

Overview of Power System Planning

Prepared for:

IESO Board of Directors Orientation

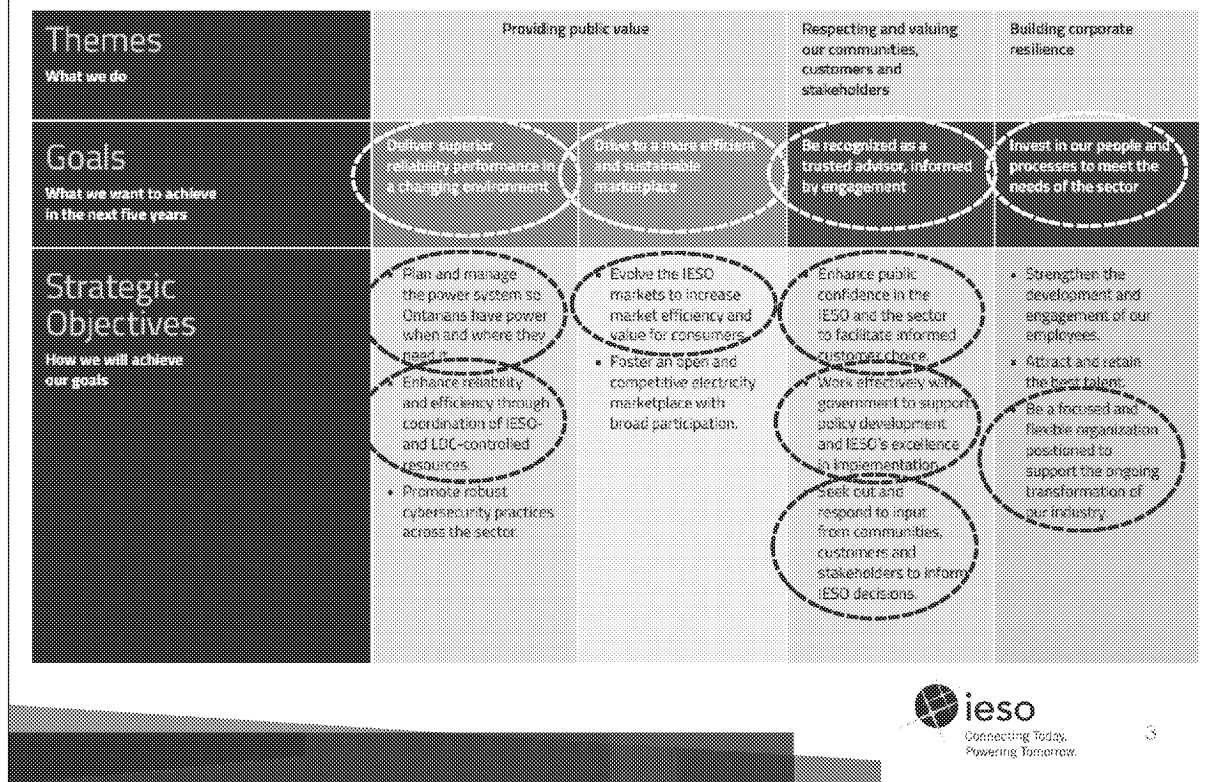
Planning, Legal, Indigenous Relations and Regulatory Affairs
April 6, 2017



Purpose

- Provide an overview of the IESO's planning function
- Discuss trends described in the recently published Ontario Planning Outlook
- Describe key areas of focus for planning over the coming year

IESO's strategy at a glance and how they relate to Planning



This is IESO's strategy for the next five years. We have three core themes, four overarching corporate goals and 11 strategic objectives that define the process which these goals will be achieved.

We deliver reliability performance to the province by:

- Adapting to changing system conditions to maintain power system reliability;
- Supporting the implementation of priority transmission projects, including the connection of remote communities;
- Evolving the regional planning process to better integrate conservation, DG , storage and DR;
- Enhancing our situational awareness through monitoring and understanding of emerging trends;
- Defining, developing and implementing coordinated operations with LDC partners

We drive a more efficient and sustainable market by:

- Designing, developing and implementing a renewed market structure, addressing known market inefficiencies and laying the foundation for a more dynamic marketplace in the future.
- Designing, implementing and administering a portfolio of competitive resource acquisition mechanisms for a variety of services to address needs identified through bulk and regional planning.

We are recognized as a trusted advisor by:

- Using communication opportunities, such as regional planning and speaking engagements, to inform the public on electricity matters;
- Enhancing transparency of and access to data to meet the needs of communities, customers, stakeholders and others;
- Building trust with government by providing unbiased expertise and advice;
- Effectively implementing initiatives that achieve government policy objectives

We invest in our people and processes to meet the needs of the sector by:

- Providing opportunities for employees to enhance cross-functional understanding;
- Evolving the IESO systems and practices to best serve our evolving business priorities

Legal and regulatory requirements related to power system planning

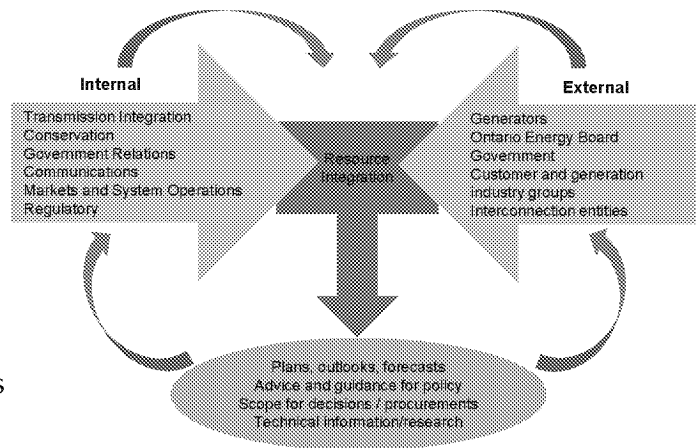
Electricity Act, 1998 (As of July 1, 2016)	IESO's License with the Ontario Energy Board	North American Electric Reliability Corporation (NERC)
IESO Objects: - Engage in activities to support goal of ensuring adequate, reliable and secure electricity supply and resources in Ontario - Forecast electricity demand and the adequacy and reliability of electricity resources for Ontario - Conduct independent planning for electricity; - Facilitate diversification of electricity supply - Engage in activities to support system-wide goals for energy sources - Facilitate conservation/load management - Assist the Board by facilitating stability in rates - Provide information on electricity needs of Ontario and the adequacy and reliability of the integrated power system to meet those needs Planning, Procurement, and Pricing: - IESO required to submit a technical report on the adequacy and reliability of electricity resources prior to and as an input into the Government's Long-Term Energy Plan - IESO required to develop implementation plan following release of LTEP	- Complete a scoping assessment to determine the appropriate regional planning approach - Complete an Integrated Regional Resource Plan and inform the lead transmitter and participating distributors of any potential investment in transmission and/or distribution facilities - Participate in regional infrastructure planning process and provide lead transmitter with any information that the transmitter requests for regional planning purposes - Provide an annual report to the lead transmitter identifying the status of any investments in electricity system initiatives where an Integrated Regional Resource Plan has been completed.	Annually conduct a 10-year assessment of the reliability and adequacy of the Ontario's power system.

