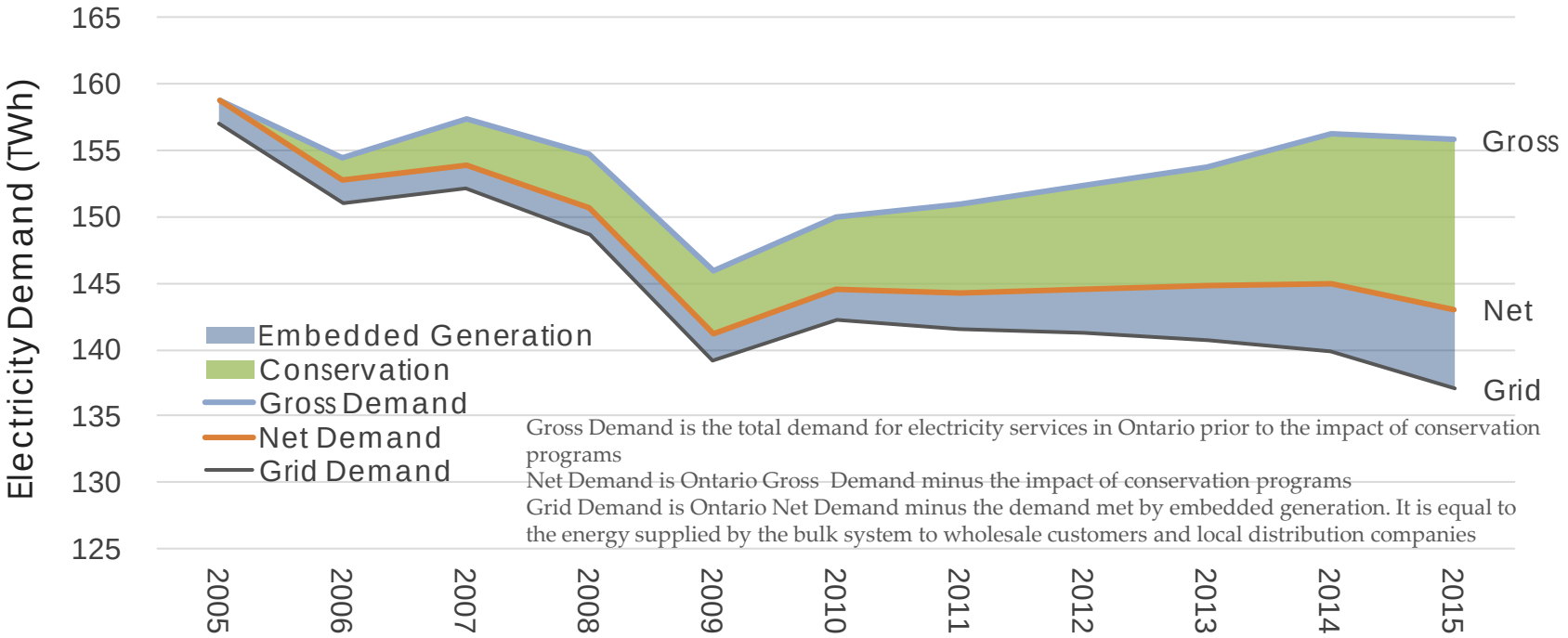
# MODULE 1:
# State of the Electricity System: 10-Year Review

August 2016

ieso
Connecting Today.
Powering Tomorrow.

# Electricity demand 2005-2015



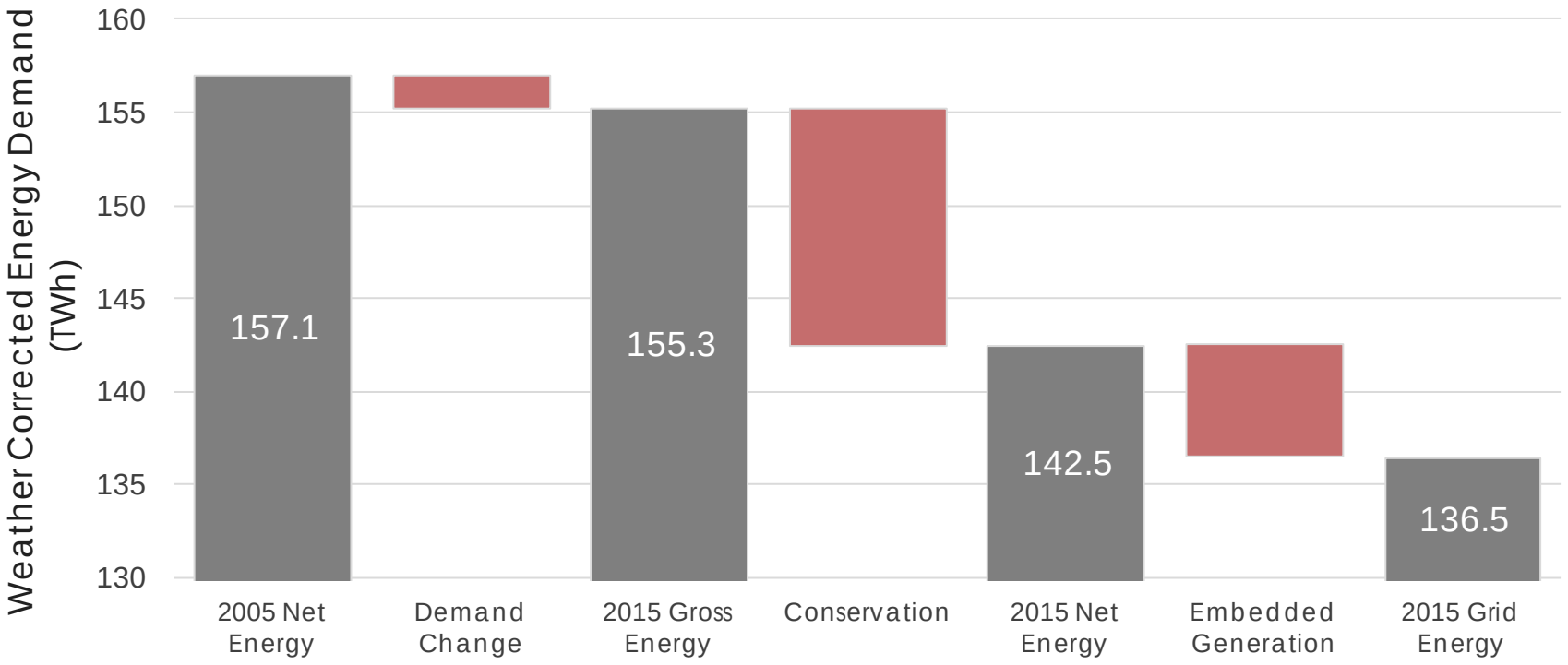

- Decline in grid demand is due to four main factors
  - Decreasing demand due to changes in the economy
  - Participation in energy efficiency programs and improvements in building codes and equipment standards
  - Changes in consumer behavior as a result of electricity prices including due to Time of Use Pricing (TOU) enabled by smart meters
  - Growing presence of embedded generation

# Ontario gross, net and grid energy demand, 2005-2015 (TWh)

| TWh | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Gross Demand | 158.8 | 154.4 | 157.3 | 154.7 | 146.0 | 149.9 | 151.0 | 152.3 | 153.8 | 156.2 | 155.8 |
| Conservation | 0.0 | 1.6 | 3.5 | 4.0 | 4.9 | 5.4 | 6.7 | 7.9 | 8.9 | 11.3 | 12.8 |
| Net Demand | 158.8 | 152.8 | 153.8 | 150.6 | 141.1 | 144.5 | 144.3 | 144.5 | 144.8 | 144.9 | 143.0 |
| Embedded Generation | 1.8 | 1.7 | 1.6 | 2.0 | 2.0 | 2.3 | 2.8 | 3.2 | 4.1 | 5.1 | 6.0 |
| Grid Demand | 157.0 | 151.1 | 152.2 | 148.7 | 139.2 | 142.2 | 141.5 | 141.3 | 140.7 | 139.8 | 137.0 |

# Net energy demand represents the total amount of electricity consumed in Ontario during the year

- Embedded generation has grown significantly in recent years through procurement programs such as RESOP, FIT and MicroFIT. These new resources caused demand on the IESO grid to decrease.
- Time of Use pricing structures have the greatest impact on peak demand. There is little direct impact on energy because load is shifted to other times

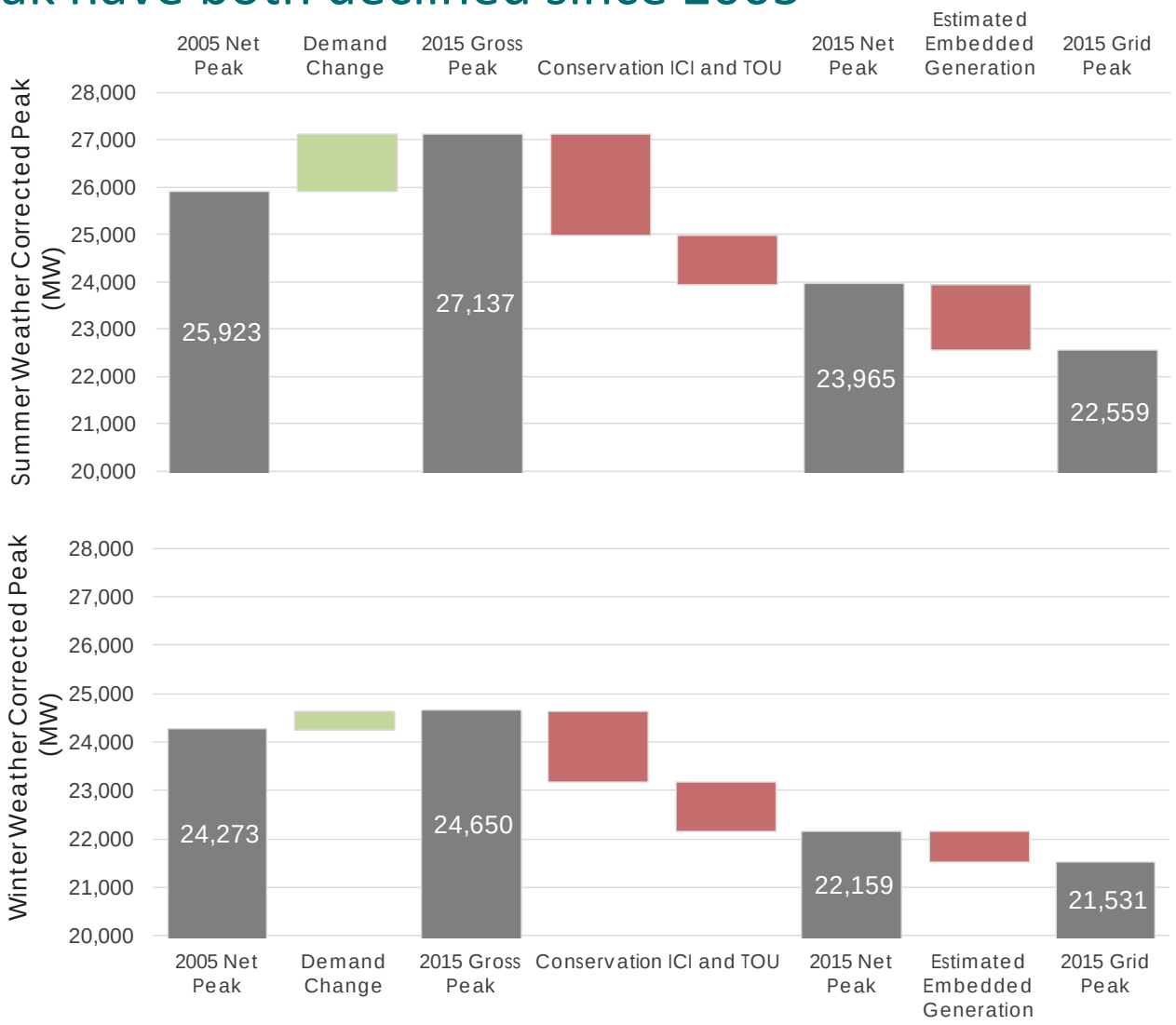


# Factors affecting energy demand

**Annual Energy (TWh, weather corrected)**

| | |
|---|---|
| 2005 Net Energy | 157.1 |
| Demand Change | 1.8 |
| 2015 Gross Energy | 155.3 |
| Conservation | 12.8 |
| 2015 Net Energy | 142.5 |
| Embedded Generation | 6.0 |
| 2015 Grid Energy | 136.5 |

# The drivers underlying peak demand have grown, but net and grid peak have both declined since 2005




Note: ICI varies year-on-year based on weather conditions. In 2015, a cold winter prompted a higher-than-usual contribution from ICI

- Summer peak demand is driven by air conditioners and other space cooling technology while winter peak is related to space heating
- In 2015, Time-of-Use pricing (TOU) and the Industrial Conservation Initiative (ICI) both reduced summer and winter peaks
- "Estimated Embedded Generation" is the peak reduction attributed to embedded resources

