

Integrating Renewable Generation: Ontario's Smart Grid Approach

Ken Nakahara
Director (A), Strategic Policy and Research
Ontario Ministry of Energy



IEEE International Conference on Smart
Energy Grid Engineering (SEGE'13)
28-30 August, 2013

Three Part Presentation

- Ontario's Long Term Energy Plan Review
- Renewable Integration
- Smart Grid and Distribution

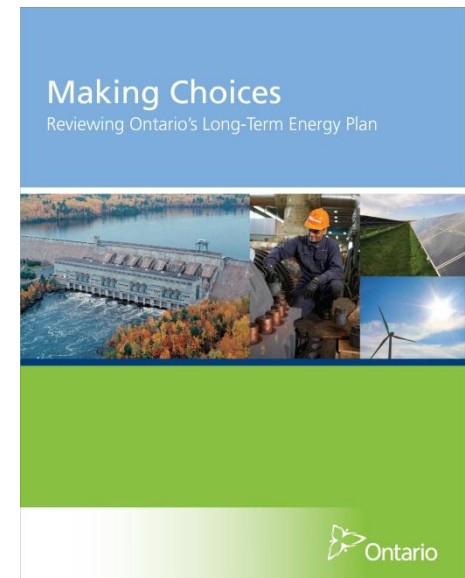
Ontario (Canada)

- 13 million inhabitants
- GDP of \$638 billion (CAD)
- Energy-intensive industries remain an important part of the provincial economy
- Hybrid market electricity structure
- Home to some of North America's densest urban areas, as well as a number of remote and isolated Northern communities



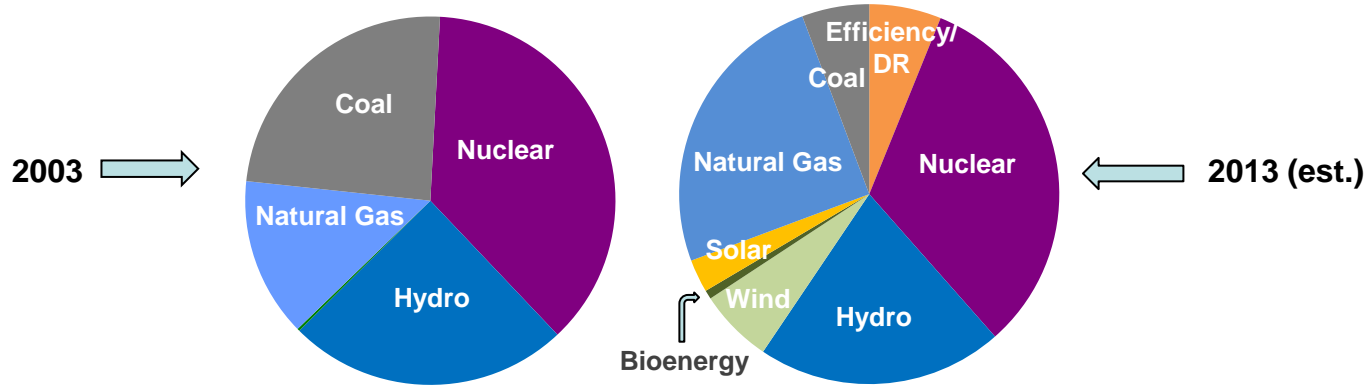
Ontario's Long-Term Energy Plan Review

- In November 2010 the government released its Long-Term Energy Plan (LTEP), a comprehensive direction for Ontario's energy future on all aspects of Ontario's electricity system, including conservation, generation, transmission, distribution, and emerging technologies such as energy storage.
- On April 16, 2013, Minister Chiarelli announced a formal review of LTEP to be completed within six months. He noted that the review process would include:
 - A strong and transparent consultation process with the public, municipalities and the energy sector;
 - Consultation sessions being held in every region of the Province;
 - Engagement with Aboriginal communities and leaders; and
 - Opportunity for the public to comment through the web.



Ontario's supply mix has changed over the years

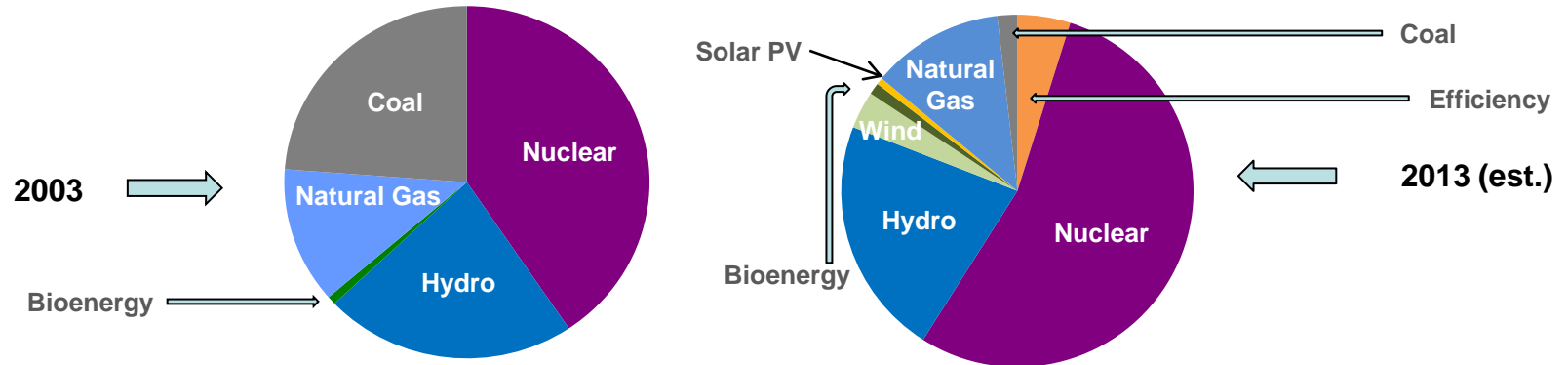
System Capacity in Ontario (MW)



Installed Capacity	2003		2013 (est.)	
	MW	%	MW	%
Nuclear	11,600 MW	37%	12,900 MW	32%
Hydro	7,700 MW	25%	8,400 MW	21%
Wind	--	--	2,500 MW	6%
Bioenergy	70 MW	<1%	300 MW	1%
Solar PV	--	--	1,100 MW	3%
Natural Gas	4,400 MW	14%	10,000 MW	25%
Coal	7,500 MW	24%	2,300 MW	6%
Efficiency/DR	0 MW	0%	2,600 MW	6%
Total	31,300 MW	100%	40,100 MW	100%

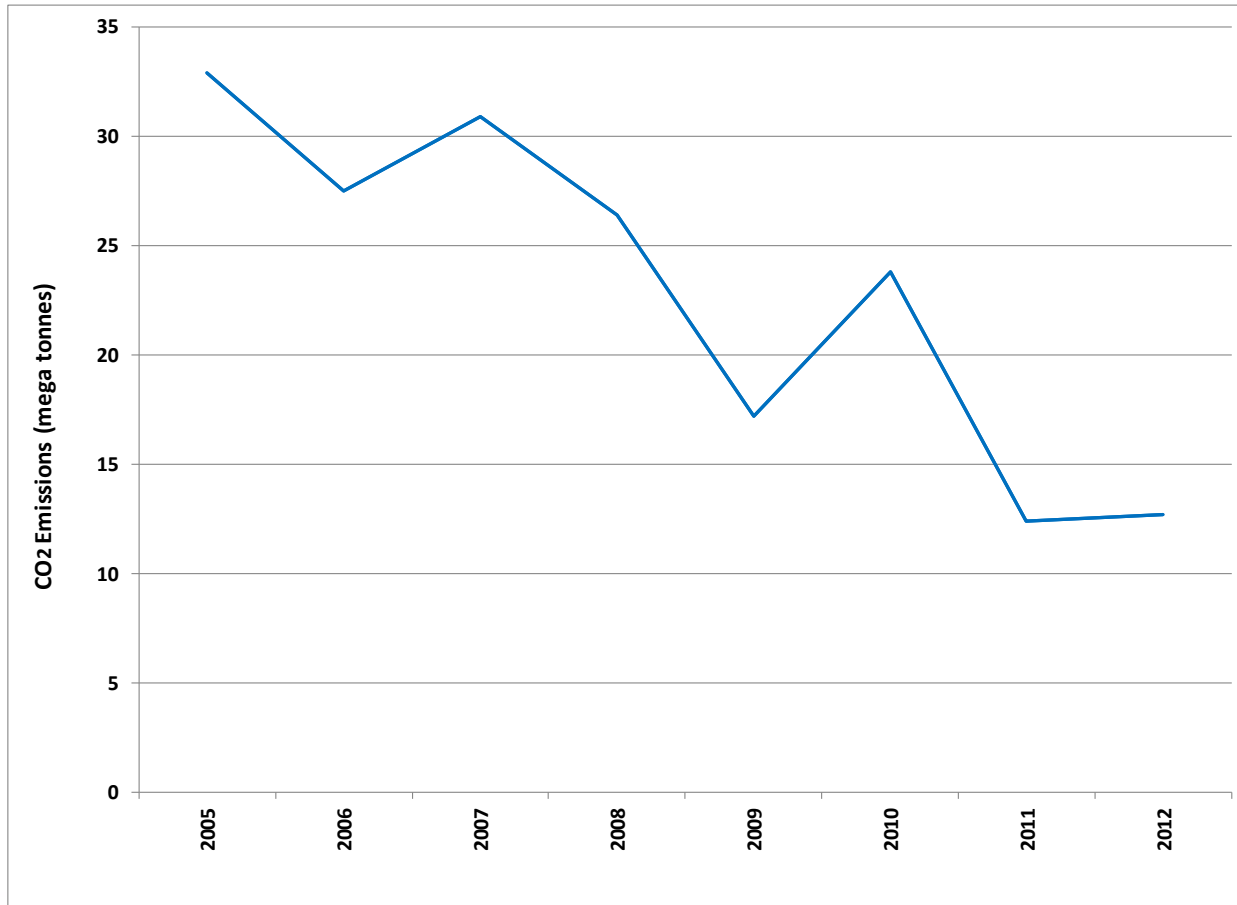
As the Portfolio evolved, the amount of energy produced from different sources has also changed

Electricity Generation and Conservation in Ontario (TWh)



Energy	2003		2013 (est.)	
	TWh	%	TWh	%
Nuclear	63 TWh	43%	89 TWh	54%
Hydro	35 TWh	23%	36 TWh	22%
Wind	--	--	6 TWh	3%
Bioenergy	1 TWh	<1%	2 TWh	1%
Solar PV	--	--	1 TWh	<1%
Natural Gas	12 TWh	8%	20 TWh	12%
Coal	37 TWh	25%	3 TWh	2%
Efficiency	0 TWh	0%	8 TWh	5%
Total	148 TWh	100%	164 TWh	100%
Imports	7 TWh		3 TWh	
Exports	4 TWh		16 TWh	