Provincial electricity system planning

- The Planning group provides an integrated view to demand, conservation, supply and transmission for the province over a 20-year timeframe
- We provide planning context and advice to policymakers and industry stakeholders. We accomplish this by:
 - Providing the status and outlook of Ontario's electricity system
 - Identifying the needs for electricity service and evaluating options to meet those needs
 - Developing integrated advice and plans
 - Assessing the implications of choices related to electricity sector policy, programs, procurements, and investments in electricity infrastructure
- Activities that support this includes:
 - Performing electricity demand forecasting over 20 years
 - Conservation and demand management planning: setting CDM targets, potential studies, avoided costs
 - Resource planning: performing long term adequacy and energy assessments, supply mix advice, procurement specifications (amount, timing, and costs)
 - Bulk transmission planning: system expansion and incorporation of generation
 - Regional planning: plans to serve customer needs
 - Forecasting electricity sector GHG emissions and the cost of electricity (cost, bills, rates).
 - Integration of all elements to form a plan and inform decisions

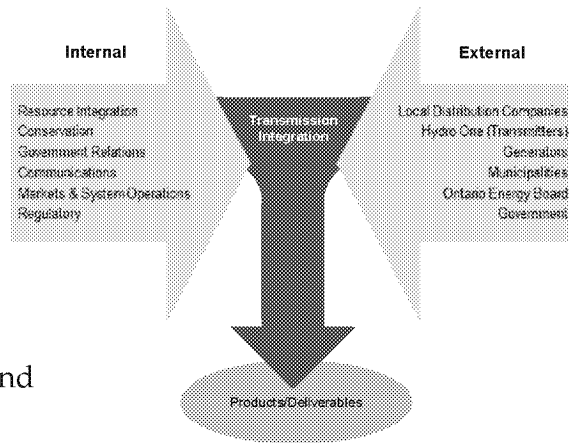
Resource Integration: responsibilities & activities

- Responsibilities: Provide assessment of integrated system plans to ensure reliable market operation, identify system requirements, assess adequacy, reliability and cost effectiveness
- Planning scope: Local & provincial; long-term & short term; big & small
- Functional areas:
 - Demand forecasting
 - Conservation integration (forecasting, program prioritization, codes/standards)
 - Supply outlook including capacity and energy assessments
 - Operability assessments
 - Ratepayer cost assessments
 - Emission outlooks



Transmission Integration: responsibilities & activities

- The need for transmission: Connect customers to generators; support a reliable & robust system; provide efficient transportation; enable interconnections with our neighbours
- Planning scope: local & provincial; long-term & short term; big & small
- Functional areas:
 - Regional planning
 - Customer reliability
 - Bulk system planning
 - System reliability
 - Transportation efficiency
 - Implementing policies & priority projects
 - Facilitating emerging technologies (where appropriate)
 - Dealing with emerging issues (e.g. end of life replacements)



Electricity Planning Process in Ontario

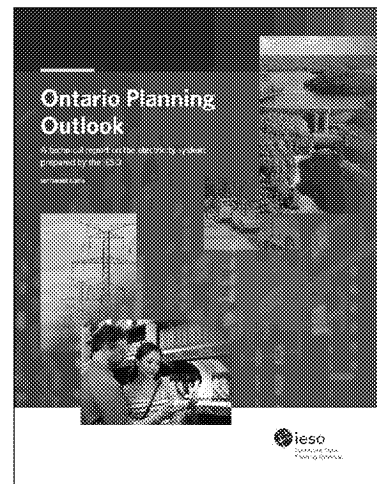
Bill 135, the
*Energy Statute
Law Amendment
Act, 2016*

Received Royal
Assent on June
9, 2016

IESO Technical Report,
"Ontario Planning Outlook"

Ontario Government's Long-
Term Energy Plan (LTEP)

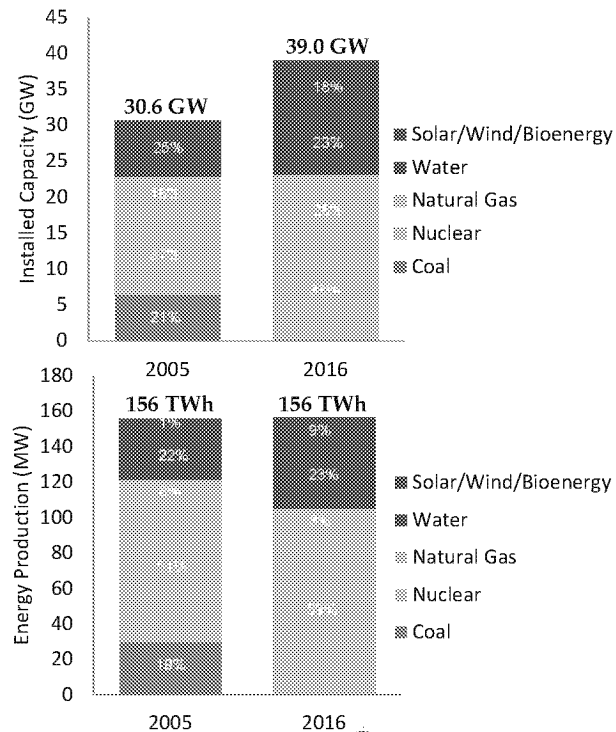
IESO Implementation Plan



The report, supporting modules,
and data tables can be found on
the IESO's website: www.ieso.ca

Evolution in Ontario's electricity supply mix

- Demand has been on a declining trend driven by increased conservation efforts and changes in Ontario's economy
- Coal-fired generation has been retired and at the same time Ontario saw additions in non-carbon emitting and natural gas-fired generation
- Reliability concerns of a decade ago have been addressed
- Greenhouse gas emissions in Ontario's electricity sector have been reduced by more than 80 percent
- Current and planned investments will meet the province's electricity needs well into the next decade.



