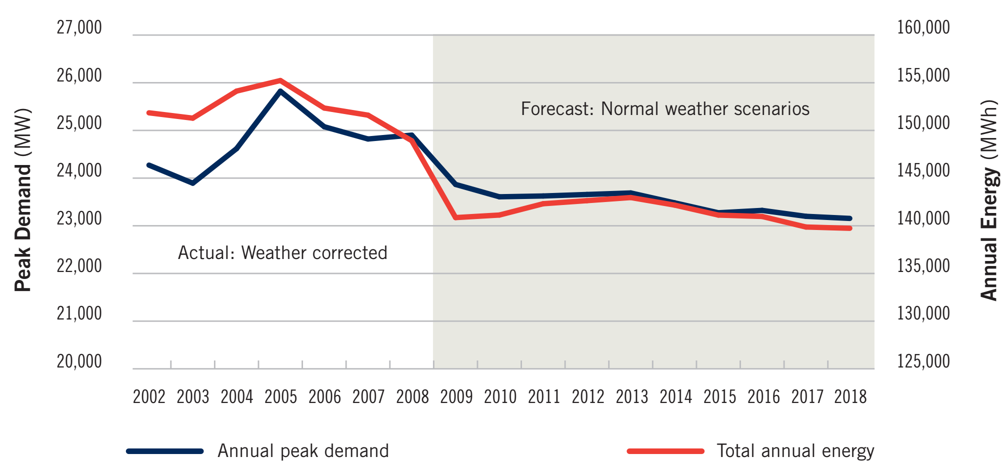
The way Ontarians use electricity – in their homes and at work – is changing and this is reflected in Ontario's demand forecasts.

Overall energy demand has been declining as a result of conservation and the economic slowdown. Ontario's energy-intensive export industries have reduced production since 2004 with the rise of the Canadian dollar. In the past year, demand then dropped sharply as a result of the global recession. As of November 2009, weather-corrected energy demand was 6.4 per cent lower than last year.

Peak demands have also recently been declining due to conservation efforts and the current economic situation. Moving forward, peak demands will continue to face downward pressure as a result of conservation and the implementation of Time-of-Use rates. Energy demand will get a boost from the economic recovery, but ongoing structural change in the Ontario economy will likely see future growth in less energy-intensive sectors. And, as more communities produce electricity to meet their own needs, this will shift demand off the provincial electricity grid.

PEAK AND ENERGY DEMANDS – HISTORIC AND FORECAST

Source: Independent Electricity System Operator, Ontario Power Authority



Plug-in hybrid electric vehicles will initially be integrated into the electricity system as a load but also have the potential to provide storage capabilities.

Veridian Corporation provides electricity to over 111,000 customers in Durham Region, Belleville and two other communities. It operates a demonstration plug-in hybrid solar electric vehicle – the first of its kind in Canada.

OPERABILITY AND INTEGRATION

As new forms of supply emerge and new patterns of demand develop, approaches to managing system issues are evolving. Tools and processes are being developed to weave all these diverse elements together effectively and efficiently. The IESO has identified five priority areas for the industry to move forward on, all of which provide more flexibility in managing an increasingly variable supply mix:

- Dispatchability of variable resources
- Visibility of distributed generation
- Flexibility through energy storage
- Active consumer response
- More meaningful price signals

Dispatchability of Variable Resources

In stark contrast to the concerns of just a few years ago created by high demand and low supply, Ontario is now experiencing significant levels of oversupply and low demand. Surplus Baseload Generation (SBG) occurs when demand is exceeded by the energy output from generators that can't readily adjust their output, whether it is for technical or contractual reasons.

A weak economy combined with conservation efforts and mild weather have resulted in unusually low overnight and weekend demand, creating ongoing SBG conditions. For the most part, excess generation is handled through exports. This spring, however, Ontario started to experience SBG on a weekly basis, resulting in nuclear unit reductions on 54 days, nuclear shutdowns on five days and water spillage at hydro facilities on 33 days. These actions impose additional costs on generators, increase wear and tear on equipment and result in an inefficient approach to managing the power system.