# Factors affecting summer and winter peak demand

**Summer Peak (MW, weather corrected)**

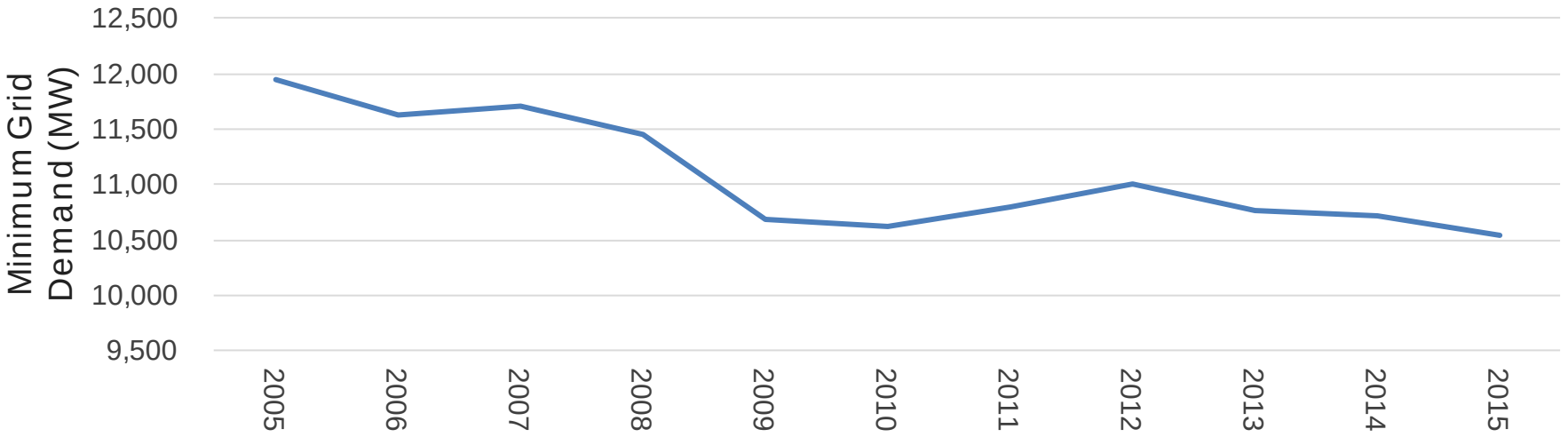
| | |
|---|---|
| 2005 Peak | 25,923 |
| Demand Change | 1,214 |
| 2015 Gross Peak | 27,137 |
| Conservation | -2,133 |
| ICI and TOU | -1,039 |
| 2015 Net Peak | 23,965 |
| Estimated Embedded Generation | -1,406 |
| 2015 Grid Peak | 22,559 |

**Winter Peak (MW, weather corrected)**

| | |
|---|---|
| 2005 Peak | 24,273 |
| Demand Change | 377 |
| 2015 Gross Peak | 24,650 |
| Conservation | -1,461 |
| ICI and TOU | -1,030 |
| 2015 Net Peak | 22,159 |
| Estimated Embedded Generation | -628 |
| 2015 Grid Peak | 21,531 |

# Minimum grid demand has declined by about 1,500 MW

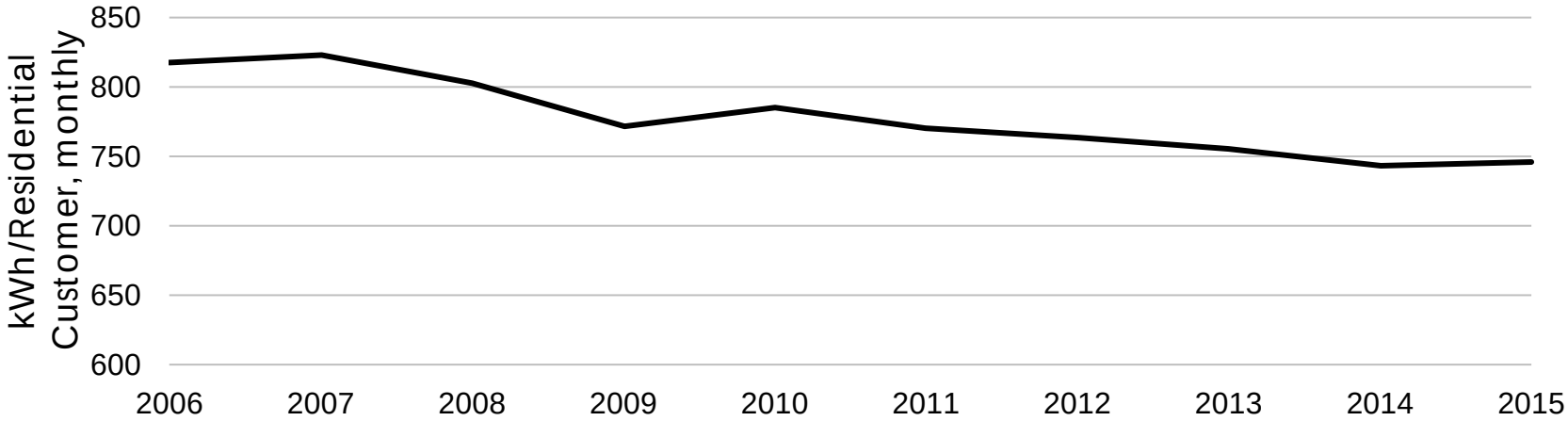
- Annual minimums typically occur during overnight hours on holidays or weekends
- Decrease in minimum demand has been driven by changes in the economy and participation in energy efficiency programs
- Embedded generation has had modest impact on minimum grid demand to date as the overwhelming majority of Ontario's distribution-connection generation is solar PV. Solar PV produces electricity during the day but is unable to meet demand overnight.




| MW | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Minimum Grid Demand | 11,950 | 11,621 | 11,699 | 11,450 | 10,678 | 10,618 | 10,799 | 10,998 | 10,765 | 10,719 | 10,539 |

# Energy efficiency has slowed demand growth in the residential and commercial sectors

- One of the main drivers of demand growth since 2005 has been expanding commercial floor space for offices, retail, and institutions. At the same time, buildings have adopted new technologies to reduce electricity demand for lighting and other end uses
- Businesses are also making more efficient use of existing space; in most sectors there are more employees per square foot today than in 2005
- Efficient technology and expanded use of natural gas heating has reduced energy intensity (measured in kWh per household) in the residential sector
- This trend is evident in the OEB's Residential Customer rate class



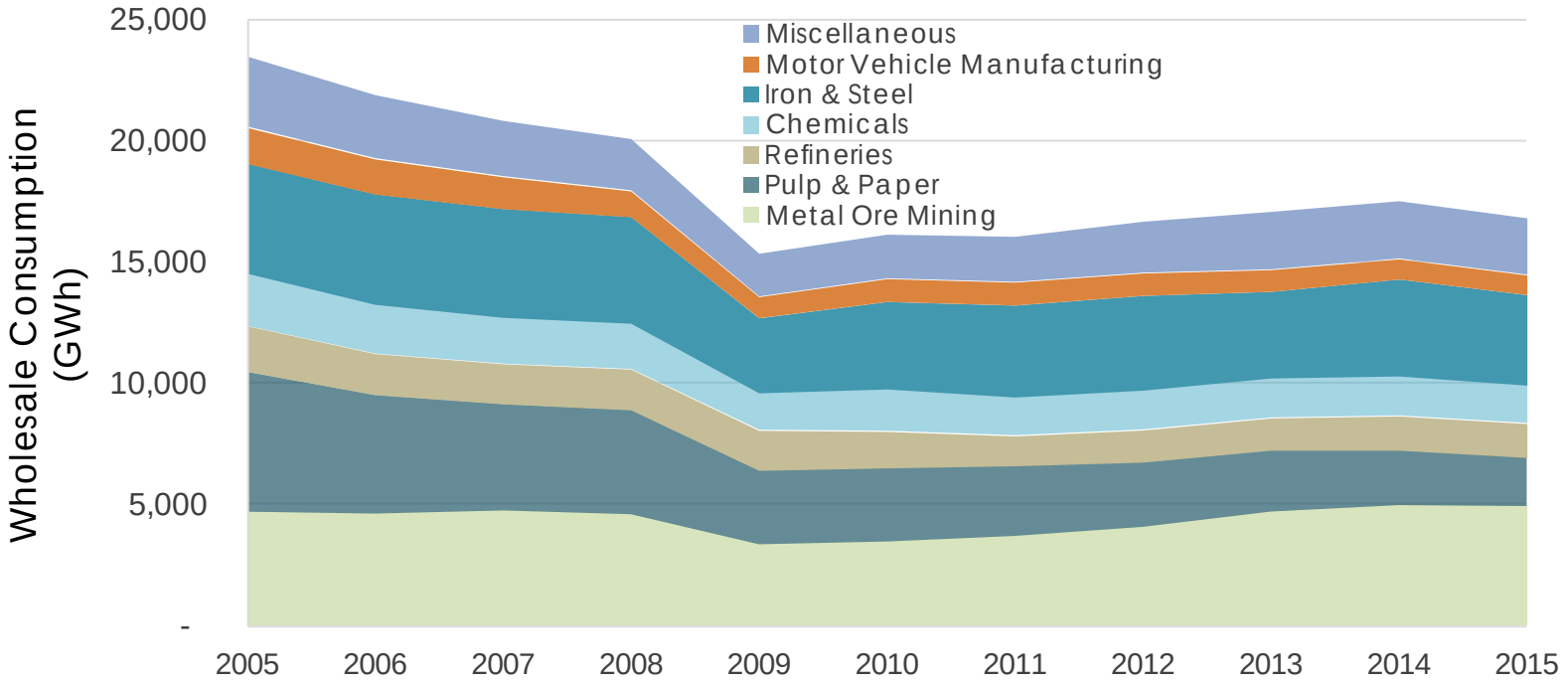

**Average of OEB Residential Rate Class**

| kWh/Household | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 |
|---|---|---|---|---|---|---|---|---|---|---|
| Energy Intensity | 817 | 824 | 802 | 771 | 785 | 770 | 764 | 755 | 743 | 746 |

OEB Yearbook of Electricity Distributors: http://www.ontarioenergyboard.ca/OEB/Industry/Rules+and+Requirements/Reporting+and+Record+Keeping+Requirements/Yearbook+of+Distributors

The Residential Customer class does not include some large apartment buildings and condos.

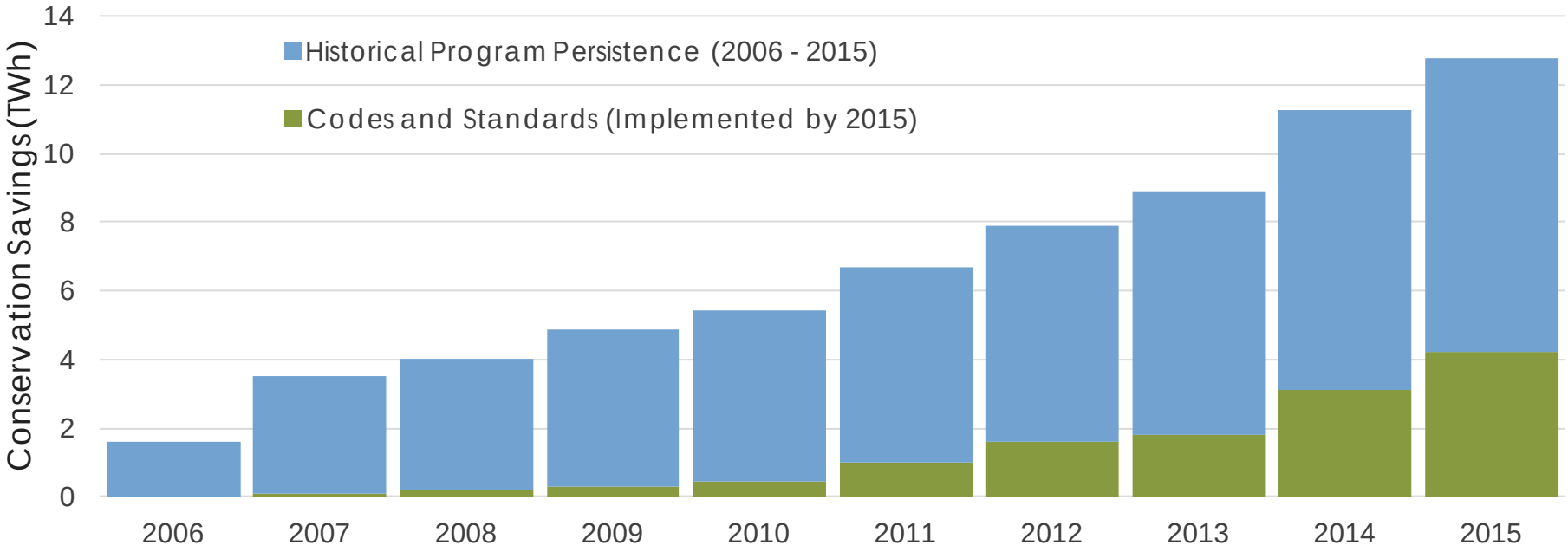
# Electricity demand from large industrial consumers




| GWh | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Metal Ore Mining | 4,691 | 4,614 | 4,743 | 4,587 | 3,348 | 3,463 | 3,693 | 4,067 | 4,697 | 4,962 | 4,923 |
| Pulp & Paper | 5,768 | 4,893 | 4,391 | 4,304 | 3,072 | 3,058 | 2,916 | 2,689 | 2,547 | 2,280 | 2,024 |
| Refineries | 1,868 | 1,680 | 1,636 | 1,661 | 1,632 | 1,488 | 1,217 | 1,311 | 1,315 | 1,397 | 1,383 |
| Chemicals | 2,189 | 2,043 | 1,923 | 1,897 | 1,524 | 1,726 | 1,578 | 1,620 | 1,632 | 1,633 | 1,562 |
| Iron & Steel | 4,546 | 4,563 | 4,494 | 4,405 | 3,094 | 3,610 | 3,795 | 3,911 | 3,573 | 4,002 | 3,735 |
| Motor Vehicle Manufacturing | 1,496 | 1,456 | 1,323 | 1,069 | 871 | 943 | 946 | 926 | 897 | 833 | 813 |
| Miscellaneous | 2,887 | 2,601 | 2,278 | 2,113 | 1,760 | 1,800 | 1,855 | 2,100 | 2,368 | 2,363 | 2,321 |

# Conservation represents savings from energy efficiency programs, changes in customer behavior, building codes, and equipment standards.