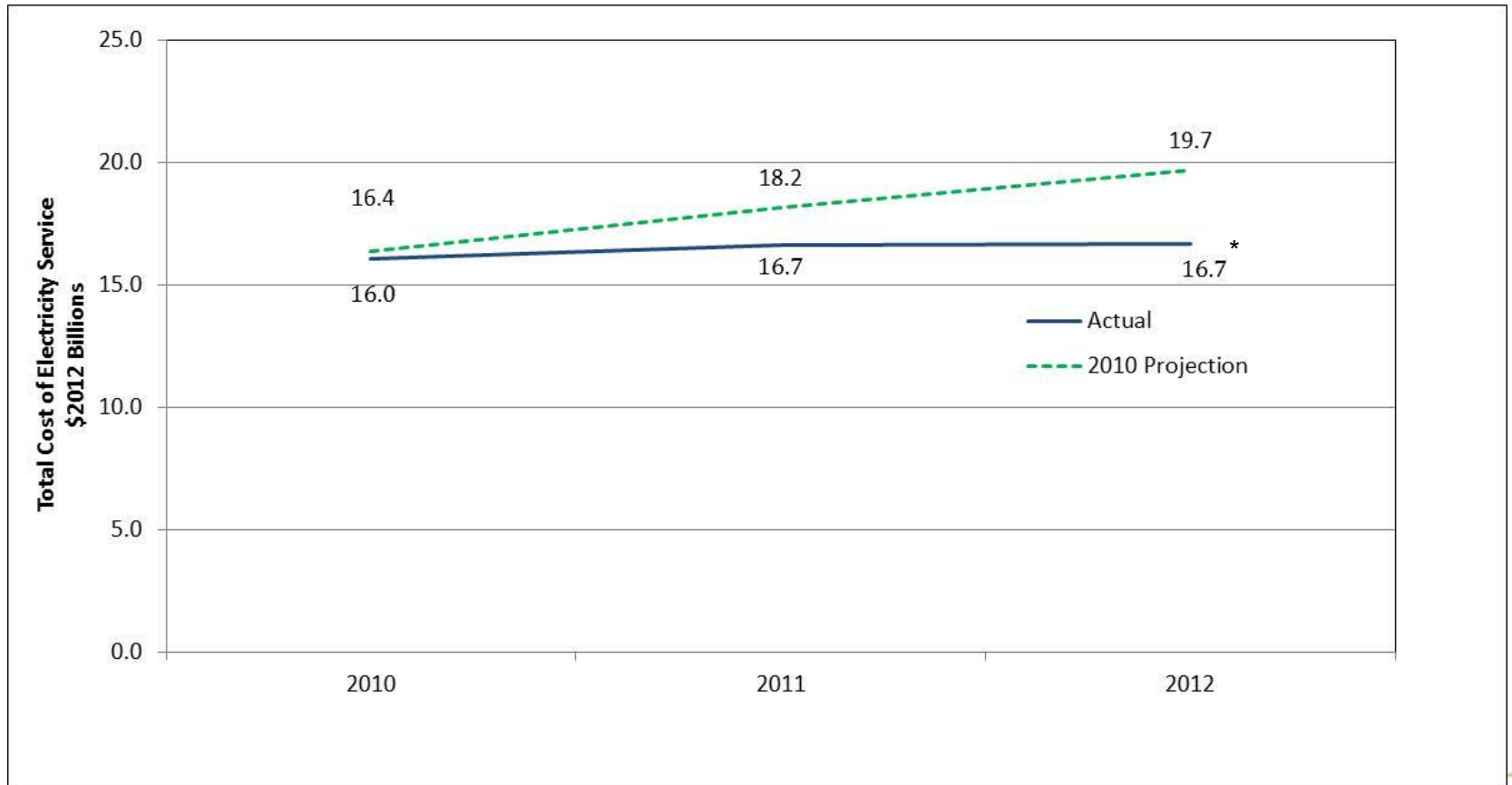
Greenhouse gas emissions are much lower



Source: OPA

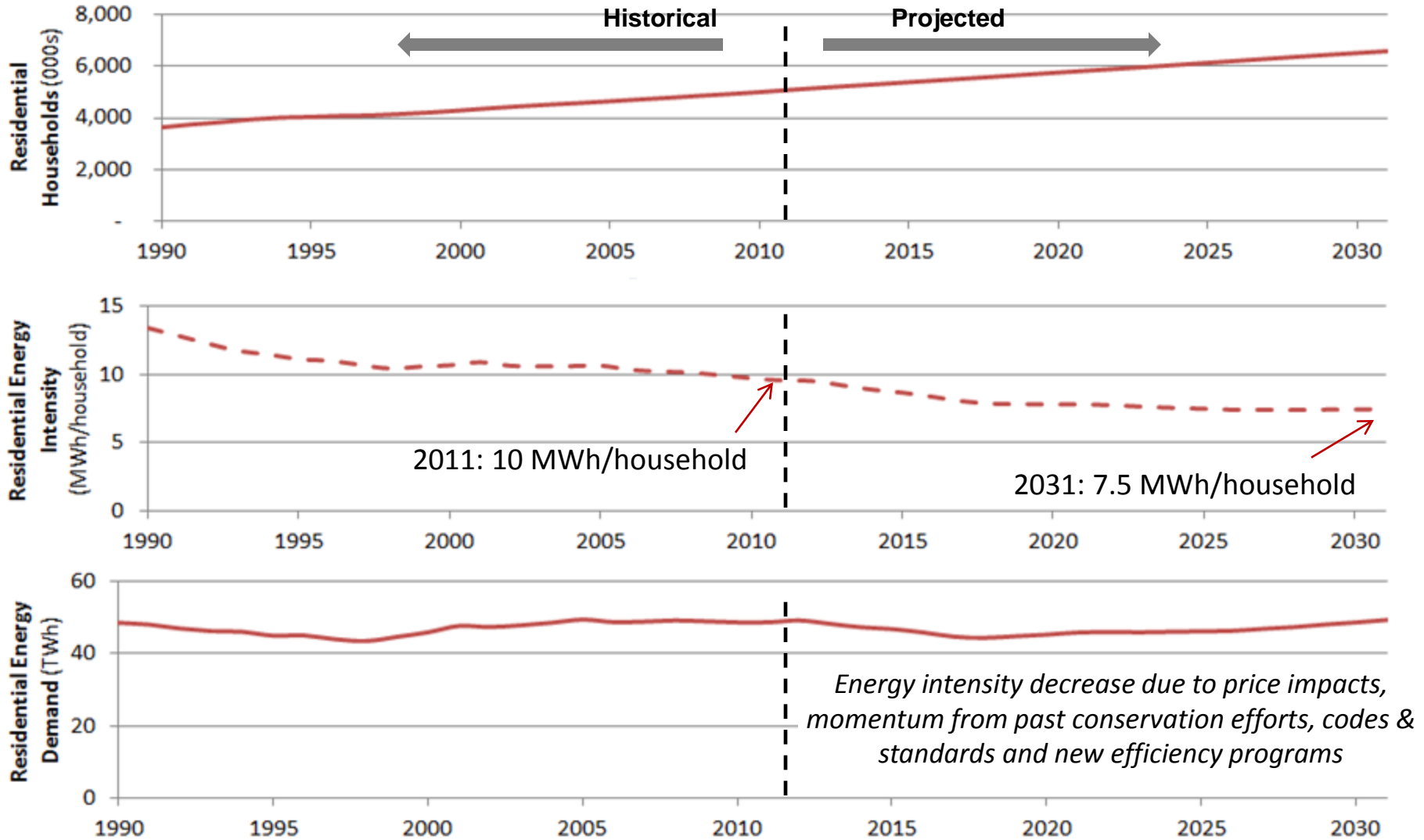


Total costs for electricity service in Ontario have increased, but less than projected in 2010; future costs depend on choices subject of this consultation