Even though the IESO now publishes daily SBG forecasts to help generators plan around SBG conditions, more significant steps are needed. As the amount of renewable generation

SOLAR ENERGY AND PEAK DEMAND

Solar-powered generation is emerging in Ontario as a new energy resource. Currently, solar capacity in Ontario is in its very nascent stages, but is expected to grow significantly within distribution systems under the FIT and microFIT programs.

Solar photo-voltaic (PV) outputs are less persistent than wind – meaning they can change output significantly within minutes or even seconds. For every kW of capacity, a solar PV can be expected to provide about 3 kWh of energy a day. And while this capacity/output ratio is far below dispatchable forms of generation, solar energy can reach almost full capacity on hot sunny days when demand is at its highest – providing a potentially valuable component to the system operator's tool kit.

Credit: ARISE Technologies

continues to grow, the amount of non-dispatchable (or non-manoeuvrable) generation will also increase, reducing flexibility in the system even further.

The IESO and its partners have been working to more effectively manage SBG conditions when output from wind and other renewables is high. Centralized wind forecasting, as an example, will provide a more accurate picture of just how much energy will be produced, allowing the IESO to more effectively manage other resources during potential SBG conditions.

As Ontario will continue to experience SBG in the coming years, it will be important to maximize flexibility in the system. Wind contracts, for example, are structured to provide financial incentives to encourage wind generators to curtail production if the system is approaching SBG conditions. Similar approaches are also required for generators operating under Non-Utility Generation (NUG) contracts, as well as for those nuclear facilities that can provide various levels of flexibility.

Making it Visible: Distributed Generation

Whether it's residential solar PVs or 10 MW wind farms within city or county boundaries, much of the new renewable generation will be connected to local distribution systems rather than the IESO-controlled grid. The anticipated growth in local generation will be fuelled by the GEA provisions which allow municipalities, local distribution companies and community groups to own and operate generation facilities.

By serving local needs, distributed (or embedded) generation reduces the amount of supply communities need from the bulk electricity system, while they continue to rely on it when additional supply is needed. As more activity takes place on a local level, the IESO needs to adjust its approaches accordingly. As system operator, it will need to know how much demand is being met by local resources to ensure that it doesn't call on additional supply unnecessarily. As a result, the need to create more "visibility" of generation output within LDC service areas has intensified.

Industry stakeholders are working together to create new processes such as direct telemetry, reporting procedures and trend analyses to create visibility. This information would be used to develop accurate forecasts, output information, and when necessary, dispatches for distributed generation.

Flexibility through Energy Storage

Bulk electricity systems were generally built on the fundamental premise that the commodity is consumed as soon as it is produced. While many jurisdictions have large pumped storage generators that pump water uphill overnight to generate electricity the next day, widespread distributed electricity storage hasn't until recently been a feasible option.

With the advent of new technologies, system operators around the world are anticipating storage options that provide increased dispatch flexibility within a supply mix that is becoming increasingly less flexible. Storage technologies are a highly reliable and versatile resource that can store energy during low demand periods for use when it's needed most. They can also provide a number of different reliability services such as operating reserve, frequency regulation and blackstart capability.

System operators and regulators alike are contemplating how to integrate new storage technologies into the system: how to dispatch them, who should own them and how to pay for them; whether storage facilities should pay the same uplifts and tariffs as other loads when they withdraw energy from the grid; and then whether they should receive the same payments as other producers when they inject it.

Ontario currently lags other jurisdictions in testing and deploying new storage technologies. While most storage is currently expensive to build and its value proposition remains uncertain, many in the industry expect improvements in technology to result in storage becoming a cost-effective means of reliably incorporating large volumes of renewables. Storage may not offer the only option to address a number of reliability needs – it could comprise an important part of the evolving approach to system management.

Active Consumer Response

Demand response also has the potential to provide system operators with a flexible and cost-effective system management tool. While Ontario has made gains in this area, it remains vastly underdeveloped as a resource. Load control, as it is sometimes called, adjusts the way electricity is consumed in response to system conditions.

A much closer interplay needs to develop between the dynamics of supply and the desire by consumers to adjust their energy use. Consumers should be able to become active contributors to the system, whether it is through formal demand response programs where they agree to be dispatched to reduce consumption, or through adjusting their daily energy use in response to prices or other factors such as the availability of renewable energy.

