An Introduction to the IESO

For discussion with MPP Todd Smith

March 27, 2017

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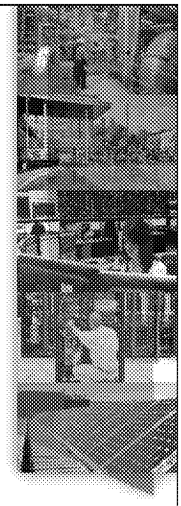
IESO: Who We Are and What We Do



The Independent Electricity System Operator (IESO) works at the heart of Ontario's power system – ensuring there is enough power to meet the province's energy needs in real time while also planning and securing energy for the future

We do this by:

- Operating the Grid
- Planning
- Enabling Conservation
- Administering the Electricity Market
- Ensuring Supply
- Engaging Stakeholders and Communities

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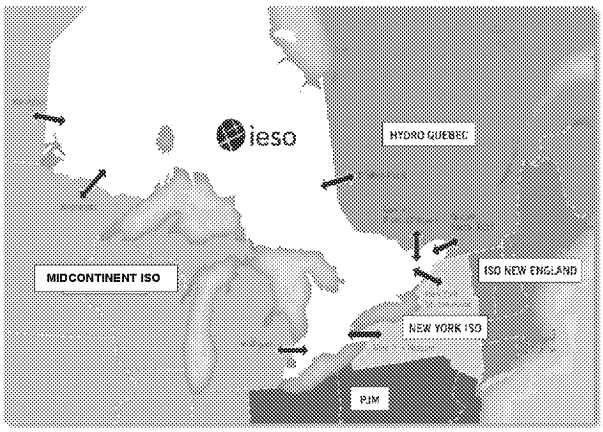
Ontario at a Glance

Installed Capacity	36,070 MW (December 2016)
Record Summer Peak	27,005 MW (August 1, 2006)
Record Winter Peak	24,979 MW (December 20, 2004)
Total Annual Energy Consumed	137 TWh (2016)
Energy Savings Through Conservation (2015)	1.3 terawatt-hours (TWh)
Customers	4.9 million
Ontario Import Capability	4,800 MW
Transmission Lines	30,000 km
Interconnections	New York, Quebec, Manitoba, Michigan, Minnesota



The IESO is the reliability coordinator for Ontario and works closely with other jurisdictions to ensure energy adequacy across North America.

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Ontario currently has an installed TX capacity of 35,221 MW

Ontario's record summer and winter peaks were in 2006 and 2004, respectively. Ontario demand is consistently lower than it used to be, which I'll speak about later on.

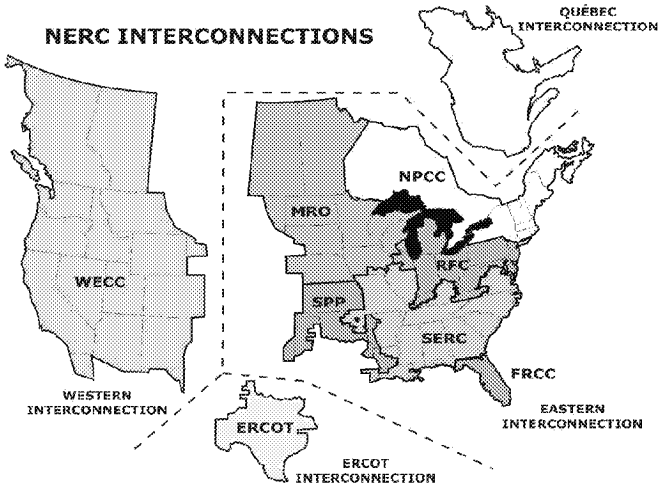
We have a number of neighbouring jurisdictions with whom the IESO works closely with.

Intertie capacity refers to the capacity of the transmission lines that go across Ontario's borders.

Our intertie capacity is 4,800 MW – although in reality it is much lower because of local transmission constraints, for example, in and around Ottawa, that prevent us from using the interties to their full capacity.

The IESO needs to keep at least 700 MW free at all times for emergency situations., called Operating Reserve.

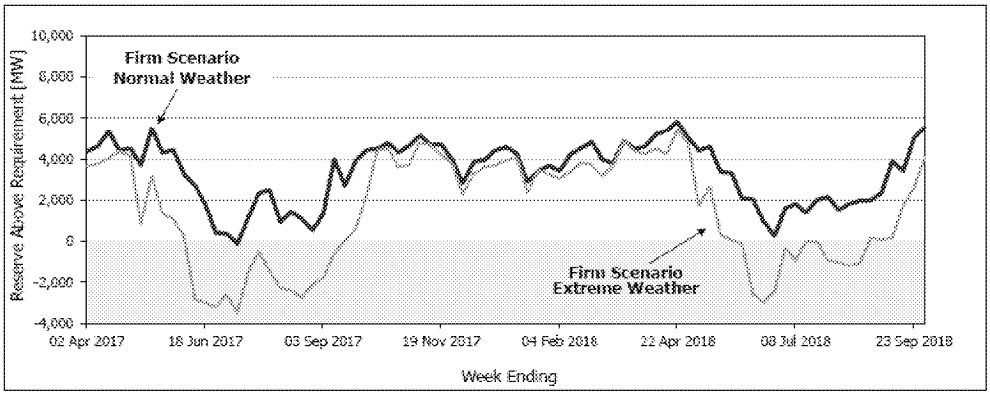
Ontario's Reliability Co-ordinator



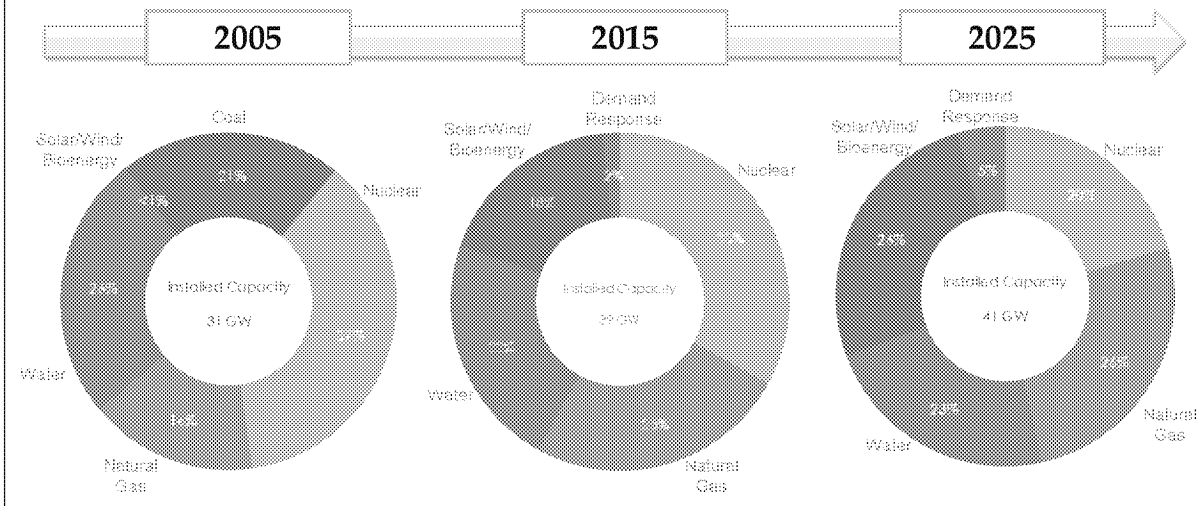
- IESO is responsible for monitoring and enforcing reliability standards in Ontario
- IESO represents Ontario's interests as member of North American Electric Reliability Corporation (NERC) and Northeast Power Coordinating Council (NPCC)
- IESO is active in the interconnected community in emergency preparedness related activities

Planning

- Through a regional planning process, the IESO invites municipalities, community groups, stakeholders and the general public to provide input into the development of their region's electricity plan.
- The IESO also publishes a quarterly *18-Month Outlook* assessing the reliability of Ontario's electricity system over the short term, and forecasts up to 20 years ahead through the *Ontario Planning Outlook*

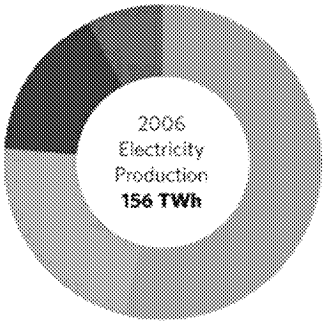


Ontario's Electricity Supply - Capacity

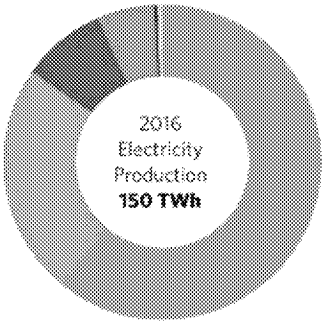


Reflects transmission grid connected and embedded generation, at year end

Electricity Production 2006/ 2016



Nuclear	84.4 TWh or 54%
Hydro	34.8 TWh or 22%
Coal	25 TWh or 16%
Other (gas, oil, alternative sources)	11.8 TWh or 8%



Nuclear	91.7 TWh or 61%
Hydro	35.7 TWh or 24%
Gas/Oil	12.7 TWh or 9%
Wind	9.3 TWh or 6%
Biofuel	0.49 TWh or <1%
Solar/Other	0.46 TWh or <1%

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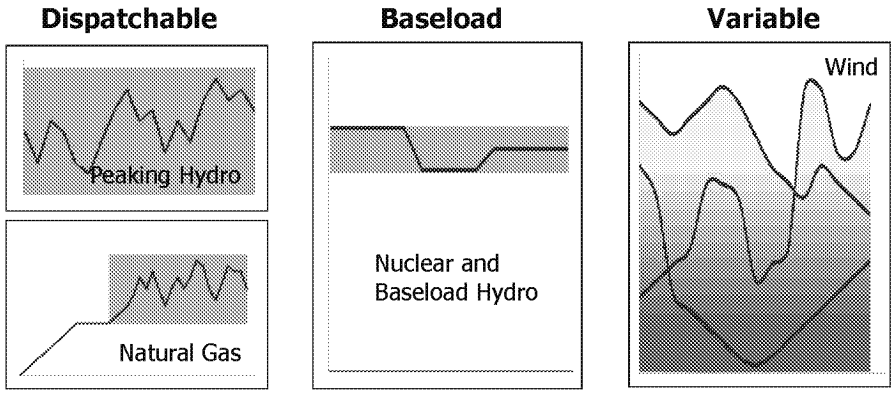
Ontario's Generation Fleet: Operating Characteristics

Each generation type has its own unique operating characteristics. The IESO has developed tools and processes to manage them reliably.