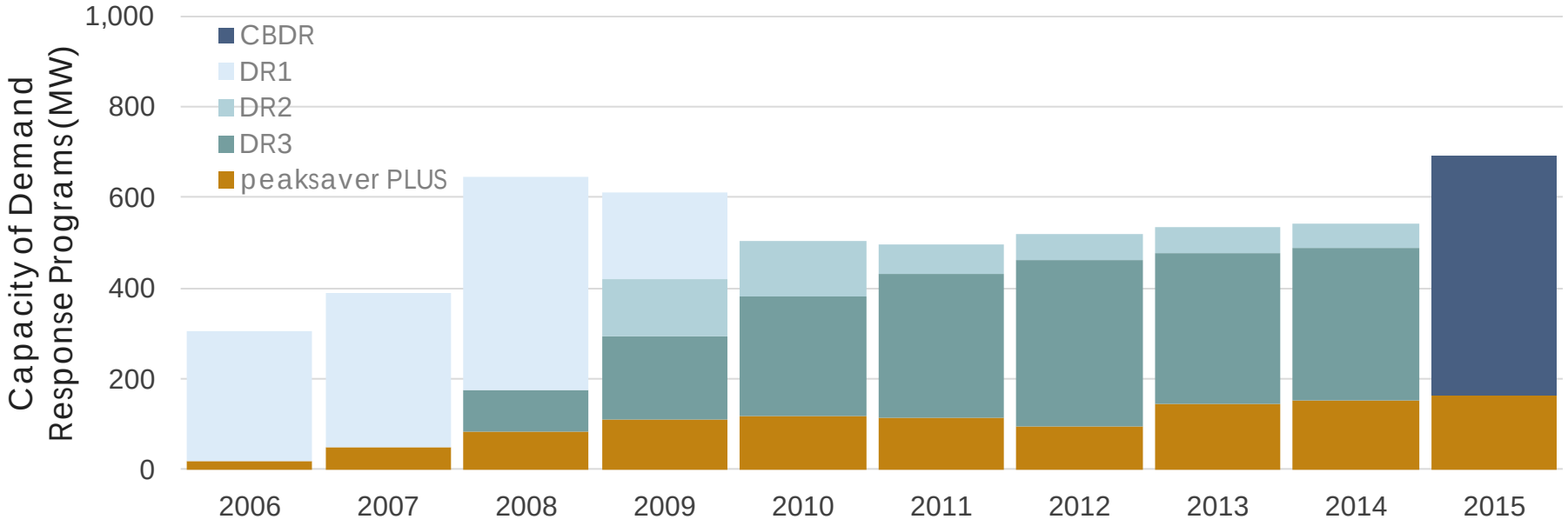
- Ontario saved a cumulative 67 TWh of electricity between 2005 and 2015 through conservation
- Nearly 13 TWh electricity was saved in 2015, about one third of savings from codes/standards, about two-thirds from conservation programs




Conservation program savings between 2006 and 2014 have been evaluated, program savings for 2015 and codes and standards savings are estimated.

# Demand response includes those demand-side actions by consumers to reduce consumption upon request by the IESO

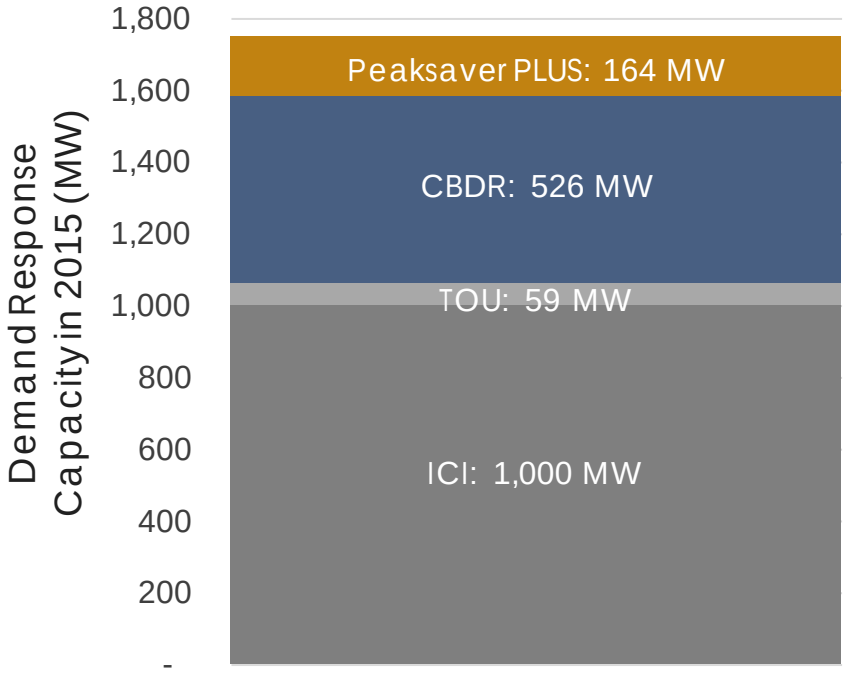
- Demand response programs prior to 2015 included DR1, DR2, and DR3 for business customers and peaksaver PLUS for residential customers
- Beginning in 2015, business DR3 programs were transitioned to the market as capacity-based demand response (CBDR)
- The first capacity-based demand response auction conducted in December 2015 is contributing 391.5 MW for the 2016 summer season and 403.7MW for the 2016-2017 winter season.




Demand Response Auction: http://www.ieso.ca/Pages/Participate/Stakeholder-Engagement/Demand-Response-Auction.aspx

# Demand response is also achieved through targeted rate structures for residential and small commercial customers and pricing incentives for large customers

- Time of Use (TOU) has existed in Ontario since approximately 2005 for low volume electricity consumers with smart meters
  - It provides an incentive for consumers to shift electricity use away from higher demand periods to lower demand periods
- Another pricing incentive program designed to reduce demand at peak times is the Industrial Conservation Initiative (ICI)
  - Certain large customers with demand greater than 3 MW (Class A customers) are eligible to participate
  - Global Adjustment amounts for participating Class A customers are adjusted to reflect their contribution to overall system demand during the top five peak hours of a year




ICI Program: http://www.ieso.ca/Pages/Participate/Settlements/Global-Adjustment-for-Class-A.aspx

- Demand response resources together amounted to approximately 1.8 GW in 2015

# Conservation program savings vs. codes & standards savings, 2006 – 2015 (TWh), demand response programs, 2006 – 2015 (MW), and demand response capacity in 2015 (MW)

**Conservation Savings**

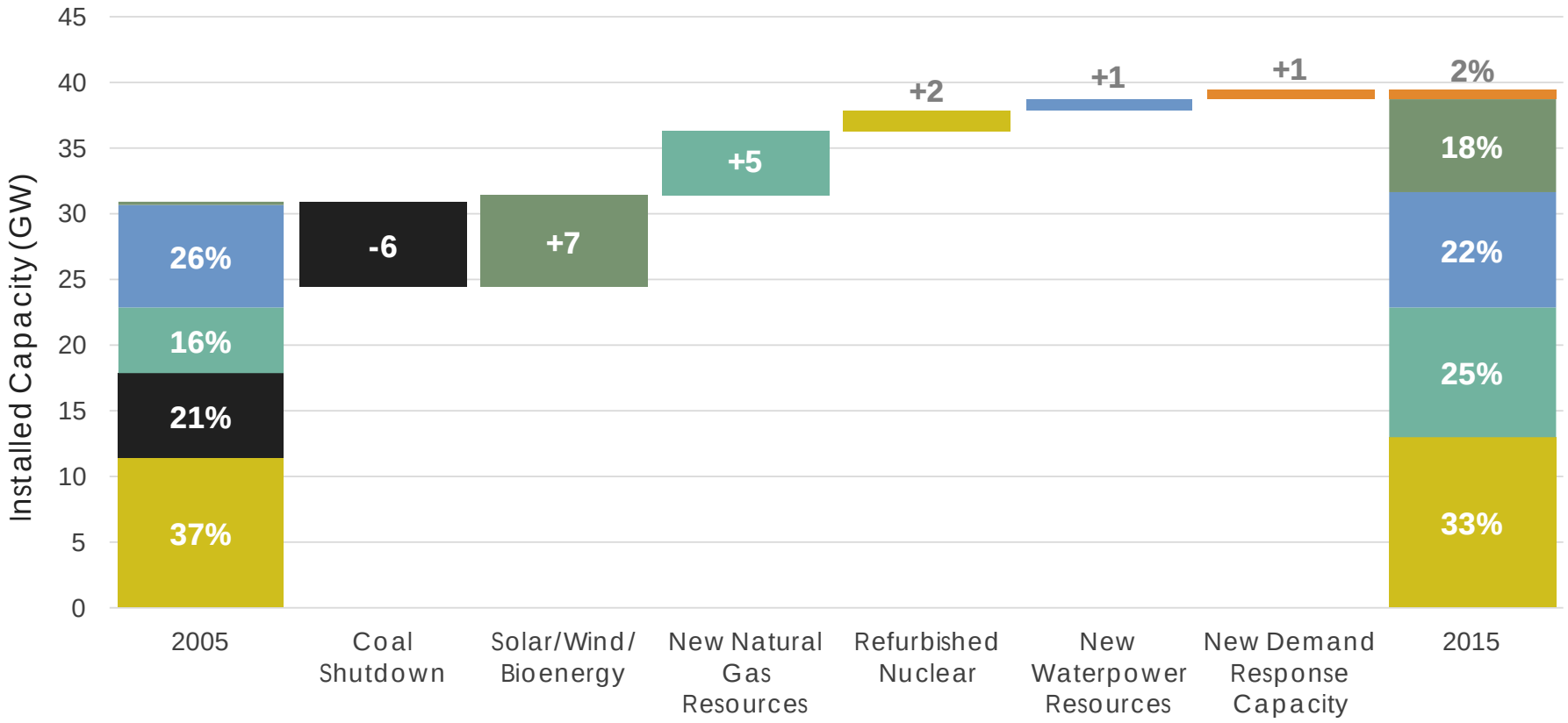
| TWh | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 |
|---|---|---|---|---|---|---|---|---|---|---|
| Historical Programs Persistence (2006-2015) | 1.6 | 3.4 | 3.9 | 4.6 | 5.0 | 5.7 | 6.3 | 7.1 | 8.1 | 8.5 |
| Codes and Standards (implemented by 2015) | 0.0 | 0.1 | 0.2 | 0.3 | 0.5 | 1.0 | 1.6 | 1.8 | 3.1 | 4.2 |

Conservation program savings between 2006 and 2014 have been evaluated, program savings for 2015 and codes and standards savings are estimated.
2015 verified program results will be available by the end of 2016

**Demand Response Capacity**

| MW | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 |
|---|---|---|---|---|---|---|---|---|---|---|
| peaksaver PLUS | 20 | 48 | 84 | 112 | 117 | 115 | 96 | 143 | 152 | 164 |
| DR3 | 0 | 0 | 91 | 182 | 264 | 315 | 367 | 335 | 335 | 0 |
| DR2 | 0 | 0 | 0 | 128 | 122 | 69 | 56 | 55 | 55 | 0 |
| DR1 | 285 | 340 | 471 | 188 | 0 | 0 | 0 | 0 | 0 | 0 |
| CBDR | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 526 |
| TOU | | | | | | | | | | 59 |
| ICI | | | | | | | | | | 1,000 |

# Change in installed supply resources 2005-2015

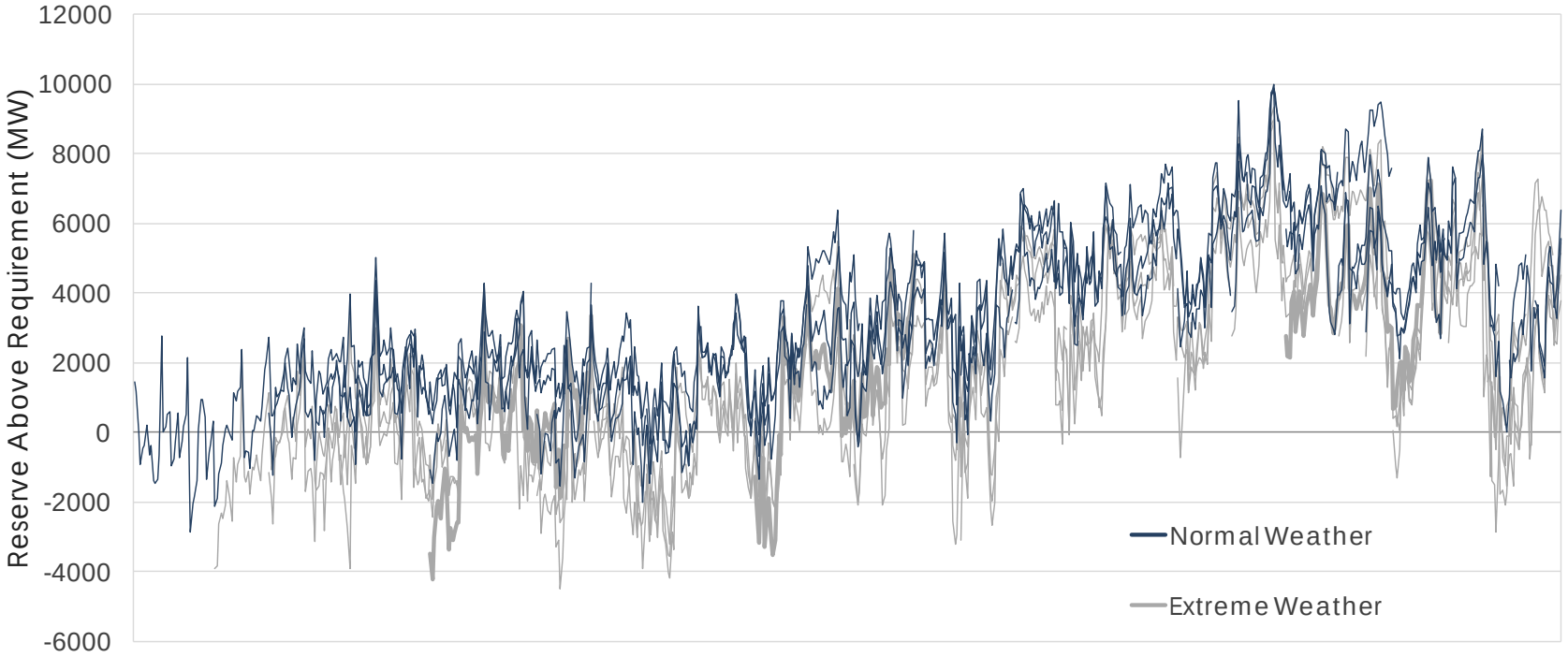


# Net changes to installed generation capacity, 2005 – 2015

| **Installed Capacity (MW)** | **2005** | **2015** |
|---|---|---|
| Nuclear | 11,397 | 13,014 |
| Coal | 6,434 | 0 |
| Natural Gas | 4,976 | 9,852 |
| Waterpower | 7,910 | 8,768 |
| Solar PV/Wind/Bioenergy | 134 | 7,068 |
| Demand Response | 0 | 690 |