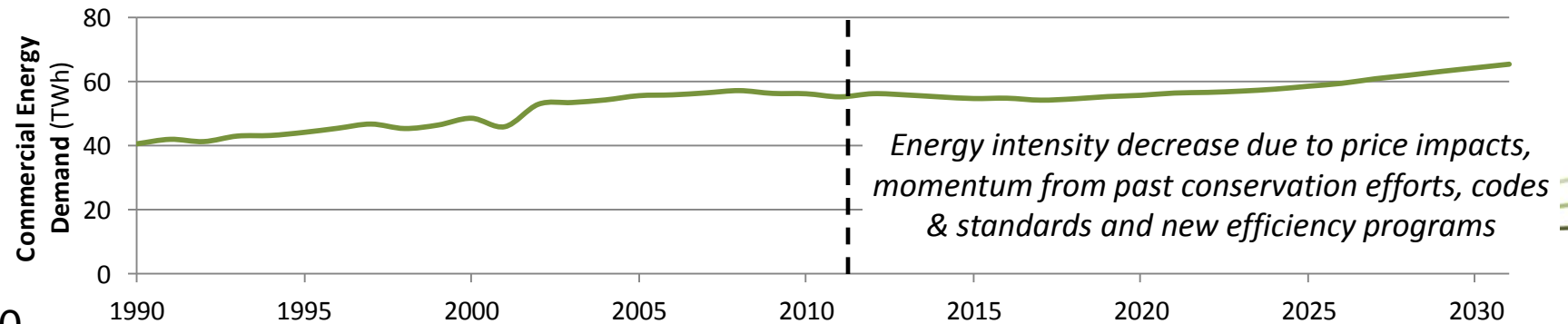
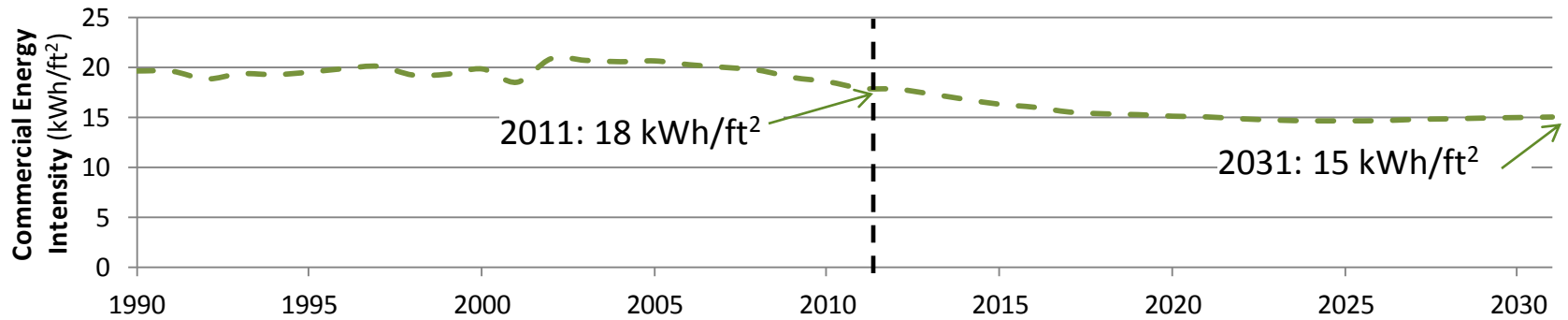
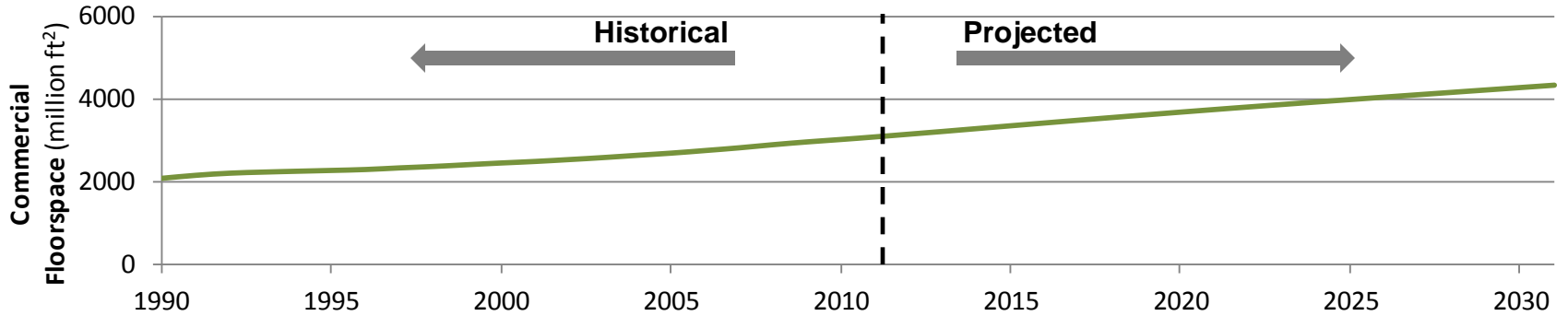
*Distribution component is an estimate

Households are increasing, energy efficiency is increasing

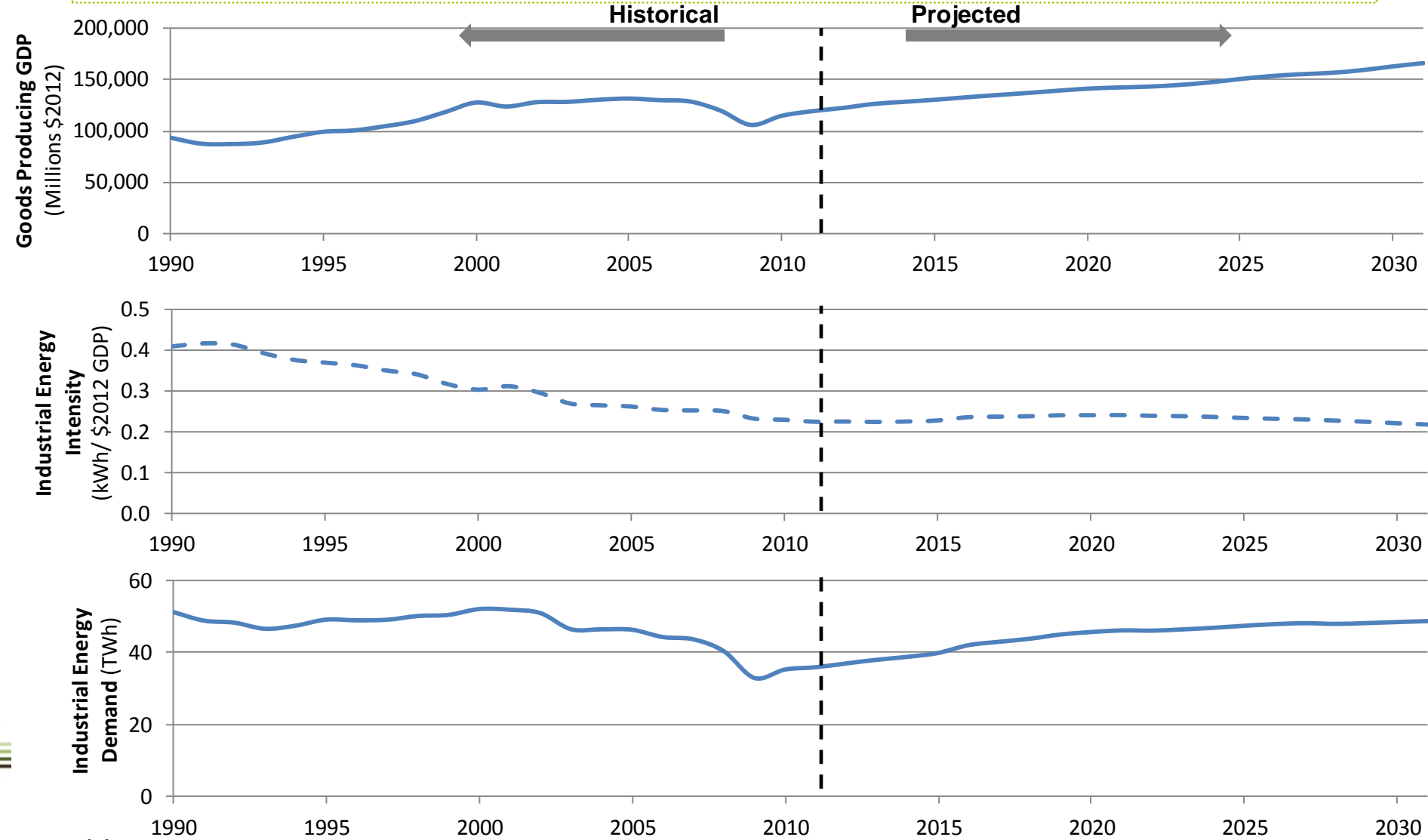


Energy intensity decrease due to price impacts, momentum from past conservation efforts, codes & standards and new efficiency programs