Flexibility is needed to:

- Provide load following
- Provide ramping
- Manage surplus baseload generation (SBG)

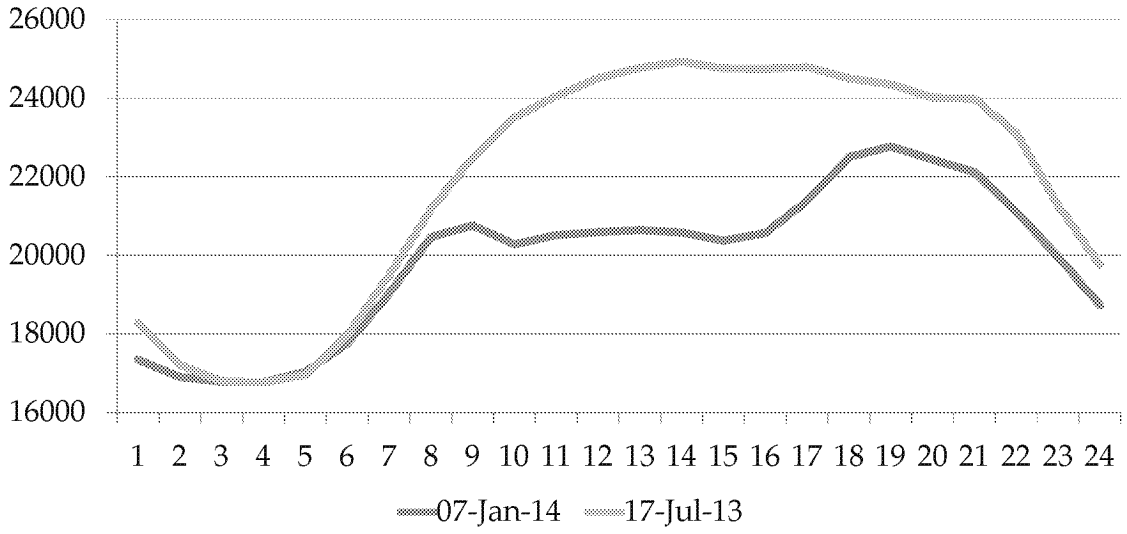
Ideally every resource is highly flexible with unlimited fuel but the reality in Ontario (and every other jurisdiction) is a mix of resources having different operating characteristics

We cannot economically have every resource highly flexible, nor can we have the entire fleet in-flexible acting like baseload generation.

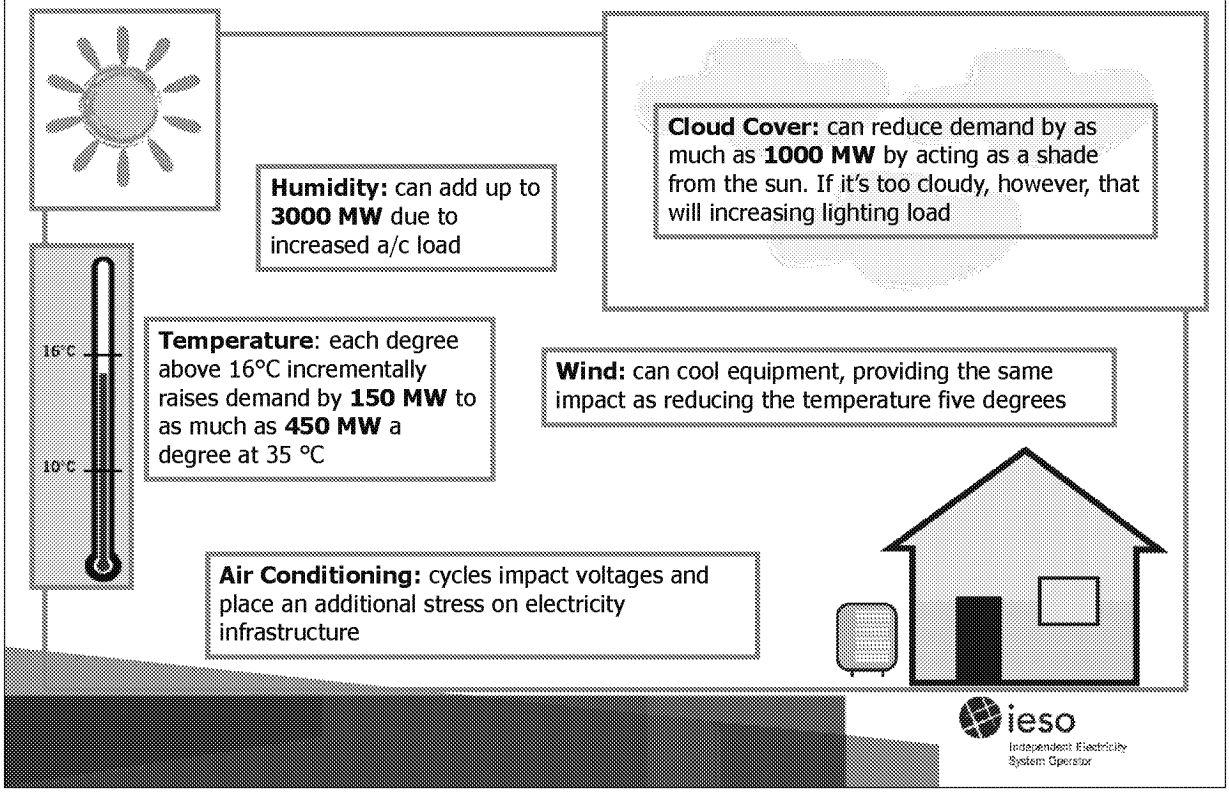
So looking at Baseload……Variable….Dispatchable….

How do we overcome this inherent inflexibility? (next slide…)

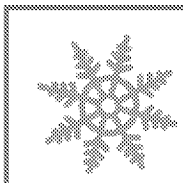
Summer vs. Winter Demand



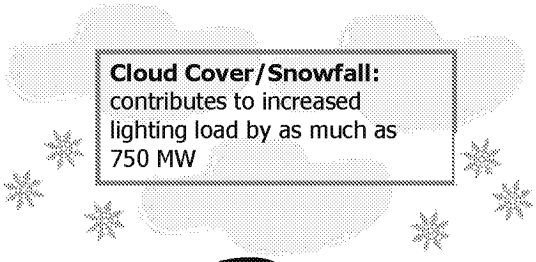
Summer Impacts



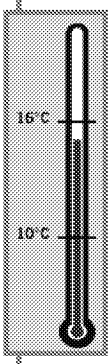
Winter Impacts



Ice: can cause significant transmission issues and make restoration and repairs troublesome. Under extreme conditions it can cause infrastructure issues (e.g. 2013 ice storm)

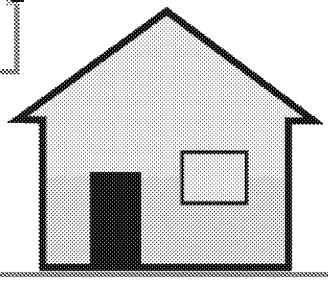


Cloud Cover/Snowfall: contributes to increased lighting load by as much as 750 MW



Temperature: each degree below 10°C incrementally raises demand by **50 MW** to as much as **250 MW** a degree at -20°C (furnace load)

Wind: strong winds (30 km/h and up) on cold days (-10°C) can increase demand by 800 MW



Lighting influences demand peaks in winter with late sunrise and early sunset

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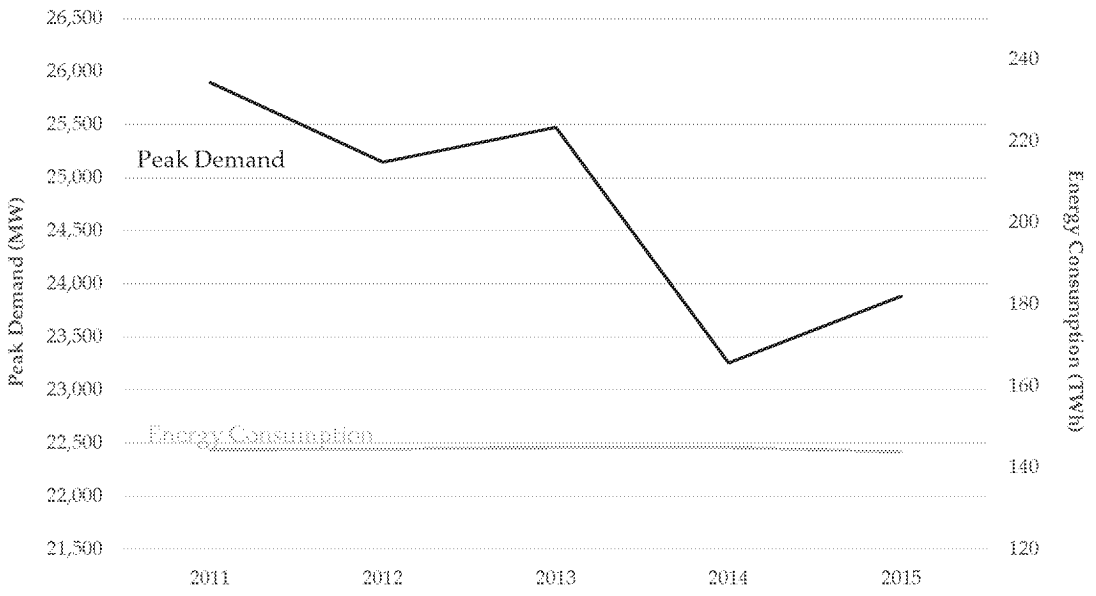
Peak Demand 2011-2015