Bringing the Consumer into the Picture

At present, consumers are not properly equipped to be more active energy users. Tools and systems are emerging to communicate with the consumer, enable them to respond according to their own preferences, and then capture that information for distributors and system operators. This is where smart grids – and smart meters – come in.

Smart grid technologies have the potential to provide LDCs with instantaneous, granular information about generation and consumption activity within their service systems. These technologies can also enable consumers to control and automate their energy use patterns in response to prices.

Earlier this year, the Ontario Smart Grid Forum – convened by the IESO – released a report highlighting the need for a coordinated and cost-effective approach to the development of the provincial smart grid. The GEA responded by requiring LDCs to prepare smart grid plans for review by the Ontario Energy Board. By incorporating smart grids within LDC business planning processes with regulatory oversight, Ontario has begun the coordinated development of smart grid capabilities.

Yet the pace of change is swift: international protocols and standards are being established; distributors are being called on to incorporate increasing levels of embedded generation; and new technologies are emerging for consumers. Moving forward to effectively capture the economic advantages and the system benefits of smart grids will continue to challenge the entire industry.

A Smart Meter in Every Home

Few jurisdictions have made as much progress in implementing smart metering and variable pricing as the province of Ontario. By the third quarter of 2009, more than three million smart meters were installed, with the majority of consumers to be switched to Time-of-Use rates by spring 2011. The province's meter data management repository, the MDM/R, is actively integrating smart meters and processing billing quality totals for LDC customer bills. And by the first quarter of next year, utilities representing approximately one million consumers will be billing either a portion or all of their customers using TOU rates.

Smart meters are, however, just the first step. While they track information on an hourly basis in order to enable variable pricing, there are a range of new technologies – such as smart appliances and home energy management systems – that will allow consumers to automate their energy use patterns. These applications are largely in the developmental stage, with pilot programs in homes and communities testing what approaches work best.

Meaningful Price Signals

Most consumers indicate that price will be their main motivation to use new energy management technologies. This means that meaningful price signals and rate designs will become central in enabling consumers to actively contribute to maintaining reliability. As more consumers are empowered to take advantage of variable rates, it becomes increasingly critical for the wholesale price to be reflective of current demand and supply conditions.

Ontario's wholesale market provides the foundation for electricity pricing in the province – whether directly as the hourly price for large business and institutional customers or through Time-of-Use rates for residential and small business customers. These prices signal to consumers the best times to consume and to generators the best times to produce, creating a more efficient use of electricity infrastructure.

On the supply side, the challenge has been to procure new capacity in ways that preserve incentives to respond to market dynamics, even while under contract or regulation. Effective real-time prices reflect the marginal cost of the last megawatt used to balance supply and demand. This price signal sends the message to generators that they should only run if they can produce energy more cheaply than the next alternative resource. The sector is working to ensure that most generators will factor the market price into their production decisions and respond appropriately to system conditions.

Price is another important driver of efficiency on the demand side. The hybrid market incorporates a Global Adjustment which accounts for the difference between the wholesale price and costs for contracted and regulated generation and conservation programs. This method of centralized procurement has been successful in ensuring that both the province's capacity and environmental targets are met.

Low market prices in 2009, primarily a result of diminished demand and generally lower fossil-fuel prices, have resulted in higher adjustment charges to compensate for lower market revenues. The Global Adjustment, currently applied equally across all hours each month, can undermine the effectiveness of the market price signal observed by consumers. This can result in a convergence of on-peak and off-peak prices, distorting price signals and resulting in inefficient consumption decisions – potentially too little consumption during off-peak periods and too much consumption during on-peak periods. Efforts are underway to improve the application of the Global Adjustment to reinforce market signals.

MOVEABLE LOAD: ELECTRIC CARS

The prospect of replacing many of the province's carbon-fueled cars and trucks with electric hybrid models holds great promise for making the province's overall energy use cleaner. Integrating electric vehicles in the power grid offers a number of potential benefits beyond reduced carbon emissions.

Balancing renewables: Plug-in hybrid electric vehicles (PHEVs) can help address SBG conditions if owners charge them up when output from renewables is high.

Efficiency: By drawing from the electricity grid during off-peak hours, PHEVs ensure a more efficient use of the electricity infrastructure.