Values shown represent grid connected generation only

Ontario's electricity supply mix has also evolved over the past decade.

All coal-fired generating plants have been retired and at the same time Ontario saw additions in nuclear, renewable, and natural gas-fired generation

These resources combined with investments in conservation and transmission:

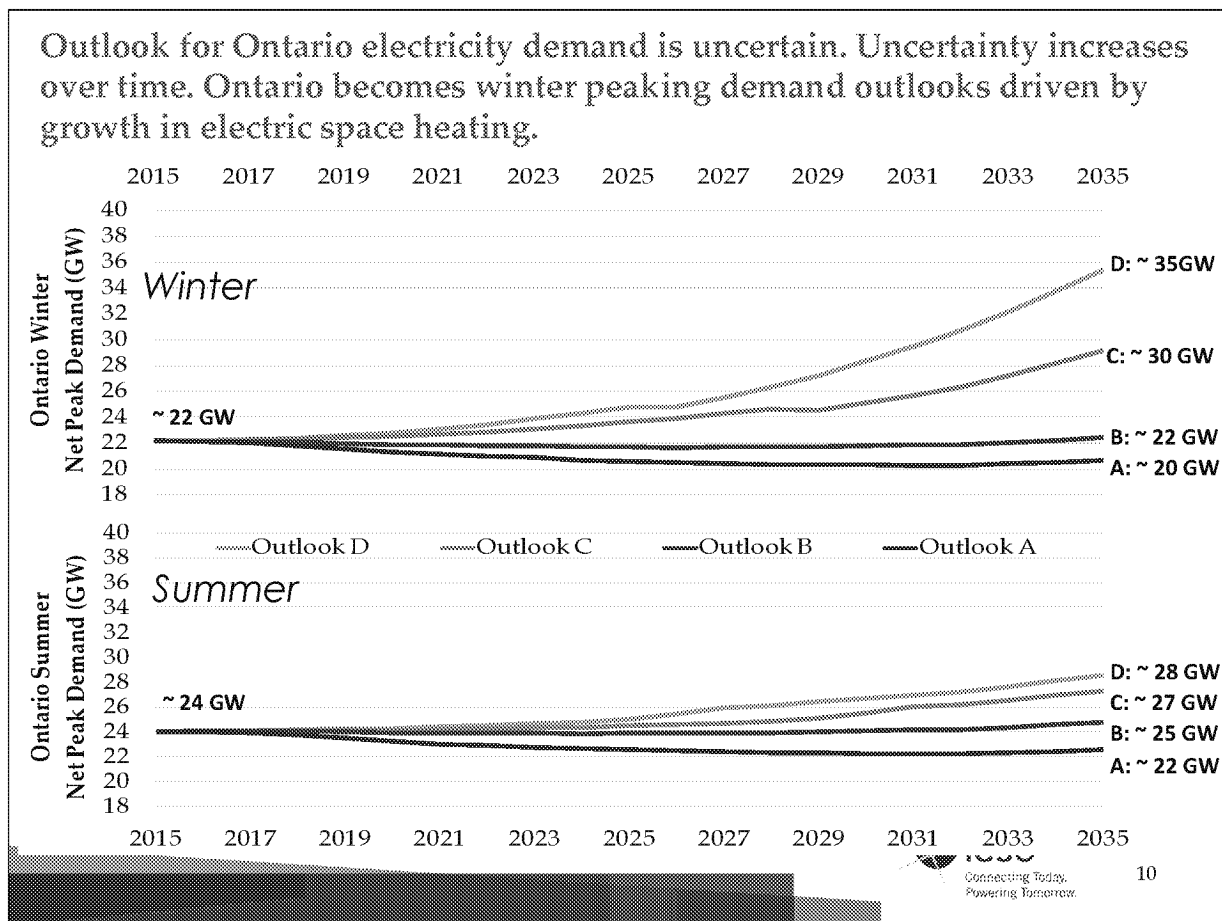
Have addressed the reliability concerns of a decade ago

Reduced greenhouse gas emissions in Ontario's electricity sector by more than 80 percent. About 90% of the electricity produced in the province today is carbon free.

And both existing and planned investments, will meet the province's electricity needs well into the next decade

Today nuclear produces about 60% of the electricity generated in Ontario, renewables 30% and gas 10%.

Non-hydro renewable generation additions saw the most growth over the past decade. Share of energy production from solar PV, wind, and bioenergy grew from virtually 0% a decade ago to about 10% of the energy mix today



With respect to peak demand, which drives supply capacity investment decisions, Ontario has a summer peak demand of 24GW today but this could range between 22 GW and 28 GW by 2035 across the four outlooks.

Winter peak demand is about 22GW today but ranges between 20GW and 35GW by 2035 across the outlooks.

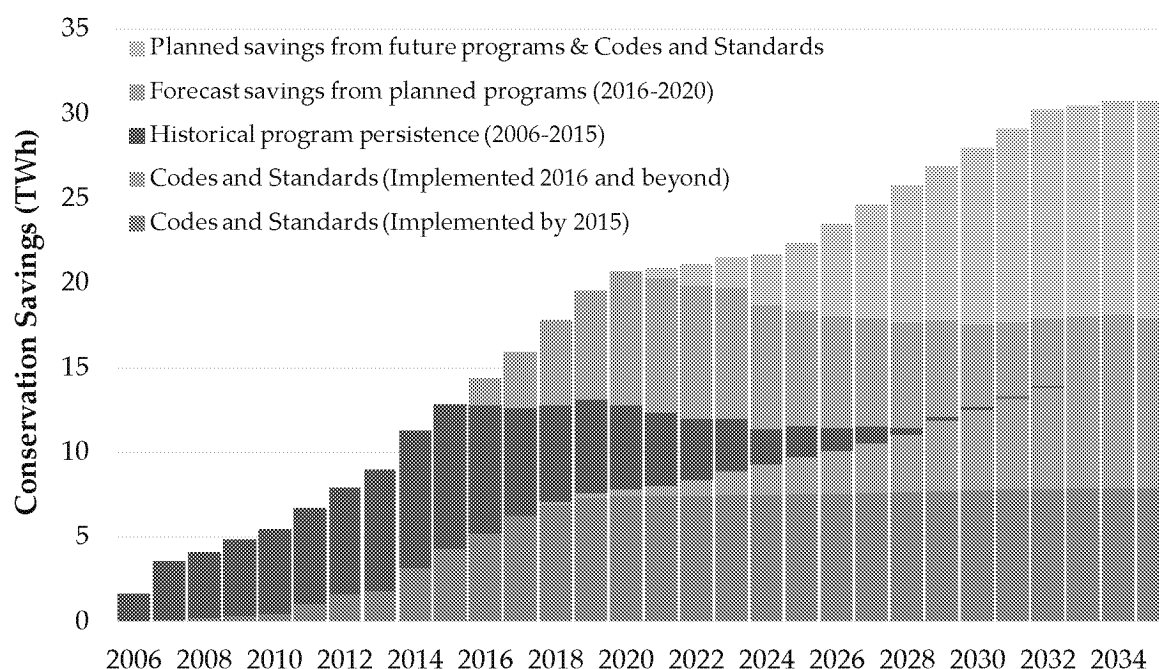
When we look at these outlooks for peak demand, three important observations are made:

The variability in demands is relatively small in the near-term but significantly increase in the longer-term, beyond the next 10 years. This gives us a sense of the timing of when new electricity infrastructure would be required.

The variability in the demand outlooks is greater in the winter than in the summer. To planners, this provides an indicator as to the amount of flexibility that is required in investment decisions so as to not over/under commit resources

The time of peak demand changes over time. Ontario is currently a summer peaking jurisdiction. In the higher demand outlooks driven by the electrification in space heating, Ontario becomes a winter peaking jurisdiction. This has implications for the types of resources available to meet peak demands. For e.g., whereas solar PV is well suited to meeting peak demands in the summer, it may be a poor substitute in the winter when solar irradiation is quite low. However, the thermal fleet operates more efficiently in the winter and wind output tends to be greater.

Ontario electricity conservation outlook



Conservation is an important tool in moderating demand growth while helping consumers manage their electricity bill. Ontario currently has a target to achieve 30 TWh of energy efficiency savings by 2032. That's roughly equal to one-fifth of electricity demand today.

The IESO recently published an Achievable Potential Study which concluded that the existing conservation targets and planned savings are feasible.

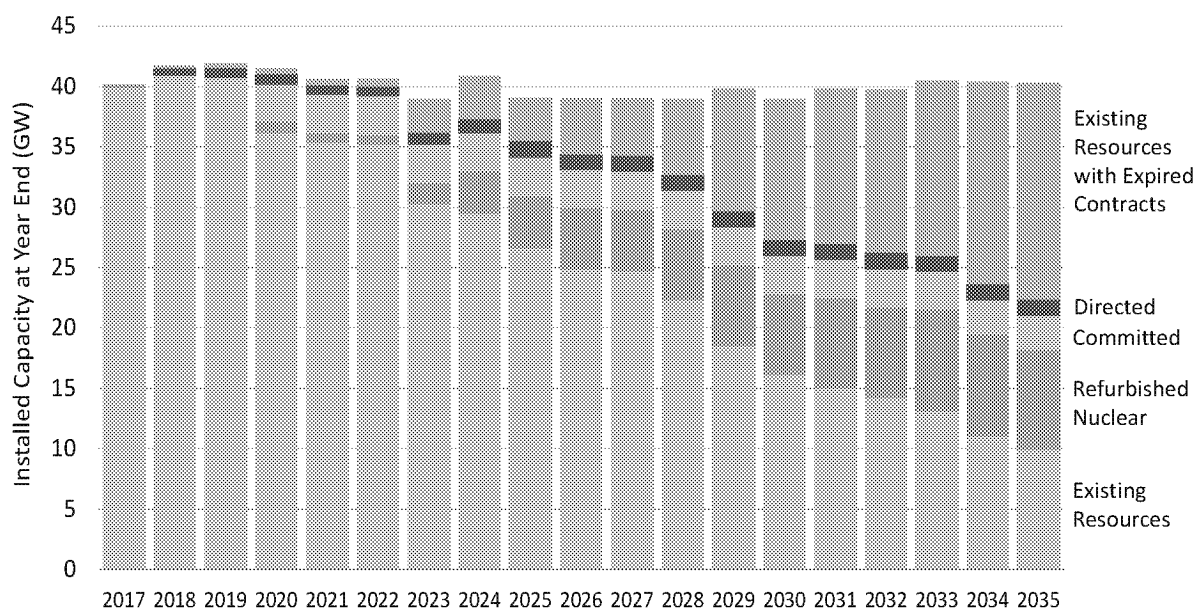
These savings are achieved through a combination of conservation programs and building codes and equipment standards.

To date, we expect to be about 60% of the way there in meeting our targets.

In the flat demand outlook, we see that conservation effectively offsets all growth due to economic activity.

Opportunities for conservation can vary with reductions or increases in demand. The value of conservation is greater under higher demands which could unlock conservation potential which was otherwise uneconomic and support higher investment in more efficient technologies.

