
Export Transmission Service (ETS) Tariff Scenario Analysis

Final Report and Findings

**Prepared for
Independent Electricity System Operator**



INTERNATIONAL

July 30, 2009

Key Study Objectives

- Assess and analyse the potential incremental impact of each ETS tariff option with respect to:
 - Hourly Ontario Energy Price (HOEP);
 - Export Revenues
 - Export and Import Volumes; and
 - Market Efficiency (i.e., total consumer and producer surplus)
- Aim is not to optimize these parameters; rather, to ascertain the potential incremental impact of each option on these key parameters.
- Observe and analyse potential incremental impacts on environmental emissions (i.e., SO₂, NO_x and CO₂) in the region attributed to each ETS tariff option.

General Conclusions

- ETS tariff options such as the *average embedded network rate* and the modeled *reciprocal treatment* tend to increase consumer surplus and decrease producer surplus
 - The average embedded network rate scenario involves a unilateral increase in the ETS tariff, consequently reducing external demand for Ontario power, and reducing the HOEP
 - Because Ontario has a lower export tariff than its neighbours, reciprocal tariff elimination reduces net exports from Ontario, decreases producer surplus, and increases consumer surplus.
- ETS tariff options such as *unilateral tariff elimination* tend to increase producer surplus and decrease consumer surplus
- Ontario's ETS revenues increase in the scenarios that involve ETS tariff increases
- Impacts on SO₂ and NO_x emissions are small as a result of:
 - Ontario's CO₂ policy concurrently reduces those emissions well below their regulated caps irrespective of the ETS tariff scenario
 - The US Clean Air Interstate Rule (CAIR) policy restricts the emissions of both pollutants in neighbouring U.S. regions.
 - However, some scenarios show small increases in regional emissions relative to the status quo (but all scenarios are well below their caps)
- Under a North American cap-and-trade policy for CO₂ emissions, the ETS tariff scenario will have no significant effect on North American power system CO₂ emissions (because emissions would be set by the cap)

Limitations of Analysis

- Contracted generator arrangements and obligations for the most part have been modeled with limited detail (i.e., with the exception of NUG/CHP resources)
- Strategic bidding behaviour within Ontario and within Ontario's neighbouring regions has been modeled in only a rudimentary fashion
 - Peaking gas units' bids are inflated to reflect strategic bidding on-peak
 - Coal units' bids are reduced to reflect bidding behaviour off-peak
- Implications of potential changes in uplift charges, and their consequential impacts on export/import transactions are not considered
- Limited understanding of hydropower output shape in Quebec and New York
- Some potential transmission constraints into, out of, and inside of Ontario are not modeled. No internal constraints are modeled.

Outline

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Unit characteristics - coal

Unit	Summer MW	Heat Rate (Btu/kWh)	SO2 Controls	NOx Controls
Atikokan GS 1	211			
Lambton GS 1	485			
Lambton GS 2	485			
Lambton GS 3	475		FGD	SCR
Lambton GS 4	475		FGD	SCR
Nanticoke 1	440			
Nanticoke 2	440			
Nanticoke 3	460			
Nanticoke 4	440			
Nanticoke 5	460			
Nanticoke 6	460			
Nanticoke 7	480			SCR
Nanticoke 8	480			SCR
Thunder Bay GS 2	155			
Thunder Bay GS 3	155			
Capacity-weighted Average	6,101			

Sources: Ventyx Velocity Suite and IESO.

Note: Heat rates are considered confidential information; accordingly, these are not disclosed.

Unit characteristics (2007) - other

Technology	Summer MW	Capacity-weighted Average Heat Rate (Btu/kWh)
Nuclear	11,504	10,500
Natural Gas Combined-Cycle	3,065	7,691
Natural Gas Combustion Turbine	397	12,257
Peaking Oil	1,070	11,000
Steam Turbine Gas/Oil	2,120	9,891
Hydroelectric	7,935	N/A
Wind Turbine	396	N/A
Other Renewables	93	N/A

Note: Non-coal units are aggregated in CRA's NEEM model. Combined-cycle units are grouped into two or three tiers (depending on year) and combustion turbines into two tiers. Tiers are based on heat rate, in-service year, and operational characteristics (NUGs are in their own tier).

Sources: Ventyx Velocity Suite and IESO.

Key assumptions

	Notes	2007	2010	2015
Load	Ontario electricity demand, in TWh	152	159	165
Peak/Min Demands*	Peak/Min hour electricity demand, in MW	25,737 / 11,798	26,986 / 10,937	28,099 / 11,350
Hydro Output	Annual total of hydro-generated electricity, in GWh	33,400	36,734	39,225
SO₂ Cap	Ontario cap on SO ₂ emissions, in kilotonnes	127	127	127
NO_x Cap	Ontario cap on NO _x emissions, in kilotonnes	41.3	41.3	41.3
CO₂ Cap	Ontario cap on CO ₂ emissions from coal-fired power plants , in million metric tons	None	15.6	coal retired
Nuclear POD**	Annual planned outage days for Ontario nuclear fleet	altered to target 2007 nuclear generation	39	36
Nuc. Forced Outage Rate**	Annual forced outage rate for Ontario nuclear fleet		3.5%	3.4%

Source: IESO data

* Minimum demand is expressed for the minimum load block in the NEEM model. Therefore, *it is not the true lowest demand for the year.*

** Nuclear POD and forced outage rate reflect a capacity-weighted annualized rate calculated from IESO reliability assessment data

Key Transfer Limits

Key Assumptions

FROM	TO	Transfer Limit (MW)
Ontario	Quebec	1,600 (only 350 MW in 2007)
Ontario	New York + PJM via NY PJM via NY	1,450 1,050
Ontario	Michigan + PJM via Michigan	2,150
Ontario	Manitoba	274
Ontario	Minnesota	140
Quebec	Ontario	1,600 (only 350 MW in 2007)
New York + PJM via NY	Ontario	1,550
Michigan + PJM via Michigan PJM via Michigan	Ontario	1,800* 1,500*
Manitoba	Ontario	342
Minnesota	Ontario	90

* PJM-to-Michigan + Michigan-to-Ontario is limited to 3,000 MW. For example, if 1,201 MW is transferred from PJM to Michigan, only 1,799 MW can be transferred from Michigan to Ontario.



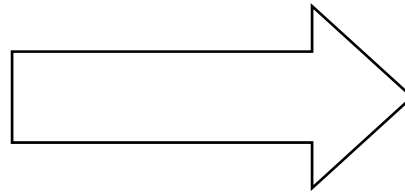
Forecasted Ontario hydro output by month was provided by the IESO

Hydro Energy On-peak and Off-peak

Month	On/Off-Peak	MWh	
		2010	2015
Jan	Off-Peak	1,507,276	1,580,781
Jan	On-Peak	1,427,344	1,650,064
Feb	Off-Peak	1,310,327	1,467,978
Feb	On-Peak	1,351,465	1,527,088
Mar	Off-Peak	1,304,916	1,592,998
Mar	On-Peak	1,645,621	1,710,196
Apr	Off-Peak	1,533,539	1,649,420
Apr	On-Peak	1,580,534	1,729,833
May	Off-Peak	1,959,169	2,027,629
May	On-Peak	1,720,857	1,807,942
Jun	Off-Peak	1,449,395	1,502,878
Jun	On-Peak	1,797,971	1,907,897
Jul	Off-Peak	1,442,111	1,456,945
Jul	On-Peak	1,615,329	1,763,502
Aug	Off-Peak	1,347,874	1,494,490
Aug	On-Peak	1,514,388	1,494,371
Sep	Off-Peak	1,267,121	1,331,106
Sep	On-Peak	1,431,909	1,508,148
Oct	Off-Peak	1,542,192	1,547,099
Oct	On-Peak	1,496,555	1,631,385
Nov	Off-Peak	1,432,817	1,574,989
Nov	On-Peak	1,776,502	1,802,899
Dec	Off-Peak	1,591,419	1,696,968
Dec	On-Peak	1,687,533	1,768,231
TOTAL		36,734,162	39,224,839

Run-of-River Hydro Output
(corresponds to off-peak output)

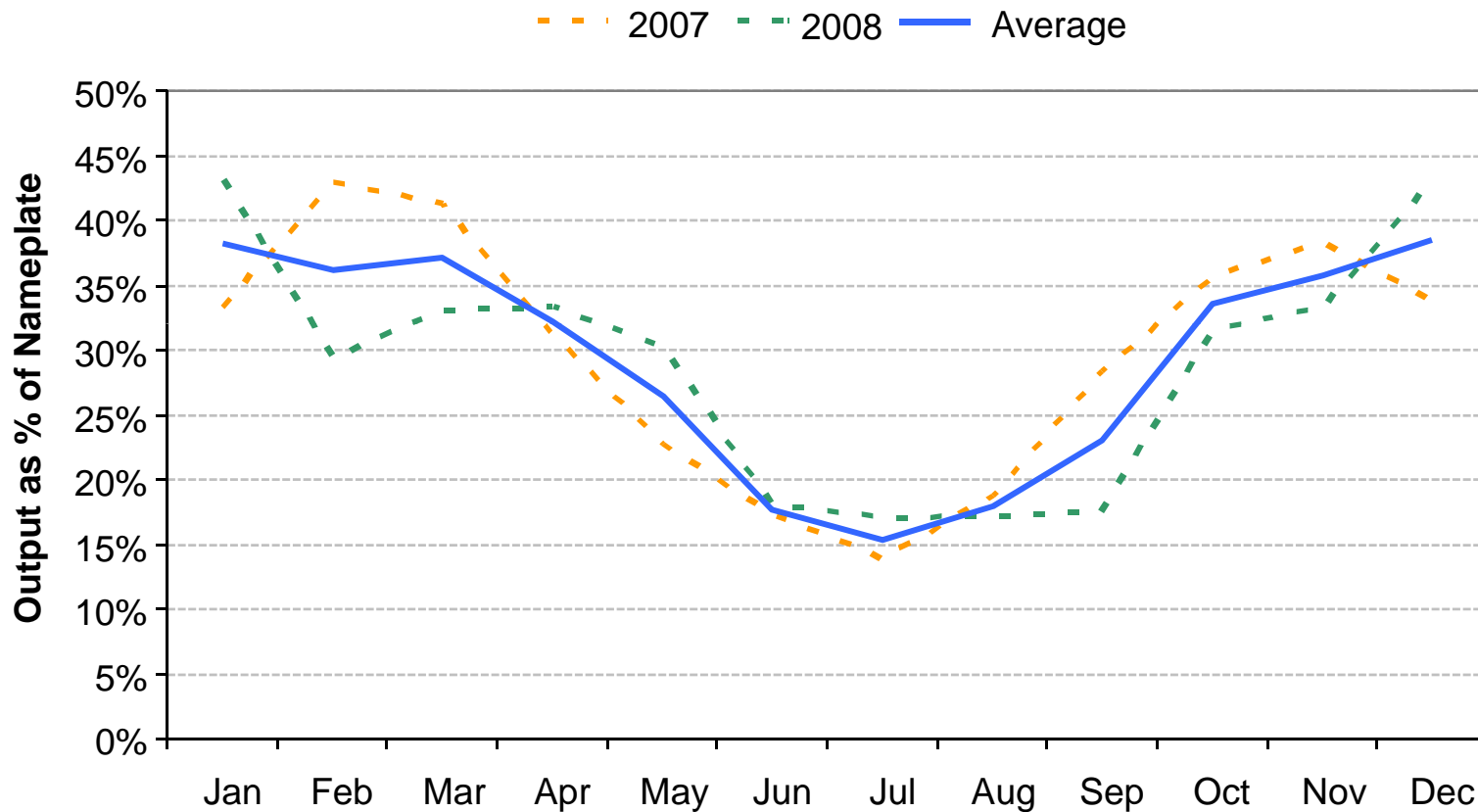
MW	2010	2015
Jan	3,621	3,797
Feb	3,485	3,904
Mar	3,135	3,827
Apr	3,807	4,094
May	4,706	4,871
Jun	3,598	3,731
Jul	3,464	3,500
Aug	3,238	3,590
Sep	3,145	3,304
Oct	3,705	3,716
Nov	3,557	3,910
Dec	3,823	4,076



Note: The hydro energy output is met by a combination of run-of-river resources and hydro resources that are economically optimized by NEEM. The maximum possible (combined) hydro output is about 7900 MW and 8700 MW in 2010 and 2015, respectively.

Source: IESO

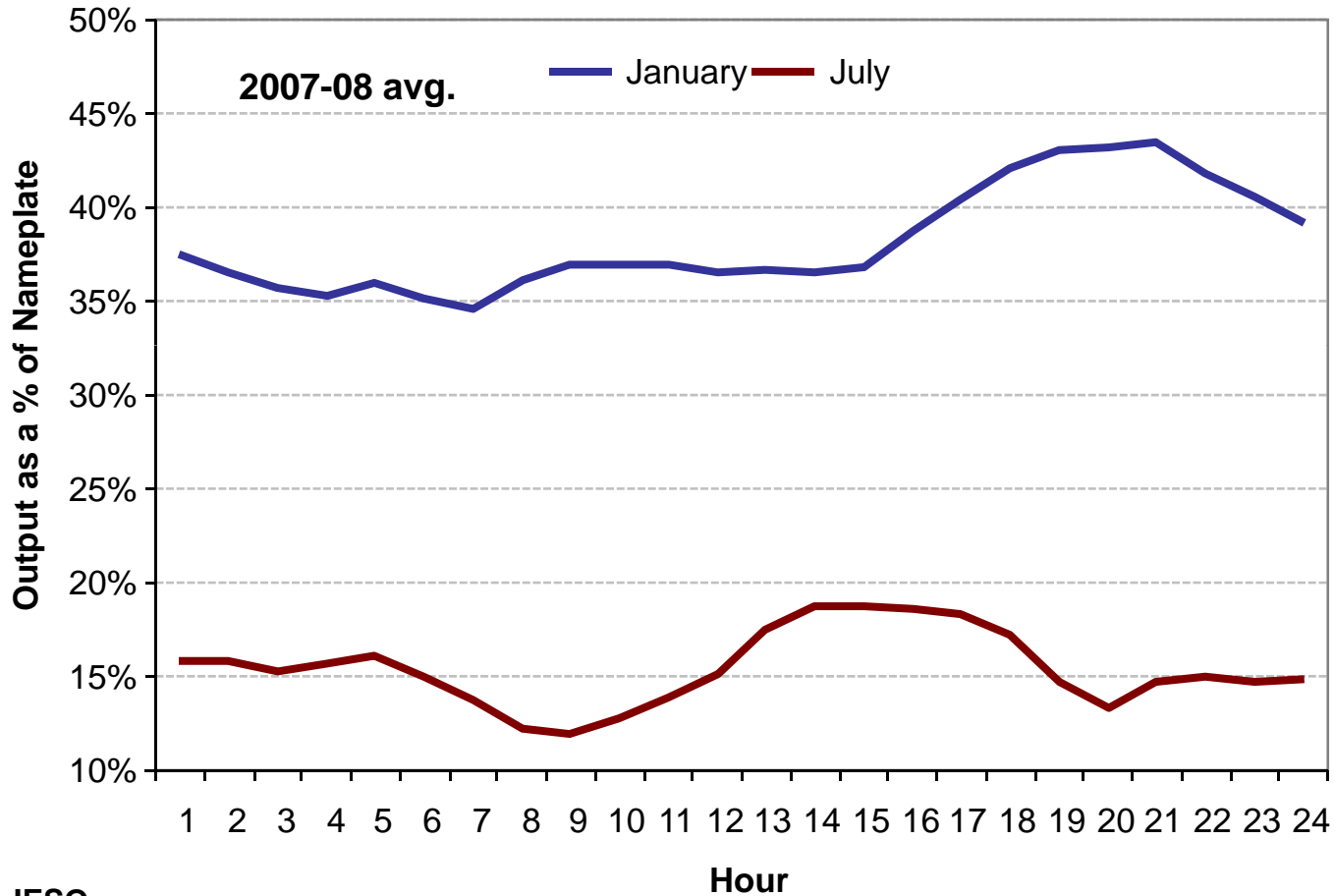
Wind output assumptions (monthly) are based on historical data



Source: IESO

Ontario wind output in NEEM reflects an average of historical wind resource performance.