Storage: PHEVs could be used to provide load following and regulation services to the system. Alternately, homeowners could use energy stored in their car batteries to offset their own energy use during peak hours.

The challenge for system planners is to anticipate the impact electric cars will have on the system and ensure that they are integrated in a way that supports reliability. For example, if motorists charge up at a "slow-charge" rate of 1.5 kWh overnight, this load would make use of the system during low demand periods. If, however, significant numbers of car owners charge up at the "fast-charge" rate of 7 kWh during the afternoon peak, those cumulative extra megawatts could require additional capability on the system. Just 100,000 vehicles charging up at the same time would require the equivalent of a generating plant the size of the new Sithe Goreway facility.

Ontario's TOU pricing regime will be an important factor in the successful implementation of electric cars in the province, as it provides a ready-made incentive for consumers to charge up during off-peak hours. It also paves the way for more sophisticated price offerings for motorists – including incentives to inject energy into the system when it is under strain.

The supporting infrastructure for electric vehicles – charging stations, home charging units and the distribution systems – will also be an important consideration. Smart grid capabilities become essential in this regard. As electric cars move through a distribution service area (and beyond), LDCs will require advanced monitoring and automated controls to manage their distribution networks reliably.

Owners of plug-in hybrid electric vehicles can take advantage of lower electricity prices by charging at night to use in the morning, or sell the electricity back into the grid to take advantage of higher daytime peak prices.

Photo taken at the Kortright Centre for Conservation.

The new Ontario-Quebec interconnection near Ottawa has a transfer capability of 1,250 MW.

RELIABILITY IN THE NORTH AMERICAN CONTEXT

Ontario's interties with neighbouring jurisdictions strengthen reliability. As levels of renewable generation increase in almost all jurisdictions across North America, Ontario and its neighbours need to leverage their interties further to provide an added level of flexibility and efficiency to system management.

In the United States, approximately $16.8 billion has been allocated to the development of new renewable resources, conservation and transmission infrastructure as part of the current administration's stimulus package. The sheer size and scope of this influx of new capital accelerates the need for system operators to develop new strategies to manage this growth.

For decades, Ontario's export and import capability has been an important factor in providing reliability. Ontario's current intertie capacity of 5,200 MW provides greater diversity to the existing system. Different geographies, time zones, supply mixes and outage scheduling needs result in different demand profiles and available capacity from jurisdiction to jurisdiction. All these differences provide system operators with access to additional resources when supplies are tight and to broader markets to absorb excess supply.

This regional advantage is prompting system operators to collaborate on a number of fronts – including looking for ways to develop consistent approaches to integrating wind. The IESO has been working with the Canadian Wind Energy Association (CanWEA) on a pan-Canadian study to address the technical, operational and market implications of increased levels of renewable penetration in electricity systems across the country. A better understanding of these issues will be needed in order to facilitate targets of increased wind penetration by 2025.

The IESO is also a member of the Eastern Interconnection Planning Collaborative (EIPC) which proposes to perform interconnection-wide transmission analyses for the U.S. Department of Energy. One of the limits to Ontario's export capabilities has been congestion within neighbouring jurisdictions, restricting the amount of electricity that can be delivered to load centres. EIPC's work would aggregate regional transmission plans to determine how to expand transmission infrastructure to accommodate renewables and open paths across regional networks to facilitate the flows of electricity.

In addition to coordinated regional transmission plans, wider-area balancing management or balancing area consolidation offers promise. As increasing levels of variable generation come into service, system operators may not have enough flexible generation within their own balancing areas to ramp down when wind output is increasing or vice versa.

Already, interties play an important role in addressing SBG, with neighbouring markets taking in excess energy. Greater levels of wind resources, will drive system operators to want increased access to ramping and ancillary services from neighbouring jurisdictions to make up for changes in wind output.

Wider-area balancing can also provide a bird's eye view of system activity across a region – valuable information that operators can use to more efficiently manage their own systems. If second-to-second electricity production is slightly under requirements, the operator may not need to take immediate action to secure additional supply if it knows that levels are running a little high in a neighbouring jurisdiction. Initiatives to take advantage of these sorts of flexibilities are already being explored by Ontario and other jurisdictions.