# Capacity margins

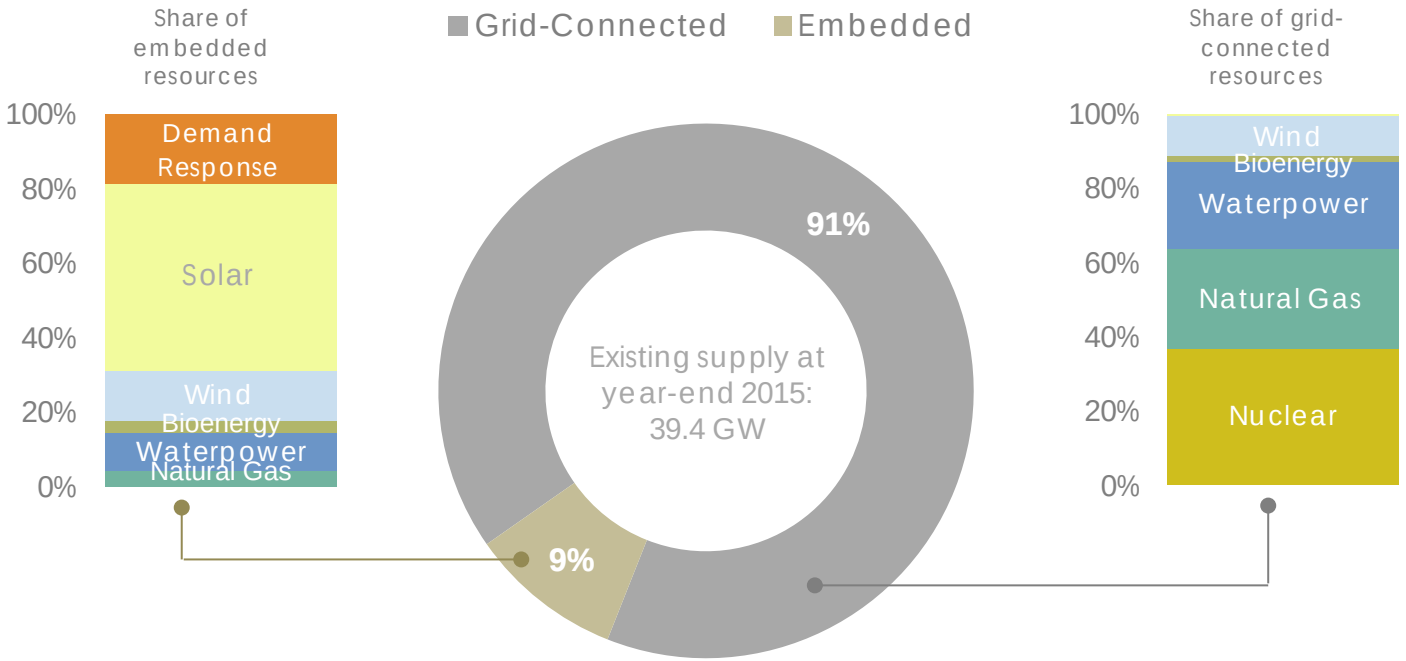
- Capacity margins, sometimes referred to as "resources above requirement" are an indicator of resource adequacy and describe the extent to which resources exceed or fall below targeted levels
- Ontario's capacity margins over the past ten years are approximated below. Weekly projections are shown from all of the IESO's 18-month outlooks published between late 2002 and 2015




Additional information and data available on IESO Website:
http://www.ieso.ca/Pages/Participate/Reliability-Requirements/Forecasts-&-18-Month-Outlooks.aspx

# Grid connected versus embedded resources

- Embedded resources are small-scale supply resources located within the distribution system and are not part of the IESO controlled grid
- In 2015, approximately 91% of Ontario supply was connected to the IESO grid while 9% is connected to the distribution system
- Most of Ontario's currently distribution-connected capacity is renewable, including resources contracted under the FIT and microFIT programs

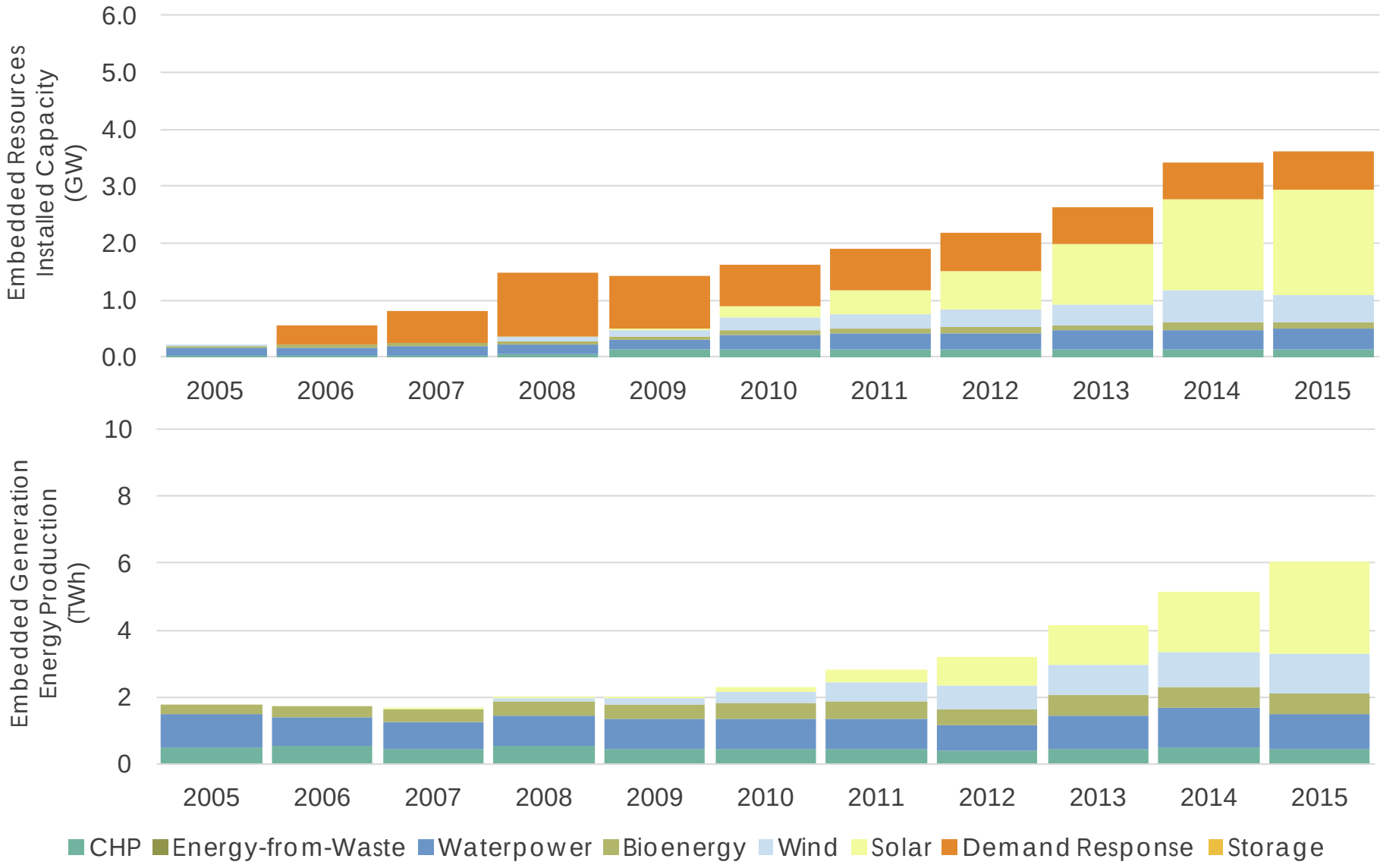


# Installed capacity of embedded resources at year-end 2015

| Installed Capacity (MW) | Grid-Connected | Embedded |
|---|---|---|
| Nuclear | 13,014 | 0 |
| Natural Gas | 9,697 | 155 |
| Waterpower | 8,401 | 367 |
| Bioenergy | 461 | 114 |
| Wind | 3,883 | 491 |
| Solar PV | 280 | 1,839 |
| Demand Response* | 0 | 690 |

* Capacity-based demand response is transitioning to a market-based resource. As of 2016 it will be 'grid-connected' and not embedded.

# Embedded generation, installed capacity, and energy production 2005-2015



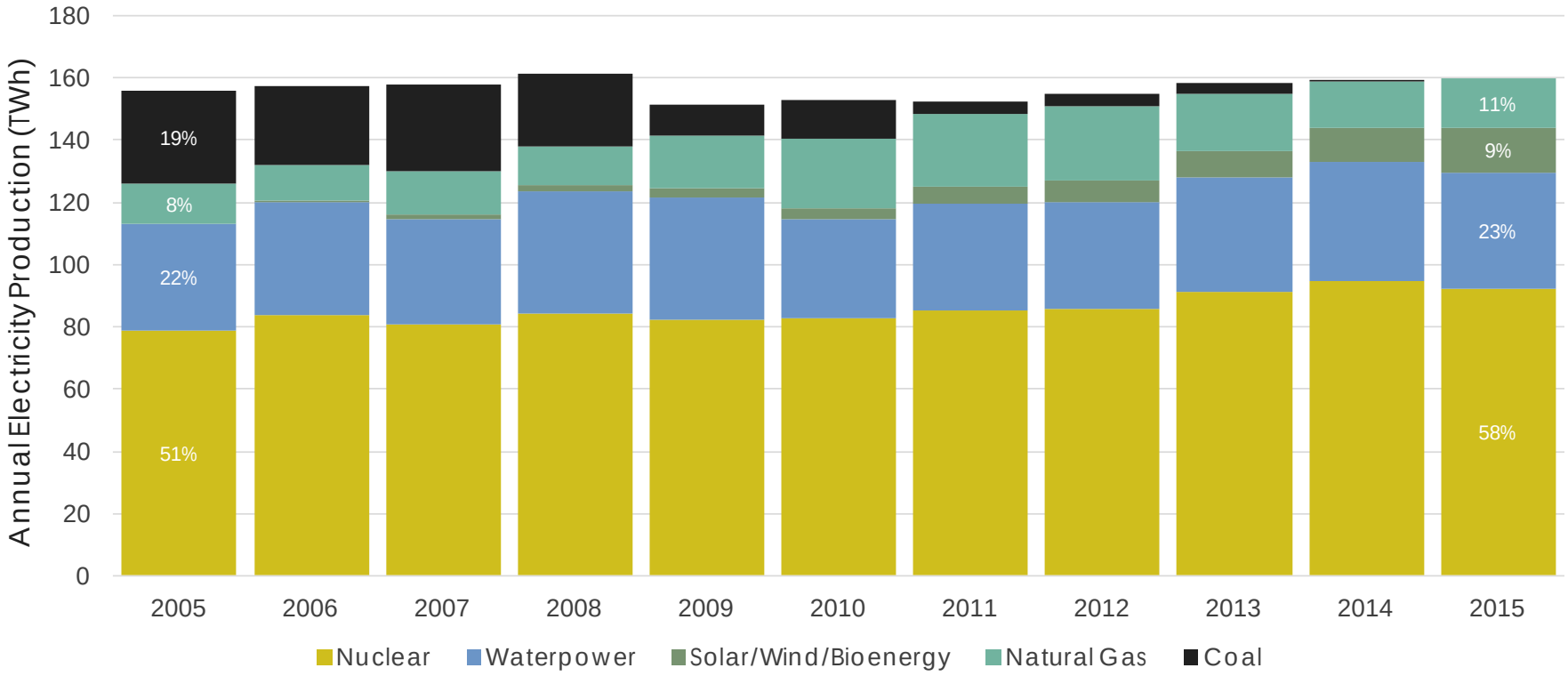
# Embedded generation, installed capacity, and energy production 2005-2015

| Installed capacity, embedded resources (MW) | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | **2005** | **2006** | **2007** | **2008** | **2009** | **2010** | **2011** | **2012** | **2013** | **2014** | **2015** |
| CHP | 17 | 35 | 35 | 66 | 129 | 129 | 136 | 137 | 134 | 139 | 140 |
| Waterpower | 146 | 146 | 153 | 158 | 178 | 270 | 276 | 295 | 333 | 336 | 363 |
| Bioenergy | 42 | 42 | 62 | 65 | 66 | 85 | 90 | 91 | 104 | 146 | 104 |
| Wind | 2 | 2 | 11 | 78 | 105 | 205 | 245 | 329 | 365 | 425 | 491 |
| Solar | 0 | 0 | 0 | 10 | 40 | 195 | 432 | 662 | 1,039 | 1,585 | 1,839 |
| Demand Response | 0 | 332 | 552 | 1,097 | 923 | 735 | 724 | 677 | 655 | 655 | 690 |
| Storage | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| **Total** | **207** | **557** | **813** | **1,473** | **1,440** | **1,619** | **1,903** | **2,192** | **2,631** | **3,286** | **3,627** |

| Energy Production, embedded resources (TWh) | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | **2005** | **2006** | **2007** | **2008** | **2009** | **2010** | **2011** | **2012** | **2013** | **2014** | **2015** |
| CHP | 0.5 | 0.5 | 0.5 | 0.5 | 0.5 | 0.4 | 0.4 | 0.4 | 0.5 | 0.5 | 0.5 |
| Waterpower | 1.0 | 0.9 | 0.8 | 0.9 | 0.9 | 0.9 | 0.9 | 0.8 | 1.0 | 1.1 | 1.0 |
| Bioenergy | 0.3 | 0.3 | 0.4 | 0.4 | 0.4 | 0.5 | 0.5 | 0.5 | 0.6 | 0.7 | 0.6 |
| Wind | 0.0 | 0.0 | 0.0 | 0.1 | 0.2 | 0.3 | 0.6 | 0.7 | 0.9 | 1.0 | 1.2 |
| Solar | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.1 | 0.4 | 0.8 | 1.2 | 1.8 | 2.8 |
| Demand Response | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Storage | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| **Total** | **1.8** | **1.7** | **1.6** | **2.0** | **2.0** | **2.3** | **2.8** | **3.2** | **4.1** | **5.1** | **6.0** |