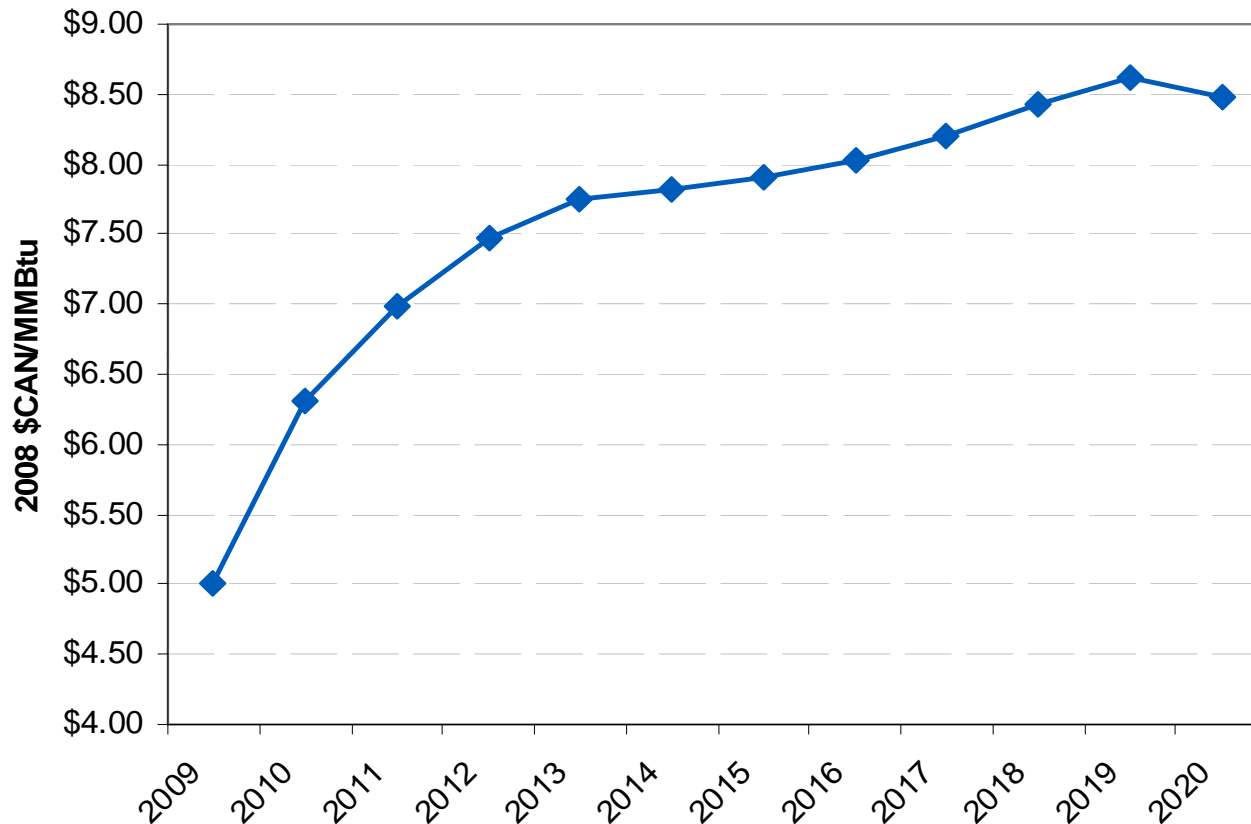
Wind output assumptions (diurnal variation in winter and summer)



Source: IESO

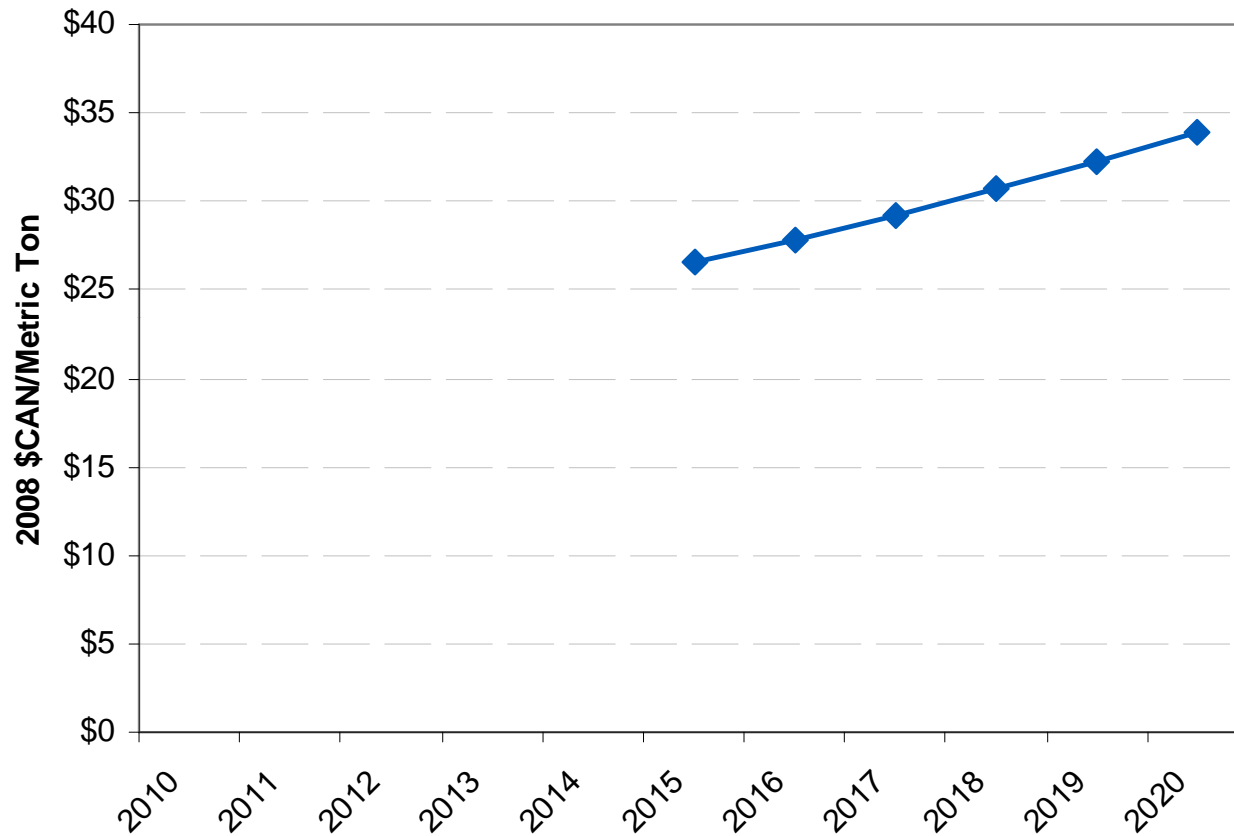
Summer and winter output levels and shapes are different.

Natural gas delivered prices to Ontario power plants



Henry hub prices are based on a blend of NYMEX futures (April 1, 2009) and Energy Information Administration's Annual Energy Outlook (AEO) 2009 forecast. A regional basis differential adjusts the AEO forecast to Ontario delivered prices.

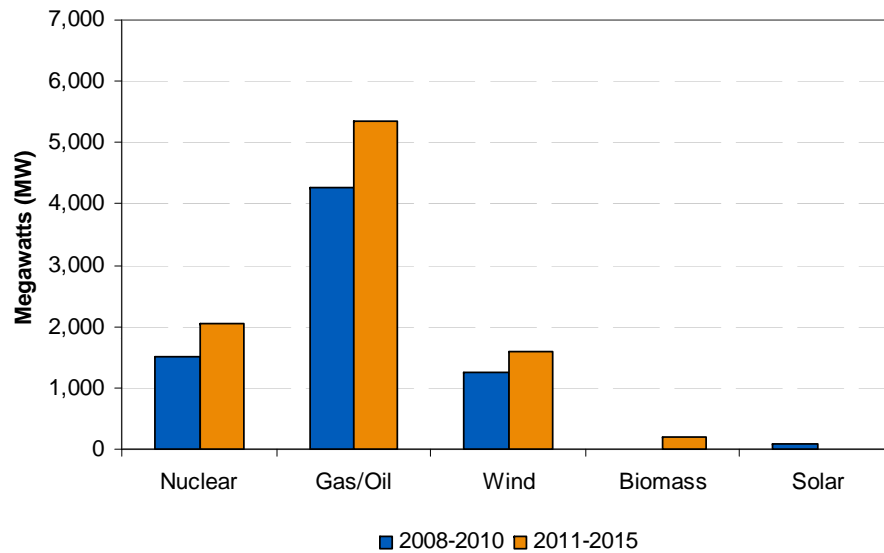
North-American CO2 policy affects 2015 assessment



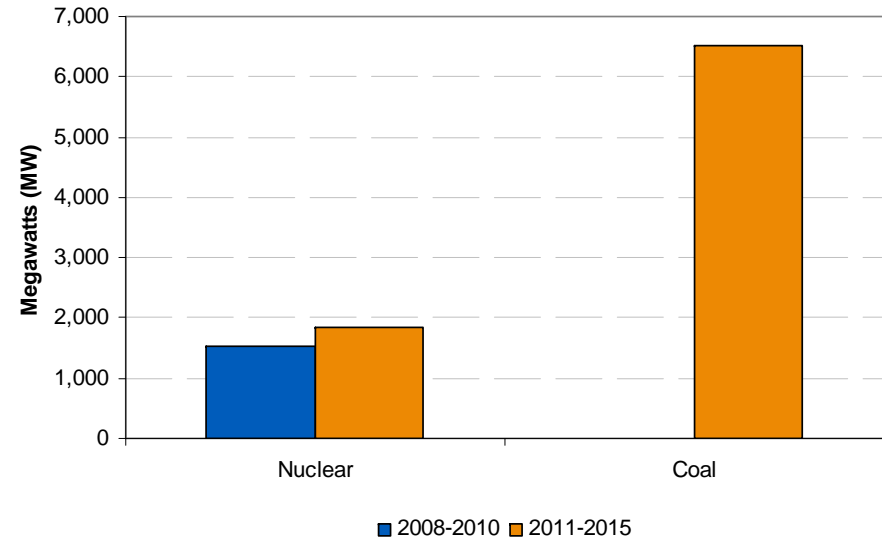
North-American carbon policy is assumed to start in 2015 at a CO2 price of \$26.53/tonne (2008 CAN\$), escalating at 5% real.

New build and retirement schedule (by 2010 and *during* 2011-2015)

Capacity Additions



Retirements



Notes: (1) Although NEEM was allowed to select economic additions, it did not choose any over or above IESO's reported planned builds/retirements schedule

(2) Gas/oil retirements were determined by the model; many of these resources remained only for capacity reasons but did not generate energy

Gas, nuclear, and wind comprise the majority of new capacity in transition to low-emissions fleet.

Calculation of Changes in Consumer Surplus and Producer Surplus (focus on Ontario producers and consumers only)

Change in Consumer Surplus in any block* = (Price_{status quo} – Price_{scenario}) * block demand

Total change in Consumer Surplus → sum across the 120 blocks

Change in Producer Surplus in any block = change in energy margin for all Ontario units

[Energy margin = Energy Revenue less all variable costs (e.g., fuel, variable operating and maintenance costs, and allowance costs, etc.)]

Total change in Producer Surplus → sum across the 120 load blocks

*** The CRA NEEM model divides the annual load curve into 120 blocks. There are 10 blocks in each month. The loads are sorted from highest to lowest (within each month) and are not necessarily sequential.**

Status Quo Economics (facilitates understanding of changes under the various scenarios reported subsequently)

- 2010 Producer Surplus = \$5,971 (Million 2008 CAN\$)
- 2015 Producer Surplus = \$9,999 (Million 2008 CAN\$)

- *Status quo consumer surplus cannot be reported because load is fixed (demand is perfectly inelastic), so consumer surplus cannot be measured*

- 2010 ETS Tariff Revenue = \$12.0 (Million 2008 CAN\$)
- 2015 ETS Tariff Revenue = \$13.5 (Million 2008 CAN\$)

Key Assumptions for Calibration and Scenario Analysis

2007 Model Calibration Results

Scenario Definitions

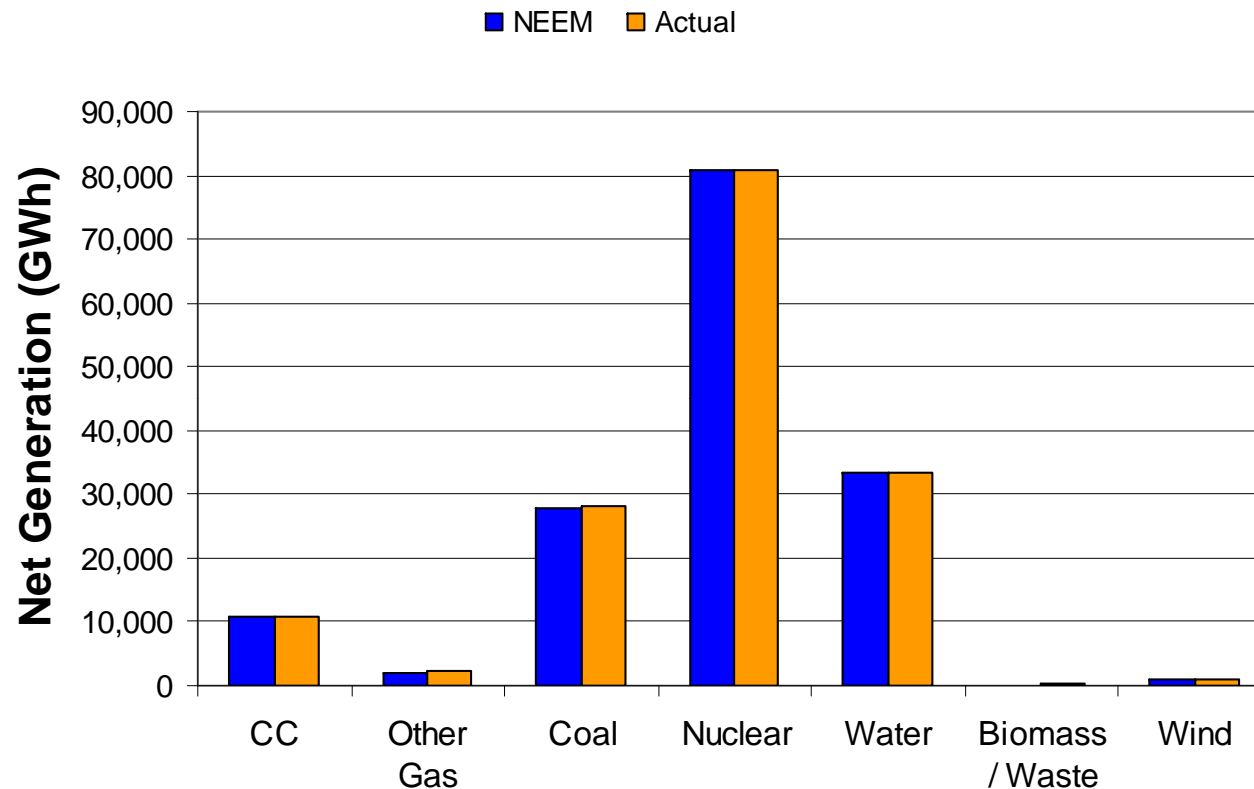
Results by Scenario

Emissions Impacts by Scenario

General Conclusions

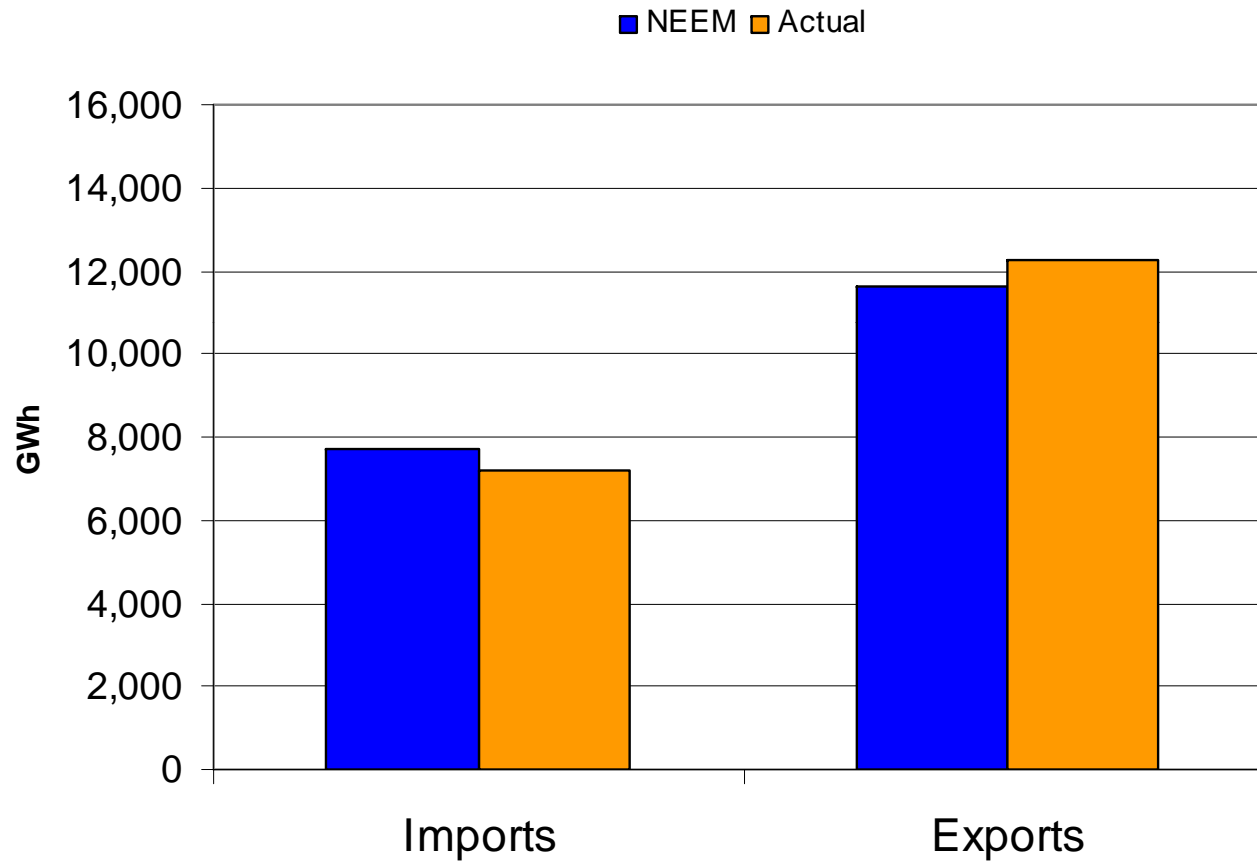
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Generation Calibration - 2007