A recent North American Electric Reliability Corporation (NERC) report *Accommodating High Levels of Variable Generation* contains a series of recommendations for the development of standards and operational processes needed to achieve this collaboration. Operators will require new and consistent tools and practices to maintain bulk power system reliability in this new environment. For example:

- Wind and solar forecasting techniques must be incorporated into day-to-day operational planning.
- Power system planners must consider impacts of variable generation and methods to maintain long-term system reliability.
- System operators must develop sufficient communication protocols with each other for monitoring and sending dispatch instructions to variable resources.
- Further study is needed to understand the impact of ancillary services through wider-area balancing management.

An active member of the NERC's Integration of Variable Generation Task Force (IVGTF), the IESO has been working with stakeholders in the province on a number of issues highlighted in the NERC report. For example, centralized wind forecasting will contribute to a more complete and timely view of wind events across central and eastern North America.

The IESO is also contemplating ways to adapt trading structures to facilitate renewable energy. If imports and exports could be scheduled on a more frequent basis – every 10 or 15 minutes instead of every hour – then system operators could also access additional ramping capabilities from adjacent markets to support increased levels of variable capacity.

The current phase of the IVGTF's work is evaluating existing standards and processes to determine what gaps exist and how to address them, as well as what new issues will have to be resolved in order to implement the operational and planning recommendations from the report. The IESO is involved in key activities of this initiative as well as other continent-wide forums working to accelerate efforts to reliably and effectively integrate renewables.

TABLE 1: GENERATION PROJECTS PLANNED OR UNDERWAY IN ONTARIO

SOURCE OF PROJECT	GENERATION PROJECTS PLANNED OR UNDERWAY	INSTALLED CAPACITY (MW)	PLANNED IN-SERVICE DATES
RENEWABLE GENERATION			
Renewables II RFP - Hydroelectric generation	Island Falls Hydroelectric Project	16	Q4 2010
Renewables III RFP - Wind generation	Byran Wind Project	65	Q4 2010
	Greenwich Wind Farm	99	Q4 2011
	Gosfield Wind Project	50	Q4 2012
	Kruger Energy Chatham Wind Project	101	Q4 2011
	Raleigh Wind Energy Centre	78	Q3 2010
	Talbot Windfarm	99	Q4 2011
Government directive for Hydroelectric Energy Supply Agreement with Ontario Power Generation	Healey Falls	16	Q3 2010
	Little Long, Harmon, Kipling and Smoky Falls	450	Unit in-service dates ranging from 2014 to 2015
	Hound Chute	10	Q4 2010
	Lower Sturgeon, Sandy Falls and Wawaitin	35	Q4 2010
GAS-FIRED GENERATION			
Clean Energy Supply RFP	Greenfield South Power Plant	280	Q3 2012
GTA West RFP	Halton Hills Generating Station	632	Q3 2010
Government directive for Northern York Region	York Energy Centre	393	Q4 2011
Government directive for Southwest	Oakville Generating Station	900	Q1 2014
COMBINED HEAT AND POWER (CHP)			
CHP RFP	Thorold Cogeneration Project	236	Q2 2010
CHP III RFP - Biomass generation	Becker Cogeneration	15	Q3 2011
NUCLEAR GENERATION			
Government directive for Bruce Power Refurbishment Implementation Agreement	Bruce A, Unit 1 back in service after refurbishment	750	Q4 2011
	Bruce A, Unit 2 back in service after refurbishment	750	Q2 2011
Upgrade to existing generator	Darlington, additional capacity	27	Q1 2010

TABLE 2: REGIONAL REQUIREMENTS – PROJECTS CURRENTLY UNDER STUDY OR PROPOSED

This table lists the projects that Hydro One is actively pursuing. Some of these projects have already been committed and are planned to be in-service within the next two to three years. Others are in the design phase and are expected to be placed in-service in the following decade.