To be updated



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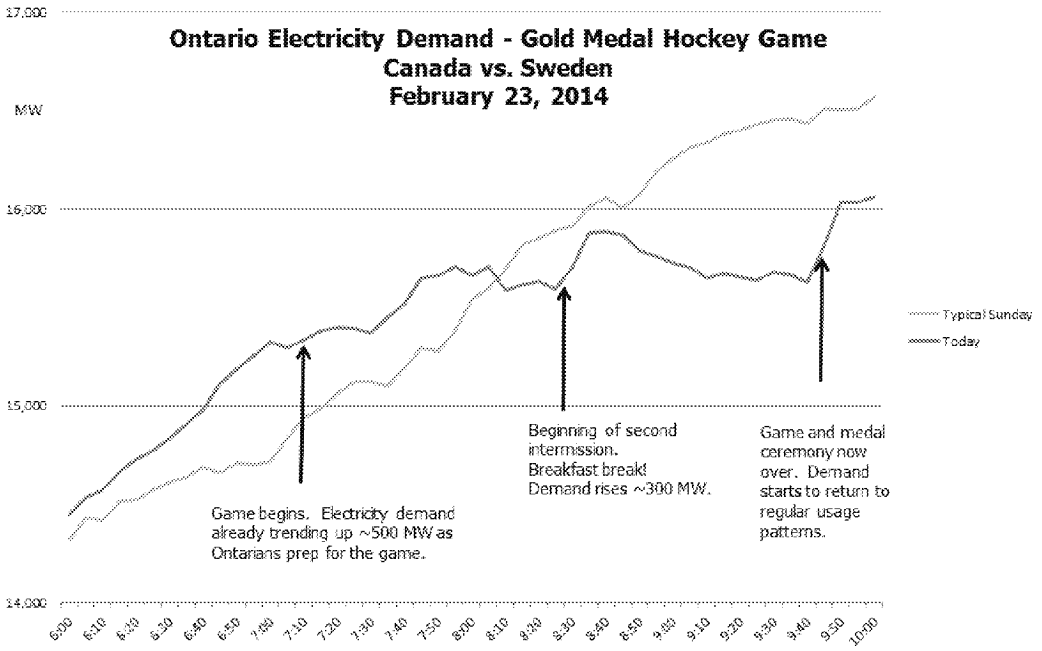
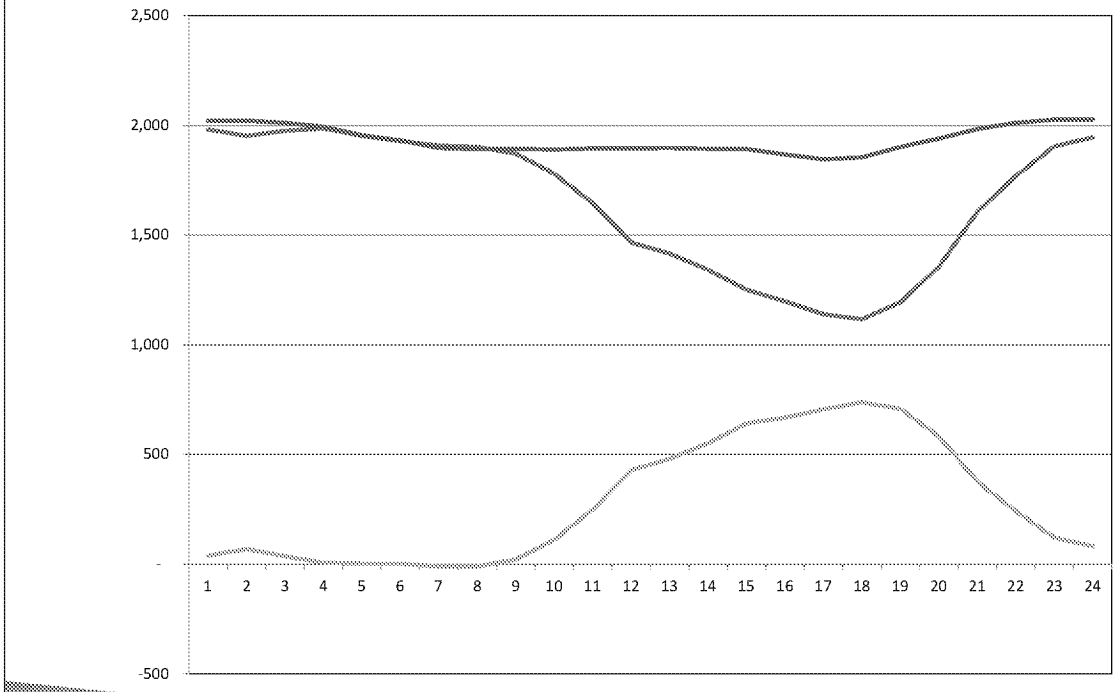
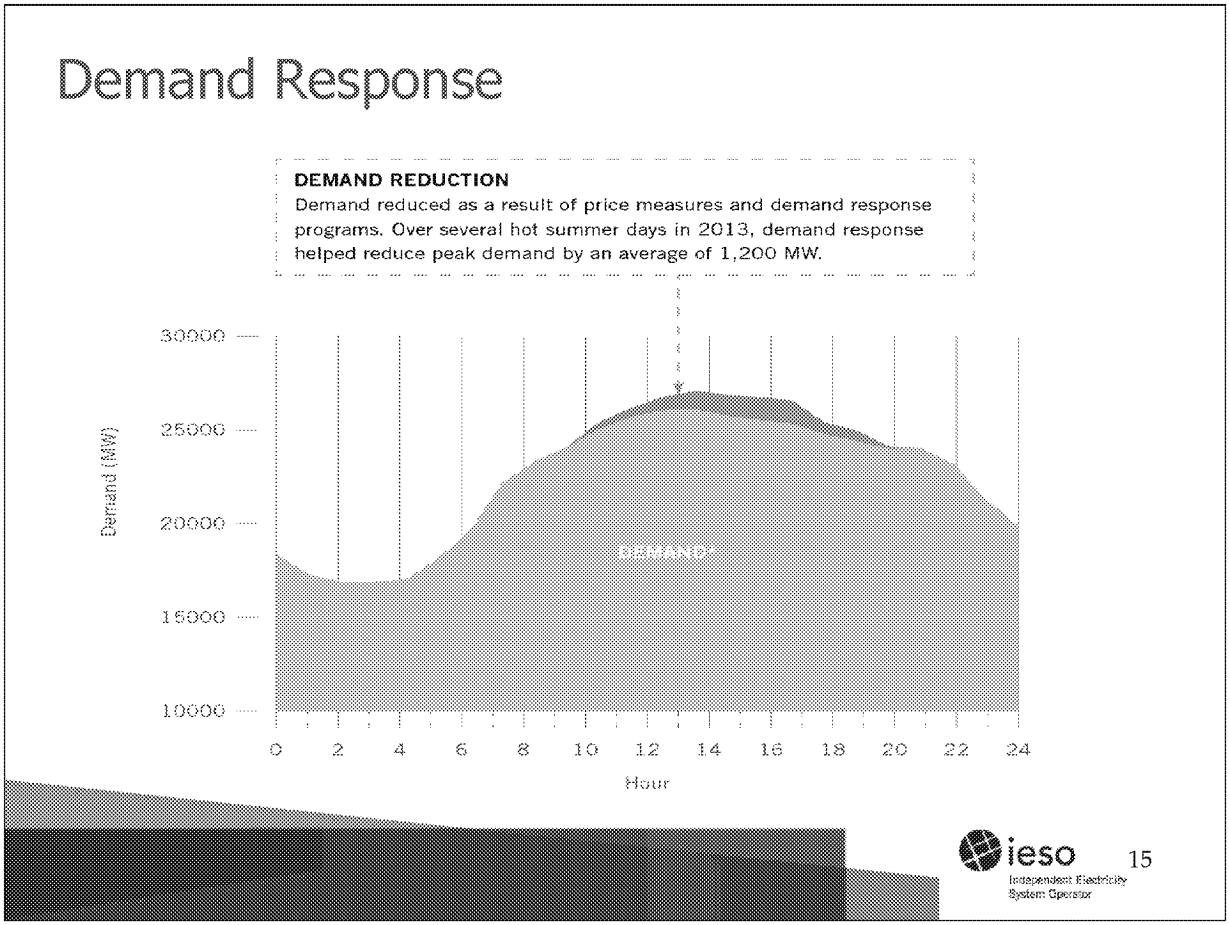
Demand for Electricity: The Impact of Consumer Behaviour



Industrial Conservation Initiative (ICI)





Demand response, which enables consumers to reduce their electricity consumption in response to prices and system needs, is playing an increasing role in Ontario's electricity sector

It has already had a significant impact on energy demand and helped reduced peaks, providing a valuable and cost-effective resource to the system

The opportunities for demand response are growing and will provide consumers with more control over their energy use, while at the same time contribute to system reliability

The province aims to have DR meet 10% of peak demand by 2025, the equivalent of ~2,400 MW under forecast conditions

By optimizing the use of infrastructure that already exists, DR enables the province to defer or avoid the costs associated with new generation or transmission assets.

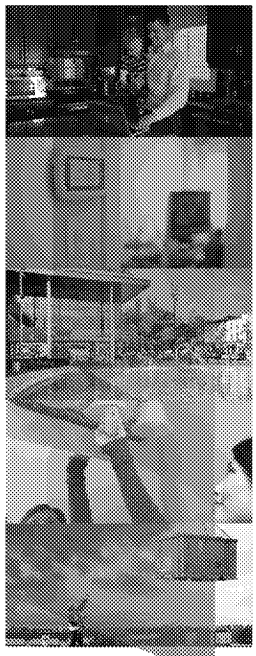
Whether it is a factory, hospital or an electric car plugged in at home, these facilities can also be leveraged to support the grid. This makes demand response an efficient approach to meeting energy needs.