Outlook for installed supply capacity in Ontario

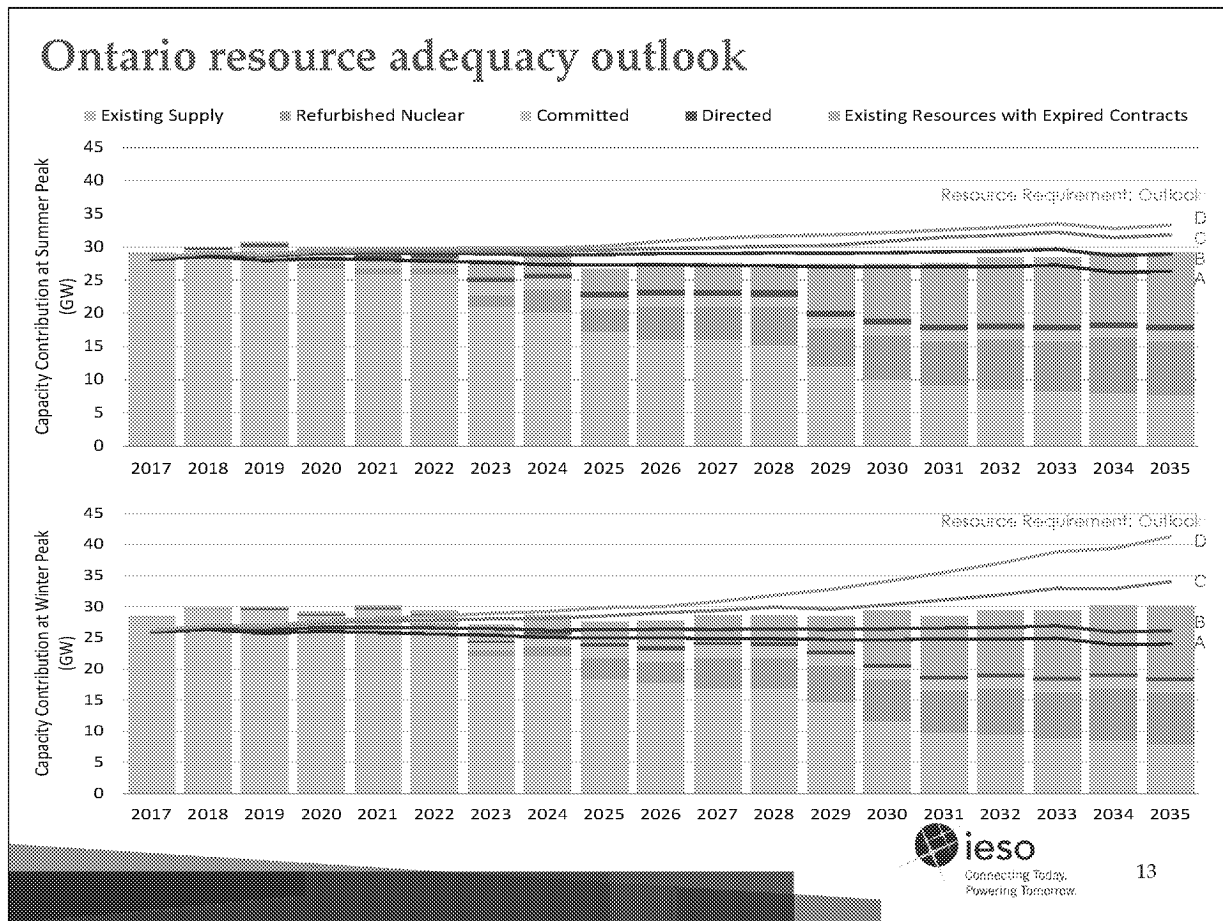


Committed resources are those that have been procured and are in development.
Directed resources are those that are planned to be procured to meet Directives.

With respect to electricity supply, Ontario currently has 40,000 MW of installed supply capacity. This is roughly 30% of Canada's installed generation capacity.

If all existing resources continue to operate through to 2035 and all planned resources come into service as scheduled, Ontario would see almost no growth in installed supply capacity over the planning outlook.

However, Ontario also has a fair amount of resources currently under various power purchase agreements that will reach the end of their contract term – approximately 18GW by 2035. If these resources cease to operate due to either technical or financial reasons, total installed supply by 2035 could be as low as 23GW



Now when we look at the amount of supply expected to be available at the time of peak demand and compare that to our four demand outlooks plus the reserve requirement, we see that Ontario is expected to have enough resources to meet a flat demand outlook

There is also enough flexibility to reduce oversupply under lower demands as well as flexibility to adapt to new opportunities or priorities

Ontario could adapt to low demand outlooks or new technologies by not recontracting with existing generation facilities when contracts expire

Ontario also has the option of exercising nuclear refurbishment off-ramps in response to sustained, very low demand expectations resulting from structural or disruptive technological change

Ontario is expected to have sufficient resources to meet demand generally over the next decade across all outlooks. However, higher demand could create a need for additional resources in the longer-term.

Resource options to meet higher demand outlooks

- Higher demand could create a need for new resources in the longer-term
- A number of choices exist across the sector
- No single resource option can meet all customer needs at all times

Example	Capacity	Energy	Operating Reserve	Load Following	Frequency Regulation	Capacity Factor	Winter Peak Contribution	Summer Peak Contribution
Conservation	Yes	Yes	No	No	No	Depends on Measure		
Demand Response	Yes	No	Yes	Yes	Limited	N/A	60-70%	80-85%
Solar PV	Limited	Yes	No	Limited	No	15%	3-5%	20-35%
Wind	Limited	Yes	No	Limited	No	30-40%	20-30%	11%
Bioenergy	Yes	Yes	Yes	Limited	No	40-80%	85-90%	85-90%
Storage	Yes	No	Yes	Yes	Yes	Depends on technology / application		
Waterpower	Yes	Yes	Yes	Yes	Yes	30-70%	67-75%	63-71%
Nuclear	Yes	Yes	No	Limited	No	70-95%	90-95%	95-99%
Natural Gas	Yes	Yes	Yes	Yes	Yes	up to 65%	95%	89%

A number of generation and demand-side technology choices exist across the sector for meeting needs driven by higher levels of demand or changes in supply availability. Some of these are illustrated on the screen and is not meant to be an exhaustive list

These choices are being driven by technological advancements, evolutions in policy and market design and increasingly engaged consumers

Each technology choice has its own merits – some are good for capacity, other for energy, while others are better for ancillary services such as frequency control and load following.

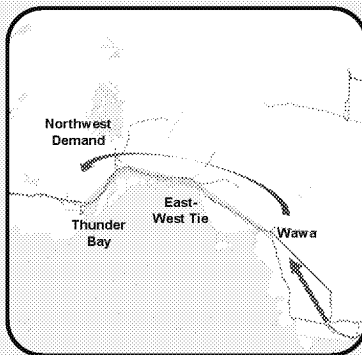
When we look at our outlooks, we see that no single resource option can meet all customer needs at all times and maintaining a diverse resource mix can provide all the different services necessary to support reliable and efficient operations

One resource in particular, which you may be familiar with, is waterpower which provides a variety of services

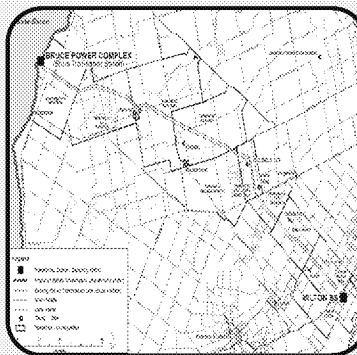
Transmission outlook: bulk system planning

- In the past two decades, bulk transmission system planning has been responding to enable off coal policies, and integrate 8,000 MW of renewable generation with minimal new investments on the grid
 - Responding to major shifts in generation patterns
- Looking forward, we see potential drivers emerging related to electrification policy decisions, and market renewal
 - May see a return to more traditional planning centred around meeting growing customer demand (electrification)
 - Role of transmission planning following market renewal still to be determined