AREA	RELIABILITY NEEDS IN THE AREA	EXPECTED/ REQUIRED BY	PROJECT(S) PROPOSED TO MEET THE REQUIREMENT
Northeast & Central Ontario	Improve operational flexibility	Winter-2009/10	Pinard TS: Install 230kV circuit-switchers
	Increase supply capability	Summer-2011	Bracebridge TS: Install second 83MVA transformer
	Increase transfer capability across the Flow-South Interface	Winter-2010/11	Porcupine TS: Install 2x125MVAr shunt capacitors
		Winter-2010/11	Porcupine TS: Install SVC
		Winter-2010/11	Kirkland Lake TS: Install SVC
		Winter-2010/11	Essa TS: Install 250MVAr shunt capacitor
		Winter-2010/11	Nobel SS: Install series capacitors in 500kV circuits
		Winter-2011/12	Hanmer TS: Install 149MVAr shunt capacitor
	Incorporate expanded facilities at the Mattagami River plants	Winter-2010/11	Pinard TS: Install two 30MVAr LV shunt capacitor
		Winter-2010/11	Harmon GS to Kipling GS: Modify 230kV transmission line
	Incorporate new, renewable generating capacity	Winter-2014/15	Manitoulin Island: Install new 230kV enabler line
		Winter 2014/15	Algoma/Sault Ste Marie area to Sudbury: Establish new 500kV connections
		Winter-2015/16	Sudbury to the GTA: Reinforce 500kV transmission system
		Winter 2015/16	North Bay Area: Install new 230kV enabler line
		Winter 2015/16	Parry Sound Area: Install new 230kV enabler line
		Winter 2017/18	Area north of Sudbury: Reinforce 500kV transmission system
Northwestern Ontario	Provide voltage support	Spring-2010	Fort Frances TS: Install 22MVAr moveable shunt capacitor
		Winter-2010/11	Dryden TS: Install shunt capacitor
	Increase supply capability	Summer-2011	Long Lac TS: Replace end-of-life transformers with two 42MVA units
	Replacement for the C7 synchronous condenser	Winter-2010/11	Lakehead TS: Install a +60/ 40MVAr SVC
	Incorporate new, renewable generating capacity	Fall-2013	Lake Nipigon Area: Install new 230kV line between Nipigon SS & Crow River DS
		Winter 2015/16	Lake Nipigon Area to Wawa SS: Install new 230kV line to reinforce East-West Tie
		Winter 2015/16	Thunder Bay Area: Install new 230 kV enabler line
Bruce Area	Increase transfer capability from the Bruce Area to accommodate a further 1,200MW of new generating capacity	Spring-2010	Bruce Complex: Modify Bruce Special Protection System
		Fall-2011	Nanticoke TS: Install 500kV 350MVAr SVC
		Fall-2011	Detweiler TS: Install 230kV 350MVAr SVC
		Winter-2011/12	Bruce Complex to Milton TS: Install new 500kV double-circuit line
		Winter-2009	Middleport TS, Nanticoke TS & Buchanan TS: Install 7 capacitor banks
	Incorporate new, renewable generating capacity	Winter-2013/14	Goderich Area: Install new 230kV enabler line
Eastern Ontario	Increase transfer capability between Ontario & Quebec	Fall-2012	Hawthorne TS to Merivale TS: Increase capacity of 230kV circuits M30A & M31A
	Increase supply capability to the area	Summer-2012	Ottawa South Area: Reinforce transmission facilities
	Incorporate new, renewable generating capacity	Winter-2014/15	Chenaux to Arnprior Area: Reinforce transmission facilities
		Winter-2014/15	Belleville to Napanee: Reinforce transmission facilities
		Winter-2014/15	Pembroke Area: Install new 230kV enabler line
		Winter-2015/16	Ottawa to Cornwall area: Install new 230kV enabler line