Commercial floor spaces are growing, energy efficiency is increasing

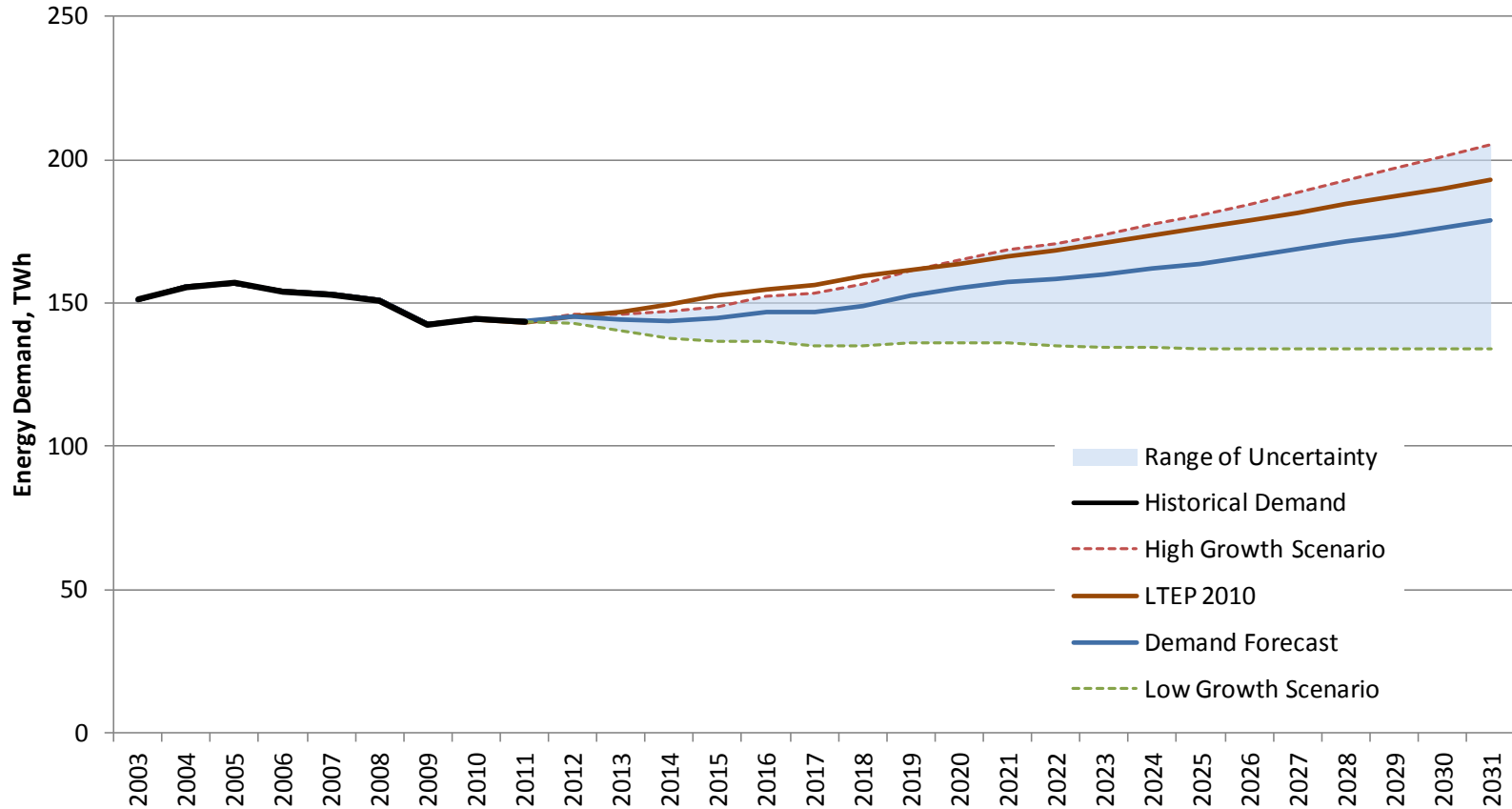


Industrial energy intensity has improved since 1990



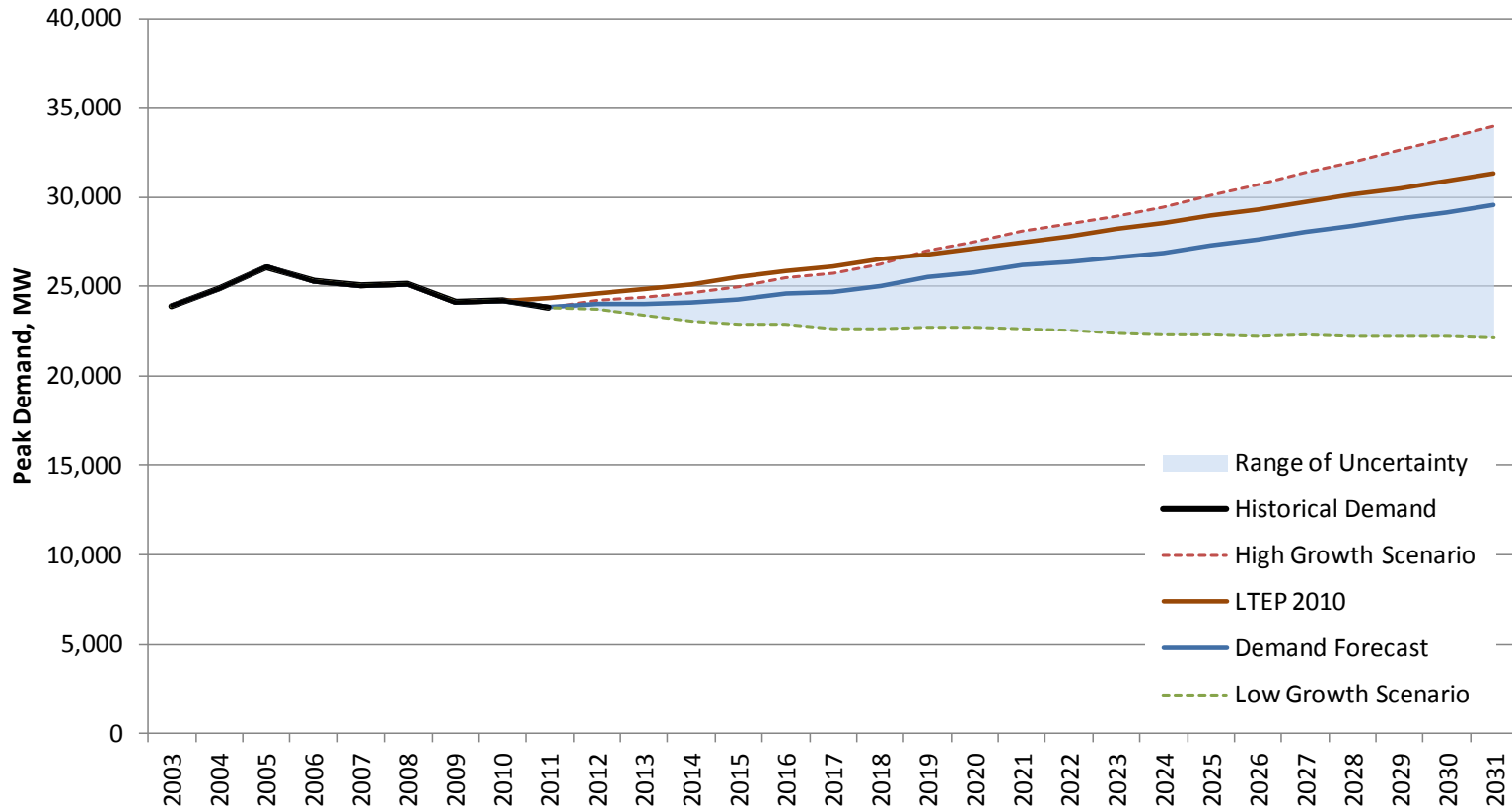
Energy demand is expected to grow slower than forecast in 2010, efficiency and end-use will reduce growth even further

Gross Energy Demand (before taking into account energy efficiency) Forecast 2003 – 2031

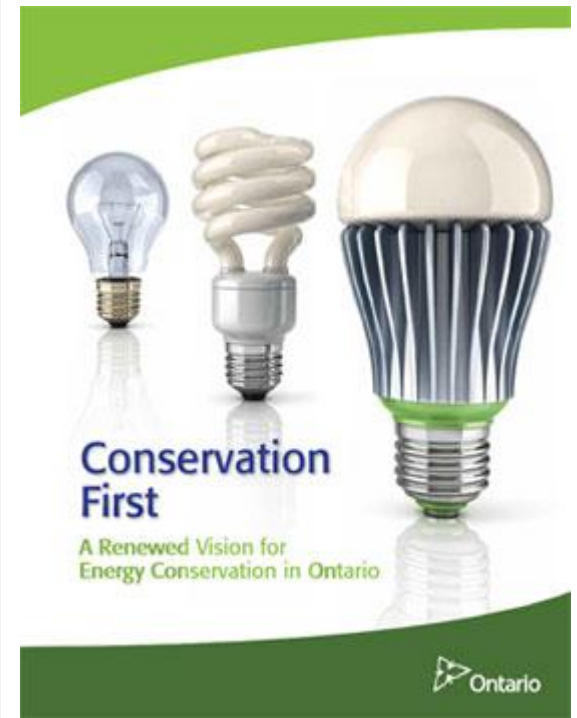
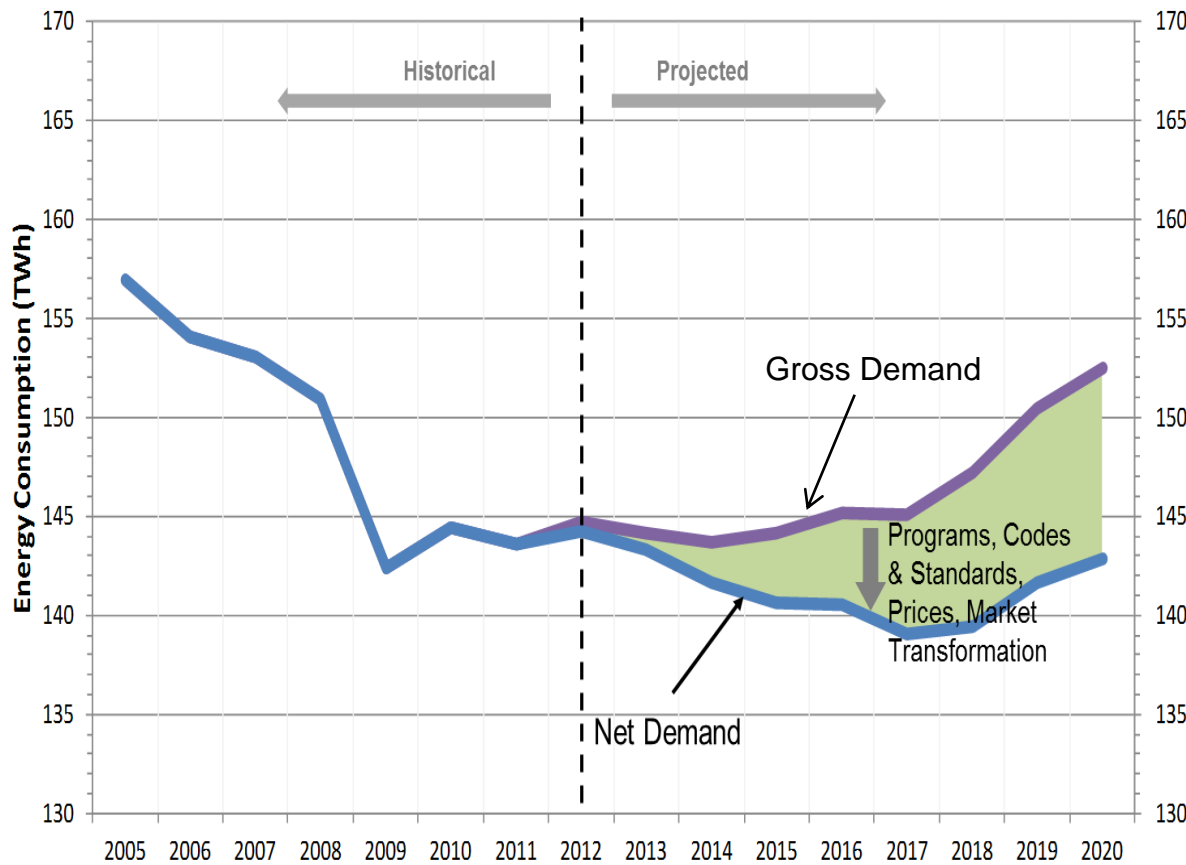


Peak Demand is lower than project into 2010, efficiency and demand reduction measures will reduce it even further