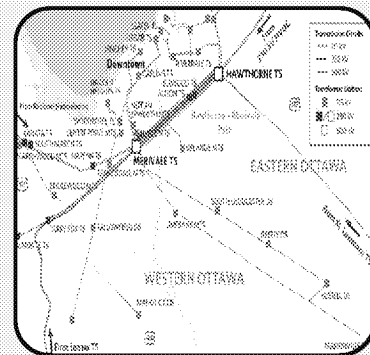
Maintaining bulk transmission system reliability and enabling the market



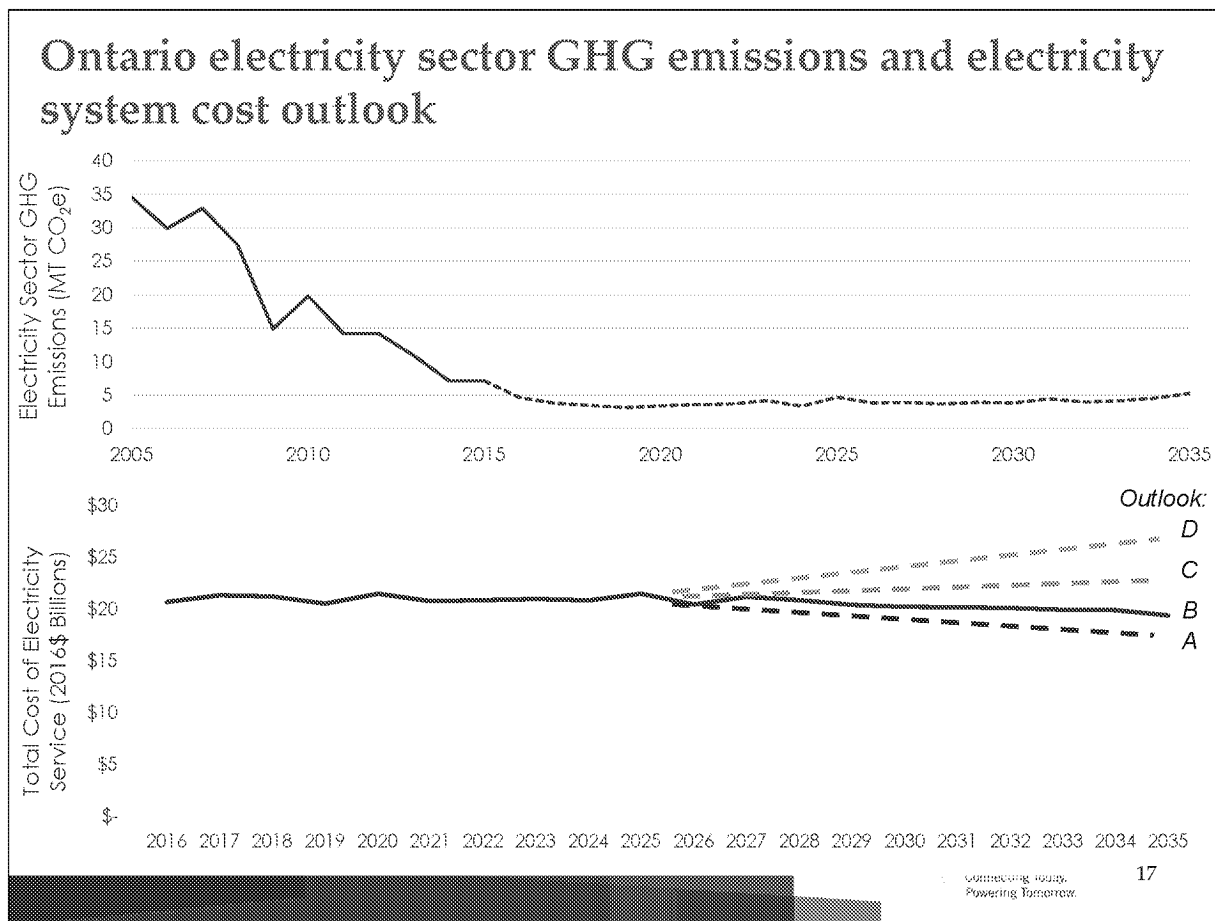
Respond to Changes in Load and Generation
(East-West Tie, Clarington TS)



Relieve Congestion
(Bruce x Milton)



Strengthen Interconnections with Neighbouring Markets
(Hawthorne x Merivale)



Regarding greenhouse gas emissions from the electricity sector, emissions are expected to continue to decline over the next five years

Cap and Trade program went into effect this year (2017). Emissions expected to be lower than what they otherwise would have been as a result of a price on carbon

In the flat demand outlook, emissions remain well below historical levels and relatively flat through to 2035 – averaging about 4 MT/year which is about 4% of total economy wide emissions (rest from buildings and transportation sector)

Ontario's combined cycle gas fleet is relatively underutilized and we could ramp up energy production from this fleet in response to higher energy demands. However this would result in increased emissions.

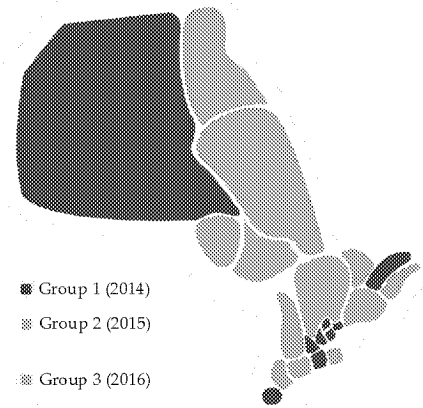
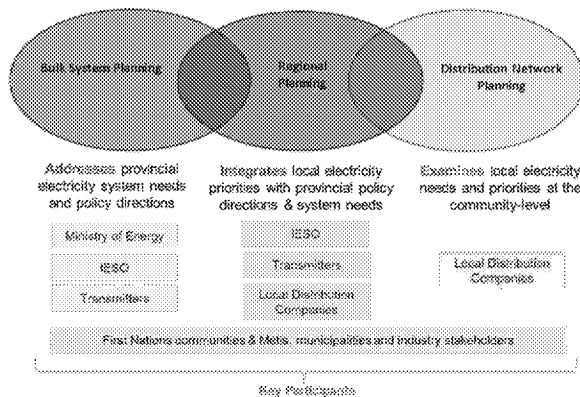
Opportunities exist for non-carbon emitting technologies to mitigate increases in emissions that could arise from increases in energy consumption.

Within our planning outlook, we looked at a number of supply mix portfolios to illustrate ways we can meet higher levels of demand while keeping GHG emissions in the electricity sector unchanged. We identified that the scope, scale, and pace of investments required to meet higher levels of demand growth while keeping emissions flat would likely pose a challenge.