The graph here shows how demand response reduced peak demand by an average of 1,200 MW over several days in 2013.

Electricity at the peak is the most expensive electricity – if you remember, offers from suppliers are taken from lowest to highest cost.

Enabling Conservation

- Conservation provides a clean and cost-effective alternative to building new generation
- Conservation can also lower peak demand, allowing the IESO to defer or avoid the need to build new infrastructure
- Conservation is expected to offset almost all demand growth until 2032
- Under the Conservation First Framework, the IESO aims to reduce electricity consumption by 8.7 TWh – the equivalent of powering nine cities the size of Sudbury for a year – by December 31, 2020
  - IESO responsible for evaluation, measurement and verification, marketing, market transformation
  - LDCs responsible for program delivery and cost-compliance



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Ontario's Long-Term Energy Plan projects that conservation will offset almost all demand growth until 2032. The cheapest MW is the one that we don't use.

The province began a six-year conservation plan this year that aims to reduce electricity consumption by 8.7 TWh – the equivalent of powering Mississauga and Sudbury for a year.

Conservation provides the cleanest and most cost-effective alternative to building new generation

It also lowers peak demand, allowing the IESO to defer or avoid the need to build new infrastructure

There are many different conservation programs being offered across the province by local distribution companies

For example, peaksaver PLUS® helps residential consumers reduce energy during peak demands by allowing their utility to remotely cycle down their air conditioners and water heaters.

And the High Performance New Construction initiative provides design assistance and incentives for building owners and planners who design and implement energy efficient equipment within their new space.

Electricity consumption data is being used in new and exciting ways to drive conservation

For example, social benchmarking programs can allow people to compare their own electricity use with their neighbours'

SAVE ON ENERGY
POWER WHAT'S NEXT

Save on Energy has programs, rebates and resources to help you:

- SAVE MONEY
- SAVE ENERGY
- STAY COMFORTABLE

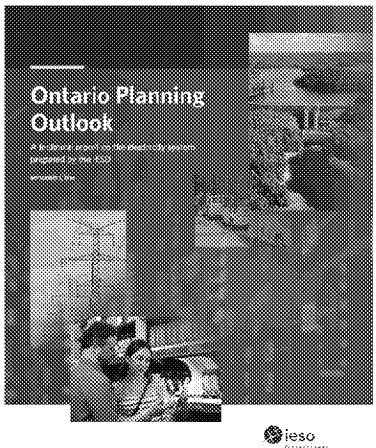
For Homes

- HEATING & COOLING INCENTIVE +
- *Peaksaver Plus®*
- COUPONS +
- Buying a New Home +
- Home Assistance Program +

For Business

- Small Business Lighting
- Retrofit Program +
- *Peaksaver Plus®*
- AUDIT FUNDING +
- EXISTING BUILDING COMMISSIONING +
- Energy Managers +
- HIGH PERFORMANCE NEW CONSTRUCTION +
- PROCESS AND SYSTEMS +
- DEMAND RESPONSE
- TRAINING & SUPPORT +
- NEW HOME CONSTRUCTION +
- Social and Assisted Housing

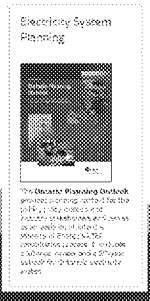
IESO's Ontario Planning Outlook



- The Ontario Planning Outlook is a technical report that provides a 10-year review (2005-2015) and a 20-year outlook (2016-2035) for Ontario's electricity system
- The report responds to a June 10, 2016, request from the Minister of Energy to have the IESO submit a technical report on the adequacy and reliability of Ontario's electricity resources

The OPO:

- Considers a range of potential long-term electricity demands
- Provides insights and considerations for the operational needs associated with implementing low carbon resources, electrification and the growth of distributed energy resources



The report can be found on the main page of the IESO's website @ ieso.ca

Net Energy Demand Across Demand Outlooks

Four Outlooks

Outlook A

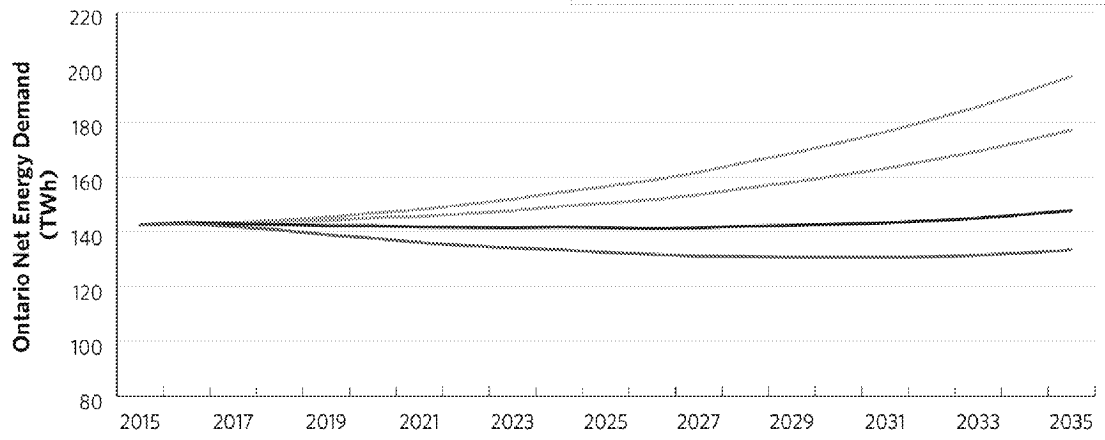
(or low demand outlook), which explores the implications of lower electricity demand

Outlook B

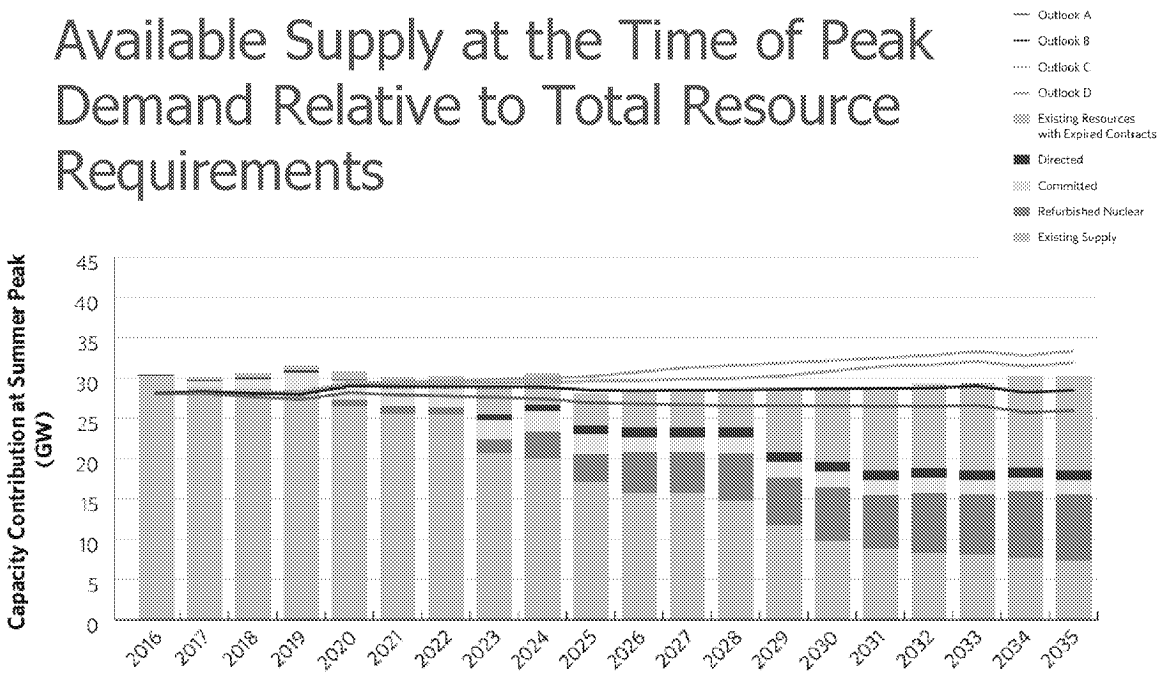
(or flat demand outlook), which explores a level of long-term demand that roughly matches the level of demand that exists today

Outlook C Outlook D

(or higher demand outlooks), which explore higher levels of demand driven by different levels of electrification associated with policy choices on climate change