# Electricity production by fuel type 2005-2015

- Nearly 90% of Ontario's annual electricity production is now derived from non-fossil sources
- Included within this figure is the production from embedded generation which grew since 2005 and now accounts for 6 TWh, or 4% of all electricity produced



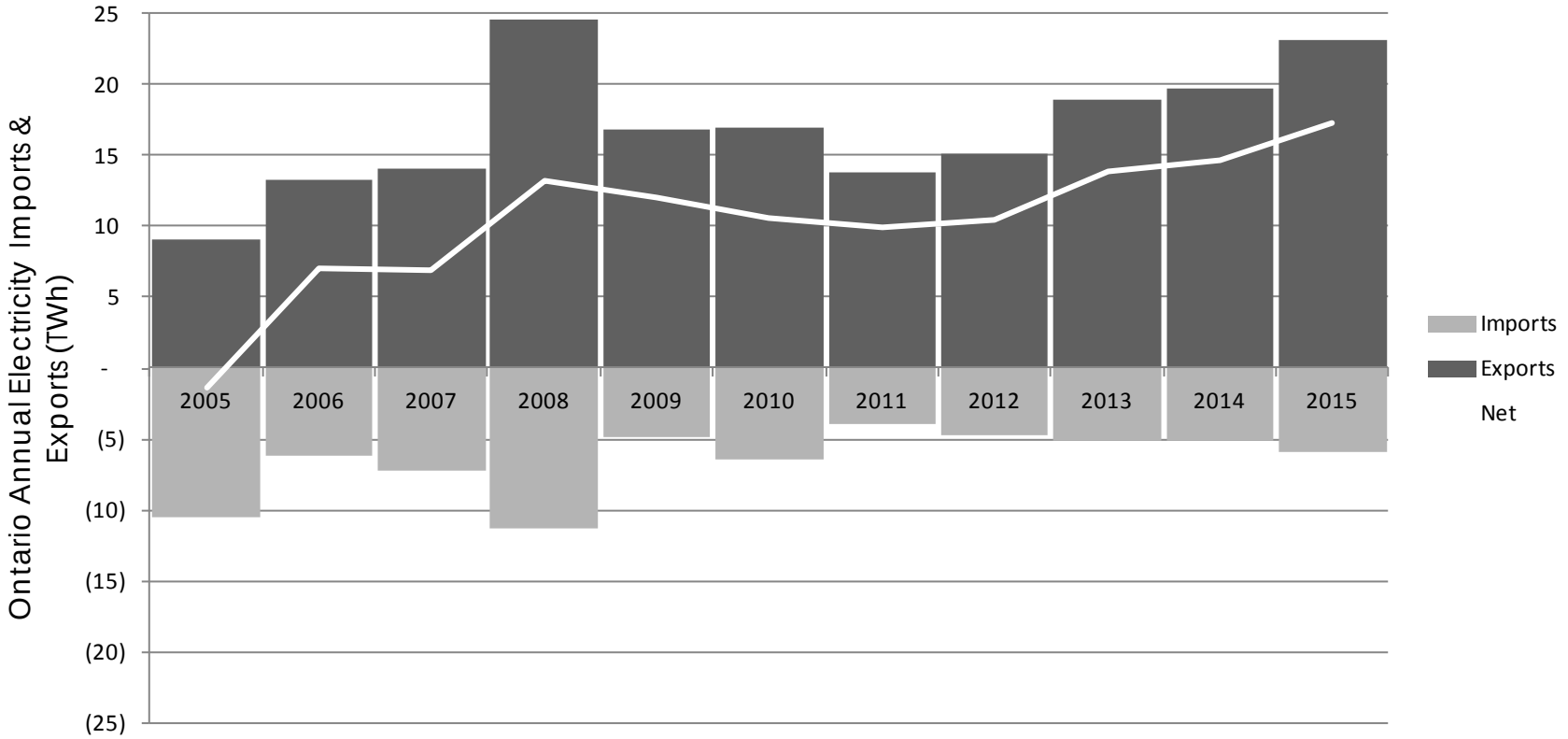
# Electricity production by fuel type 2005-2015

**Ontario electricity production**

| TWh | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Solar/Wind/Bioenergy | 0.3 | 0.7 | 1.4 | 1.9 | 2.9 | 3.7 | 5.4 | 6.6 | 8.1 | 10.6 | 14.2 |
| Natural Gas | 12.9 | 11.5 | 13.8 | 12.5 | 17.1 | 22.2 | 23.6 | 23.9 | 18.7 | 15.3 | 15.9 |
| Nuclear | 79.0 | 84.0 | 81.0 | 84.4 | 82.5 | 82.9 | 85.3 | 85.6 | 91.1 | 94.9 | 92.3 |
| Coal | 30.0 | 25.0 | 28.0 | 23.2 | 9.8 | 12.6 | 4.1 | 4.3 | 3.2 | 0.1 | 0.0 |
| Waterpower | 34.0 | 35.9 | 33.8 | 39.2 | 39.0 | 31.6 | 34.2 | 34.6 | 37.1 | 38.2 | 37.3 |

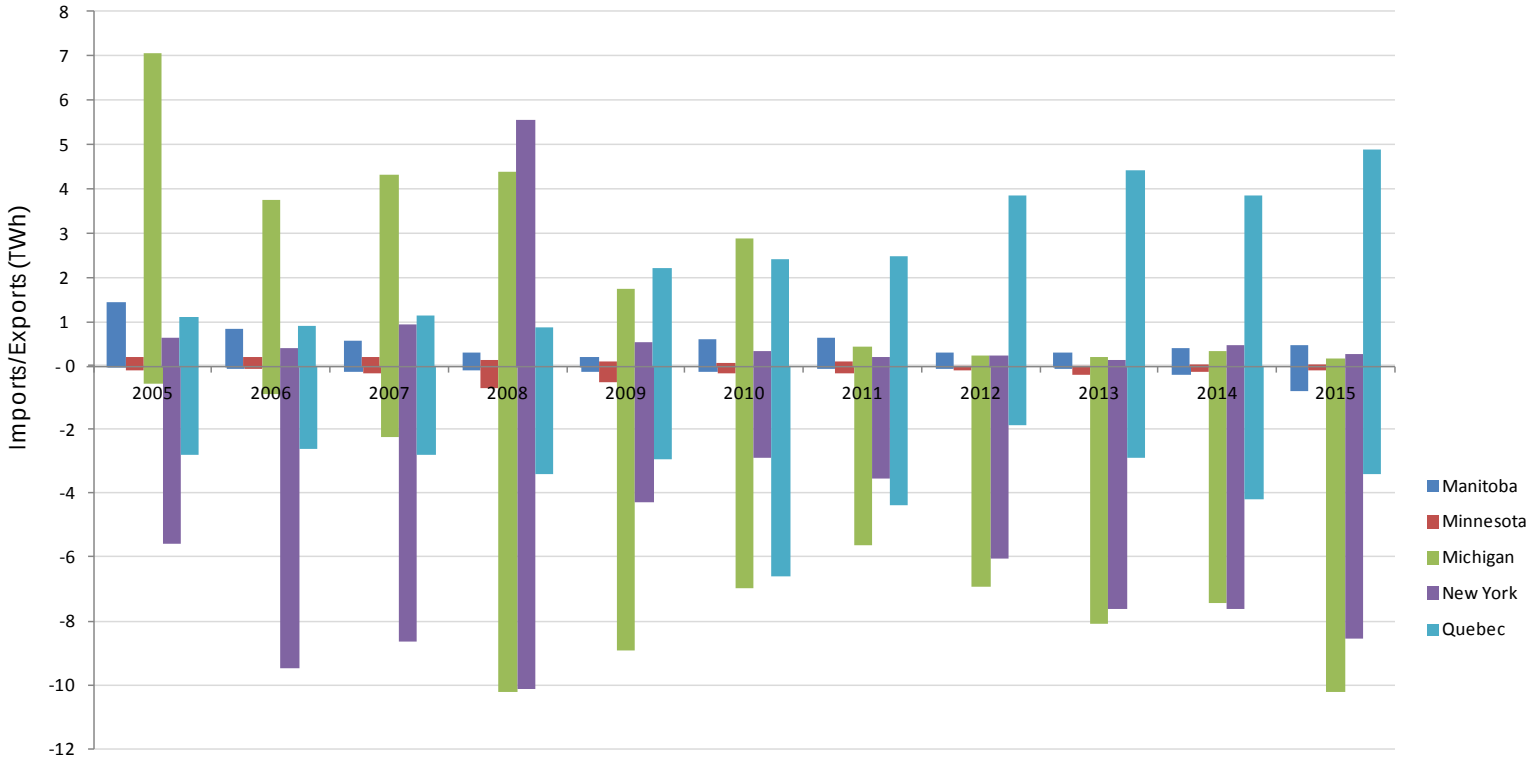
# Electricity imports and exports 2005-2015

- Since 2005, Ontario has become a net exporter of electricity



# Electricity imports and exports 2005-2015 by jurisdiction

- The majority of Ontario's exports are delivered to the United States, mostly to New York (NYISO) and further south to the PJM market (which serves over 13 states, including Pennsylvania, New Jersey and Maryland)
- Ontario's exports to the U.S. Midwest have grown in recent years
- Electricity imports today are mostly sourced from Québec and Manitoba



# Electricity imports and exports 2005-2015 by jurisdiction

**Trade with neighbouring jurisdictions**

| TWh | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Imports | 10.50 | 6.18 | 7.20 | 11.30 | 4.86 | 6.38 | 3.92 | 4.71 | 5.12 | 5.13 | 5.90 |
| Exports | 9.11 | 13.22 | 14.13 | 24.56 | 16.85 | 16.98 | 13.85 | 15.10 | 18.98 | 19.77 | 23.15 |
| Net Exports | -1.39 | 7.04 | 6.93 | 13.26 | 11.99 | 10.6 | 9.93 | 10.39 | 13.86 | 14.64 | 17.25 |

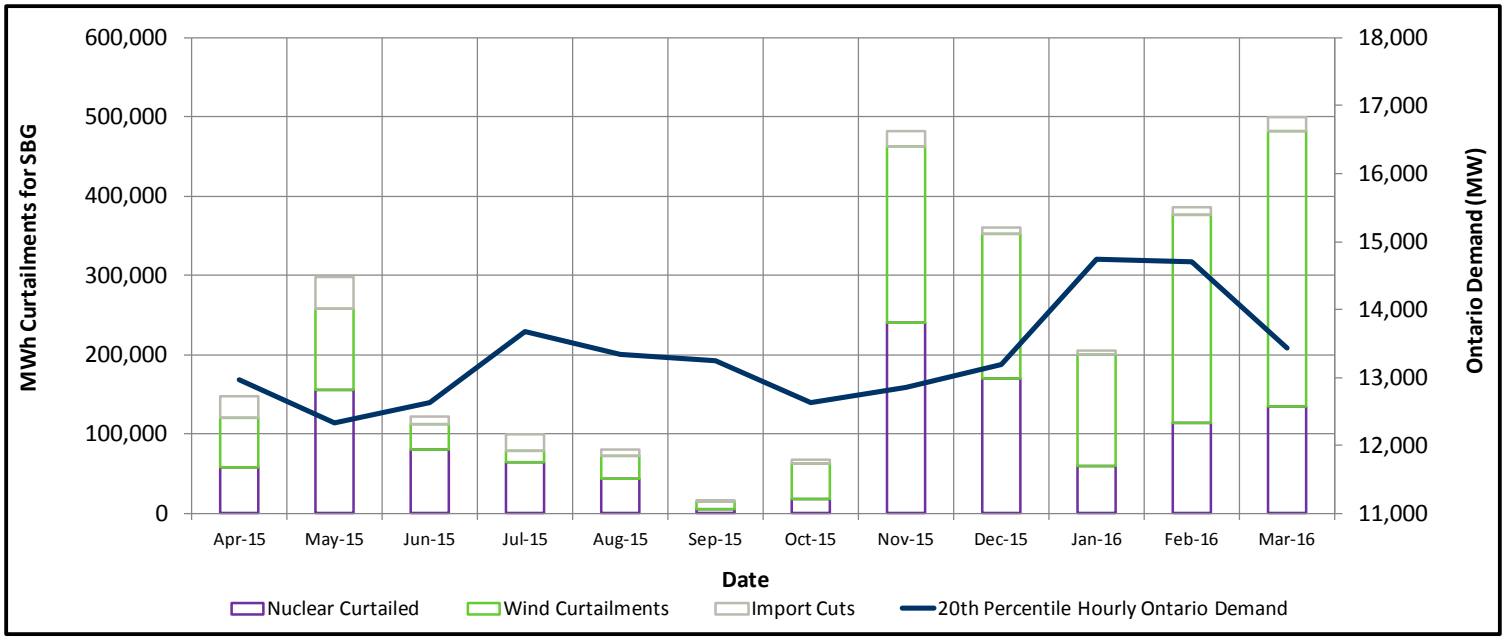
| Imports (TWh) | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Manitoba | 1.45 | 0.86 | 0.58 | 0.32 | 0.22 | 0.62 | 0.66 | 0.33 | 0.32 | 0.41 | 0.48 |
| Minnesota | 0.22 | 0.21 | 0.21 | 0.14 | 0.11 | 0.10 | 0.12 | 0.02 | 0.02 | 0.04 | 0.04 |
| Michigan | 7.07 | 3.75 | 4.31 | 4.40 | 1.76 | 2.88 | 0.45 | 0.26 | 0.21 | 0.34 | 0.20 |
| New York | 0.65 | 0.43 | 0.94 | 5.55 | 0.54 | 0.34 | 0.21 | 0.27 | 0.14 | 0.48 | 0.28 |
| Quebec | 1.11 | 0.93 | 1.16 | 0.89 | 2.23 | 2.43 | 2.48 | 3.84 | 4.42 | 3.85 | 4.90 |
| Total | 10.50 | 6.18 | 7.20 | 11.30 | 4.86 | 6.38 | 3.92 | 4.71 | 5.12 | 5.13 | 5.90 |
| | | | | | | | | | | | |
| **Exports (TWh)** | **2005** | **2006** | **2007** | **2008** | **2009** | **2010** | **2011** | **2012** | **2013** | **2014** | **2015** |
| Manitoba | 0.04 | 0.10 | 0.18 | 0.13 | 0.19 | 0.21 | 0.09 | 0.09 | 0.12 | 0.30 | 0.79 |
| Minnesota | 0.13 | 0.12 | 0.25 | 0.69 | 0.54 | 0.26 | 0.25 | 0.17 | 0.27 | 0.20 | 0.16 |
| Michigan | 0.56 | 0.88 | 2.24 | 10.21 | 8.91 | 6.99 | 5.63 | 6.91 | 8.07 | 7.44 | 10.25 |
| New York | 5.59 | 9.48 | 8.65 | 10.16 | 4.28 | 2.89 | 3.52 | 6.05 | 7.62 | 7.62 | 8.57 |
| Quebec | 2.78 | 2.63 | 2.80 | 3.38 | 2.93 | 6.62 | 4.36 | 1.89 | 2.90 | 4.21 | 3.38 |
| Total | 9.11 | 13.22 | 14.13 | 24.56 | 16.85 | 16.98 | 13.85 | 15.10 | 18.98 | 19.77 | 23.15 |