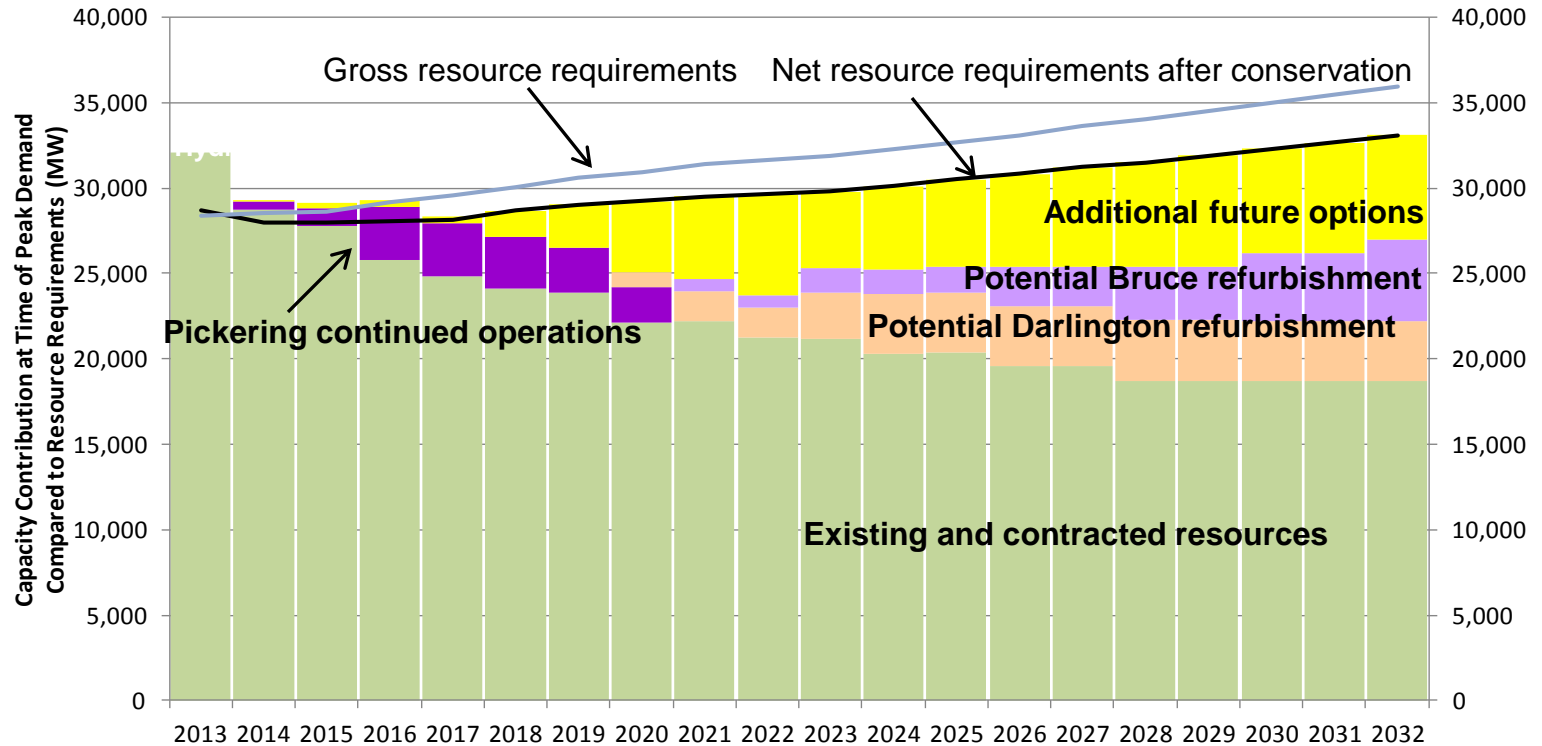
Gross Peak Demand Forecast 2003 – 2031



The assumptions about efficiency reduce the expectations for demand of electricity - how best to achieve this efficiency is subject of this consultation



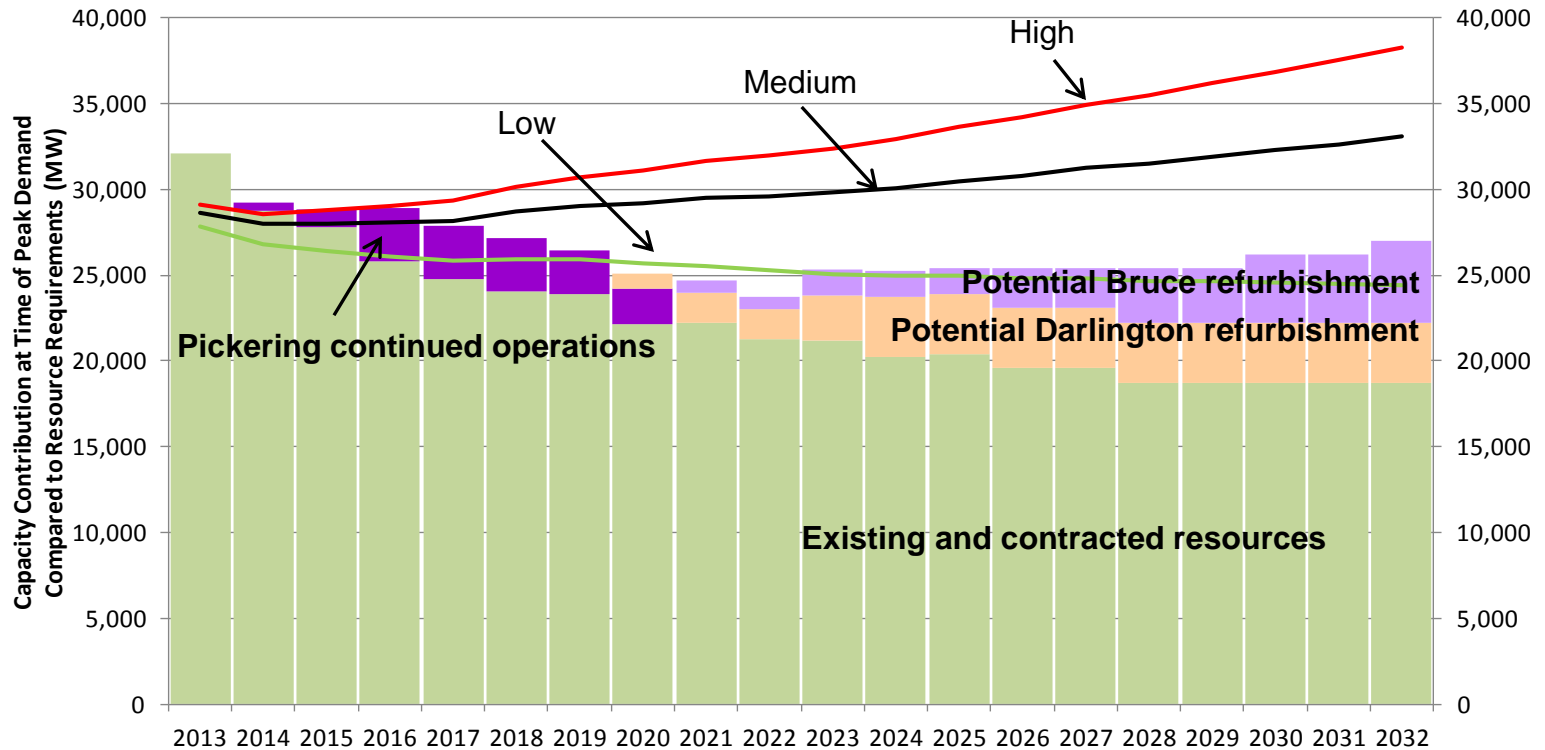
Ontario has surplus generation in the near term, needs begin to emerge in 2018; options are part of our consultation



Notes:

Resource requirements is comprised of demand plus planning reserve as required by reliability standards.
 Contracted resources include contracted renewables and contracted natural gas.

Different scenarios may unfold that result in different electricity demands and consequent infrastructure needs



Notes:

Resource requirements under low, medium and high scenarios are comprised of demand plus planning reserve as required by reliability standards.

Contracted resources include contracted renewables and contracted natural gas.

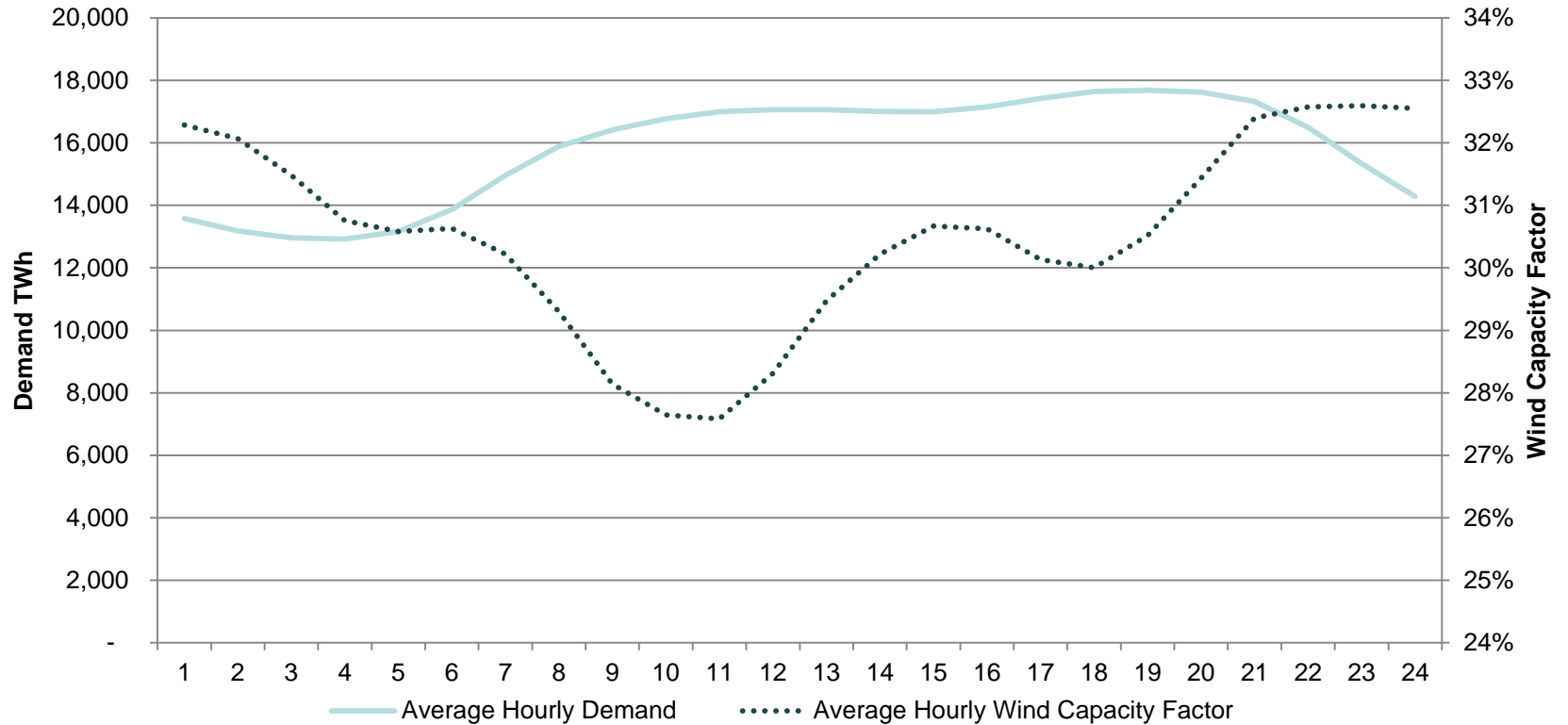
Three Part Presentation

- Ontario's Long Term Energy Plan Review
- Renewable Integration
- Smart Grid and Distribution

Integrating Renewables: A Global Challenge

- Achieving very high shares of renewable energy requires proactively addressing challenges shared across jurisdictions:
 - Managing intermittency and variability.
 - Balancing supply and demand.
 - Addressing power quality issues leading to connection constraints.
- Jurisdictions around the world are increasing the presence of distributed renewable generation on their electricity systems
- Ontario is moving forward with an aggressive expansion of smart grid technologies in order to enable its renewable energy ambitions.
- Ontario is looking to share experiences and learning with other jurisdictions.