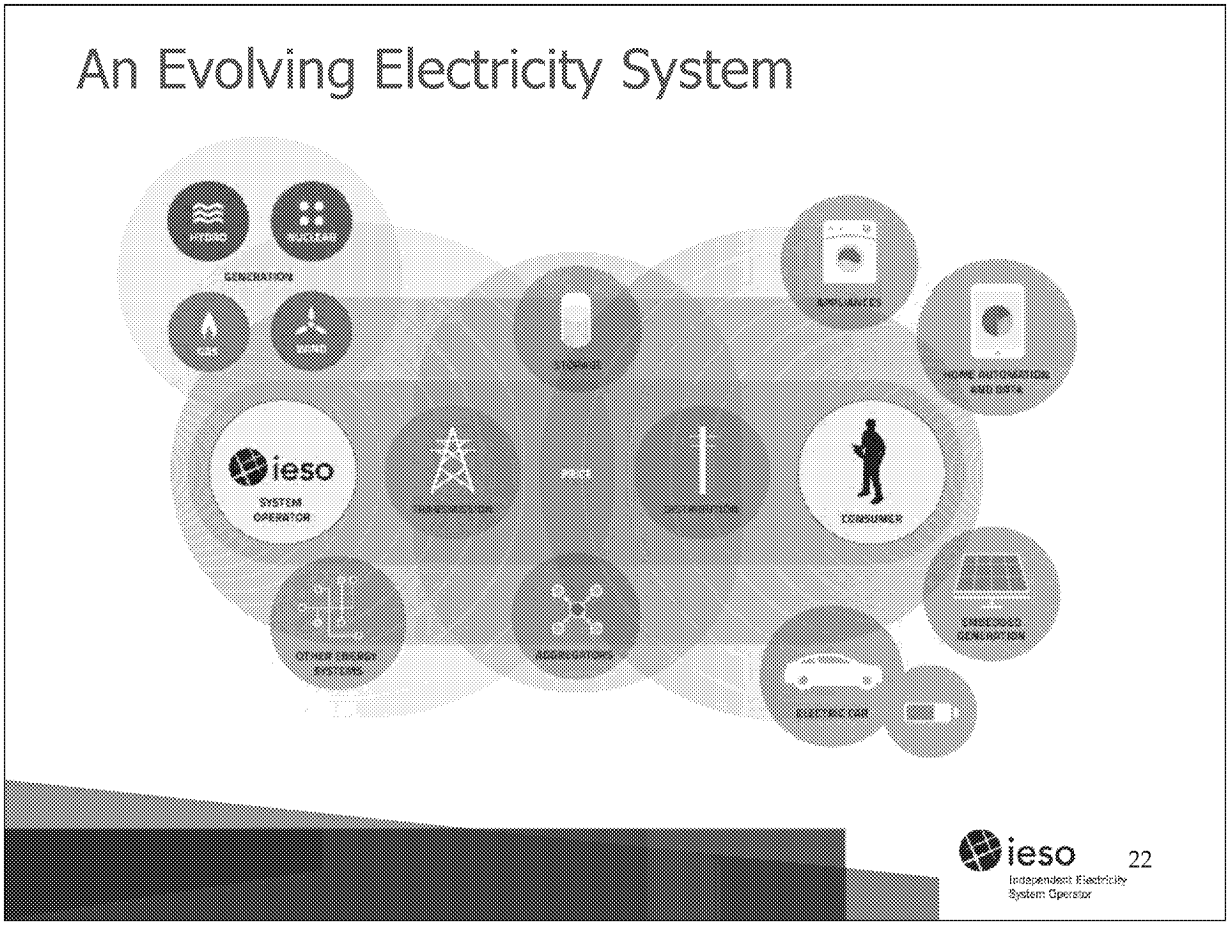


Available Supply at the Time of Peak Demand Relative to Total Resource Requirements



Conclusions

- Because of current and past investments, Ontario is well-positioned to meet provincial needs until the mid-2020s, while continuing to adapt to significant change across the sector.
- Implementation of the province's climate change policies will have an impact on the demand for electricity, including through greater electrification of the economy.
- In higher demand outlooks, additional investments in new resources (conservation, generation and transmission) would be required to meet the increase in demand. However, opportunities for increased conservation will also vary with increases and decreases in demand.
- The total cost of electricity service over the planning outlook will be a function of demand growth, the cost of operating the existing system and the investments required in new resources to meet potential needs.



The smart grid is ushering in a new area of distributed control over the power grid

Third party control centres, consolidated LDCs, and even your home, vehicle and end-use devices will eventually have the capability of making sophisticated optimization decisions over energy consumption, storage and production

This distribution of control is driving changes in the way the IESO operates the grid

For example, if the Ontario government's electric vehicle targets are met by 2020, over 8,600 MW of battery storage capacity could be connected to the electricity system, creating up to 1,800 MWh of daily load shifting capacity

New market entrants and new technologies are being enabled by the smart grid and changing the nature of what it means to be in the electricity sector

For example, an aggregator market participant role is starting to be widely recognized as a critical link between wholesale markets, end-use consumers and the rest of the smart grid

Interoperability will play an important role in making the smart grid work

Technological standards – particularly in the area of behind-the-meter services – threatens to become one of the biggest barriers to the timely development of the smart grid

These changes will require revisions to regulatory instruments (codes, licences, etc.) and government policy

Interest in Ontario is growing at a rapid rate

For example, over the past few years the IESO has been approached by various companies with various technologies wishing to explore the possibility of integrating a grid-scale energy storage solution with the IESO-administered markets

We are also starting to identify some of the changes that would be required to Market Rules, registration and enrolment, business processes and documentation, tools and systems to eventually accommodate new participants

While it won't necessarily be an easy fix, we see significant upside potential in trying to integrate these new technologies:

Create new markets and areas of economic activity for Ontario

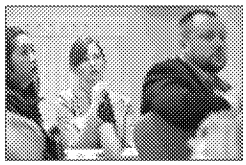
Greater wholesale market liquidity

Market efficiency gains
Absorb SBG and reduce Global Adjustment
Congestion relief and peak load trimming

Seeking and acting on input from our communities, customers and stakeholders

Stakeholder and community engagement is integral to the IESO's decision-making process:

- The **Stakeholder Advisory Committee** – stakeholder representatives provide advice and recommendations on market development, conservation and planning decisions directly to the IESO's Board of Directors and Executive Leadership Team
- **Stakeholder Engagement Initiatives** – sessions on a range of topics designed to provide open, two-way dialogue with stakeholders to help the IESO understand the views of stakeholders about proposed changes that may affect them
- **Engagement Forums** – collection of forums including Technical Panel, Standing Committees, Working Groups, Change Management
- **Community Engagement in Regional Planning** – through the development of the Integrated Regional Resource Plan (IRRP), the IESO invites municipalities, community groups, stakeholders and the general public to provide input into the development of their region's electricity plan



Engagement Principles

1. Analyze Opportunities for Engagement
2. Ensure Inclusive and Adequate Representation
3. Provide Effective Communication and Information
4. Promote Openness and Transparency
5. Provide Effective Facilitation
6. Communicate Outcomes
7. Measure Satisfaction

Introduction to Ontario's Markets

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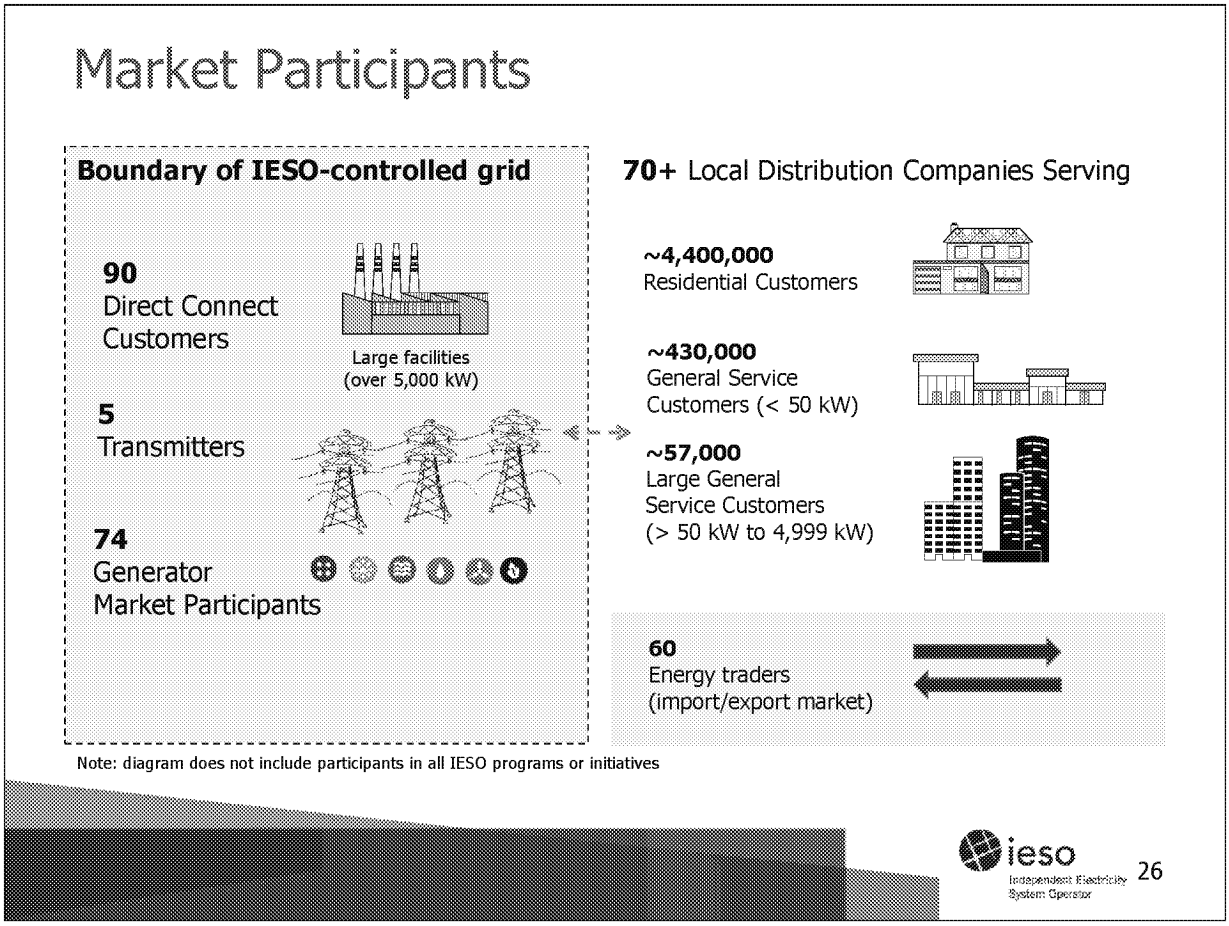
The Wholesale Electricity Market

- Primary role of the spot market - the **efficient dispatch** of resources to meet system demand
- The market helps to maintain the reliability of the electricity system by enabling the efficient allocation of resources.
- Produces a **transparent, efficient price signal** that reflects the incremental cost of energy
- **Competition** amongst resources encourages resources to offer reflecting their marginal cost of production, lowering costs for consumers
- Wholesale market includes the economically efficient **scheduling of energy** between Ontario and neighbours (imports and exports)