# Operability: Overview

- Operability relates to aspects of a power system that allow the main components of load, supply and transmission to function
- Operability is an indicator of whether resources can be reasonably and reliably coordinated to deliver power to the loads in real-time dispatch to match varying loads and extreme system conditions
- The power system must be capable of delivering power and be able to sustain significant system events, while maintaining reliability across a spectrum of system operating conditions and requirements
- In a balanced system there is enough redundancy and technological diversity to meet electricity needs without over-reliance on any one particular resource

# Surplus baseload generation (SBG)

- SBG occurs when the baseload generation is higher than the Ontario Demand plus net exports. SBG typically occurs during periods of low demand in Ontario and/or connected neighbouring systems. The expected baseload generation includes nuclear generation, baseload waterpower generation, and intermittent generation such as wind and solar.
- The IESO has enhanced its processes to maintain supply-demand balance. The system is balanced using market mechanisms which include export scheduling, dispatch of renewables, and manoeuvering/shutdown of nuclear units. Out-of-market mechanisms such as import cuts could also be utilized to alleviate SBG conditions




Source: IESO 18-month outlook, June 21, 2016.
http://www.ieso.ca/Documents/marketReports/18MonthOutlook_2016jun.pdf

# Load-following and operational flexibility

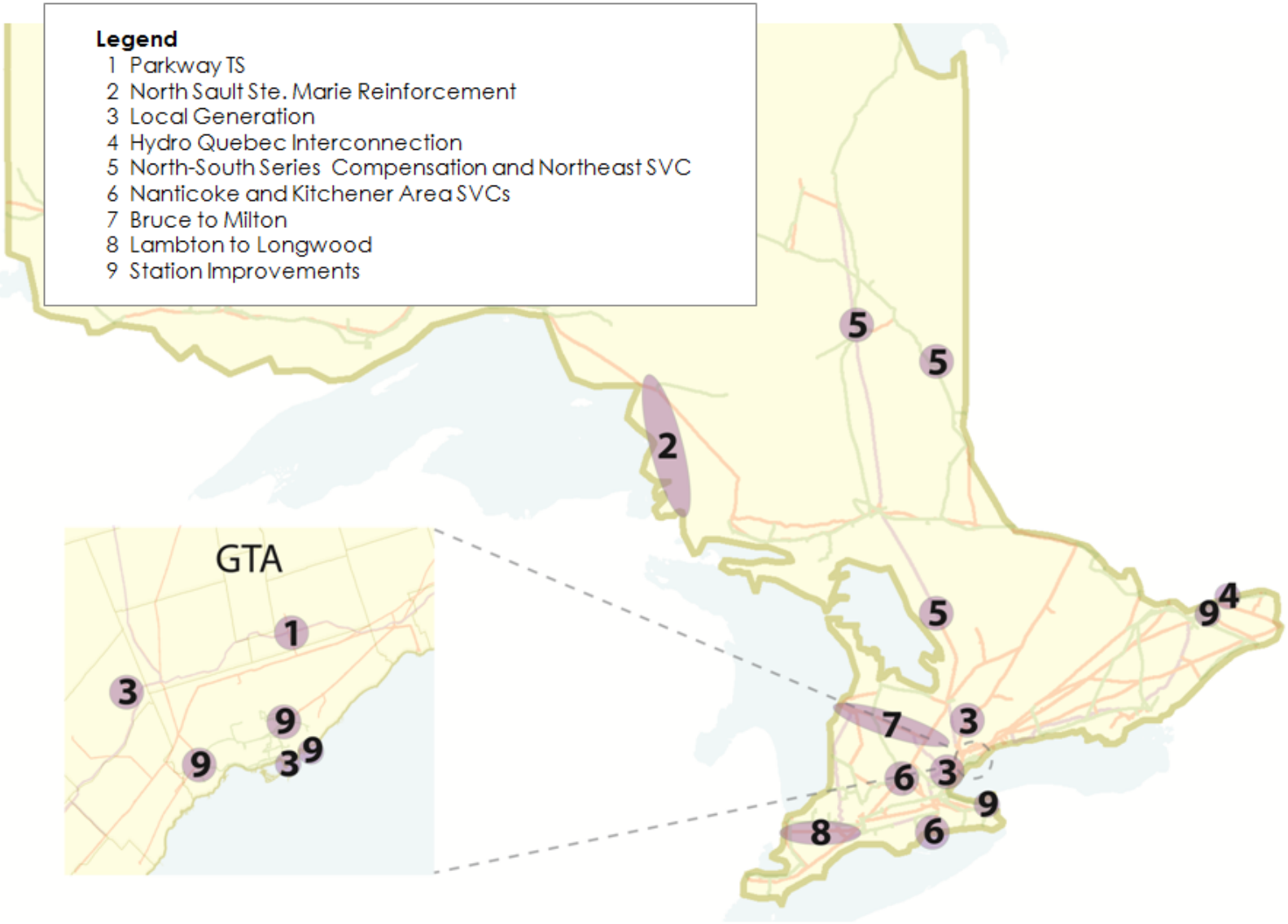
- Load-following is the capability of the generation fleet to increase and decrease its output in response to changes in demand (commonly referred to as ramp rate). Operational flexibility is the ability to commit and schedule resources to meet load-following requirements within the available timeframe
- Operational flexibility required by the power system has been increasing, driven by increased variable generation and changing load behaviour due to weather, economic conditions, and embedded generation
- Operational flexibility has been decreasing because of the phase-out of coal-fired generation and a transition to natural gas as Ontario's intermediate resources
- Despite the significant system changes, the flexibility and capability of the Ontario fleet along with the enhanced operational actions taken have been adequate to maintain reliability

# Operating reserve and frequency regulation

- Operating Reserve
  - It is the supply or load reduction capacity which can be called upon on short notice (within 10 mins and 30 mins) to address sudden changes in supply or demand
  - Variable generation (VG) output variability has been within the conditions addressed by both 10 minute and 30 minute reserve requirements
  - The amount of operating reserve procured during this timeframe was adequate for the supply mix and system conditions experienced

- Frequency Regulation
  - It is the service required to control power system frequency and maintain the balance between load and generation on a second-by-second basis
  - The IESO's Renewables Integration Initiative (RII) introduced centralized resource forecasting to help reduce forecast errors associated with increasing amounts of variable generation. The IESO also started to explore the use of new technologies to provide regulation (Alternative Technologies for Regulation procurement in 2012)
  - The frequency of the power system was adequately maintained by available resources. However, it has been observed that in adequately regulating the frequency, the resources providing regulation have often been stretched to their limits

# Recent transmission investment & planning activities: Locations

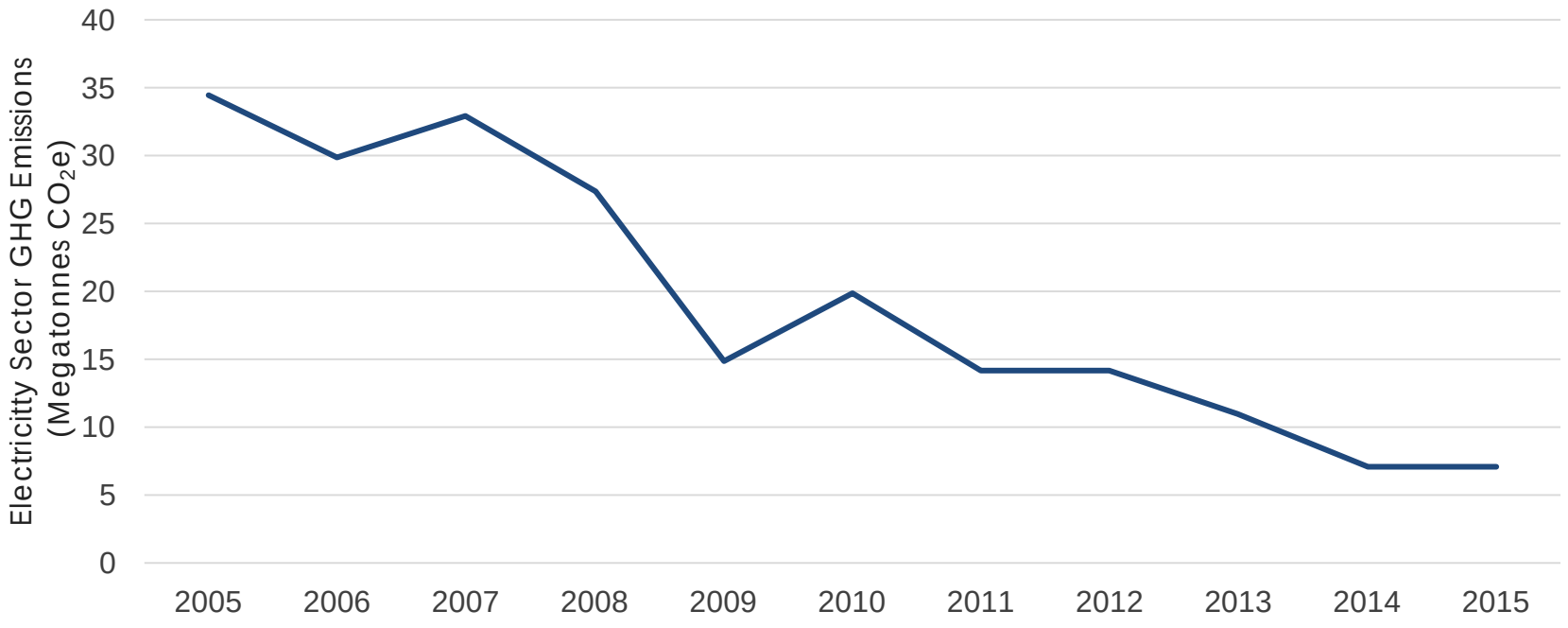


# Recent transmission investment & planning activities: Drivers

| Investment/Planning Activities | In-Service | Drivers | | | |
|---|---|---|---|---|---|
| | | Facilitating the Off-Coal Policy | Maintaining System Reliability and Security | Facilitating Interconnection with Neighboring Jurisdictions | Enabling Renewable Resources |
| **Parkway 500/230kV transformers** | 2005 | X | X | | X |
| **North Sault Ste. Marie Transmission Reinforcement: Third Line to Wawa** | 2006 | | X | | X |
| **Local Generation: Portlands Energy Centre, Halton Hills, Goreway, York Energy Centre** | 2008-2013 | X | X | | |
| **Hydro Quebec HVDC (High-Voltage Direct Current) Interconnection** | 2009 | | | X | |
| **Voltage Support in Northern Ontario** | 2011 | X | | | X |
| **Voltage Support at Nanticoke and Kitchener area** | 2012-2013 | X | | | X |
| **Bruce to Milton Transmission Reinforcement** | 2012 | X | X | | X |
| **West-of-London Reconductoring : Lambton to Longwood Transmission Upgrade** | 2014 | | | | X |
| **Station Improvements: Leaside, Hearn, Manby, Hawthorne, Allanburg** | 2014-2015 | | X | | X |

# Ontario electricity sector GHG emissions, 2005 - 2015

- Due to the retirement of coal-fired generation and the reduced demand for electricity, the greenhouse gas (GHG) emissions from Ontario's electricity sector fell by 80% since 2005.
- GHG emissions from the electricity sector now make up roughly only 4% of the province's total emissions.
  - Total Ontario economy wide emissions in 2014 were 170.2 MT (Environment Canada)
  - Electricity sector emissions in 2014 were ~4% (= 7.1 MT/170.2 MT) of this