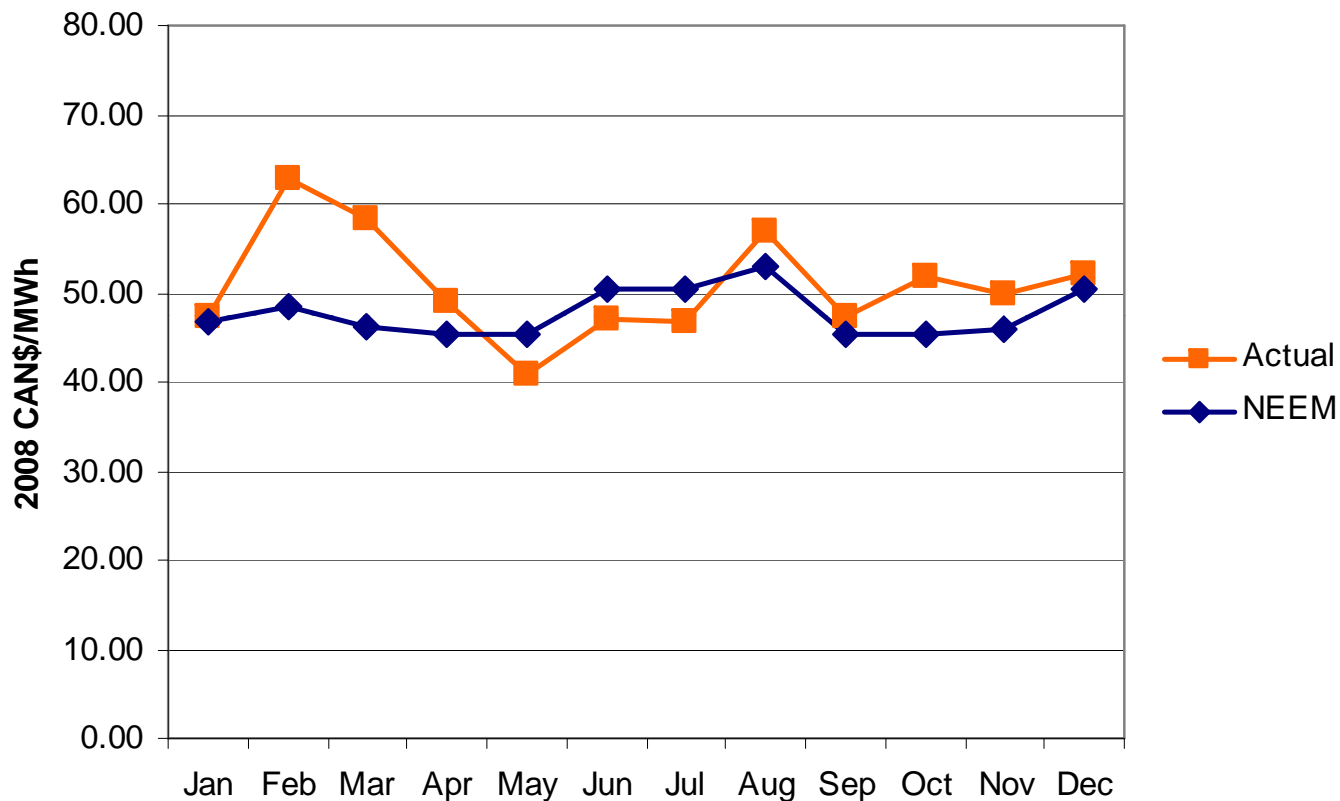
Coal bids are calibrated to roughly match generation. NUGs (included in CC or Combine-Cycle) are assumed to operate with 74% capacity factor. Other Gas is bid down by 25-35% percent. In 2010 and 2015, the Coal/Gas adjustments are the same except Other Gas is not bid down because of expected contractual changes (i.e., Lennox RMR Agreement). In 2010 and 2015, CHP is projected to operate at 42% capacity factor.

Import/Export Balance Calibration - 2007



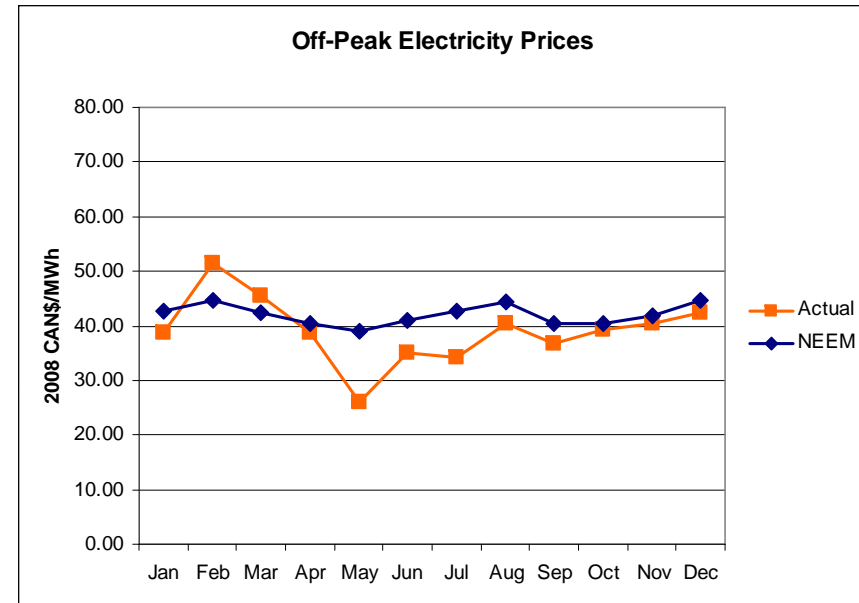
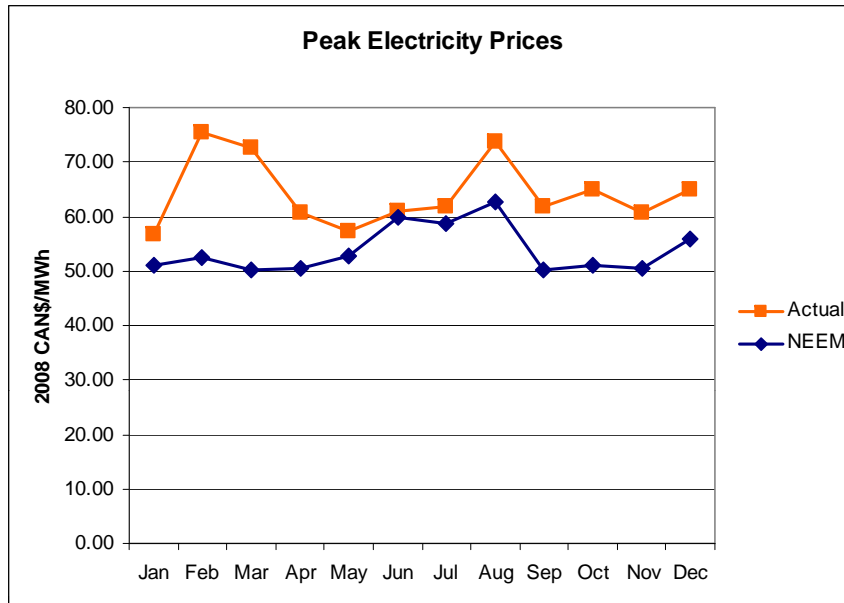
All-Hours Prices Calibration

All Hours Electricity Prices



NEEM-projected all-hours prices are quite close to actual (with the exception of February and March). In these two months (especially February), even though actual Ontario prices are high, actual exports were high and imports were low.

Peak and Off-peak Prices Calibration



On-peak prices from production cost models (like CRA's NEEM Model) typically are lower than real-world on-peak prices. Production cost models anticipate load and generator outages perfectly and hence do not have periods when units that are otherwise available are not committed. In the real world, these unit commitment errors result in peakers running more than they would otherwise (increasing on-peak prices). Similarly, production cost models tend to have off-peak prices that are higher than actual prices because they do not capture the off-peak bidding behaviour of base load units. Base load units often offer capacity at prices below marginal cost to remain on-line during low load periods.

Key Assumptions for Calibration and Scenario Analysis

2007 Model Calibration Results

Scenario Definitions

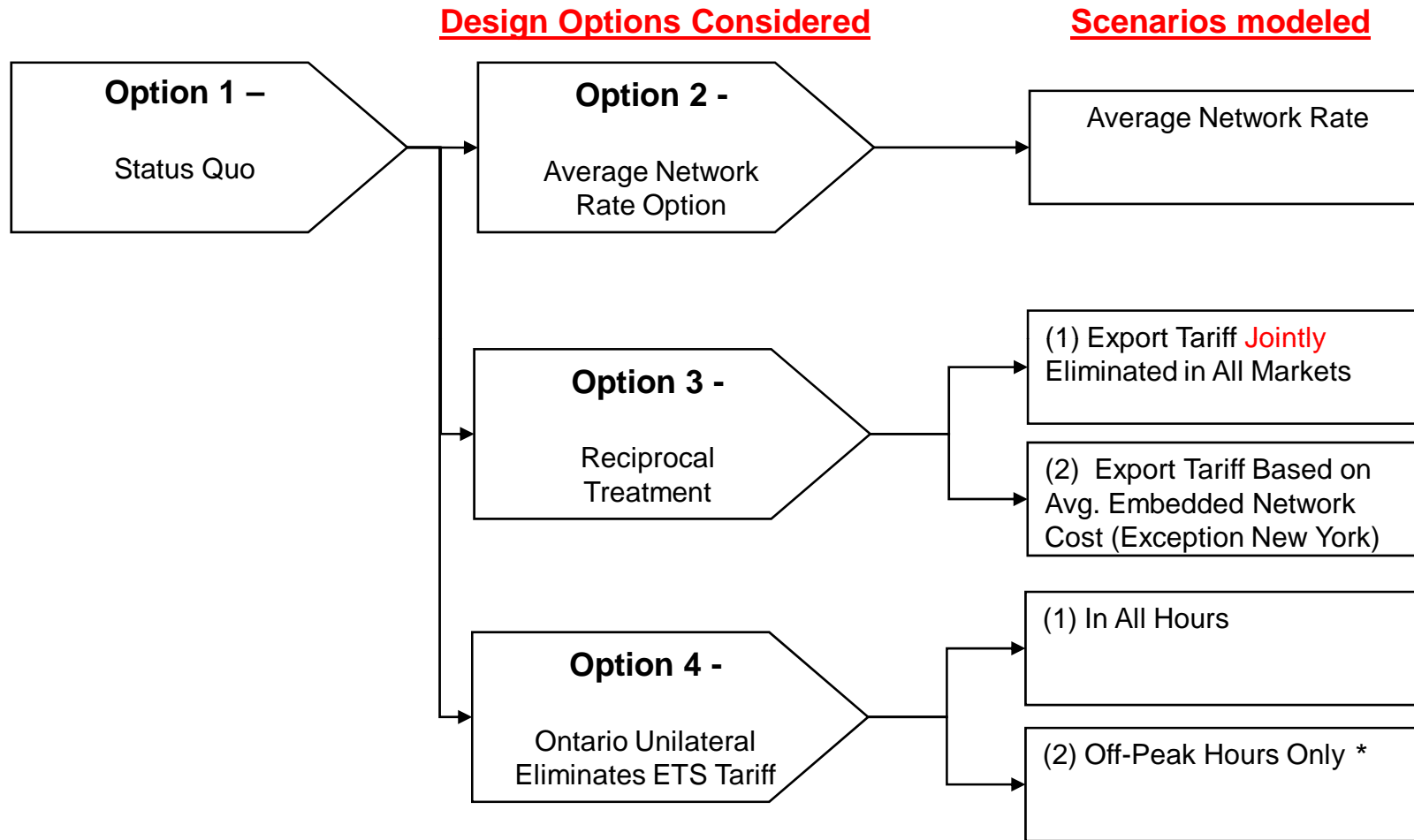
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ETS Tariff Design Options and Scenarios Considered



* On-peak is 5x12 basis for this scenario.

See Appendix B for more detail on the ETS tariff and all-in costs scenarios considered.

Key Assumptions for Calibration and Scenario Analysis

2007 Model Calibration Results

Scenario Definitions

Results by Scenario

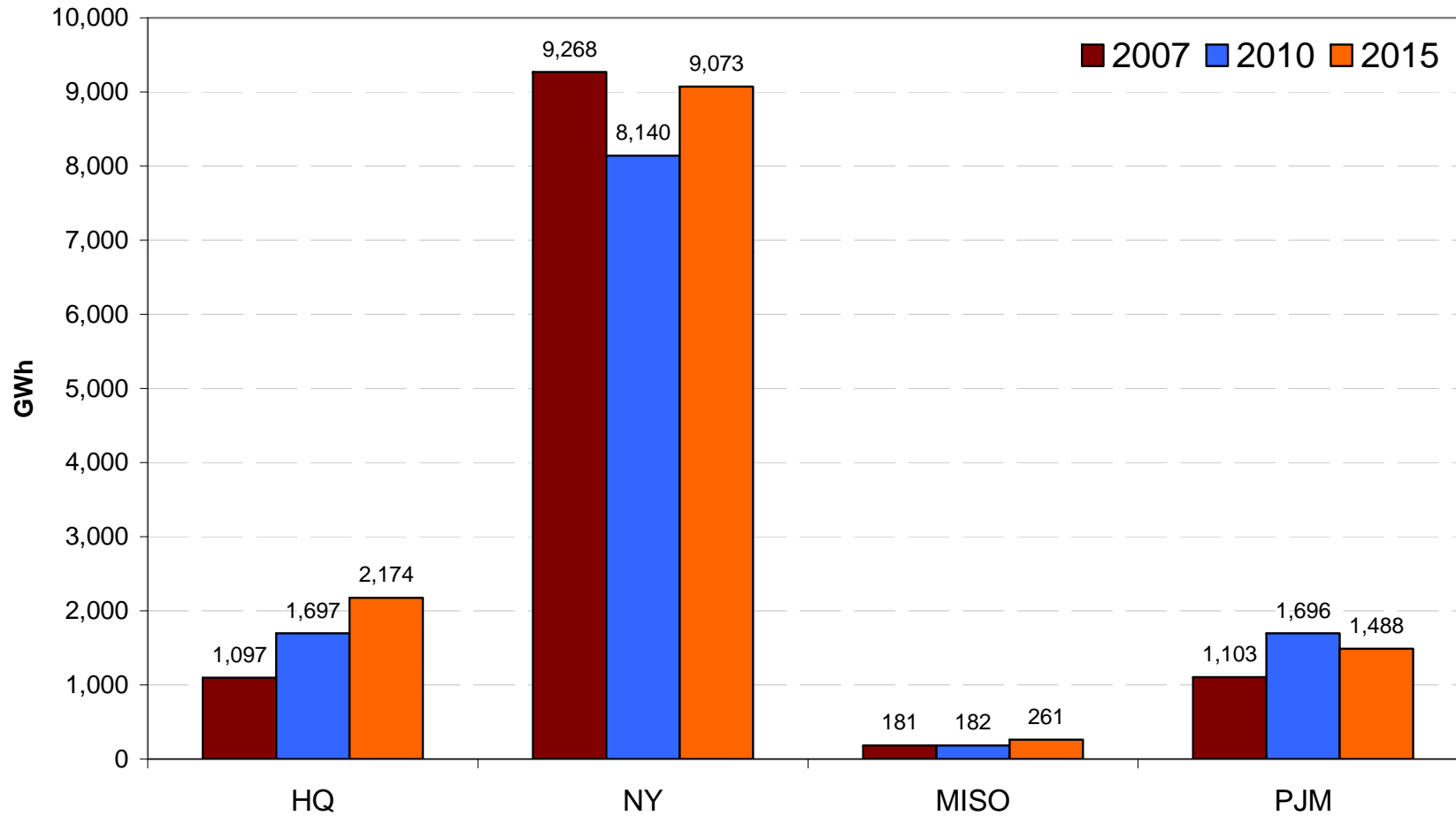
Emissions Impacts by Scenario

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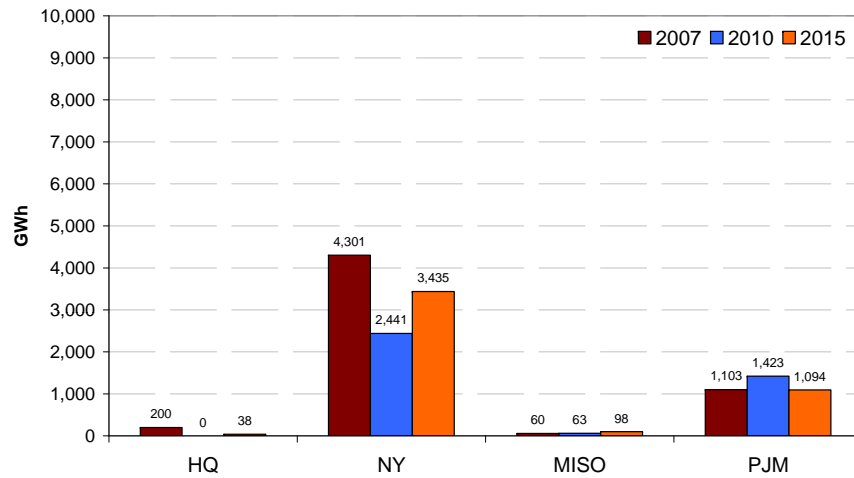
Observation: Exports are predominantly to NYISO