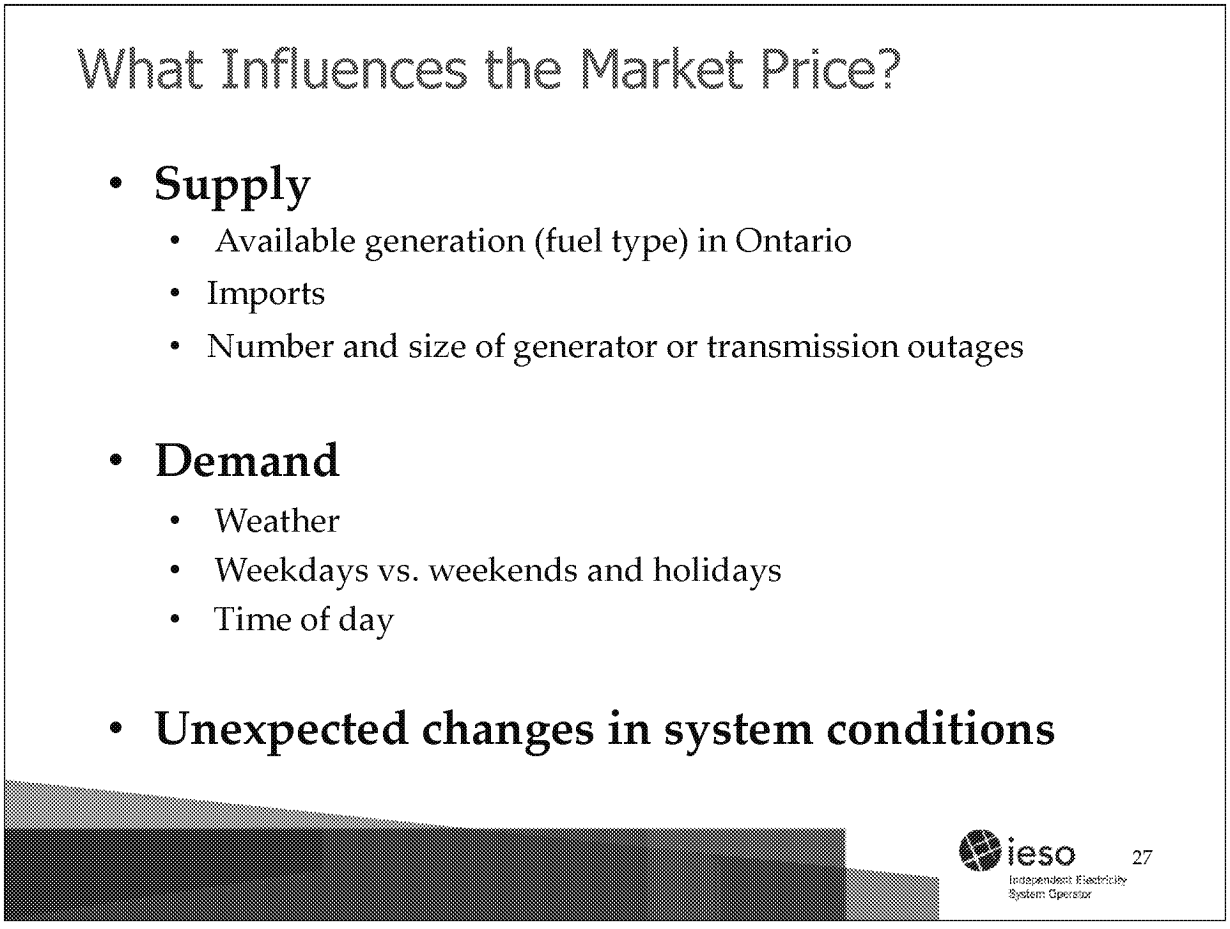


Our electricity market spans the IESO-controlled grid, which includes all transmission lines above 50,000 volts. This includes about 90 large-scale industrial facilities that connect directly to the high-voltage transmission grid. It also includes a number of large generating stations, including nuclear, hydroelectric, natural gas, biomass, solar, wind and others.

Although Hydro One is by far the largest transmitter in the province, there are several other, smaller transmission networks serving local needs. The deal hasn't gone through yet, but earlier this year, Hydro One announced it had entered into a purchase agreement to acquire Great Lakes Power Transmission LP from Brookfield Infrastructure.

And then there are the province's distribution companies that buy power from our spot market to serve over 5 million residential and small business customers across the province. Ongoing mergers and acquisitions mean the number is a little fluid, but there are currently approximately 70 local utilities in Ontario.

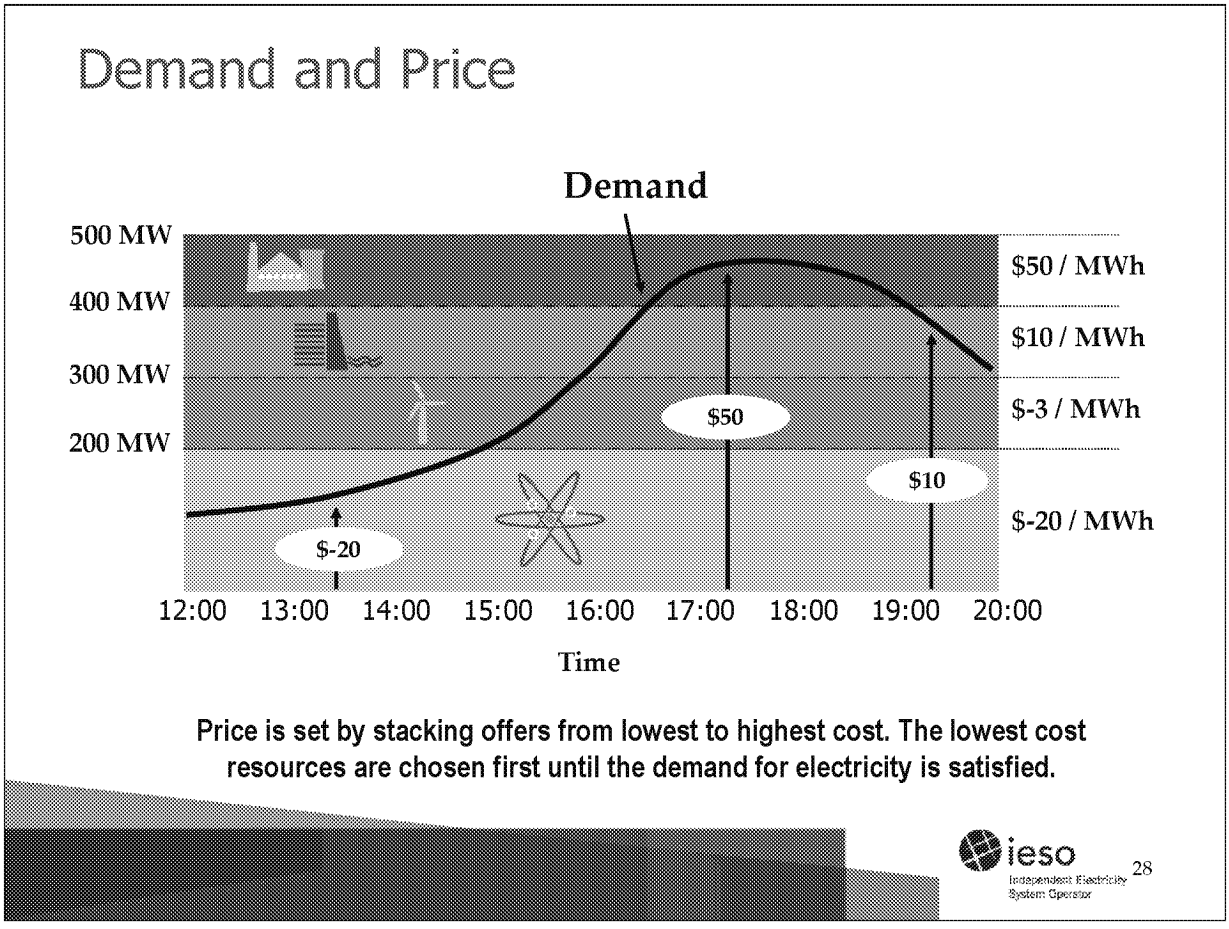
Increasingly, we are finding that this market boundary is starting to erode. As we will see later in this presentation, a growing number of retail customers are generating and storing their own power. They are also making more sophisticated use of electricity and electricity prices.



Which leads me to my next topic – What influences the Wholesale Price. Why can price fluctuate so much from day to day, hour to hour, and even 5-minute interval to 5-minute interval?

The basic answer, not surprisingly perhaps, is supply and demand – Anything that affects these two will influence price.

On the supply side, there are two main influencers –
The total supply of energy available both within Ontario and regionally, and
The type of available generation, as different generators have different cost structures



Every five minutes, we determine where the demand curve crosses the supply stack. Where supply and demand meet, we set the market clearing price.

In this example, the demand at 13:30 is about 60MW. This can be entirely satisfied by GEN 1. Therefore, GEN 1 is dispatched to 60MW. GEN 2 and GEN 3 are out of the money, and are not dispatched. MCP is set at $15. This is a uniform price – All generators in Ontario are paid this price and all loads are charged this price

By 17:30, demand has increased to about 225MW. Therefore, GEN 1 is dispatch to 125MW, GEN 2 is dispatch to 50MW, GEN 3 is dispatch to 50MW, and MSP is set at $38.

By 19:30, demand has dropped to about 175MW. Therefore, price is set at $25. This means that GEN 1's $38 offer is out of the money. Therefore, GEN 1 is dispatch to 100MW, GEN 2 is dispatch to 50MW and GEN 3 is dispatch to 25MW.

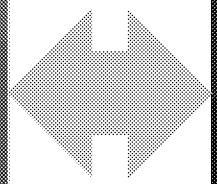
Prices are set every 5-minutes, however, non-dispatchable loads are charged an hourly price. This price is called HOEP and is the arithmetic average of the prices over the hour.