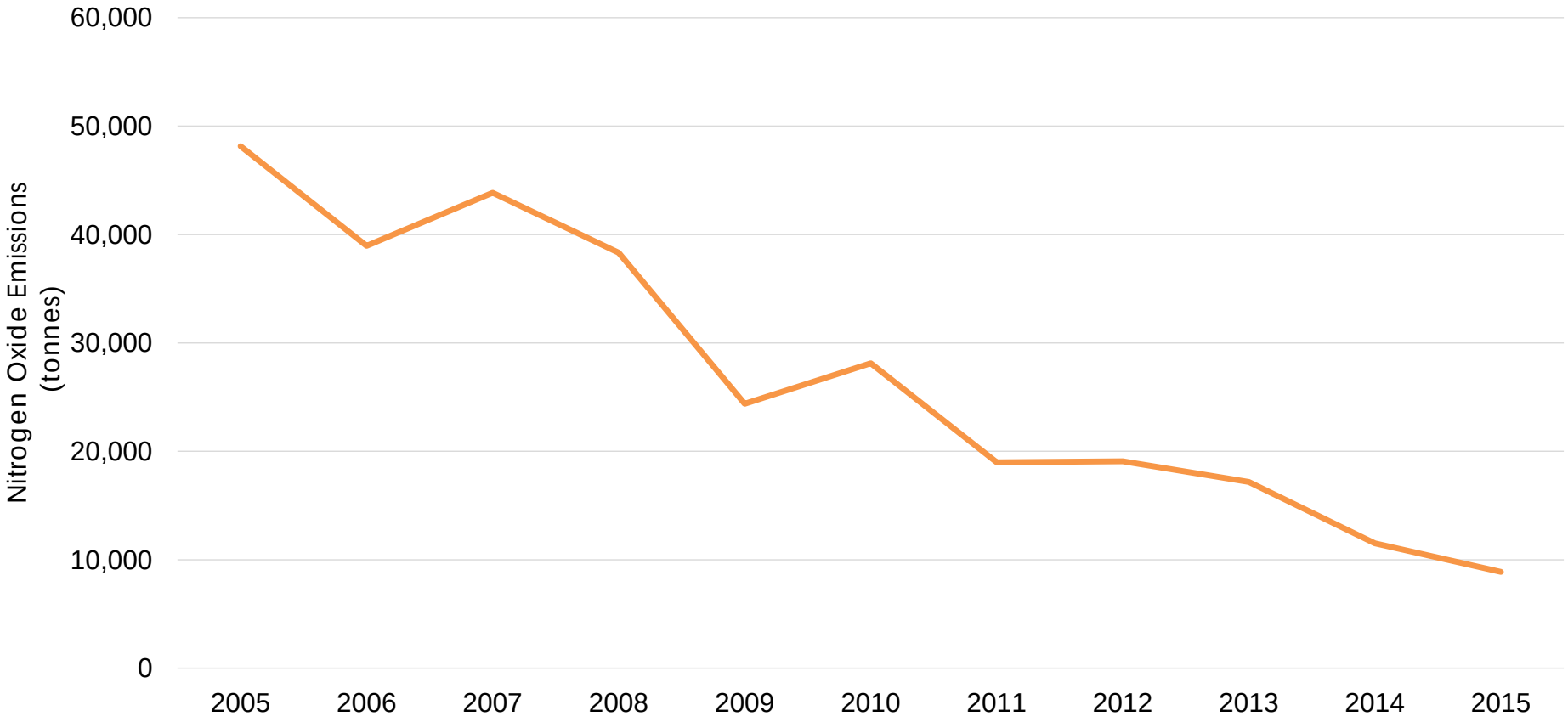


# Ontario electricity sector GHG emissions, 2005 - 2015

| MT $CO_2e$ | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Electricity Sector GHG Emissions | 34.5 | 29.9 | 32.9 | 27.4 | 14.9 | 19.8 | 14.2 | 14.2 | 10.9 | 7.1 | 7.1 |

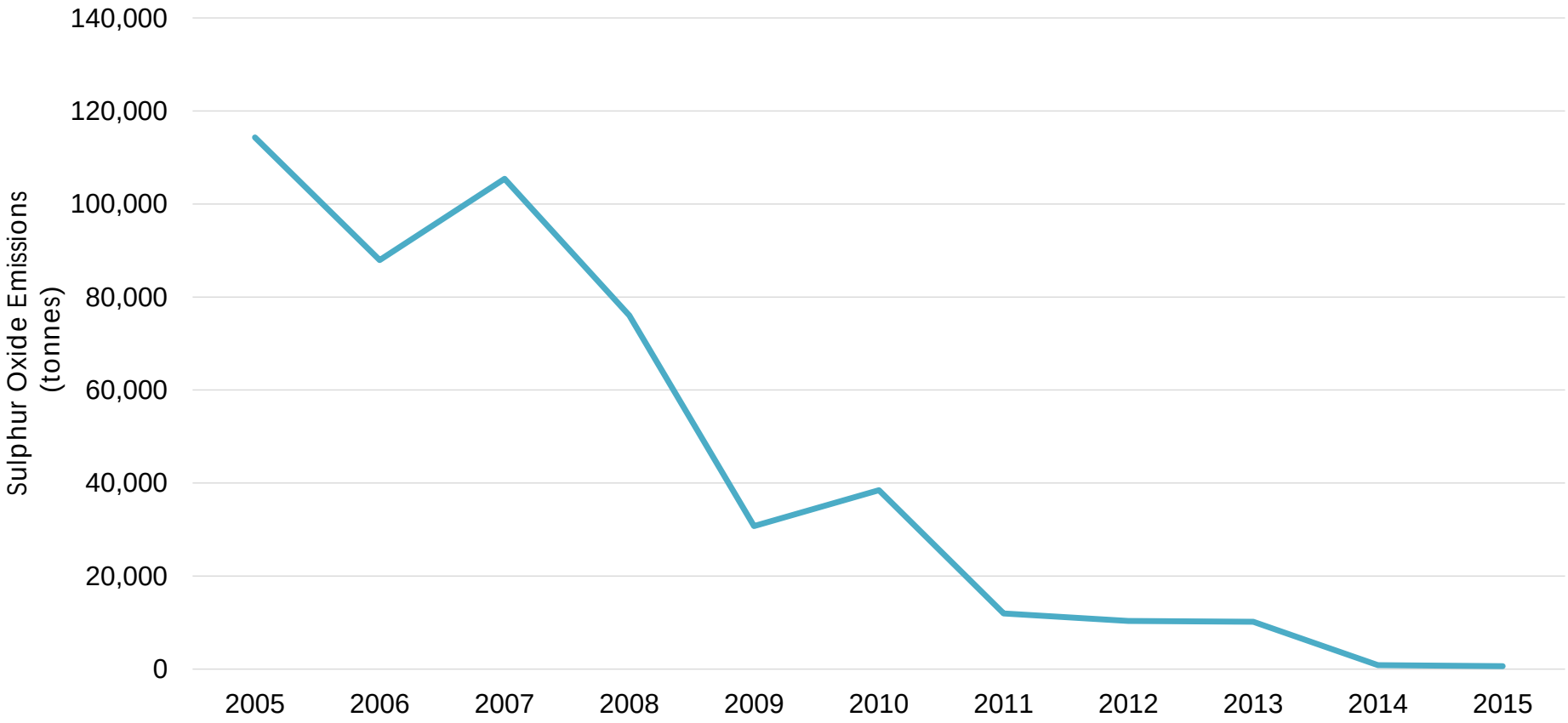
Note: 2005-2013 is from Environment Canada, 2014-2015 is estimated by IESO.

# Historical nitrogen oxide emissions



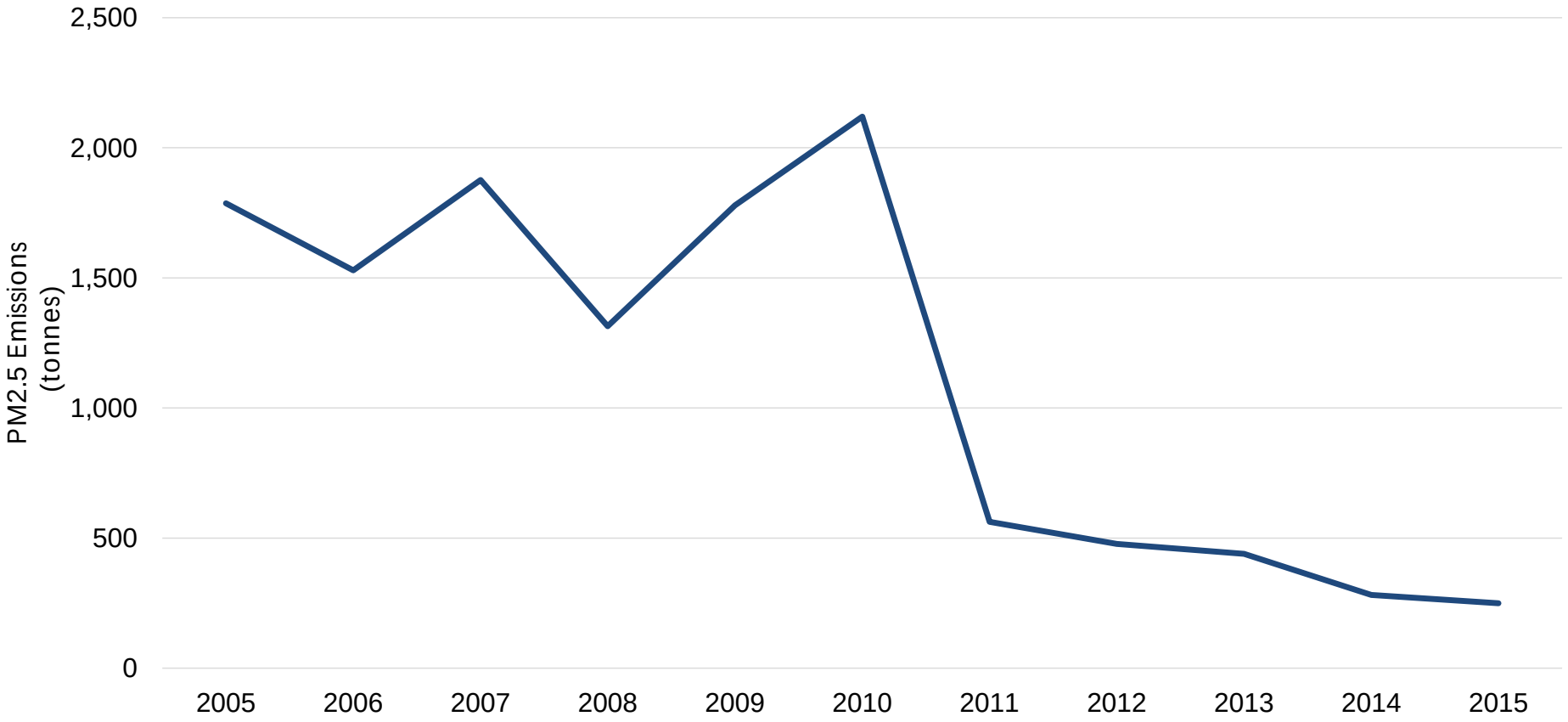

Source: Environment Canada (2005-2014), IESO (2015 estimate)

# Historical sulphur oxide emissions



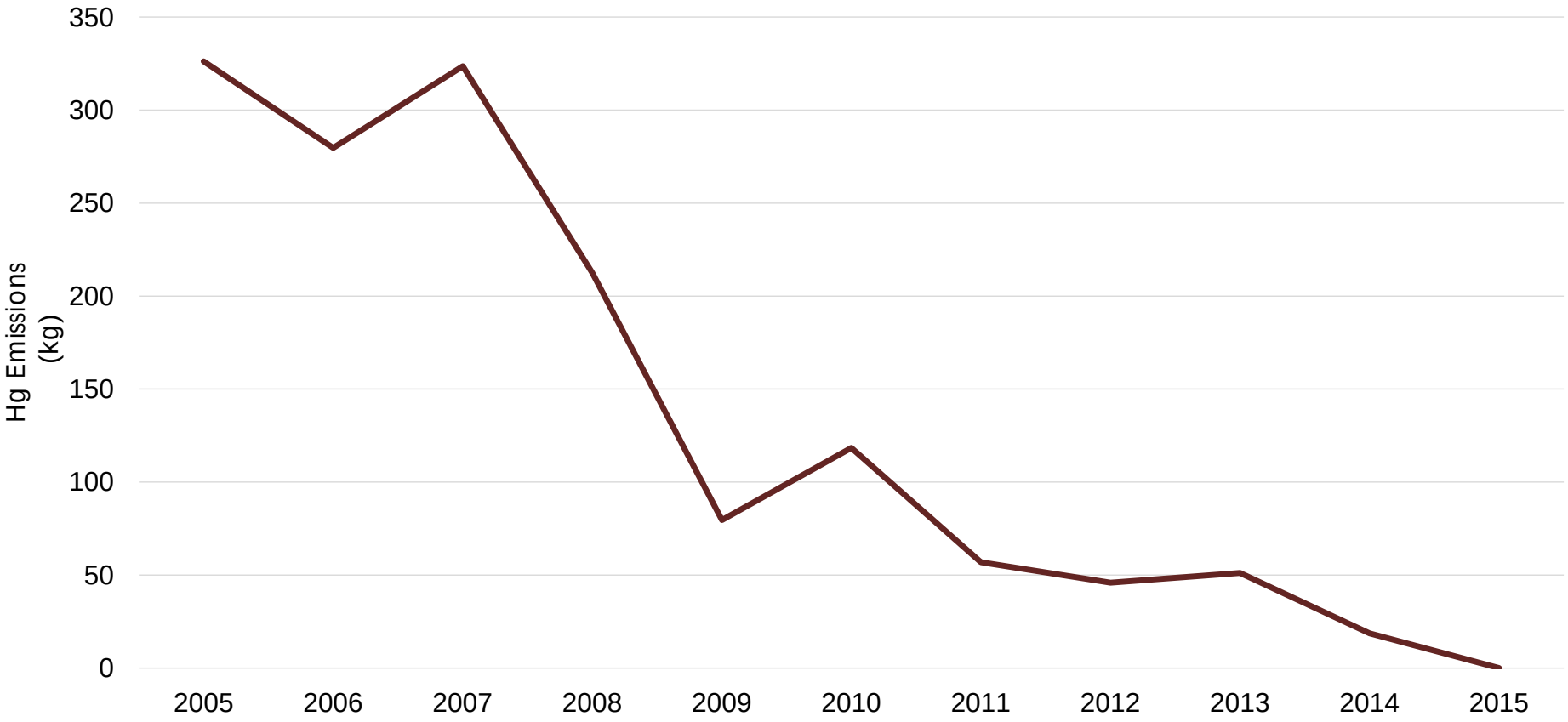

Source: Environment Canada (2005-2014), IESO (2015 estimate)

# Historical fine particulate matter (<2.5µm) emissions




Source: Environment Canada (2005-2014), IESO (2015 estimate)

# Historical mercury emissions




Source: Environment Canada (2005-2014), IESO (2015 estimate)