Regional planning overview

Background

- The OEB formalized the Regional Planning Process in 2013 with a goal to develop long-term electricity plans for 21 electricity planning regions across Ontario, every 5 years at a minimum
- The first round of Regional Planning has now been complete, with all 21 Regions reviewed. Sixteen IRRPs have been released
- The next round is expected to begin late 2017



Benefits of Regional Planning

- Protect consumers by minimizing unwarranted or risky investments
- Better positioned to integrate and optimize new technologies
- A more formalized planning process that integrates Local needs and Bulk planning
- Community buy-in through engagement



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Benefits of Regional Planning

Minimize unwarranted or risky investments

Provides unbiased assessment for the benefit of ratepayers

A more realistic look at the need for major expansion, in view of growth uncertainties associated with electrical demand, which is a primary driver for capital investments

Considers incremental solutions, the effect of Provincial and Local government policies and plans, new technologies and asset end-of-life opportunities

Better positioned to integrate and optimize

Examines both bulk and regional needs; allows for exploration of synergies and benefits from both the bulk and regional planning processes

Not limited to specific service territory boundaries when assessing needs and solutions

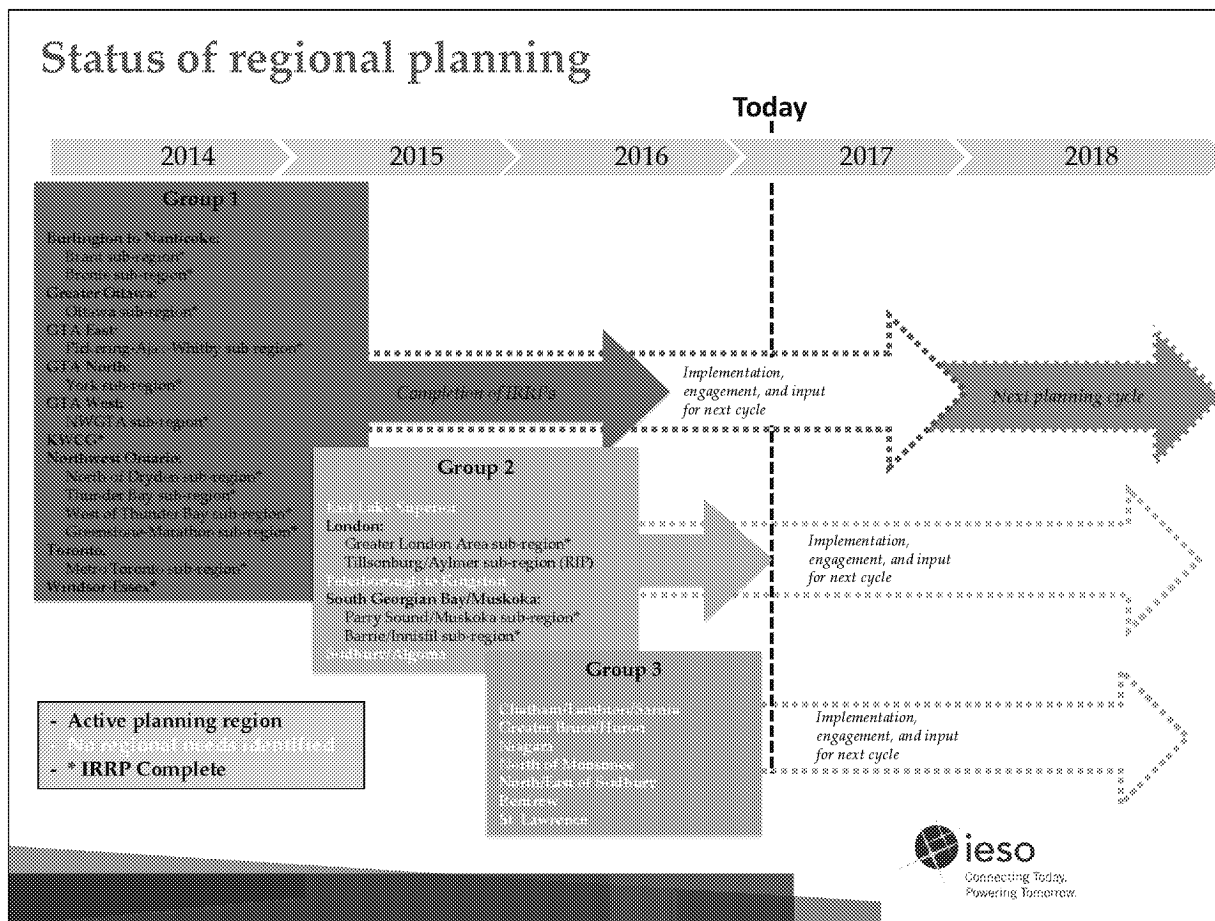
Conservation, wires (transmission and distribution), generation (centralized and local / distributed) and local/provincial aspects are all considered in the development and assessment of solutions

A more formalized planning process

Consistency; adherence to standards; common methodology

Greater transparency; public/community/First Nations and Métis awareness and opportunities for input in the early planning stages; coordination with community energy planning initiatives

Near/medium/long-term perspectives; projects as part of a larger context



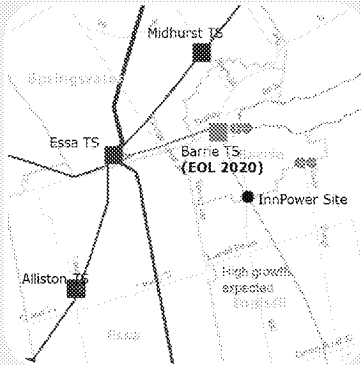
The electricity needs of all 21 of Ontario's planning regions have now been evaluated for regional planning with the recent completion of the final group of needs assessments; this marks the completion of one full cycle of regional planning assessments across the province

The first IRRP was posted in January 2015, with an additional seven IRRPs posted in April 2015; four additional plans were posted summer 2016, three in Q4 2016 and one in Q1 2017

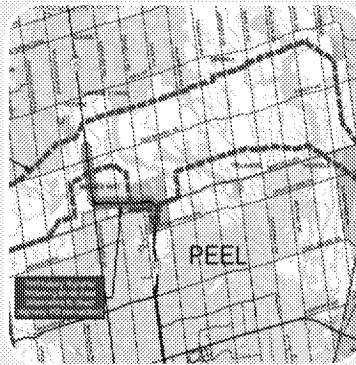
Sixteen IRRPs were undertaken through the first round of Regional Planning