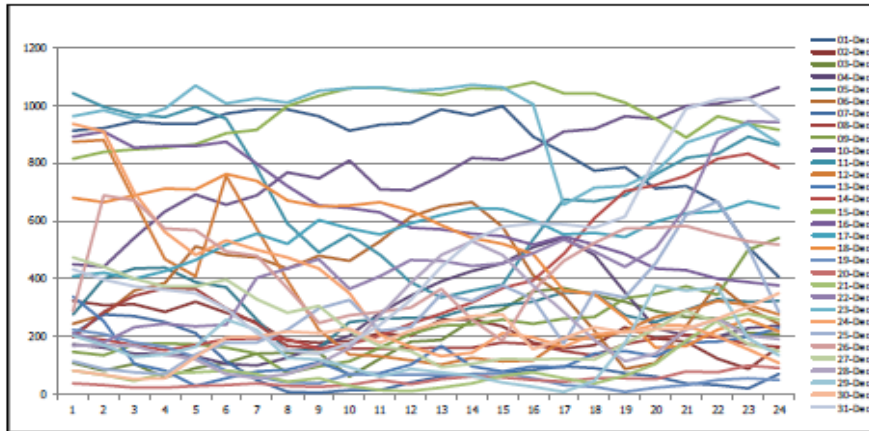
Off-Peak Generation



Source: Ministry of Energy

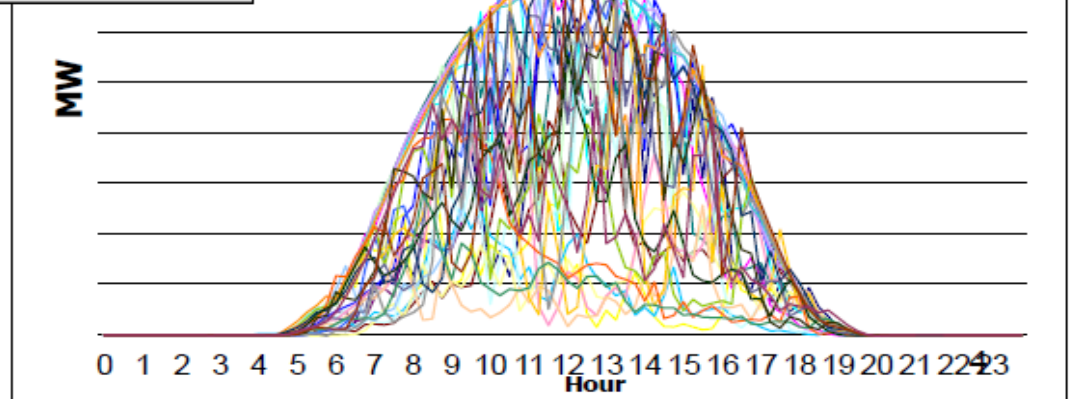
Output Variability

Daily Wind Output for One Month



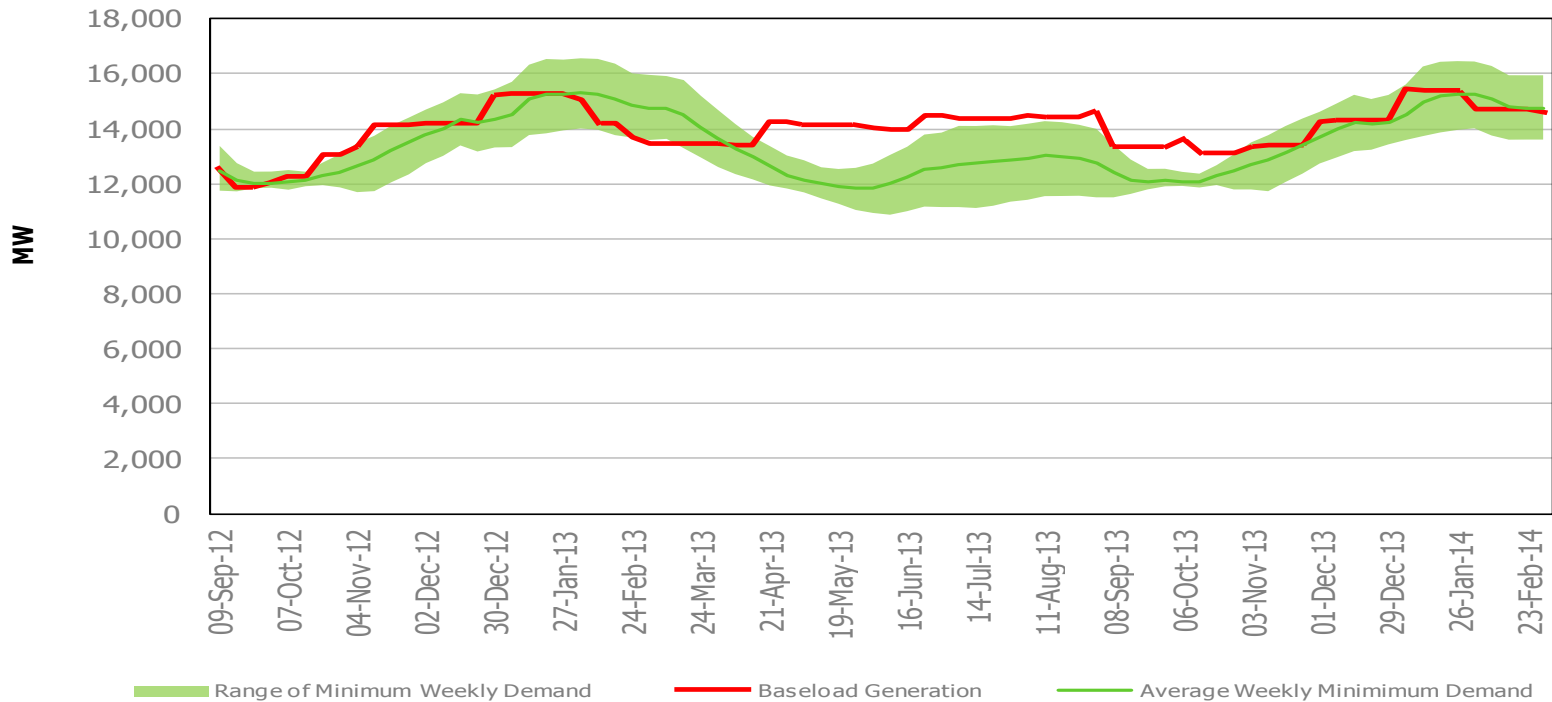
Daily Solar Output

Typical Summer Month



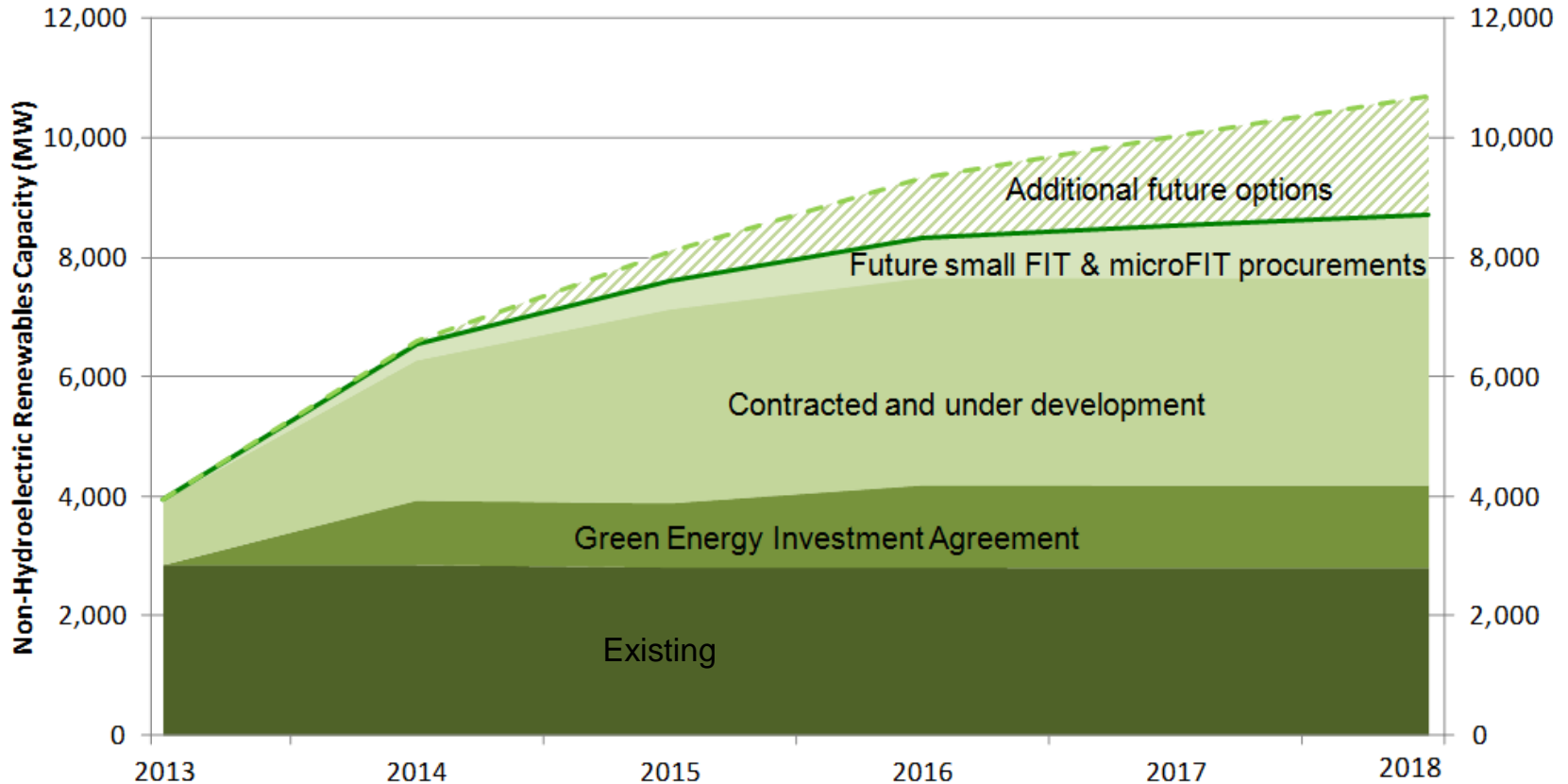
Source: IESO

Surplus Baseload



Source: IESO

The extent and pace of further increases to wind, solar, and bioenergy resources is subject of our consultations



Notes:

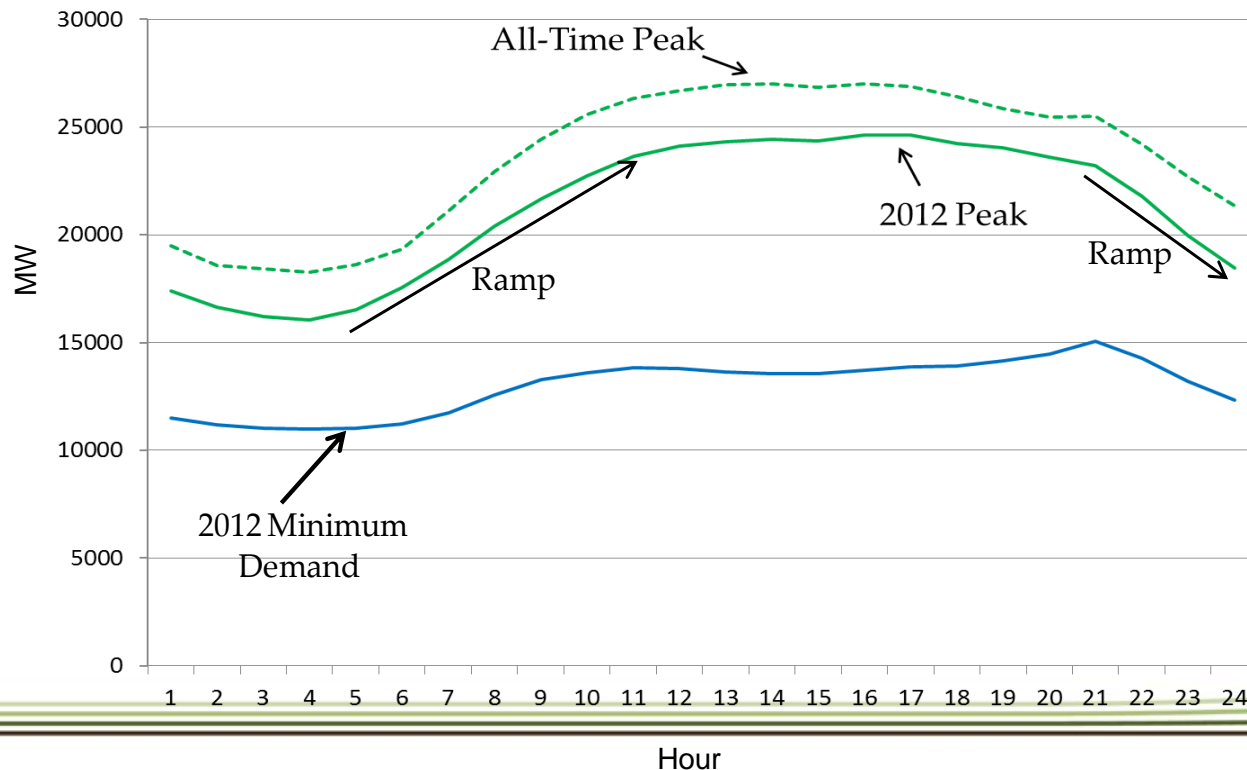
This diagram illustrates the components of non-hydroelectric renewables. The pace of development depends on how each of these categories evolves.

Options work together in an integrated fashion to meet customer needs

System needs and resource attributes must be taken into account when making supply decisions:



Resources must reliably and efficiently be available to balance supply and demand:



Integrating Renewable Assets

- Currently, system operators cannot see the performance of embedded distributed generators. This makes it difficult to accurately predict how these resources will perform on any given day.
- Expanding the capabilities of Ontario's utilities in these areas is vital to effectively integrating renewable generation assets, and reducing the negative impacts of intermittency, variability, and surplus baseload.
- Ontario's Independent Electricity System Operator (IESO) is implementing an integration plan that expands its forecasting, visibility, and dispatch capabilities for renewable generation resources.

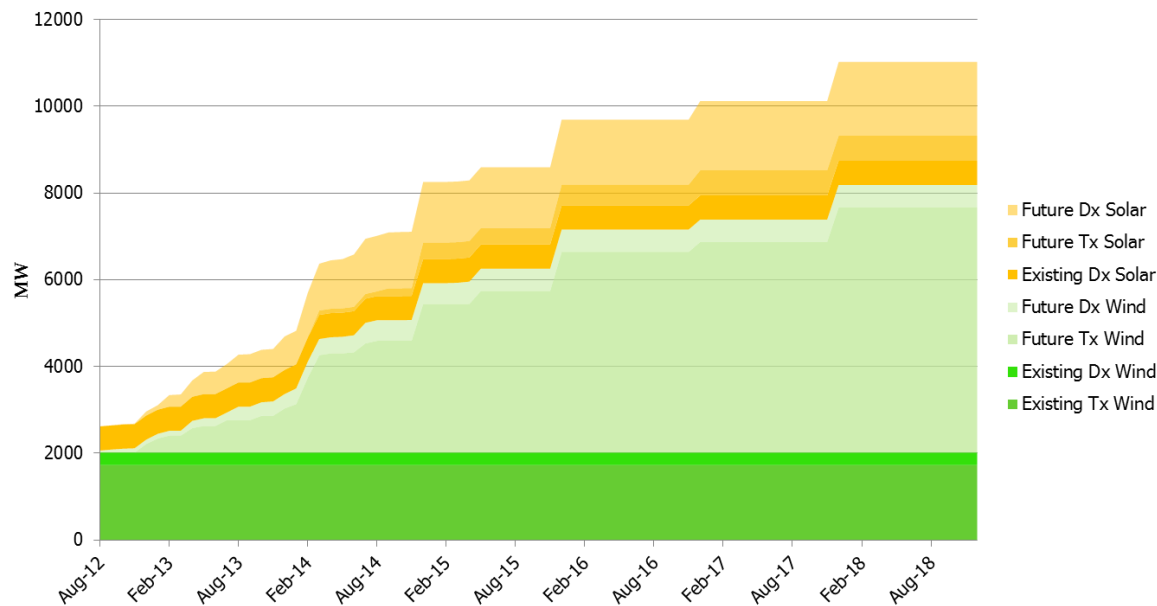
Forecasting	Visibility	Dispatch
Ability to predict output from variable resources is essential for maintaining system reliability and market efficiency	New processes such as direct telemetry and reporting may be needed to ensure visibility of large-scale embedded wind and solar generators	Integration of renewables into economic dispatch model should help resolve issues like surplus baseload generation

Three Part Presentation

- Ontario's Long Term Energy Plan Review
- Renewable Integration
- Smart Grid and Distribution

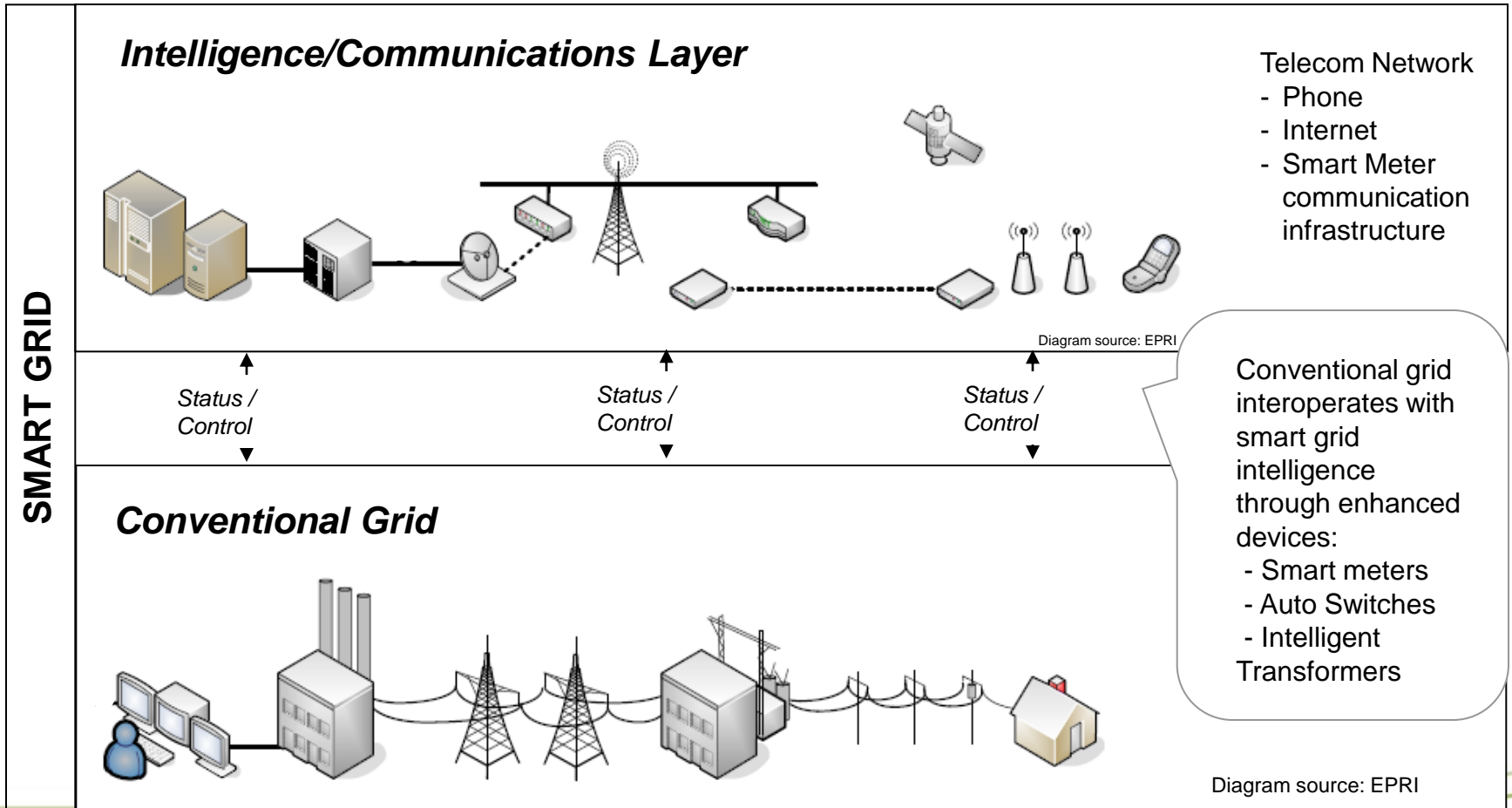
Renewable Integration at the Distribution Level

- Achieving Province’s renewable integration and conservation goals requires a smart grid and its associated technologies, like storage.
- Already the case for conservation, increasingly more of the renewable impact will be felt on the distribution grid (see right)
- In addition, storage itself can help mitigate potential issues on both the DX/TX system related to power fluctuations in the grid from very high shares of renewable energy