Status Quo, All-Hours Flows
Ontario Exports

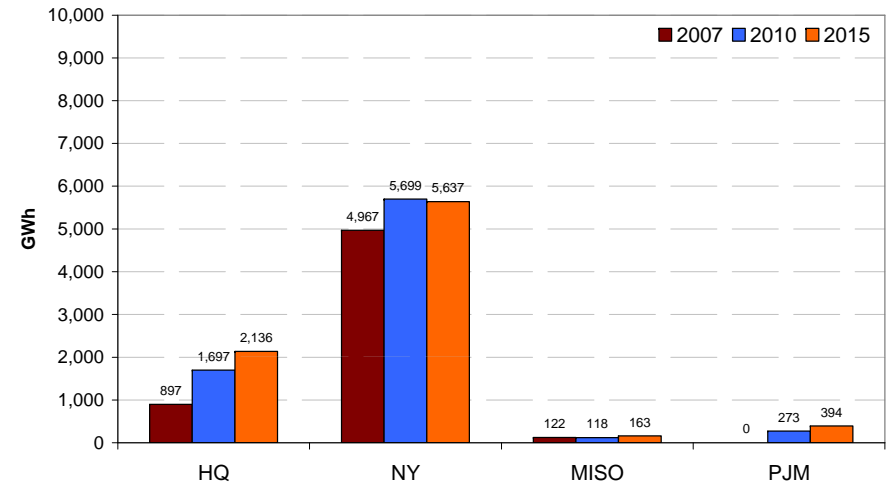


Status Quo Exports: On-Peak and Off-Peak

Status Quo, On-Peak Flows
Ontario Exports



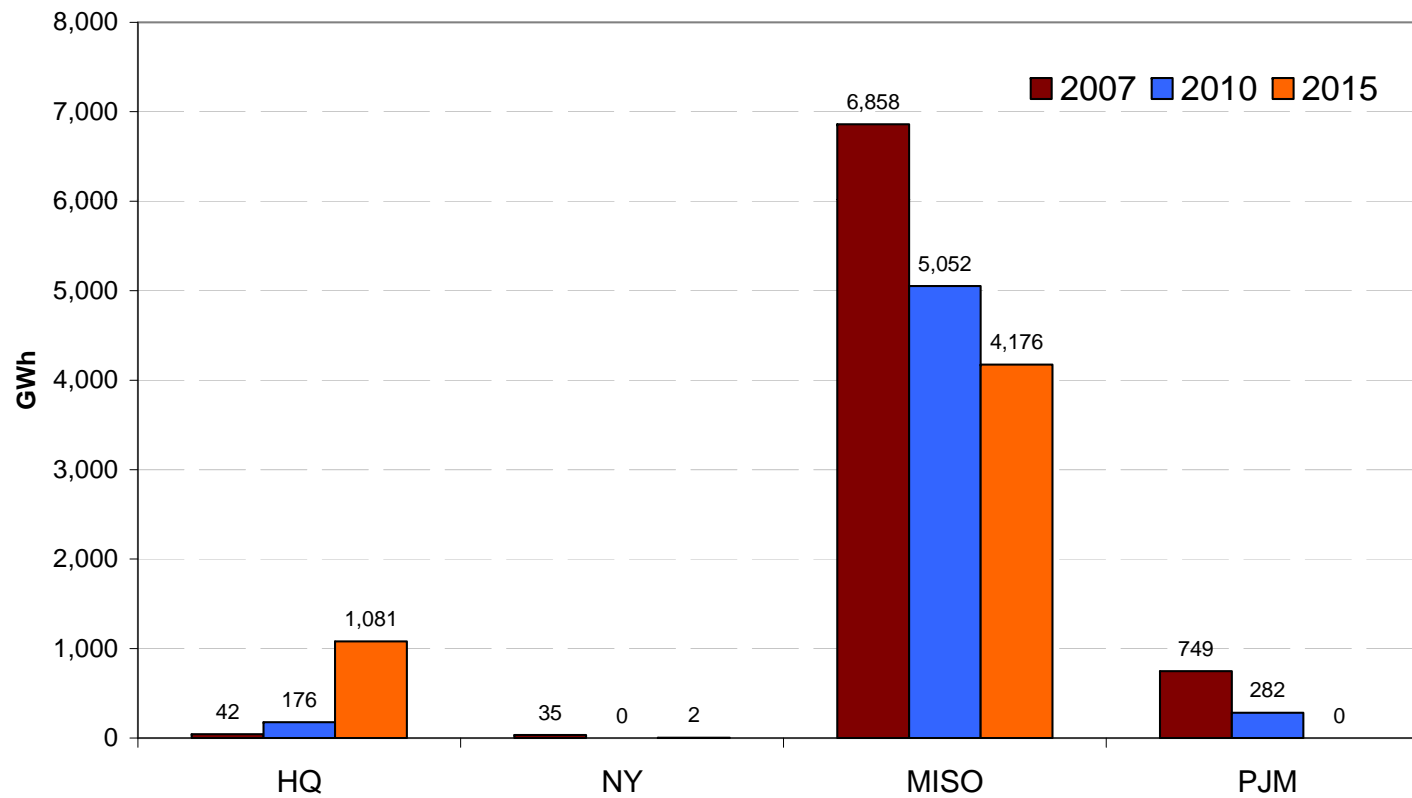
Status Quo, Off-Peak Flows
Ontario Exports



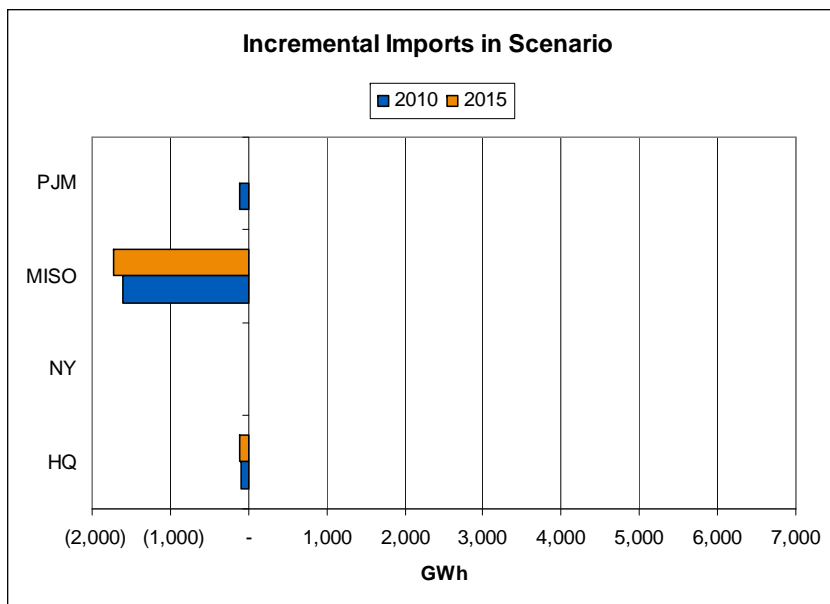
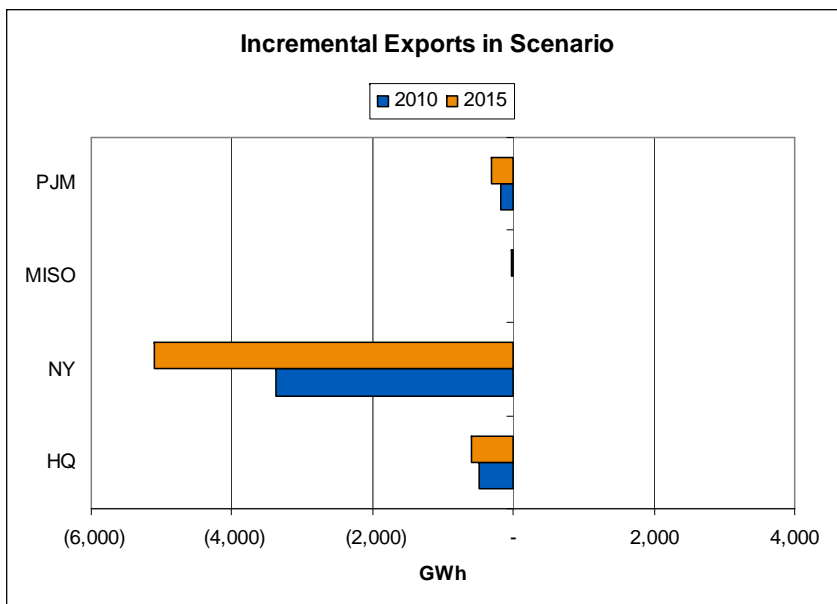
Exports to Quebec are primarily off-peak.

Observation: Imports are predominantly from PJM/MISO

Status Quo, All-Hours Flows
Ontario Imports



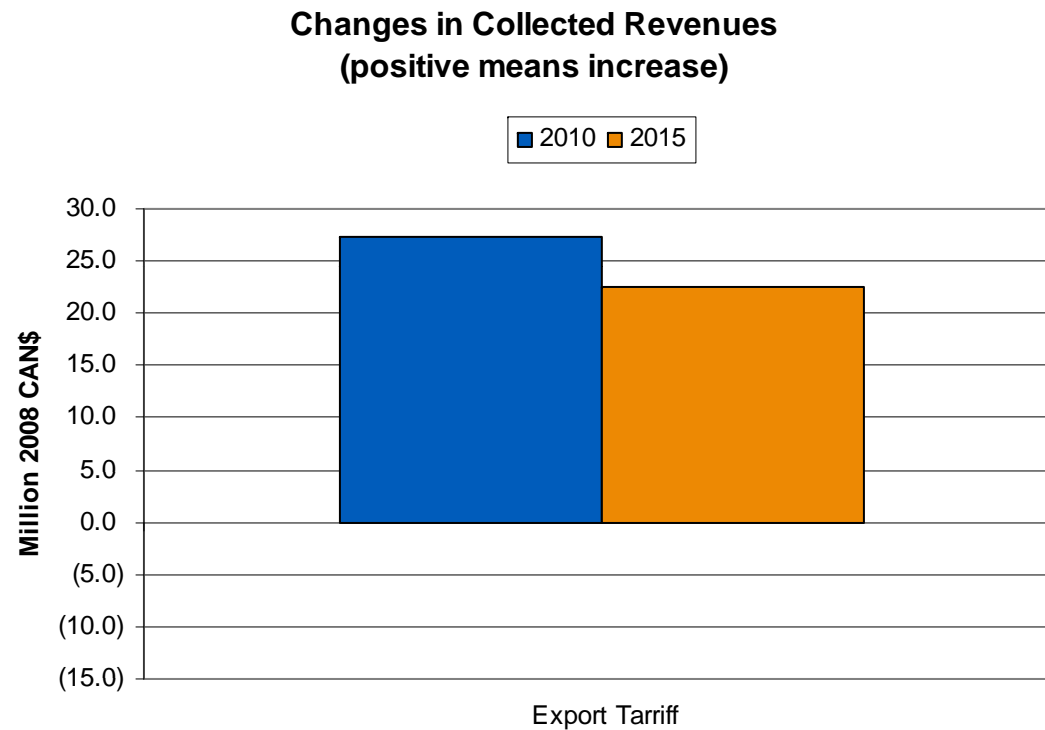
Option 2 (average network rate option)



Year	Change in Total Exports from Status Quo	Change in Total Imports from Status Quo
2010	(35%)	(33%)
2015	(46%)	(35%)

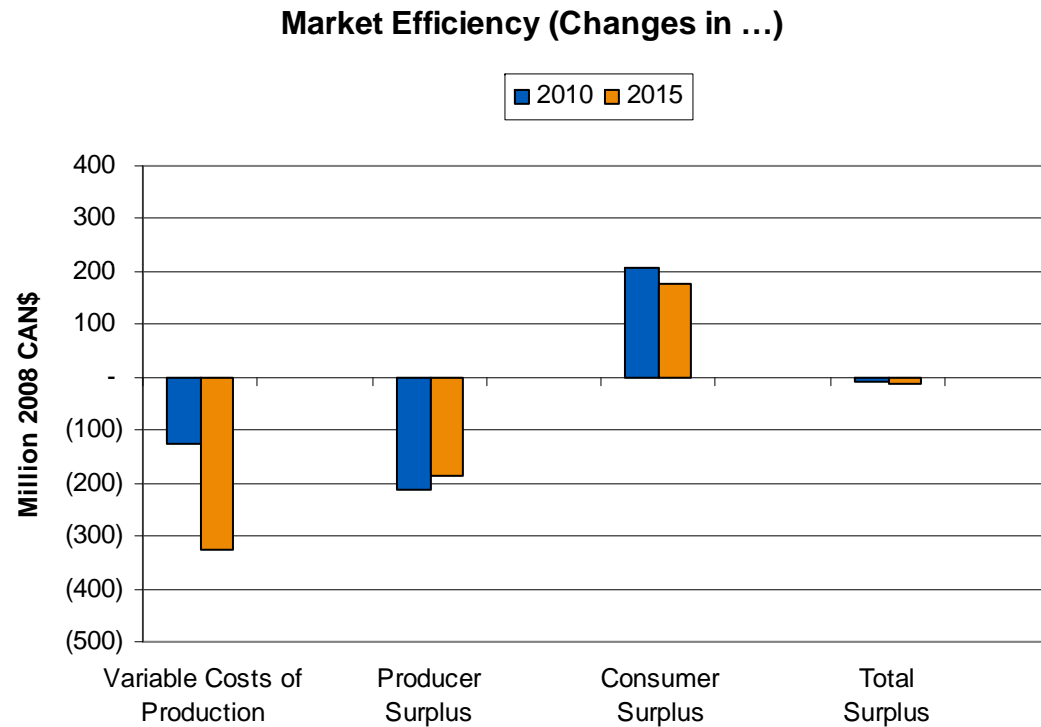
Observation: Exports are reduced because of the increased ETS tariff. Imports are less affected on an absolute basis.

Option 2 (average network rate option)



Observation: A reduction in export volume is more than offset by the higher ETS tariff; accordingly, there is an increase in ETS tariff revenues.

Option 2 (average network rate option)



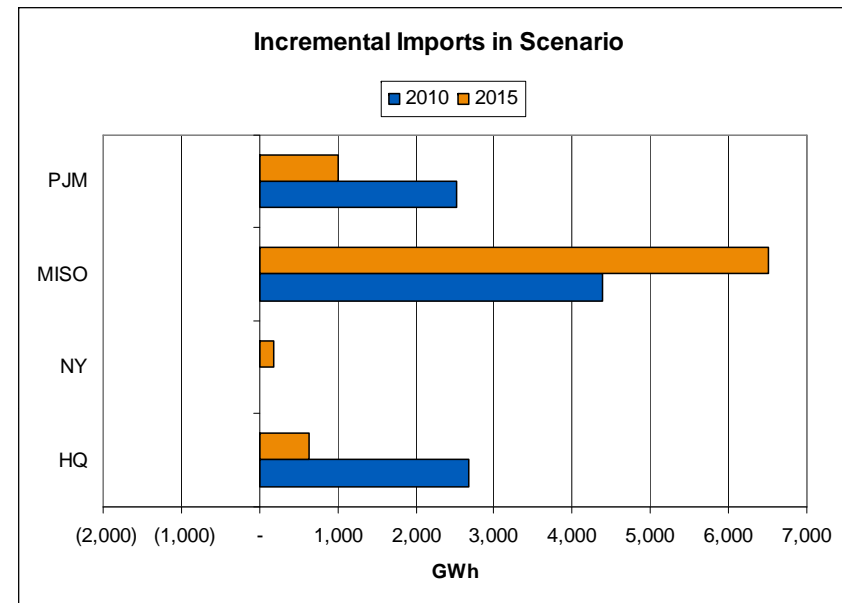
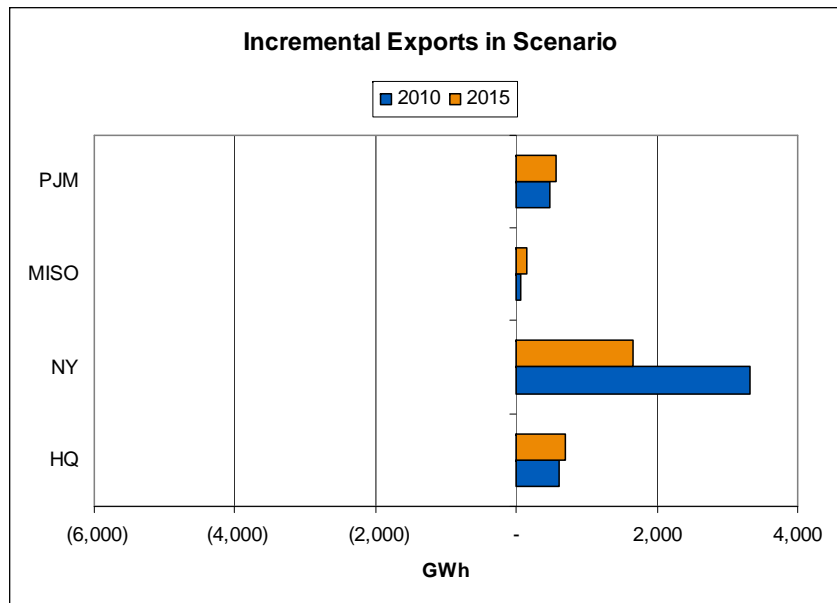
Observation: A unilateral increase in the ETS tariff reduces producer surplus (through reduced exports) but increases consumer surplus by lowering prices (i.e., there is less upward pressure on prices due to reduction in external demand).