TABLE 2: CONTINUED

GTA-West	Increase supply capability to the area	Summer-2010	Goreway TS: Establish second DESN
		Fall-2010	Churchill Meadows TS: Establish new TS in northwest Mississauga
		Summer-2012	New TS: Establish new TS in northern Mississauga
	Enhance the supply capability to Pleasant TS and Jim Yarrow TS and limit amount of load lost to individual contingencies	Spring-2010	Hurontario SS: Establish new SS & extend 230kV line from Cardiff TS
		Spring 2011	Hurontario SS to Jim Yarrow Jct: Build two 3km 230kV circuits
	Increase supply capability of the corridor and reduce transfers on the 500kV circuits to Claireville TS	Spring-2015	Milton SS: Install 500/230kV auto-transformers & construct new 230kV lines to Hurontario SS to create a new 230kV transmission corridor between Milton SS & Claireville TS.
GTA-Central	Increase transfer capability of transmission corridor	Winter-2010/11	Cherrywood TS to Claireville TS: Unbundle the two 500kV super-circuits
		Spring-2012	Leaside TS to Birch Jct: Build new 115kV circuit. Birch Jct to Bayfield Jct: Replace 115kV cables
	Increase capability to incorporate new generation	Winter-2012/13	Upgrade short-circuit capability of Hearn TS, Manby TS & Leaside TS
	Improve supply reliability	Summer-2016	Reinforce transmission facilities into downtown Toronto
GTA-East	Increase supply capability	Summer-2011	Enfield TS: Establish new TS in the Oshawa/Clarington area
	Increase transfer capability of transmission corridor	Winter-2016/17	Bowmanville TS to GTA: Reinforce the 500kV transmission facilities
	Reinforce supply to the Oshawa/ Whitby/Ajax areas	Summer-2016	Oshawa Area: Build new 500/230kV transformer station
Niagara Area	Increase transfer capability of the Queenston Flow West Interface	Originally scheduled for Summer-2006. Delayed indefinitely	New 230kV double-circuit line between Allanburg TS to Middleport TS to reinforce the 230kV transmission corridor
	Increase supply capability to the area	Spring-2010	St Catharines Area: Uprate circuits D9HS, D10S & Q11S
	Increase supply capability	Summer-2010	Vansickle TS: Replace two 33MVA transformers with 75MVA units
		Fall-2013	Dunville TS: Replace two 18.7MVA transformers with 41MVA units
		Summer-2014	Crowland TS: Establish second DESN
		Fall-2013	Glendale TS: Replace two 15MVA transformers with 41.7MVA units
Burlington-Brantford-Woodstock Areas	Increase station's load meeting capability	Spring-2012	Burlington TS: Switchyard 115kV
	Improve 115kV supply in the Woodstock area	Summer-2011	Karn TS: Extend 230kV tap to new 230/115kV transformer station
		Summer-2011	Commerce Way TS: Replace existing single circuit with a double-circuit line. Install new 115/27.6kV DESN station
Southwestern Ontario	Increase supply capability	Fall-2011	Durat TS: Establish new DESN
	Reinforce supply to the Windsor/ Leamington/ Kingsville Areas	Winter-2012/13	Essex County: 230kV double-circuit line to the new Leamington TS
	Increase the transfer capability through Keith TS	Spring-2016	Keith TS: Replace the two 115MVA transformers with 250MVA units
	Increase supply capability for Windsor	Spring-2016	Keith TS to Essex TS: Uprate 115kV circuits J3E & J4E
	Incorporate new, renewable generating capacity	Winter-2016/17	Huron South Area: Install new 230kV enabler line
	Increase transfer capability of transmission corridor	Winter-2016/17	Sarnia to London area: Reinforce transmission system at 500kV or 230kV
Kitchener-Waterloo-Cambridge-Guelph & Orangeville Areas	Provide dynamic voltage support	Fall-2011	Detweiler TS: Install 230kV 350MVAr SVC. (Note: This SVC is the same device that has been identified under the Bruce Area additions. It is listed here since it also provides essential support to this area.)
	Increase supply meeting capability for the Guelph area	Spring-2012	Hanlon No. 2 TS: Establish new DESN
	Increase the supply meeting capability for the Cambridge area	Spring-2013	Reinforce transmission facilities in the area

THE ONTARIO RELIABILITY OUTLOOK IS ISSUED BY THE INDEPENDENT ELECTRICITY SYSTEM OPERATOR (IESO) TO REPORT ON PROGRESS OF THE INTER-RELATED GENERATION, TRANSMISSION AND DEMAND MANAGEMENT PROJECTS UNDERWAY TO MEET FUTURE RELIABILITY REQUIREMENTS.

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The Independent Electricity System Operator (IESO) manages the province's power system so that Ontarians receive power when and where they need it. It does this by balancing demand for electricity against available supply through the wholesale market and directing the flow of electricity across the transmission system.