Through this first complete cycle, it was determined that the remaining regions do not require coordinated regional planning at this time and that identified needs can be managed either through a wires only solution, through local planning or through bulk planning

Regional planning examples



Barrie/Innisfil
Right-size End of Life Assets
Barrie TS Rebuild

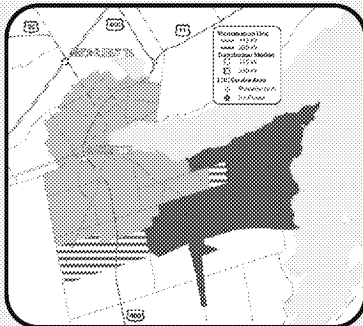


GTA West
Land Use Planning for Future
Needs
Setting Aside Corridors



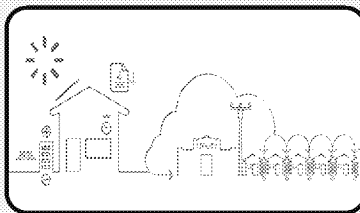
Parry Sound/Muskoka
Working with Communities
Addressing Reliability Needs

Facilitating emerging technologies as potential alternatives to wires in regional planning



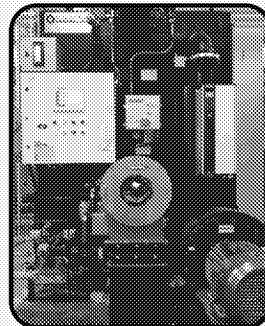
Conservation & Demand Management

- Targeted CDM, Local Achievable Potential Studies
- Local Demand Response (Brant, Toronto)



Virtual Power Plants & Microgrids

- PowerHouse
- Microgrid pilots
- Interoperability



More Effective Energy Use

- District energy
- Deep lake water cooling

Examples of some of the many activities led by the Planning team to date

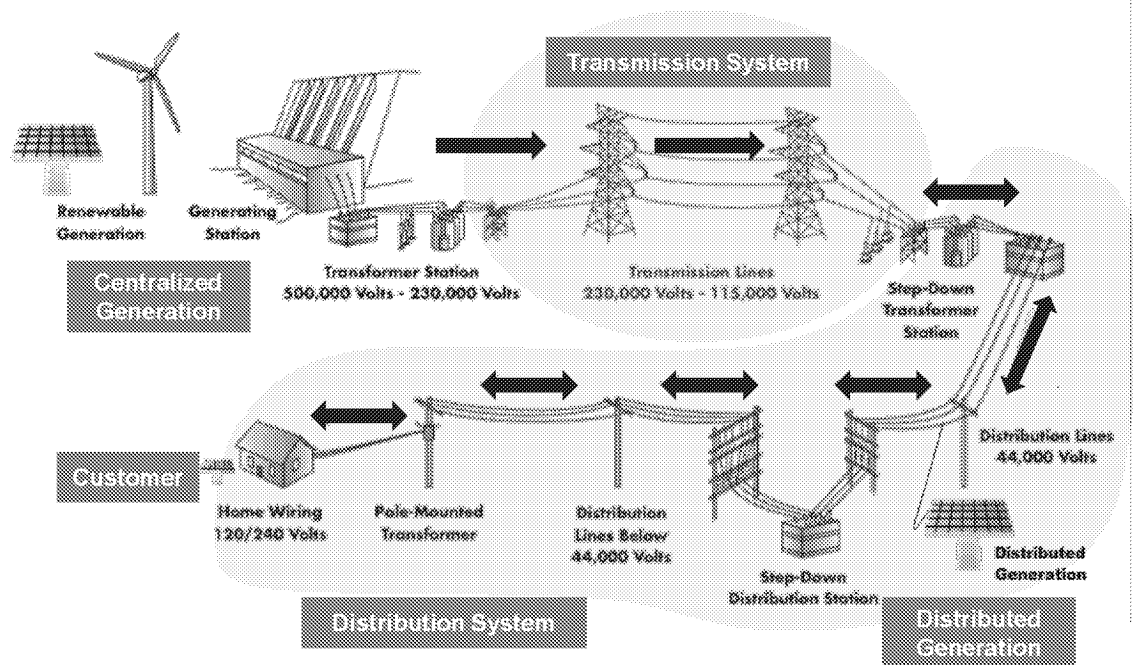
- Implementing coal phase-out
- Forecasting demand – from day ahead to 20 year outlooks
- Providing planning input into conservation targets and potential studies
- Development of avoided costs for conservation program implementation
- Bruce and Darlington refurbishment programme (outage coordination, economic analysis/establishing prices for contract negotiations)
- OPG and Hydro One rate application support for various projects (Pickering extension, Clarington TS, Bruce X Milton, etc)
- Implementation support for procurement programs
- Ontario Intertie Report
- Non-Utility Generation (NUG) Framework Assessment
- Hydro-Quebec import agreement (scoping, product design)
- Energy storage procurement
- Cap and trade design support
- Integrated Power System Plan (2007), Ontario Planning Outlook (2016), Long-Term Energy Plan development (2010, 2013, & 2017)
- Advice on renewable procurement on Large Renewable Procurement II
- Outlooks for electricity costs – system costs, residential bills, and industrial rates
- Outlooks for emissions
- “Bending the cost curve” assessment
- Ontario’s Fair Hydro Plan
- <Transmission to add>

Emerging issues and priorities for the Planning team

- Market renewal initiative
- Government's next Long Term Energy Plan (LTEP)
- Implementation plan post-LTEP
- Conservation First Framework mid term review
- End of life asset extension (ex. Pickering NGS, nuclear refurbishments)
- Attention to performance and availability risks (resource turnover, aging generators, expiring generator contracts)
- Integration of distributed energy resources
- Non-wires solutions (conservation and supply) in regional planning
- Cost allocation & responsibility for non-wires solutions
- End of life asset replacements
- Role of transmission integration in the market environment
- Interconnections
- Long-term function of the grid
- Standards & resiliency
- Managing long lead times in a changing environment
- Monitor evolving trends
- Community acceptance and involvement
- Responding to government policy & regulations (see next slide)

Responding to government policy & regulations

- Implement changes to mandate
 - Transmission Procurement (Bill 135); process to be developed as part of 2017 LTEP implementation
- Carry out policy directives
 - 2017 Long Term Energy Plan support and Implementation Plan development
 - Support approvals
- Rate applications, Leave to Construct, handoff letters, project specs
 - Facilitate approval of generation procurement by determining adequacy of system to accommodate project



Thank you.