Option 2 (average network rate option)

	Change in Electricity Prices Relative to Status Quo		
Year	All-Hours	Peak	Off-Peak
2010	(2.5%)	(1.9%)	(3.2%)
2015	(1.4%)	(1.2%)	(1.7%)

Observation: Prices are lower because the increased ETS tariff dampens external demand.

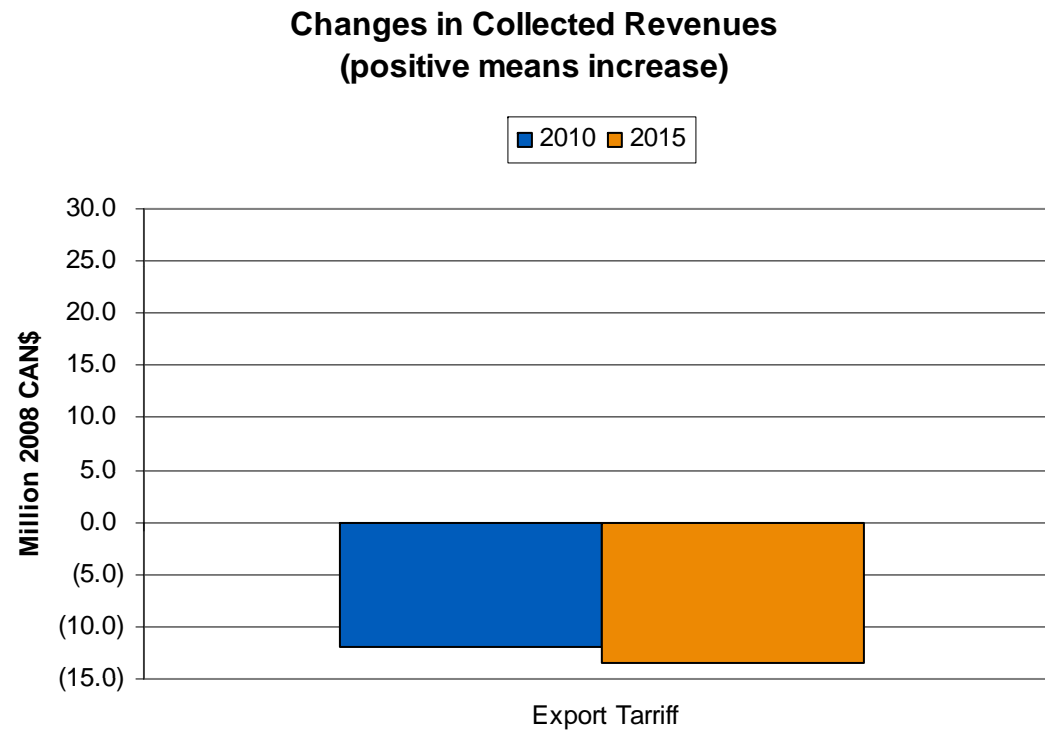
Option 3, Scenario 1 (reciprocal treatment, ETS tariff jointly eliminated)



Year	Change in Total Exports from Status Quo	Change in Total Imports from Status Quo
2010	38%	174%
2015	24%	158%

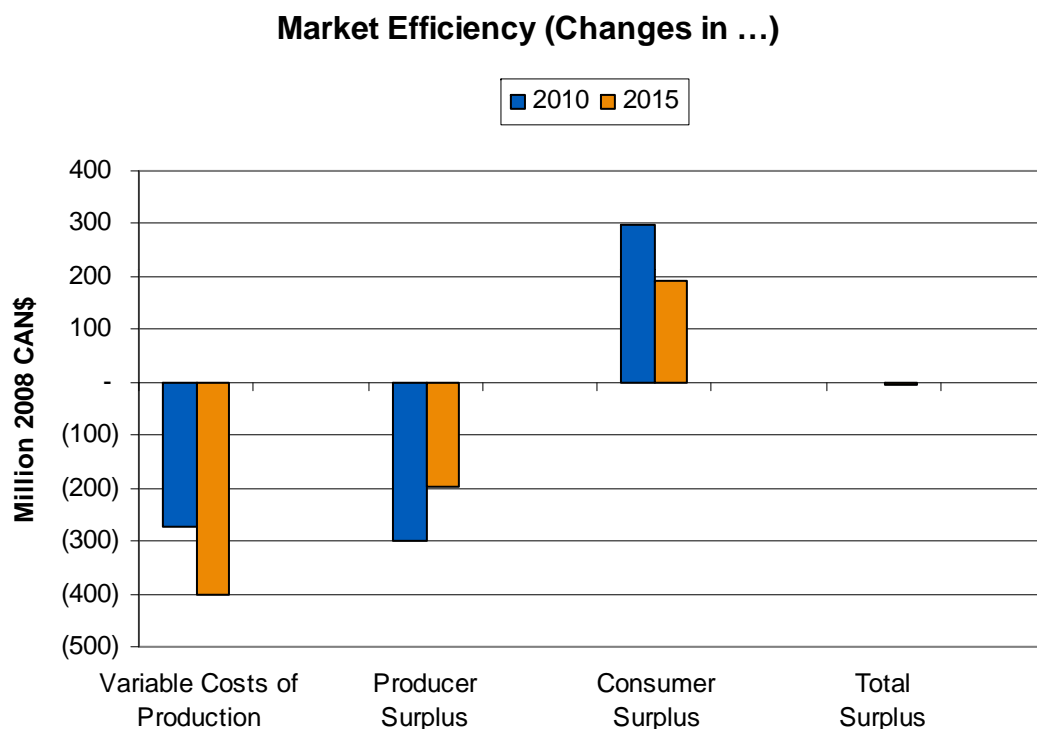
Observation: Reducing Ontario’s ETS tariff to zero has a relatively small impact on exports because the tariff is low in status quo. However, imports to Ontario are more affected because Ontario’s neighbours have a higher export tariff to begin with in status quo.

Option 3, Scenario 1 (reciprocal treatment, ETS tariff jointly eliminated)



Observation: ETS tariff revenue is reduced to zero when the tariff is eliminated.

Option 3, Scenario 1 (reciprocal treatment, ETS tariff jointly eliminated)



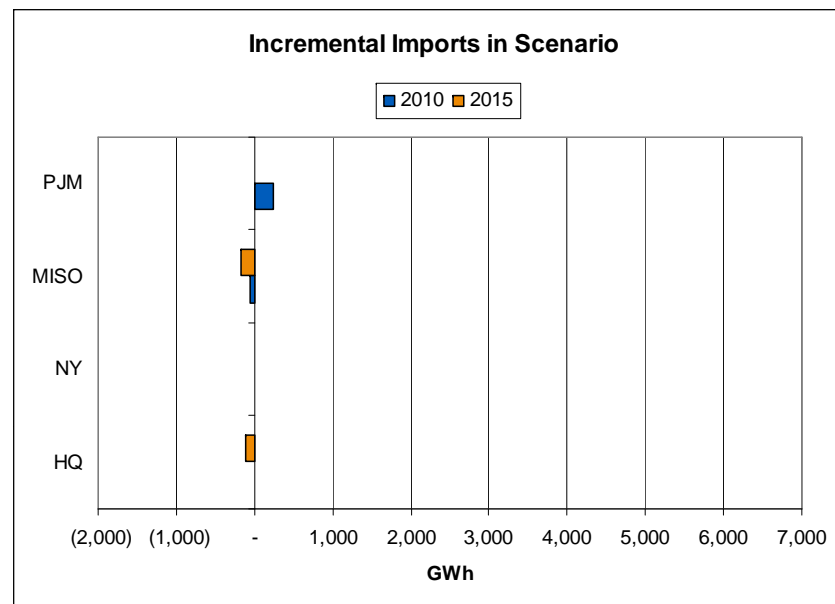
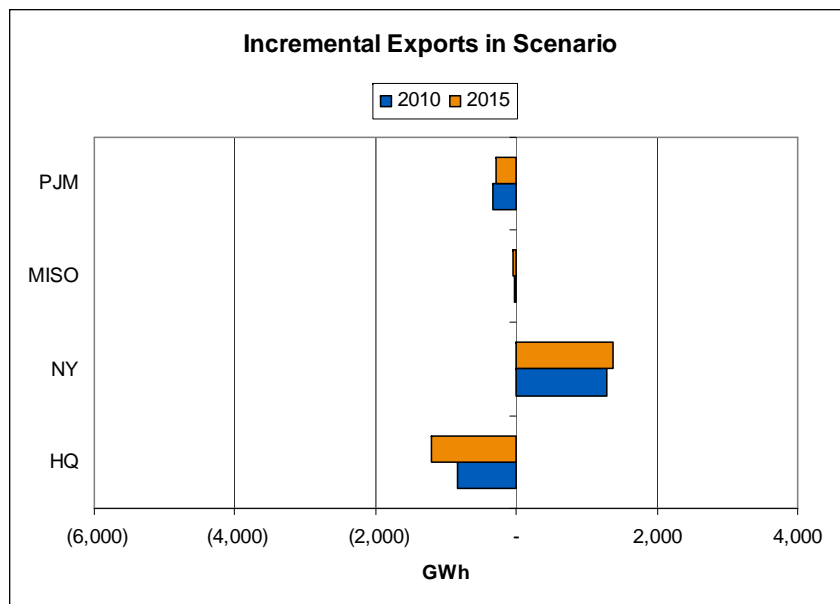
Observation: Since Ontario’s neighbours’ export tariffs are higher to begin with (i.e., in status quo), Ontario’s net exports (after tariff is eliminated) decrease and therefore producer surplus decreases. Consumer surplus increases as imports are subject to lower tariffs when exiting Ontario’s neighbours’ systems.

Option 3, Scenario 1 (reciprocal treatment, ETS tariff jointly eliminated)

	Change in Electricity Prices Relative to Status Quo		
Year	All-Hours	Peak	Off-Peak
2010	(3.7%)	(2.7%)	(4.9%)
2015	(1.6%)	(1.0%)	(2.4%)

Observation: Prices are lower in Ontario in this scenario. As export tariffs are eliminated in neighbouring regions (i.e., by a larger increment than in Ontario), export costs from those regions are lowered, exerting downward pressure on prices in Ontario.

Option 3, Scenario 2 (reciprocal treatment, avg. embedded network cost)

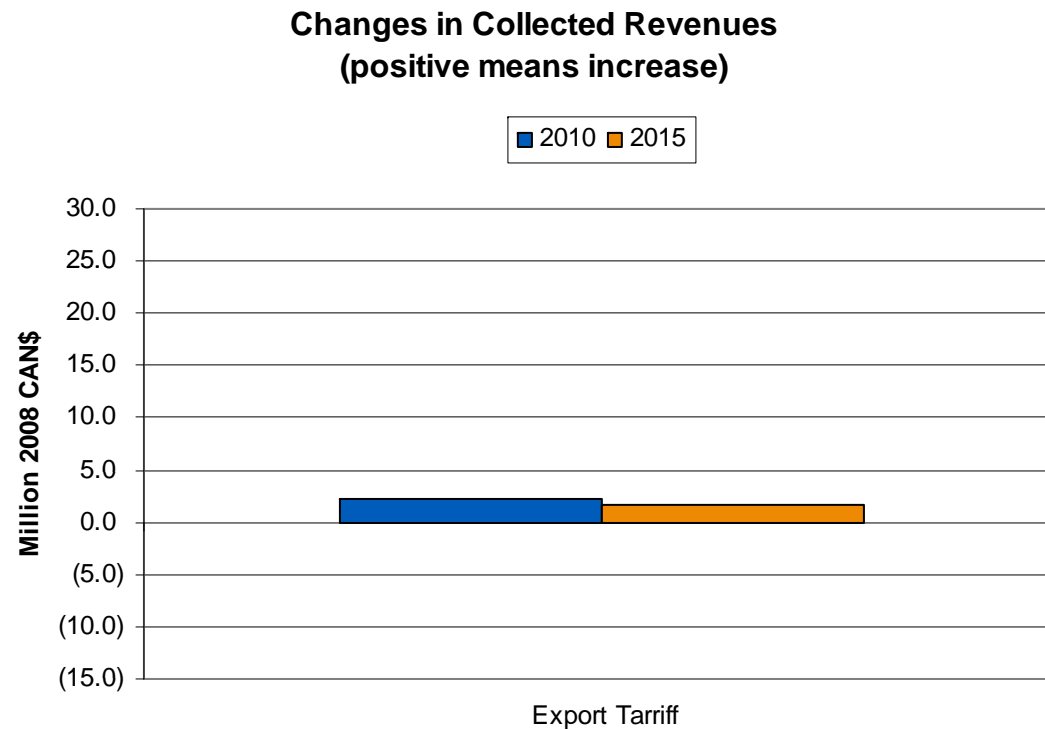


Year	Change in Total Exports from Status Quo	Change in Total Imports from Status Quo
2010	1%	3%
2015	(1%)	(5%)

Impacts on Ontario’s total imports/exports are relatively small under this scenario.

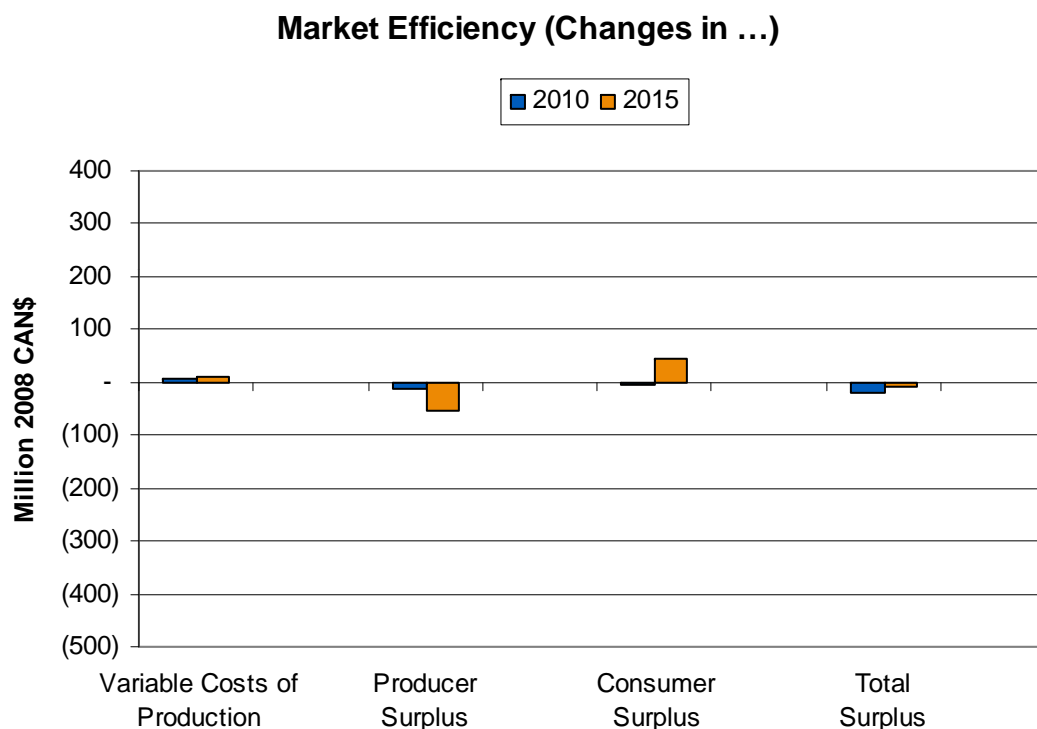
Exports to NY are expected to increase in both test years because NY is the only neighbour to which the ETS tariff is assumed to be eliminated.

Option 3, Scenario 2 (reciprocal treatment, avg. embedded network cost)



Observation: The export revenue that is lost on exports to NY (when the NY tariff is eliminated) offsets most of the revenue gained in exports to Ontario’s other neighbours.

Option 3, Scenario 2 (reciprocal treatment, avg. embedded network cost)



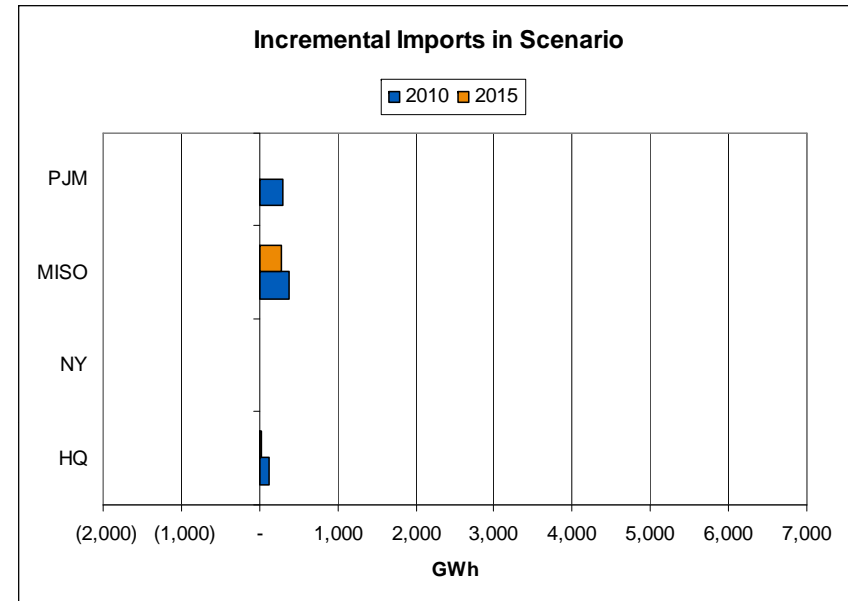
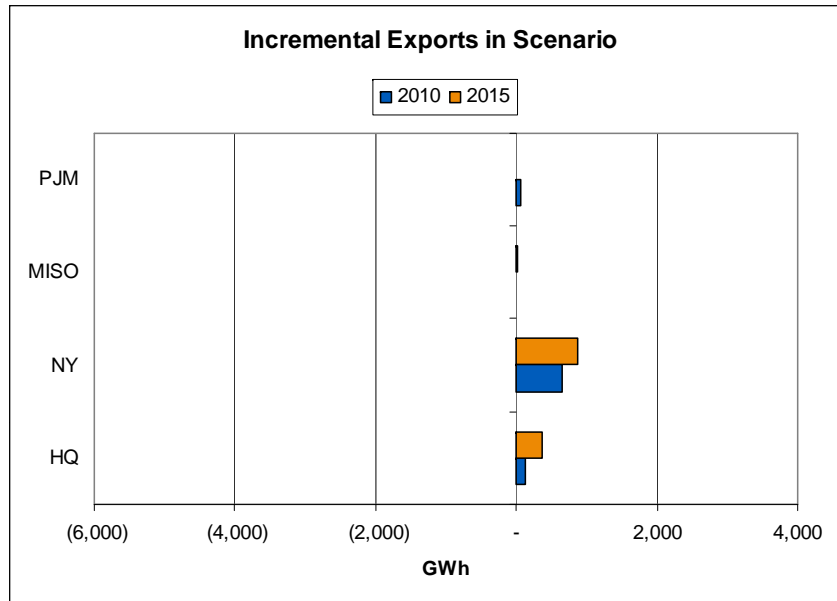
Observation: Because impacts on net exports are relatively small, the impacts on producer and consumer surplus are relatively small. In 2015 (when impacts are somewhat larger), lower prices lead to increased consumer surplus and decreased producer surplus.