Generators will offer as low as possible in order to be scheduled
Tested in other markets
Ran simulations and found massive inefficiency in economic dispatch as everyone tried to figure out what the highest possible price would be

Market Price and Global Adjustment

Market Price

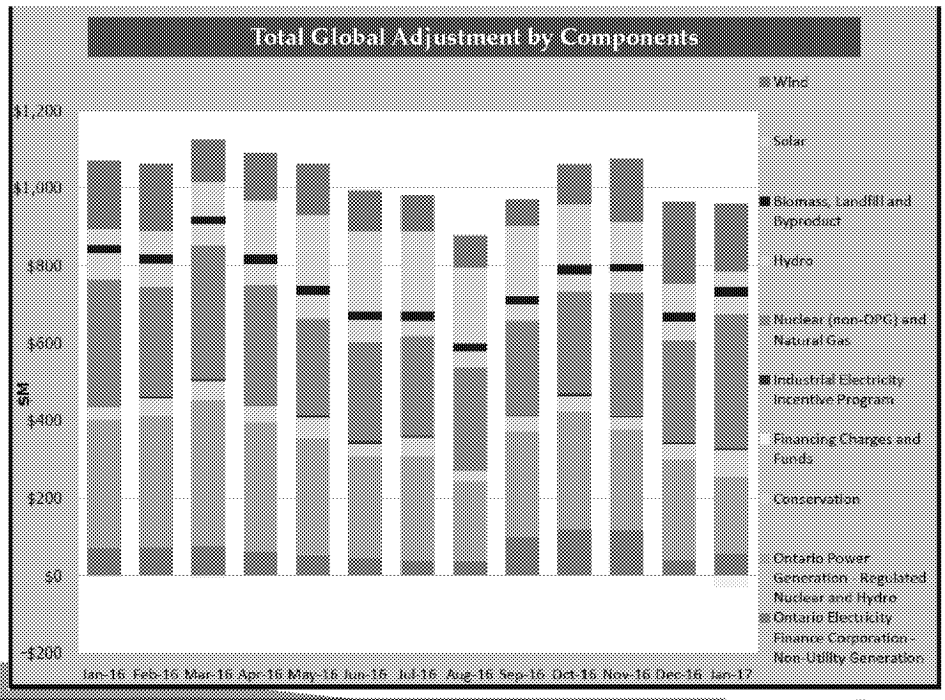
- Signals current supply and demand situation
- Covers operational costs of electricity production – such as fuel
- Impacted by consumption, weather, time of day, season, and sometimes contracts
- Set every 5 minutes



Global Adjustment (GA)

- Fixed investment or capacity costs to build or refurbish infrastructure
- Revenues that are not recovered through market price
- Includes contracts, and regulated rates to generators, as well as conservation
- Set on a monthly basis

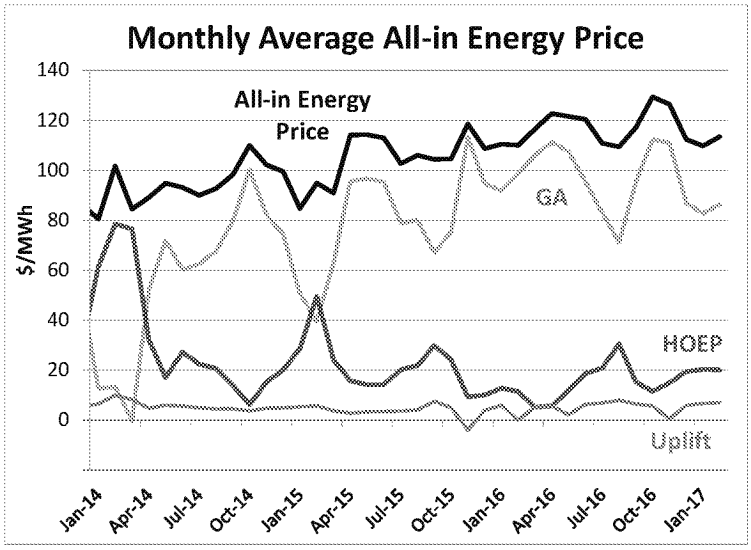
Global Adjustment



Source: IESO Monthly Market Report | January 2017

All-In Price of Electricity

- Global Adjustment and HOEP *(the market price)* have inverse relationship
  - As HOEP decreases, costs recovered through Global Adjustment must increase
  - Costs not recovered through HOEP revenues are recovered through Global Adjustment
- GA + HOEP + Uplift = All-in Energy Price
- Uplift charges recover costs for other services that ensure reliability



Note: consumers must also pay for other charges, like distribution and transmission

When generators recover costs through the market, they need to recover less through the Global Adjustment

GA + HOEP = the All-in Price for electricity

Uplift charges include things like:

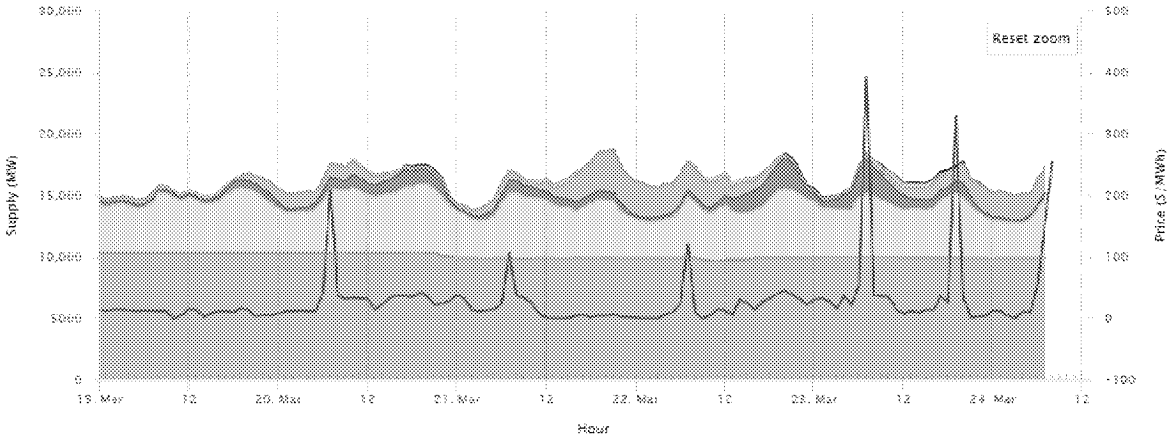
Energy losses

Intertie Offer Guarantees (IOG) – the real-time price can change from the point when we secure an import to when it is scheduled to be imported

Congestion Management Settlement Credits (CMSC) – payment to generators and large consumers when they are instructed to take specific actions to avoid possible overloads of the transmission system, or to maintain the balance of supply and demand

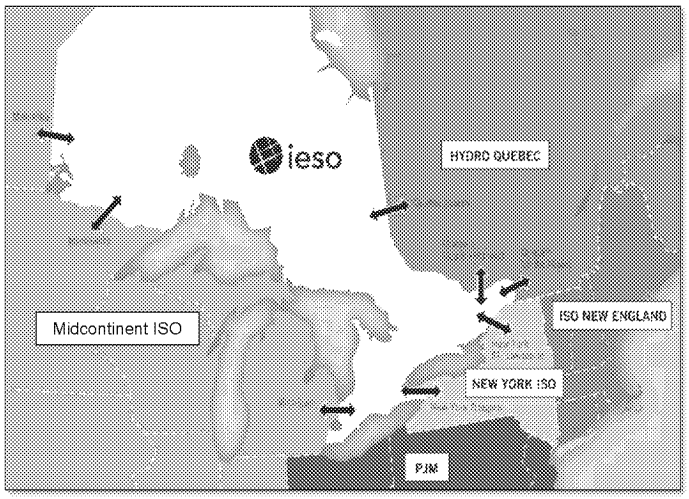
Operating Reserve Prices

Supply, Demand and Price in Real Time



Interjurisdictional Trade

- Ontario currently exports and imports electricity between adjacent jurisdictions as part of the regular operation of its electricity market:



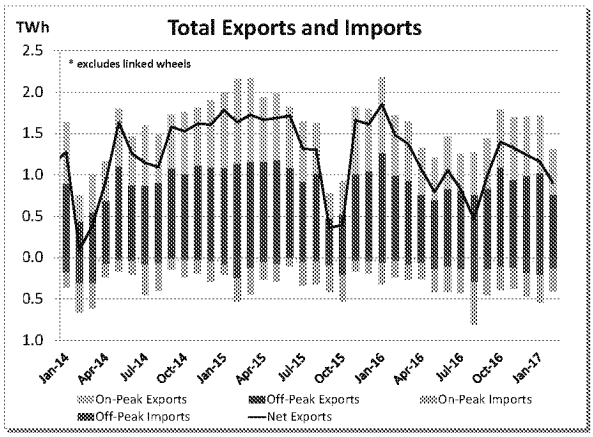
- **Imports** compete with domestic generation allowing the least expensive resources to be scheduled to supply electricity to the system
- **Exports** assist with managing surplus conditions and provide revenue that contributes towards reducing costs that otherwise would have had to be paid for by Ontario consumers

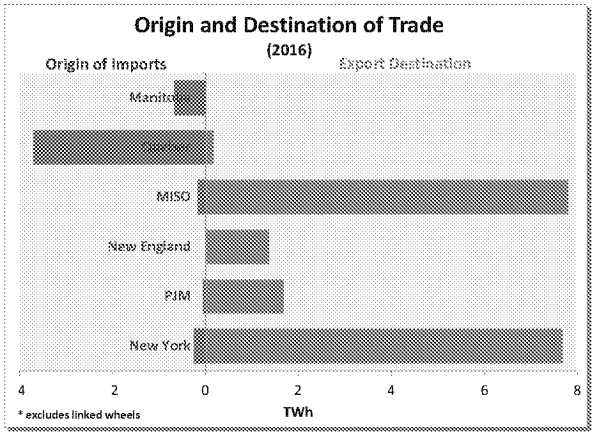
From a reliability perspective:
the IESO works with other system operators to use these resources to maximize reliability within the province.
From an economic perspective:
the Ontario wholesale electricity market is designed to constantly seek out the least cost supply to meet Ontario's electricity needs – including imports