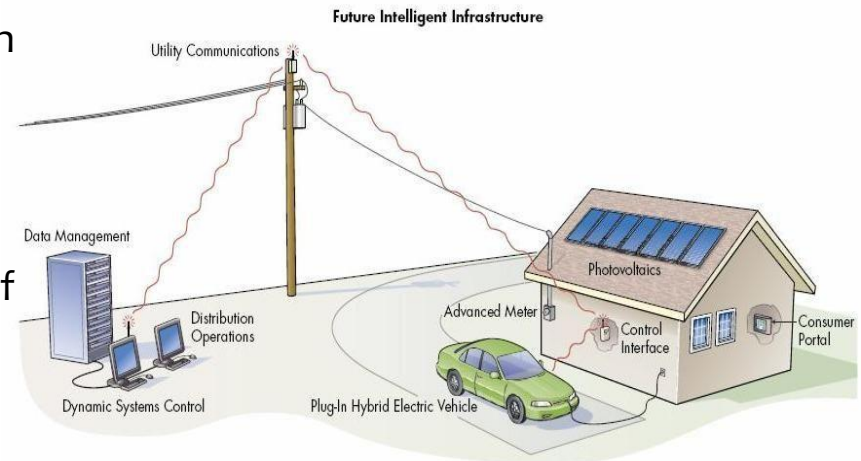
Source: IESO

Smart Grid: Integration Through Communication



Ontario's Push for Smart Grid

- Ontario has seized the opportunity to become a leader in smart grid to support achievement on various key provincial priorities:
 1. Aggressive integration of renewable, distributed generation into the distribution grid
 2. One of North America's most ambitious conservation targets
 3. One of the largest smart meter and time of use rollouts globally
 4. Significant effort to create conditions for accelerated electric vehicle adoption
 5. Economic benefits being created from the opportunity to leverage existing leading edge assets in manufacturing, research, and electricity distribution systems

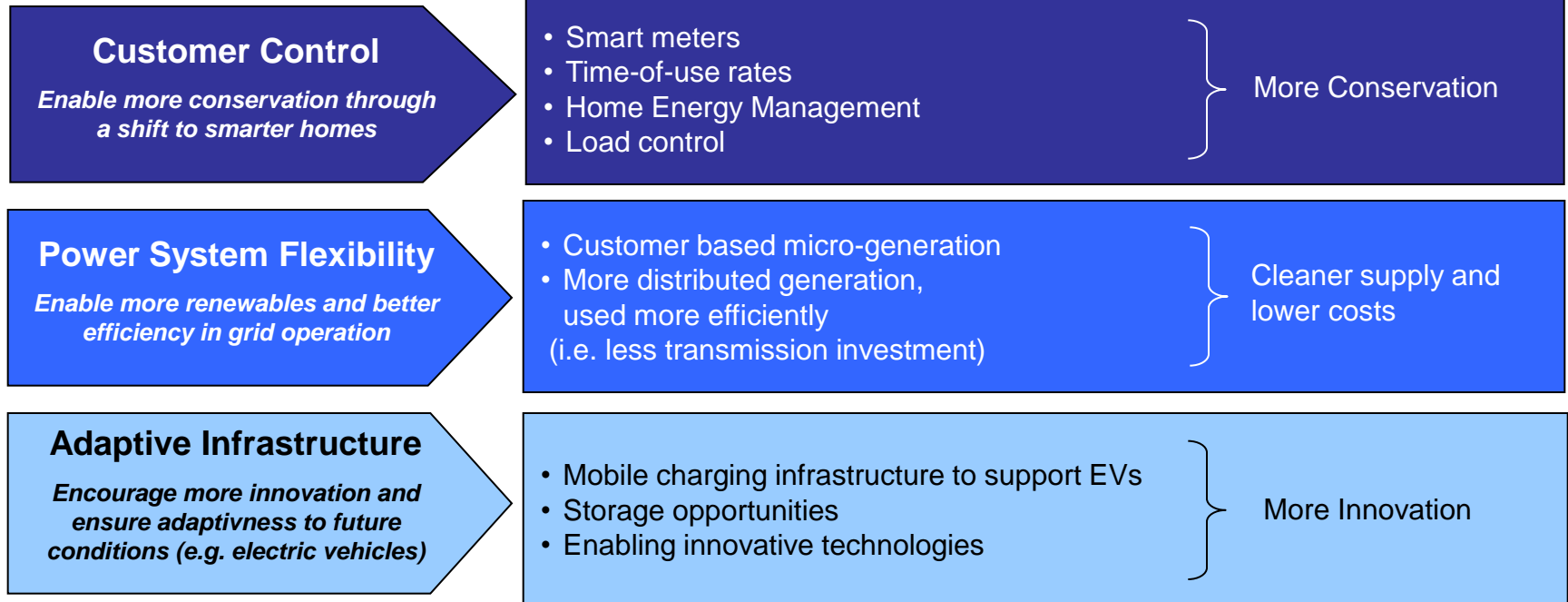


A Framework for Smart Grid

The *Green Energy Act* has provided guidance on smart grid for Ontario. Our energy regulator is undertaking a regulatory review exercise to respond this policy framework.

Focus Area

Expected Outcomes



ONTARIO'S ELECTRICITY DISTRIBUTION SYSTEM

LOCAL DISTRIBUTION COMPANY SERVICE AREAS

Ontario has 80 LDCs

- Each with Mandatory Conservation Targets
- And Each Required to Develop Smart Grid Plans



Smart Meters

What do Smart Meters do?

- Modernize outdated meter infrastructure
- Enable time-of-use pricing and conservation
- Provide basis for smart grid / smart homes



Ontario's Unique Rollout:

Ontario's Advantages:

Progress:

Smart Meters

- 1st in North America to implement (beginning in 2004)
- 5 different AMI systems (Trilliant, Elster, Sensus, Silver Springs, Tantalus)
- Integration with Meter Data Management/Repository

- Attractive as a test bed for emerging technology development
- Early mover advantage: ready for next steps
- Enhanced access to interval data improves broader system planning

➤ 4.7 million deployment complete

TOU Pricing

- 1st in the world to mandate for all residential and small business customers (2010)
- Prices set independently by Ontario Energy Board
- Implemented following successful pilot studies across a variety of utilities

- More incentive to respond to usage information than opt-in programs
- Real opportunities for businesses to shift load and reduce cost
- Opens the door to various energy storage business models, based on buying low and selling high

➤ 4.5 million

Examples of Ontario Research Activities

Focus Areas	High Profile Researchers	Centres*
Grid Auto-mation	Queen's: Power Systems (P. Jain) UWO: Grid Connection (R. Varma) McMaster: Vehicle-to-grid (A. Emadi)	14
Data Mgt.	UofT: High vol. data management (R. Miller) Waterloo: Database structures (F. Tompa)	4
Wind Energy	Waterloo: Aerodynamic (D. Johnson) UWO: Grid connection (R. Varma)	6
Behind the Meter	Waterloo: Energy Efficiency (I. Rowlands), Demand-side Management (D. Mountain) McMaster: Modeling & Simulation (S. Chidiac)	3
AMI	Waterloo: Energy Management (I. Rowlands)	3
Solar PV	McMaster: Ultra-high efficiency PV (R. Kleiman) UofT: PV Quantum Dot (E. Sargent), Organic Solar Cells (T. Bender, D. Seferos)	18
PEV	McMaster: Vehicle to Grid (A. Emadi) UWO: Grid Connection (R. Varma) Waterloo: Power Systems (C. Canizares), Battery Storage for PEV (L. Nazar)	13
Storage	Queen's: Fuel cell (B. Peppley), Waterloo: Fuel cell reliability (M. Fowler), Materials (L. Nazar)	14

% Research Centres, Laboratories, and Initiatives* Established in Ontario		
2006 – 2011	2000 – 2005	1999 and Earlier
58%	20%	23%
Total		85

Federal and Provincial Research Funding		
Funding Source	Year of Funding	Amount (in million)
NSERC	2011 – 2015	\$5.3
MEDI (MRI) to establish CONII	2006 – 2012	\$13.7
Knowledge Infrastructure Program	2009 – 2013	\$122.3
Ontario Research Fund **	2008 – 2013	\$250

NSERC Canada Excellence Research Chair (CERC), Research Chair (CRC) and Industry Research Chair (IRC)	
Type of Chair	# of Research Chairs
CERC	1
CRC	26
IRC	14

* Most research centres are active in multiple areas
 ** Program funds other non-related energy research

Source: Ontario Centres of Excellence



Smart Grid Fund

- The Smart Grid Fund is a \$50M competitive grant program designed to leverage Ontario's advantages in the energy sector and build the smart grid industry.
- SGF is currently sponsoring 11 projects in the areas of behind the meter, integrating distributed energy resources, regional integration, data management, and grid automation.
- The SGF launched Round 2 on July 2nd, 2013. Applications close on September 6th.

dTechs

IBM



Energate

enbala
POWER NETWORKS®



ecobee



n-dimension
solutions

ESSEX ENERGY
CORPORATION

prolucid

clever solutions for complex problems

TEAM ONTARIO
Queen's University | Carleton University | Algonquin College



Conclusions

1. The global push for a cleaner and more reliable electricity system is resulting in a number of technical challenges, and Ontario is not unique in this regard.
2. Ontario's position as a world leader in Smart Grid is allowing it to take a proactive role in integrating distributed renewable generation through expanded forecasting, visibility, and dispatch capabilities.
3. The Ministry is in the process of reviewing Ontario's Long-Term Energy Plan. Please contribute to the discussion by submitting comments to Ontario's Environmental Registry or by filling out the online survey.

APPENDIX: Helpful Links

- Making Choices: Reviewing Ontario's Long-Term Energy Plan:
<http://www.energy.gov.on.ca/en/ltep/>
 - Environmental Registry: <http://www.ebr.gov.on.ca/ERS-WEB-External/displaynoticecontent.do?noticeId=MTE5OTg3&statusId=MTc5NTIx&language=en>
 - Long-Term Energy Plan Survey: <http://www.energy.gov.on.ca/en/ltep/ltep-survey/#>
- Ontario's Long-Term Energy Plan: <http://www.energy.gov.on.ca/en/ltep/ontarios-long-term-energy-plan/>
- FIT Program 2-year report: <http://www.energy.gov.on.ca/en/fit-and-microfit-program/2-year-fit-review/>
- Smart Grid Fund Projects: <http://www.energy.gov.on.ca/en/smart-grid-fund/>
- Ontario Smart Grid Forum:
http://www.ieso.ca/imoweb/marketsandprograms/smart_grid.asp
- IESO Renewable Integration Initiative:
http://www.ieso.ca/imoweb/consult/consult_se91.asp
- Videos Highlighting Ontario's Smart Grid Progress:
<http://canmetenergy.nrcan.gc.ca/news/varences/3131>