Option 3, Scenario 2 (reciprocal treatment, avg. embedded network cost)

	Change in Electricity Prices Relative to Status Quo		
Year	All-Hours	Peak	Off-Peak
2010	(0.2%)	1.0%	(1.5%)
2015	(0.4%)	0.0%	(0.8%)

Observation: All-hours prices (duration-weighted) are reduced under the scenario in both years. Higher peak prices in 2010 reduce consumer surplus slightly as shown on the previous slide (*note: the change in the load-weighted all-hours price in 2010 is actually positive and not negative*).

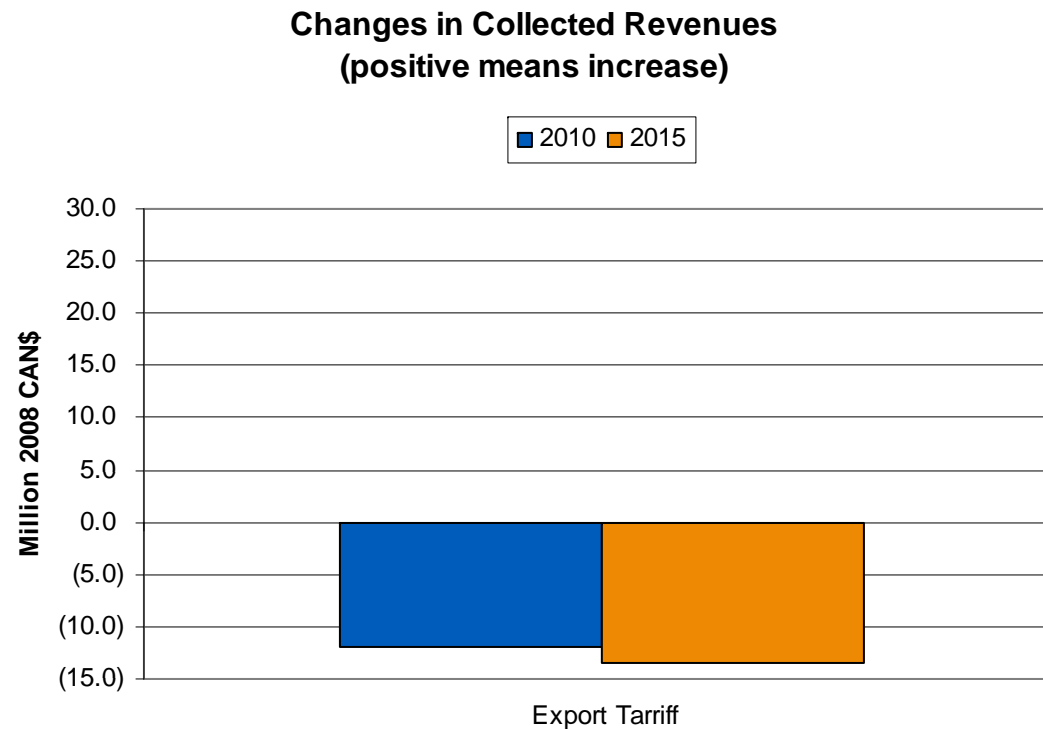
Option 4, Scenario 1 (unilateral tariff elimination in all hours)



Year	Change in Total Exports from Status Quo	Change in Total Imports from Status Quo
2010	7%	14%
2015	10%	6%

Observation: Since the Ontario ETS tariff is relatively small, increases in export volumes are expected to be small when the ETS tariff is unilaterally eliminated. Likewise, impacts on imports are expected to be small.

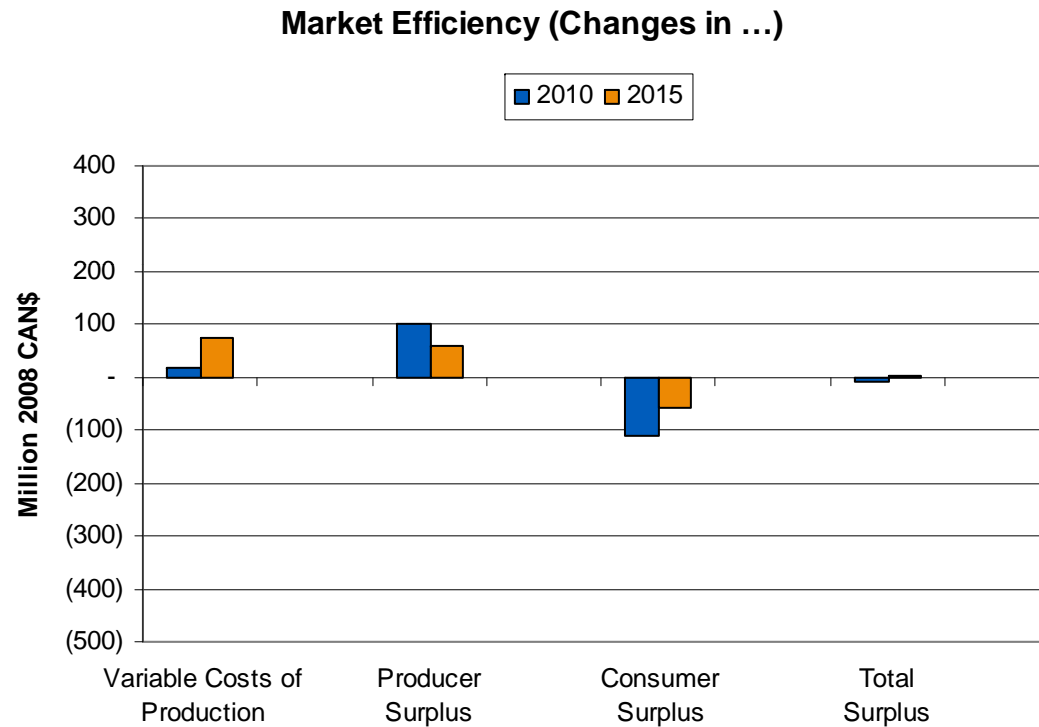
Option 4, Scenario 1 (unilateral tariff elimination in all hours)



Observation: The ETS tariff revenue is eliminated under this scenario. The consequential loss in ETS tariff revenue is the same as in Option 3, scenario 1.

Option 4, Scenario 1 (unilateral tariff elimination in all hours)

Scenario Results



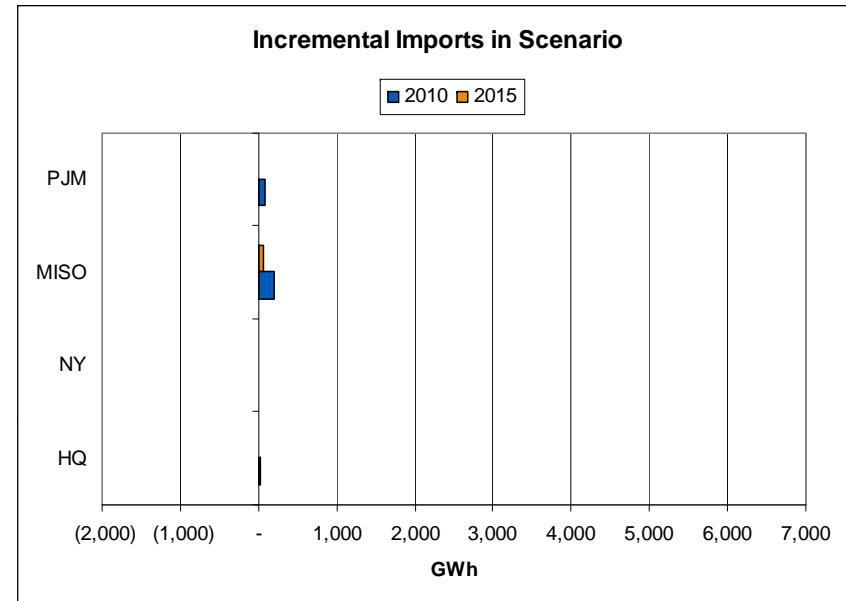
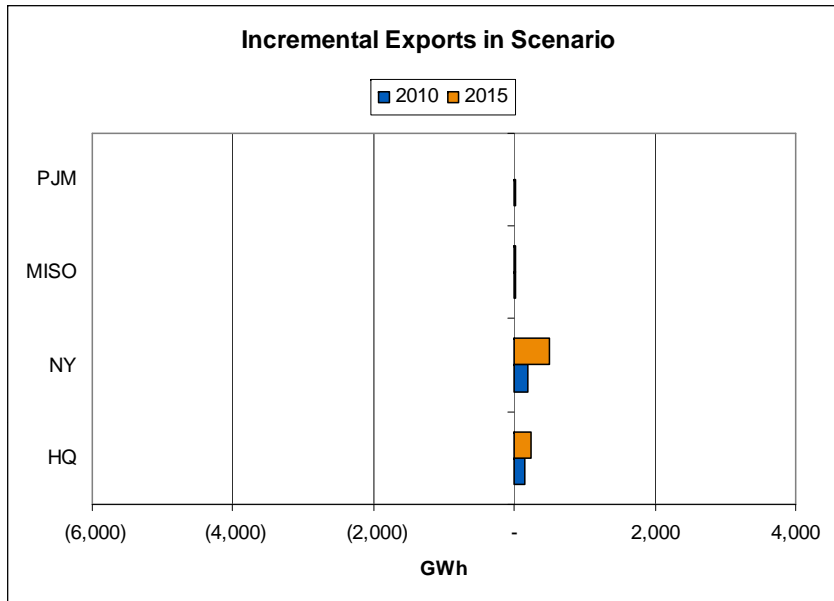
Observation: When the ETS tariff is unilaterally eliminated there is a consequential increase in exports, as well as prices. This increases producer surplus and reduces consumer surplus.

Option 4, Scenario 1 (unilateral tariff elimination in all hours)

Year	Change in Electricity Prices Relative to Status Quo		
	All-Hours	Peak	Off-Peak
2010	1.3%	1.4%	1.2%
2015	0.4%	0.5%	0.3%

Observation: A unilateral reduction in the ETS tariff increases prices in Ontario because external demand and exports increase.

Option 4, Scenario 2 (unilateral tariff elimination, off-peak only)

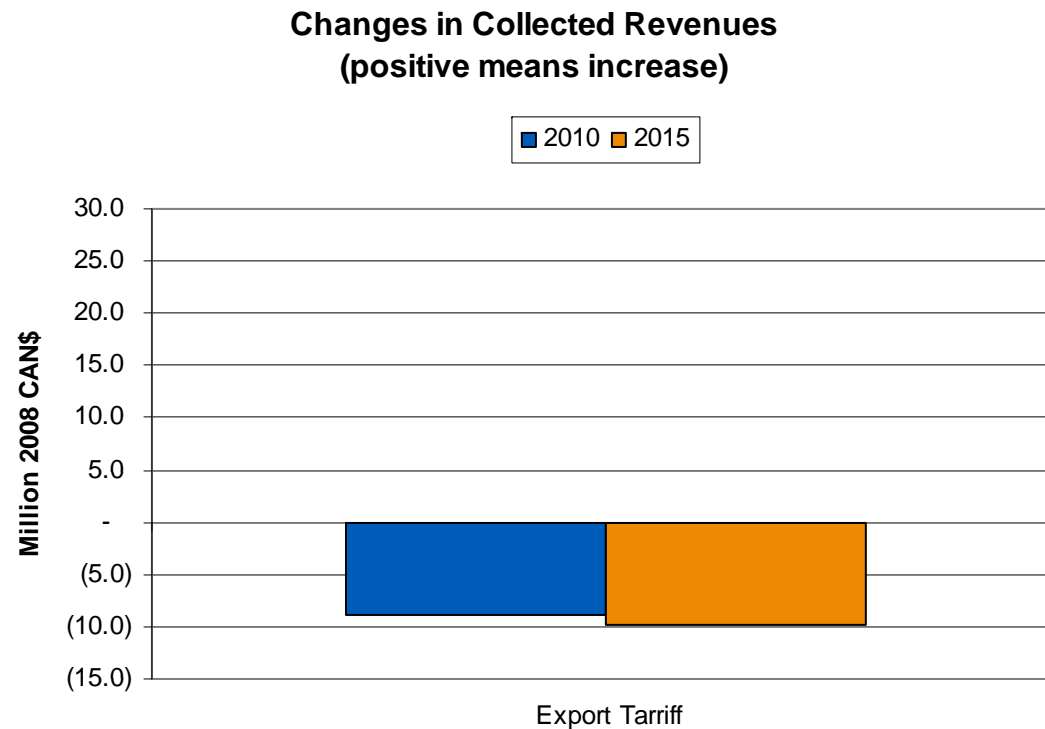


Year	Change in Total Exports from Status Quo	Change in Total Imports from Status Quo
2010	3%	6%
2015	6%	1%

Observation: This results in a similar outcome as Option 4, Scenario 1. Given that the Ontario ETS tariff is small, impacts on exports are expected to be modest when the tariff is eliminated in off-peak hours. Impacts on imports are also modest.

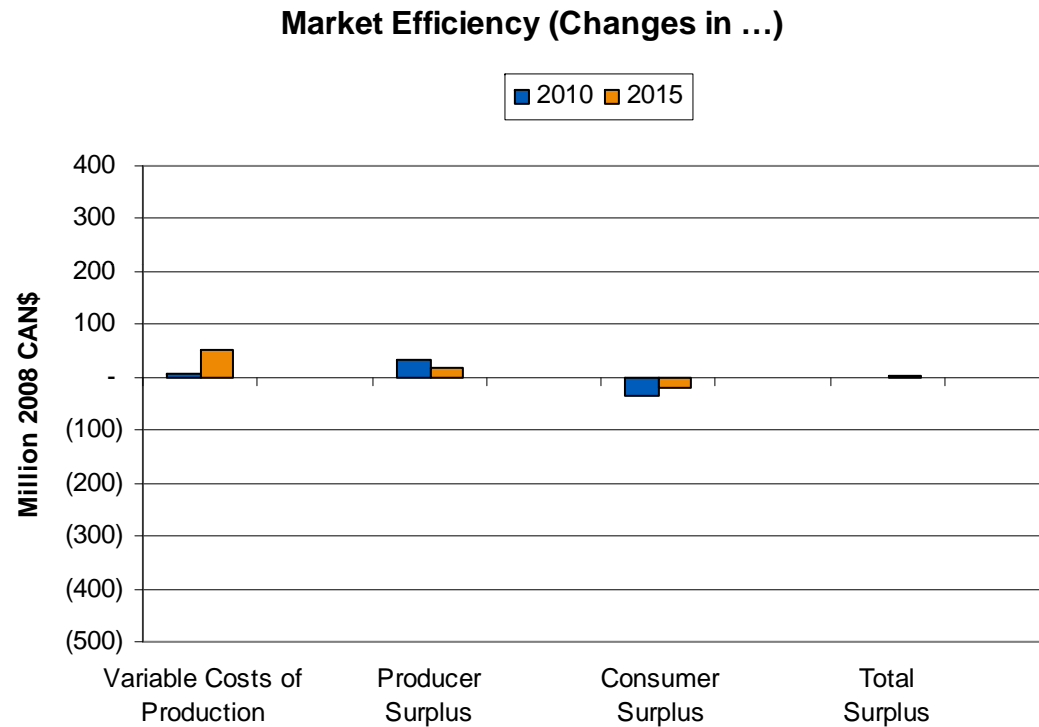
Option 4, Scenario 2 (unilateral tariff elimination, off-peak only)

Scenario Results



Observation: This scenario has a lower-magnitude (negative) impact on the ETS tariff revenue than Option 4, scenario 1 (because the tariff is retained during peak hours, creating a revenue stream).

Option 4, Scenario 2 (unilateral tariff elimination, off-peak only)



Observation: When compared to Option 4, Scenario 1, the incremental increase in producer surplus and decrease in consumer surplus are smaller. This is due to the ETS tariff being retained during on-peak hours under Option 4, Scenario 2.