Transmission Rights Auction

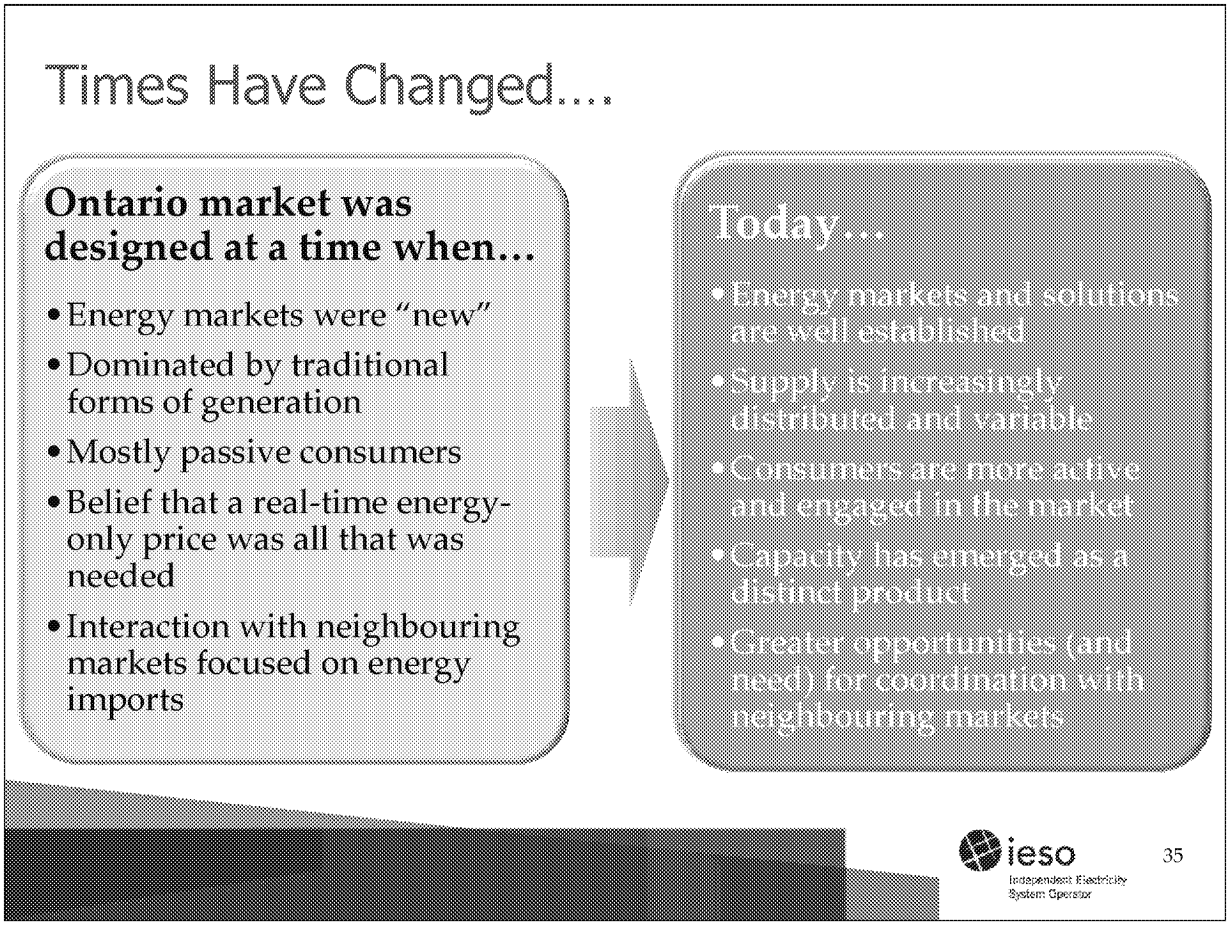
Most uplifts apply to exports (except RRA, DRC and OPA fee)

Import and Export Trends Cont'd





High energy prices in fall 2015 led to a reduction in export volumes and in one-quarter of all hours, Ontario was a net importer of electricity.



In 2002 there was no accepted "best practice" for energy market design.

Markets were developed to provide reliable electricity supply from a known and established supply mix

Customers had little experience (or desire) to manage electricity costs in response to market conditions

Energy-only markets were seen as the panacea and all that was required to manage the system

Today, Ontario has shown the world it is possible to retire coal-fired generation, which used to provide as much as 25% of supply, with cleaner forms of generation

However, the supply mix is more complex and distributed than it was in 2002

More than 24,000 generators, from the large Bruce nuclear generating stations to the thousands of rooftop solar installations, combine to power Ontario.

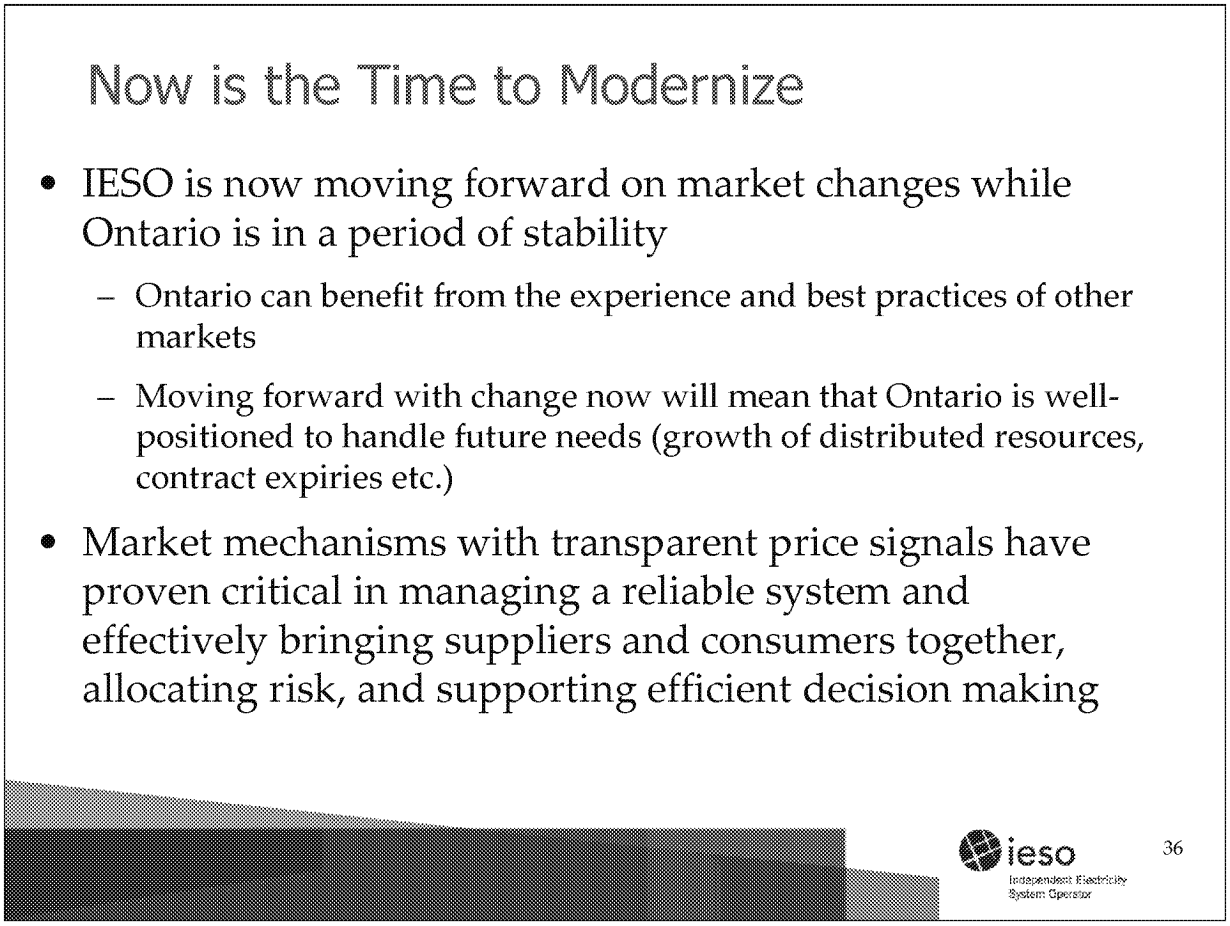
As a result we see increased variability - both in supply at the grid level, but also in the demand that the grid must satisfy

Consumers are far more active - ranging from large industrial facilities reducing strain on the power system on high demand days to individual homeowners changing their consumption in response to time of use pricing

But I believe we have only scratched the surface - customers are looking for even more opportunities to manage their electricity costs and provide benefit to the system.

The coordination of all of these different factors efficiently requires finding a way to make sure the right information gets to both generators and consumers at the right time to inform effective decision making – this is where markets can help

However, the market design we have today was developed at a time when the landscape was far different from what it is today



Now is the right time to move forward on market changes while we are in a period of stability and surplus
The system needs in Ontario are common to many jurisdictions across North America
Ontario can learn from the experience of other markets to understand how to apply these lessons to our own system
In a way this is an opportunity to take best practice and build on their efforts
Moving forward with change now will mean that the market is well-positioned to handle future needs
We have seen how effective markets can be in other jurisdictions
We don't pretend that they are always easy – they are often complex, contentious and frustrating
We know there will be issues
But we also know they bring transparency to the market and, if designed well, enable suppliers and consumer to interact efficiently
We have time to get it right and we have a duty to do our best to put in place the best possible mechanisms to serve our system in the future – when needs emerge and reliability depends upon the efficient operation of the marketplace
The time is right since we are in a period of stability and surplus and can learn from the lessons of other jurisdictions

Evolving the Market: Market Renewal

- The IESO is currently engaging stakeholders on its Market Renewal initiative, a series of projects that will occur over the next few years
- Purpose is to address known market inefficiencies and lay the foundation for a more dynamic market in the future
  - Make changes to more efficiently schedule resources
  - Use capacity auctions to allow all resources to compete to meet future incremental capacity needs
  - Changes to meet emerging operability needs, such as more frequent scheduling of energy imports and exports
- The Market Renewal draft benefits case shows the potential for about $3.4 billion in savings between 2021 and 2030, about $3 billion of which would benefit consumers