# Historical air contaminant emissions

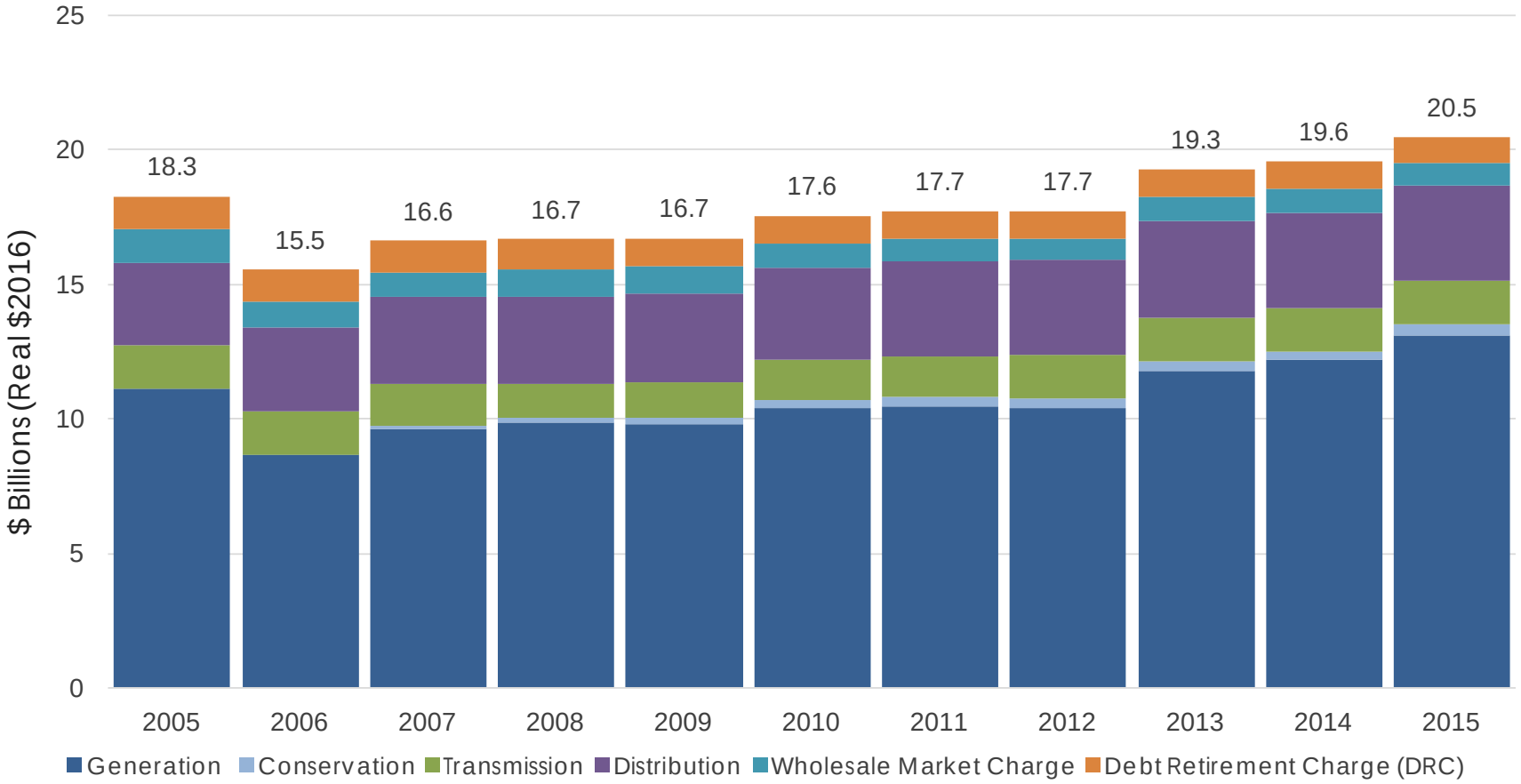
**Historical Air Contaminant Emissions**

| | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Nitrogen oxide emissions (tonnes) | 48,143 | 38,955 | 43,846 | 38,314 | 24,389 | 28,130 | 18,988 | 19,077 | 17,183 | 11,520 | 8,877 |
| Sulphur oxide emissions (tonnes) | 114,323 | 87,932 | 105,420 | 76,020 | 30,768 | 38,448 | 11,971 | 10,342 | 10,192 | 847 | 620 |
| Fine particulate matter (<2.5µm) emissions (tonnes) | 1,787 | 1,529 | 1,876 | 1,314 | 1,779 | 2,120 | 562 | 478 | 439 | 281 | 249 |
| Mercury emissions (kg) | 326 | 280 | 324 | 212 | 80 | 118 | 57 | 46 | 51 | 19 | 0 |

Source: Environment Canada (2005-2014), IESO (2015 estimate)

# Total cost of electricity service 2005-2015

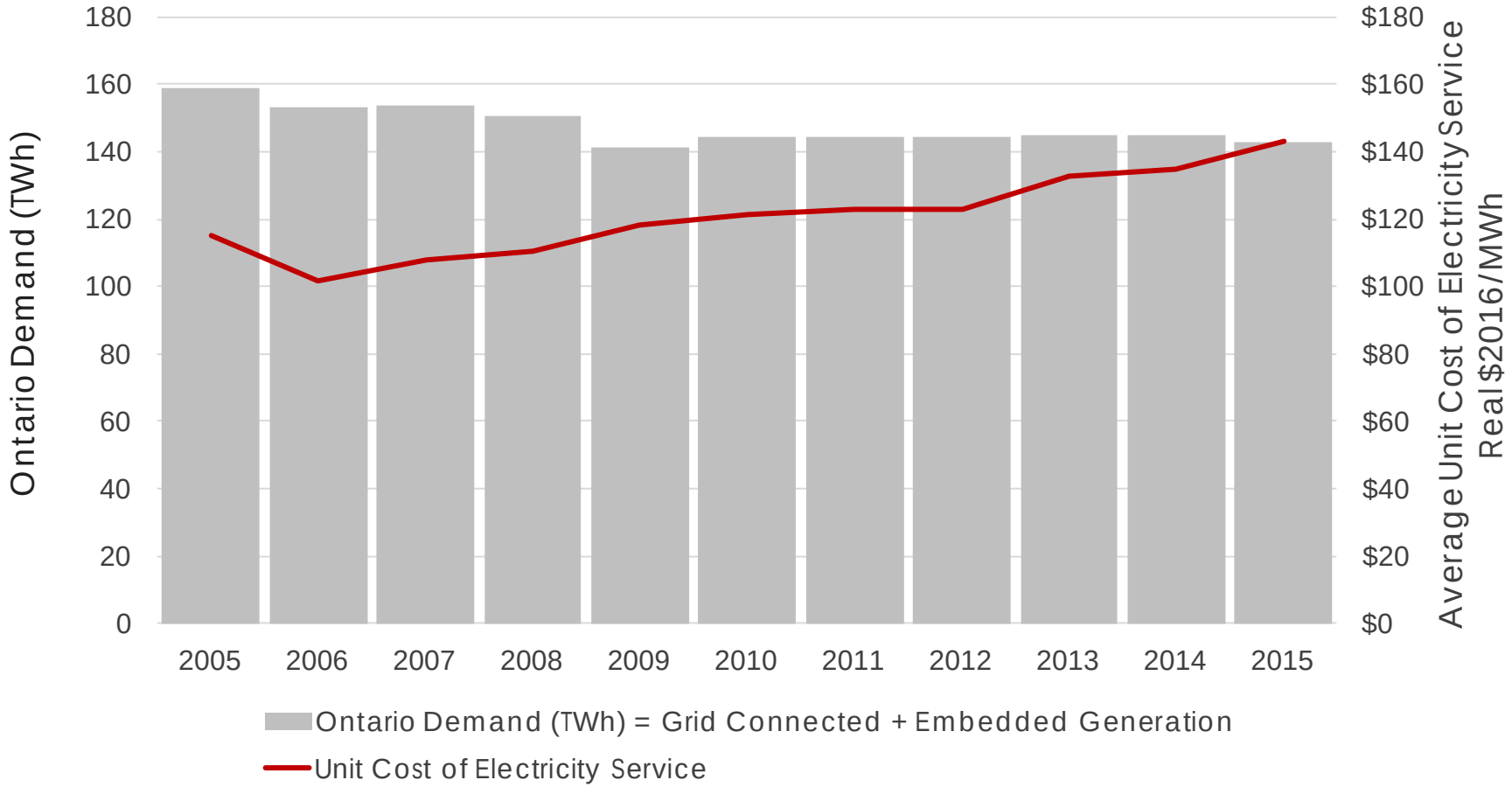
- 2005 was an anomalous year.[1] Total cost of electricity grew 3.2% per year (on average) from 2006 to 2015 in real 2016$.




[1] Unusual weather and tight supply conditions led to very high demand and record market prices for power, adding about $3B to the cost of electricity bill.

# Average unit cost of electricity service 2005-2015

- 2005 was an anomalous year.[1] Average unit cost of electricity grew 3.9% per year (on average) from 2006 to 2015 in real 2016$.




[1] Unusual weather and tight supply conditions led to very high demand and record market prices for power, adding about $3B to the cost of electricity bill.

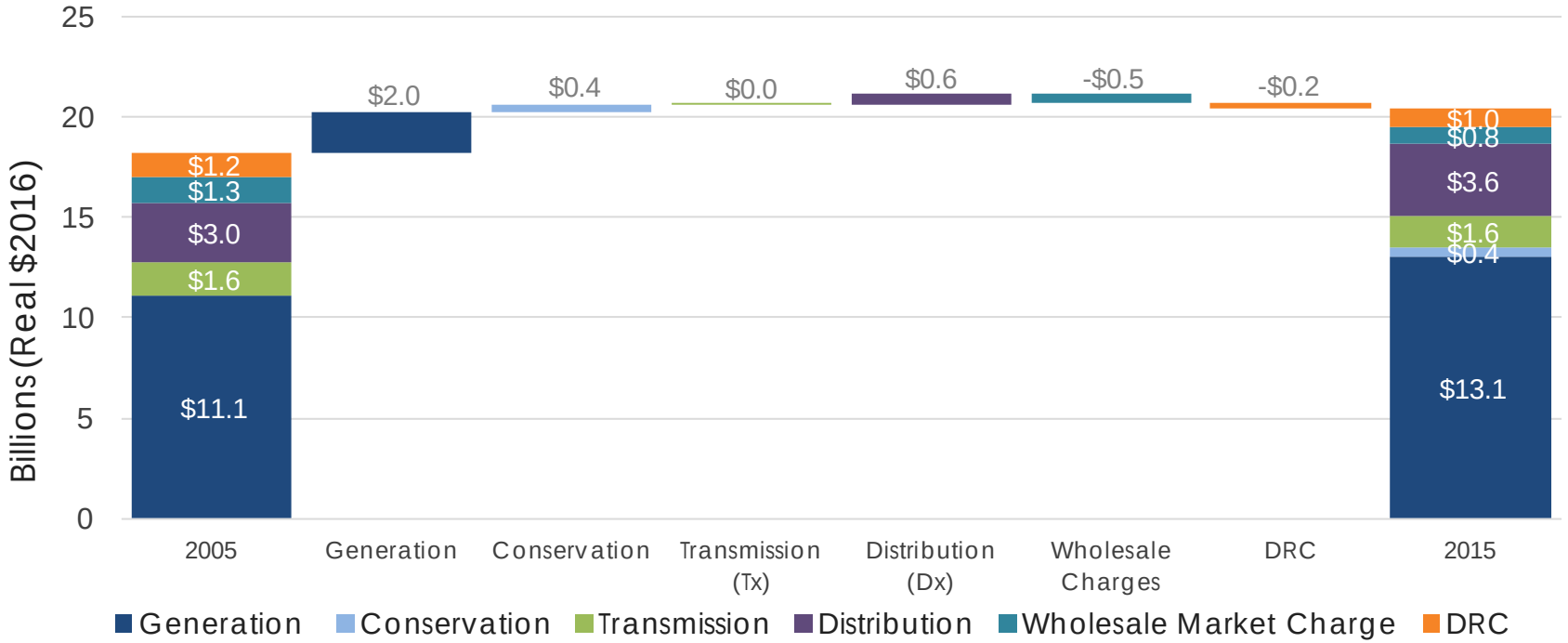
# Total cost of electricity service and average unit cost of electricity service

**Total Cost of Electricity Service**

| Real $2016, Billions | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Generation | 11.1 | 8.6 | 9.6 | 9.9 | 9.8 | 10.4 | 10.5 | 10.4 | 11.8 | 12.2 | 13.1 |
| Conservation | 0.0 | 0.0 | 0.1 | 0.2 | 0.2 | 0.3 | 0.4 | 0.4 | 0.4 | 0.3 | 0.4 |
| Transmission | 1.6 | 1.6 | 1.5 | 1.3 | 1.3 | 1.5 | 1.5 | 1.6 | 1.6 | 1.6 | 1.6 |
| Distribution | 3.0 | 3.2 | 3.3 | 3.2 | 3.3 | 3.4 | 3.5 | 3.5 | 3.6 | 3.5 | 3.6 |
| Wholesale Market Charge | 1.3 | 0.9 | 0.9 | 1.0 | 1.0 | 0.9 | 0.9 | 0.8 | 0.9 | 0.9 | 0.8 |
| Debt Retirement Charge (DRC) | 1.2 | 1.2 | 1.2 | 1.1 | 1.0 | 1.1 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 |
| Total | 18.3 | 15.5 | 16.6 | 16.7 | 16.7 | 17.6 | 17.7 | 17.7 | 19.3 | 19.6 | 20.5 |

| | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **Ontario Demand (TWh) = Grid Connected + Embedded Generation** | 158.8 | 153.0 | 153.8 | 150.6 | 141.1 | 144.5 | 144.3 | 144.5 | 145.0 | 144.9 | 143.0 |
| **Average Unit Cost of Electricity Service ($/MWh - Real $2016)** | $115.07 | $101.53 | $107.93 | $110.68 | $ 118.42 | $ 121.48 | $ 122.85 | $ 122.73 | $ 132.78 | $ 134.96 | $ 143.48 |

# Change in total cost of electricity service By service type




| 2016 $ Billions | 2005 | 2015 | Delta 2015 - 2005 |
|---|---|---|---|
| Generation | $11.1 | $13.1 | $2.0 |
| Conservation | $0.0 | $0.4 | $0.4 |
| Transmission | $1.6 | $1.6 | $0.0 |
| Distribution | $3.0 | $3.6 | $0.6 |
| Wholesale Market Charge | $1.3 | $0.8 | -$0.5 |
| Debt Retirement Charge (DRC) | $1.2 | $1.0 | -$0.2 |
| Total Cost of Electricity Service | $18.3 | $20.5 | $2.2 |

Figures may not add due to rounding.
Generation costs were unusually high in 2005. In 2004, generation was $8.4 billion and 2006 it returned to $8.6 billion.