Option 4, Scenario 2 (unilateral tariff elimination, off-peak only)

	Change in Electricity Prices Relative to Status Quo		
Year	All-Hours	Peak	Off-Peak
2010	0.5%	0.1%	0.9%
2015	0.2%	0.1%	0.2%

Observation: A unilateral elimination of the ETS tariff increases prices because external demand increases. Under Option 4, Scenario 2, this is more pronounced during the off-peak hours when the ETS tariff is eliminated.

Key Assumptions for Calibration and Scenario Analysis

2007 Model Calibration Results

Scenario Definitions

Results by Scenario

Emissions Impacts by Scenario

General Conclusions

Appendices

Changes in Net Exports (these generally drive emissions impacts)

Change in Net Exports - 2010

GWh

Option	Scenario	Destination				Total
		PJM	MISO	NY	HQ	
Option 2		(76)	1,610	(3,379)	(406)	(2,252)
Option 3	Scenario 1	(2,037)	(4,338)	3,319	(2,080)	(5,135)
Option 3	Scenario 2	(560)	41	1,289	(836)	(66)
Option 4	Scenario 1	(235)	(369)	656	4	56
Option 4	Scenario 2	(78)	(186)	195	133	64

Change in Net Exports - 2015

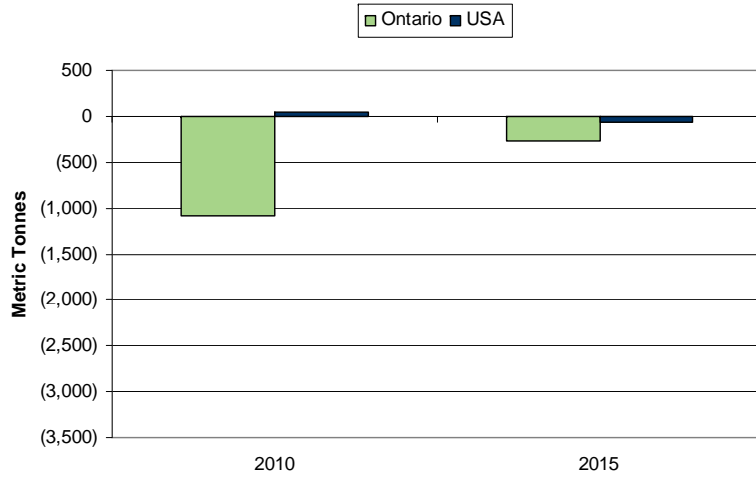
GWh

Option	Scenario	Destination				Total
		PJM	MISO	NY	HQ	
Option 2		(312)	1,700	(5,104)	(469)	(4,185)
Option 3	Scenario 1	(445)	(6,357)	1,487	73	(5,243)
Option 3	Scenario 2	(283)	129	1,364	(1,101)	108
Option 4	Scenario 1	(3)	(257)	867	337	944
Option 4	Scenario 2	(10)	(55)	494	233	663

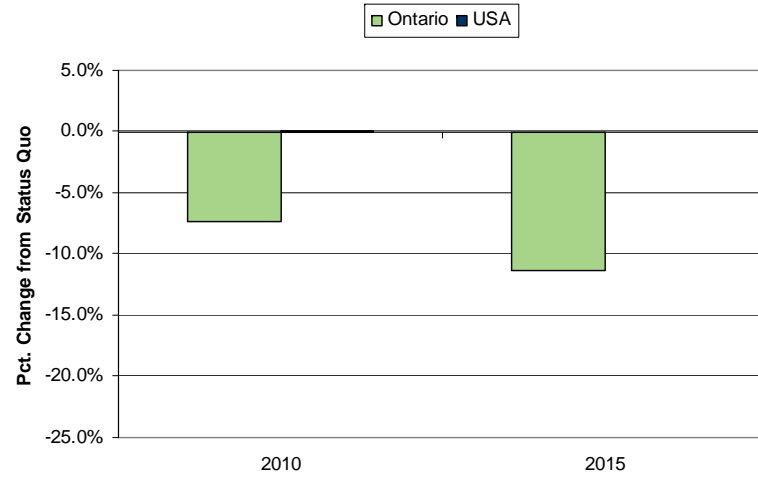
Note: A negative value means that Ontario's net exports (exports less imports) would decrease.

Option 2 (average network rate option)

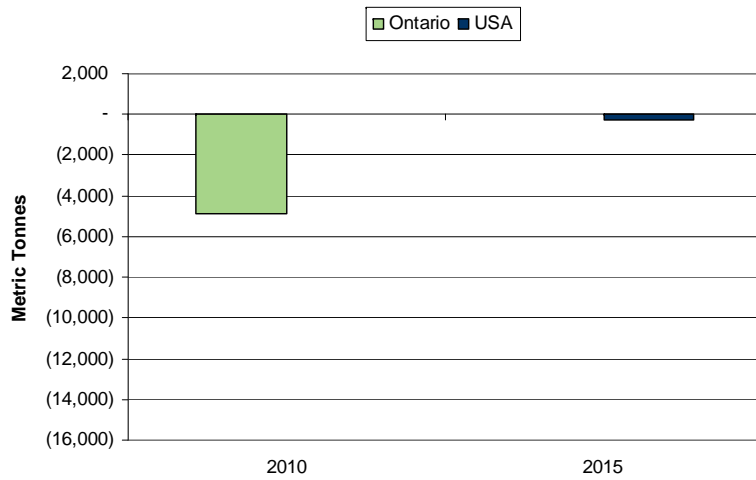
Incremental NOx in Scenario



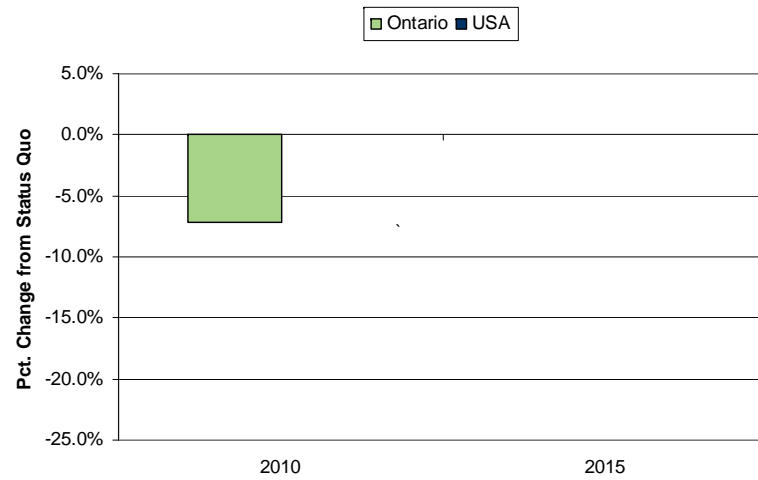
Incremental NOx in Scenario



Incremental SO2 in Scenario



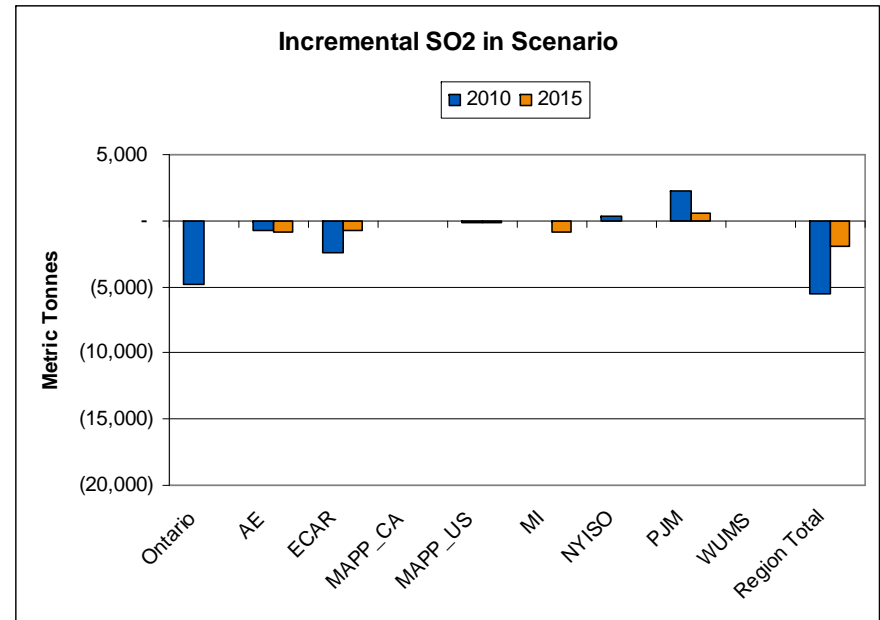
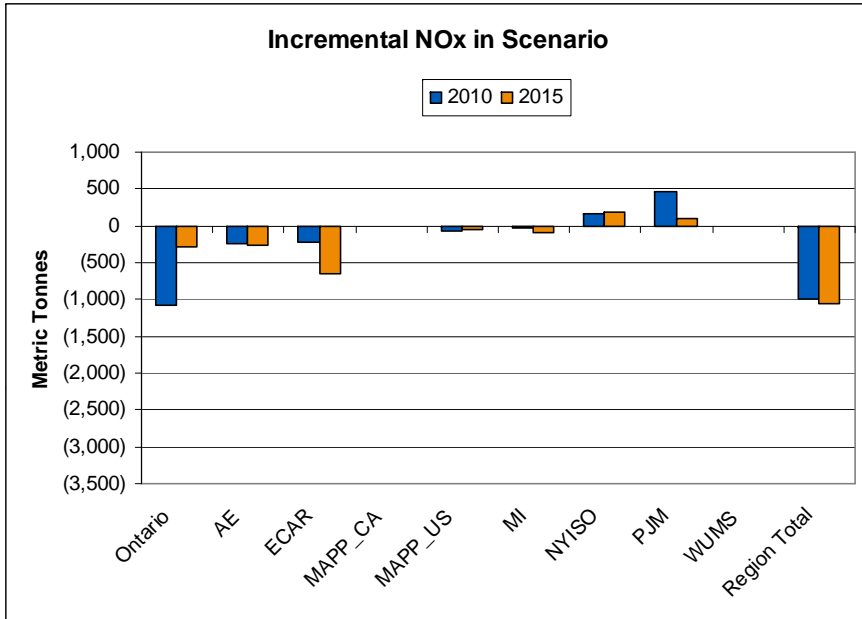
Incremental SO2 in Scenario



Option 2 - SO₂ and NO_x

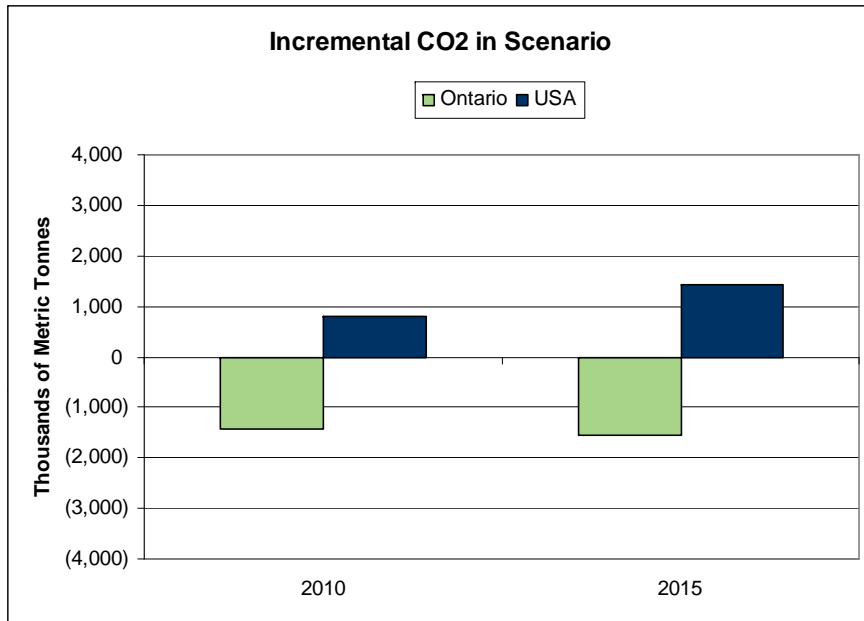
- Ontario SO₂ and NO_x emissions would be well under the caps in both Status Quo and Option 2 (in 2010 and 2015) due to the consequential impacts of Ontario's CO₂ cap (and Ontario's policy to retire the coal-fired generation fleet by the end of 2014)
- Option 2 reduces Ontario emissions relative to Status Quo because Option 2 assumes Ontario has unilaterally increased its export tariff; accordingly, there is a decrease in net exports
- There is no change in SO₂ in Ontario in 2015 (versus status quo) because the coal-fired fleet is assumed to be retired by the end of 2014, and hence there are no SO₂ emissions
- SO₂ and NO_x emissions are relatively unchanged (versus status quo) in the U.S. because of US CAIR policy restrictions pertaining to both pollutants

Option 2 (average network rate option)

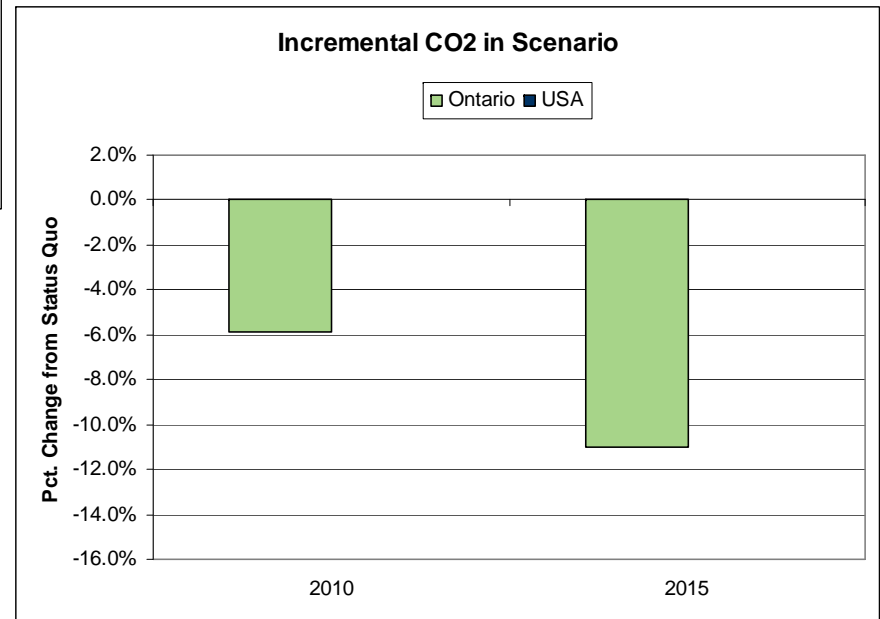


See Appendix C for a map of NEEM's regions.

Option 2 (average network rate option)

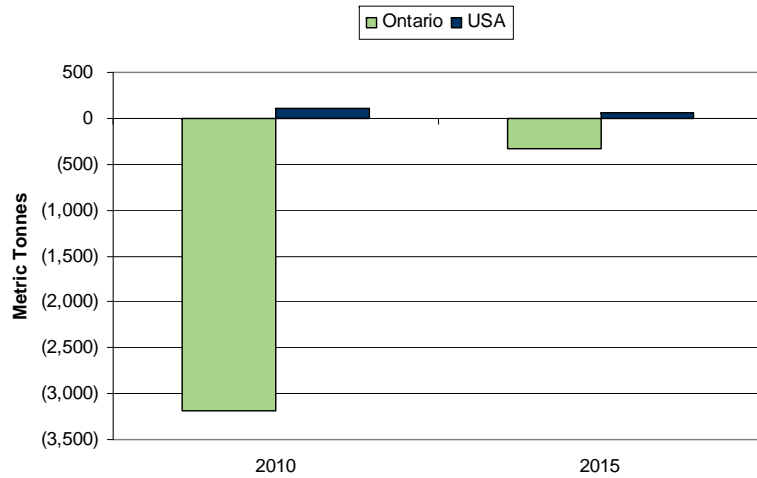


CO2 impacts are small and offsetting.

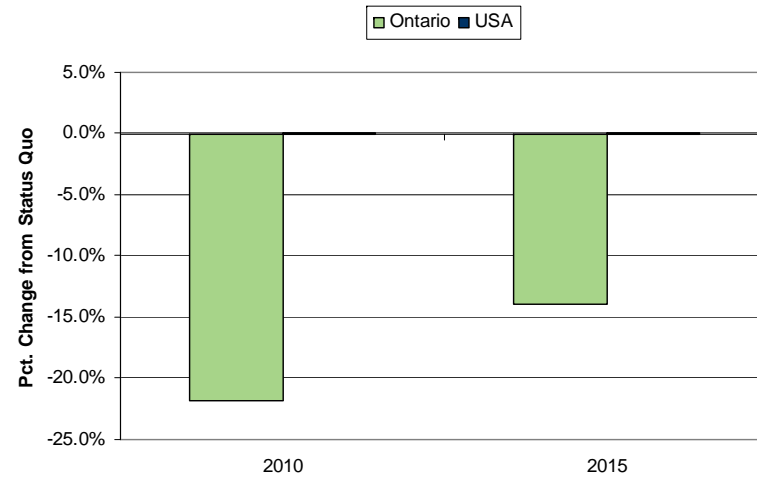


Option 3, Scenario 1 (reciprocal treatment, tariff eliminated)

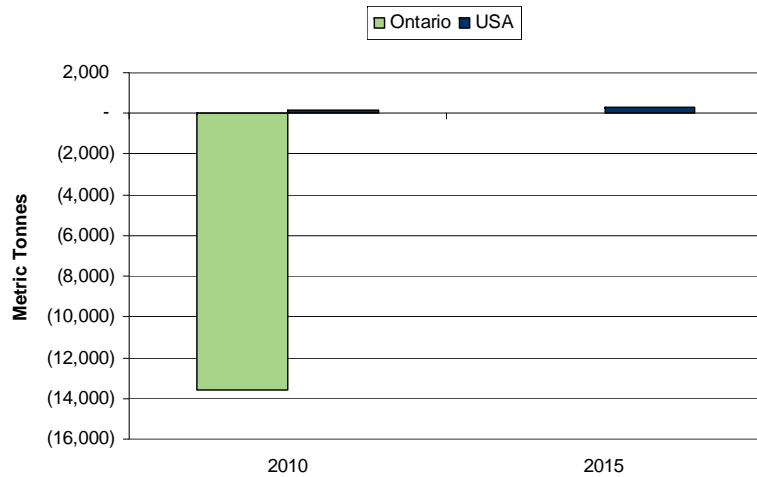
Incremental NOx in Scenario



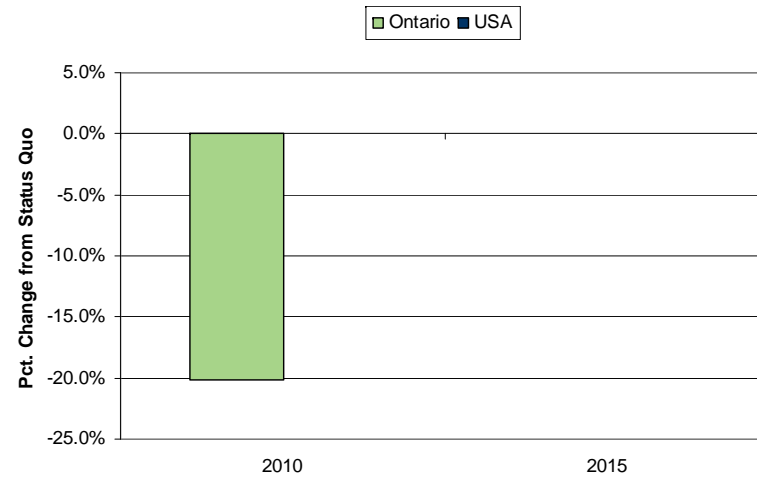
Incremental NOx in Scenario



Incremental SO2 in Scenario



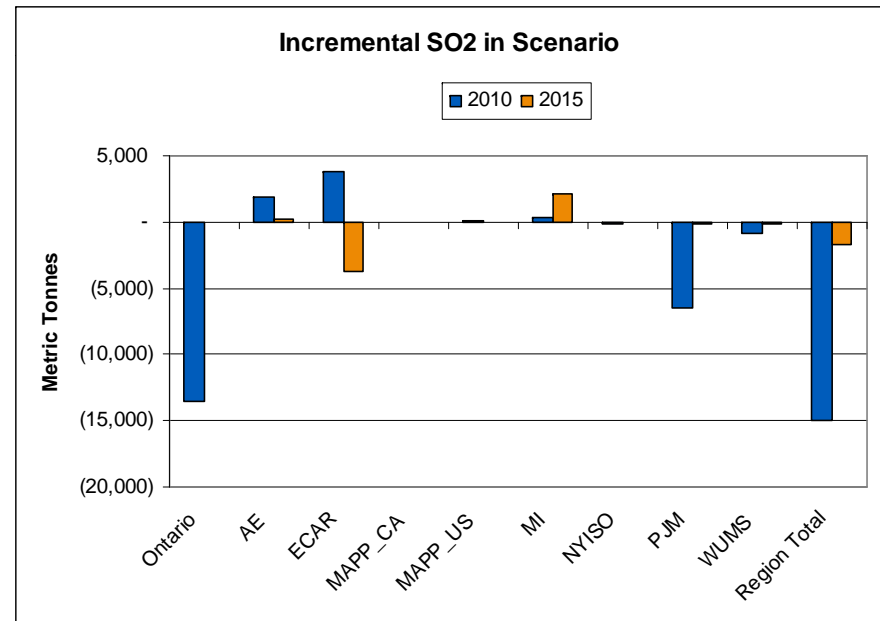
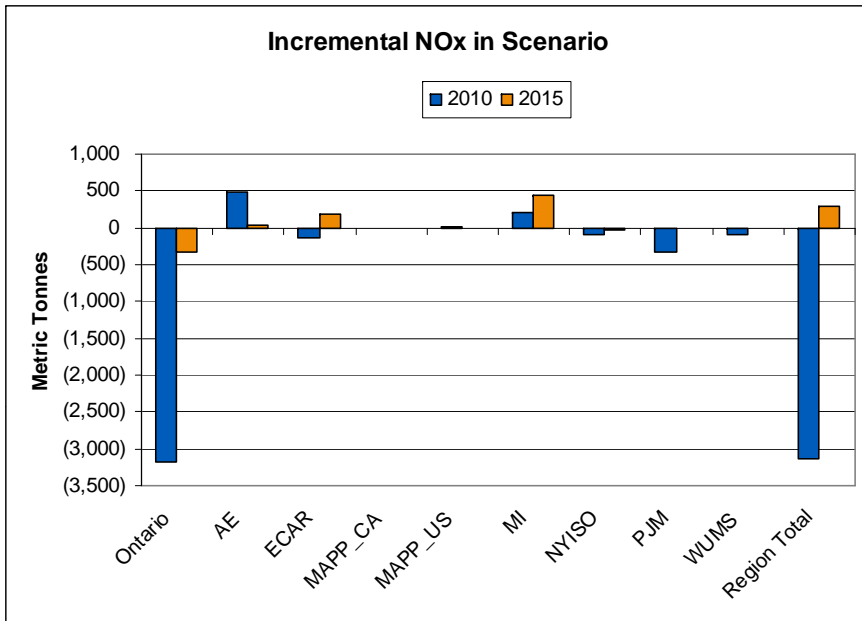
Incremental SO2 in Scenario



Option 3, Scenario 1 – SO₂ and NO_x

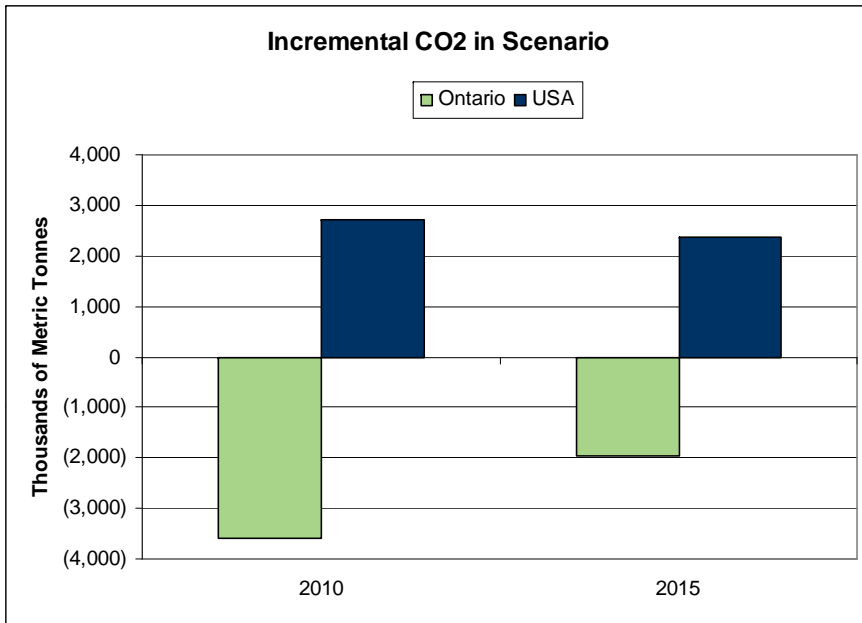
- Ontario SO₂ and NO_x emissions would be well under the caps in both Status Quo and Option 3, Scenario 1 (in 2010 and 2015) due to the consequential impacts of Ontario's CO₂ cap (and Ontario's policy to retire the coal-fired generation fleet by the end of 2014)
- Option 3, Scenario 1 reduces Ontario emissions relative to Status Quo because Ontario's net exports are decreased (because Ontario's neighbours' tariffs are cut more than Ontario's tariffs)
- There is no change in SO₂ in Ontario in 2015 (versus status quo) because the coal-fired fleet is assumed to be retired by the end of 2014, and hence there are no SO₂ emissions
- SO₂ and NO_x emissions are relatively unchanged (versus status quo) in the U.S. because of US CAIR policy restrictions pertaining to both pollutants

Option 3, Scenario 1 (reciprocal treatment, tariff eliminated)

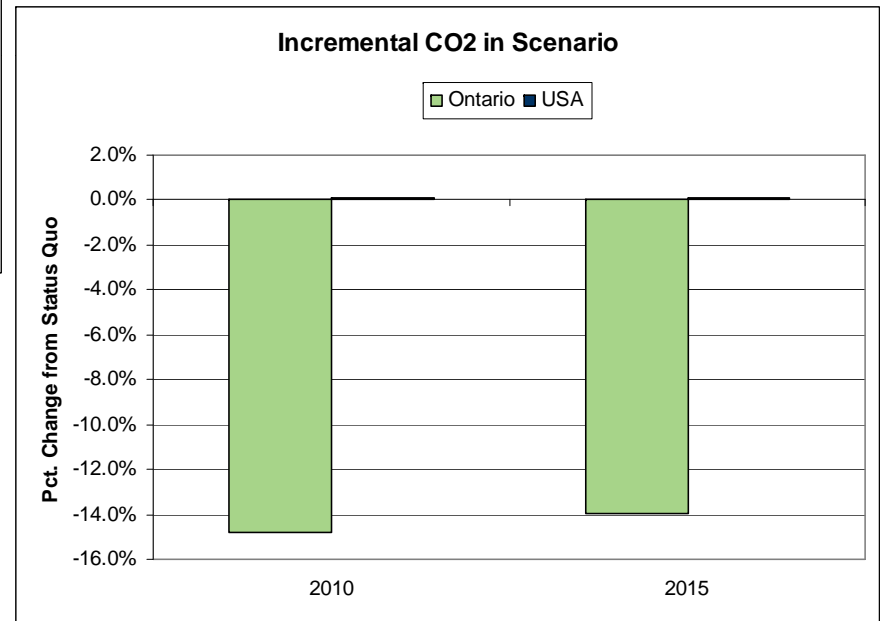


See Appendix C for a map of NEEM's regions.

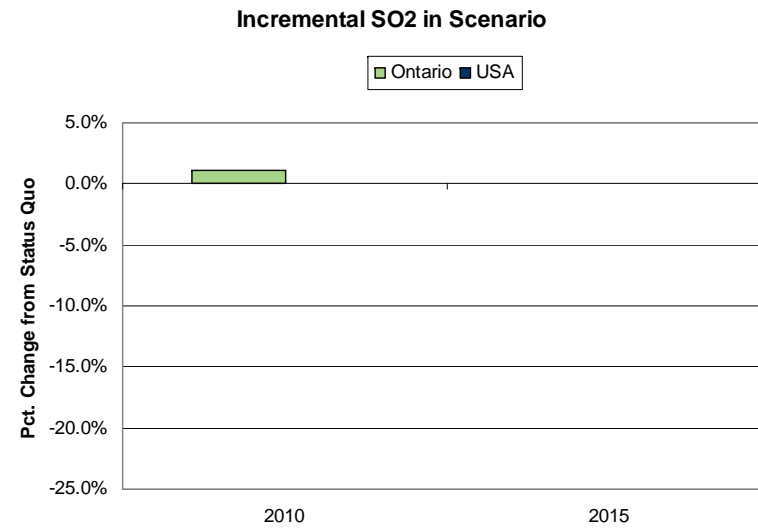
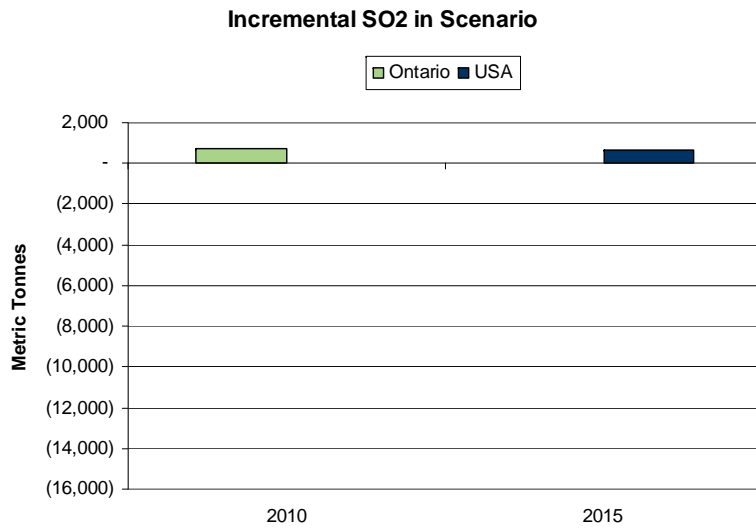
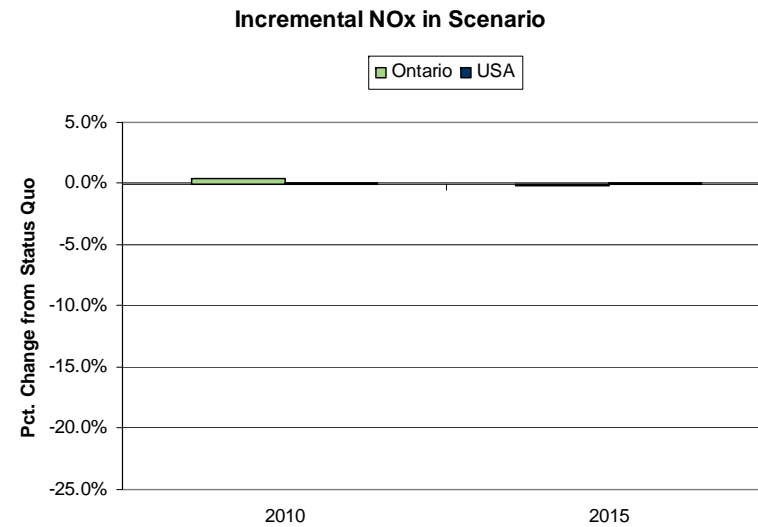
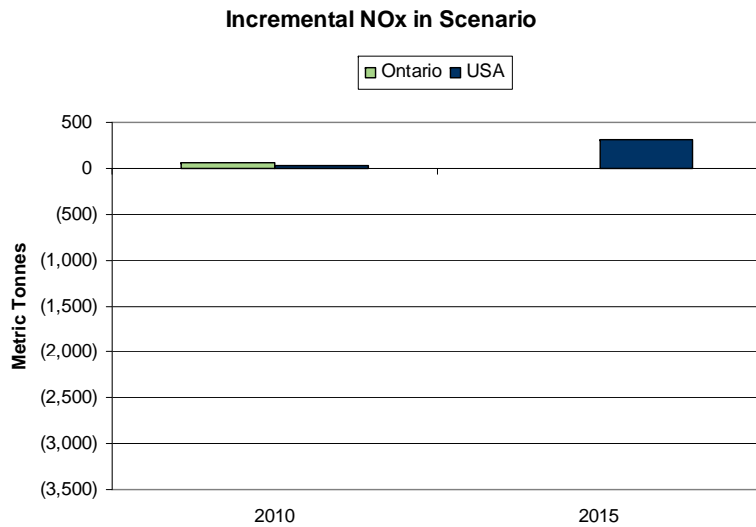
Option 3, Scenario 1 (reciprocal treatment, tariff eliminated)



CO2 impacts are small and nearly offsetting.



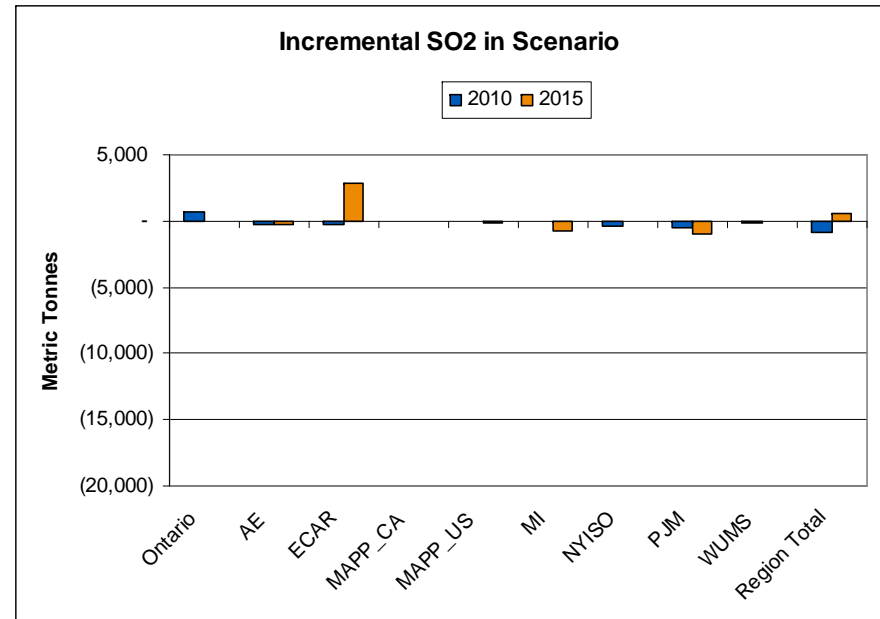
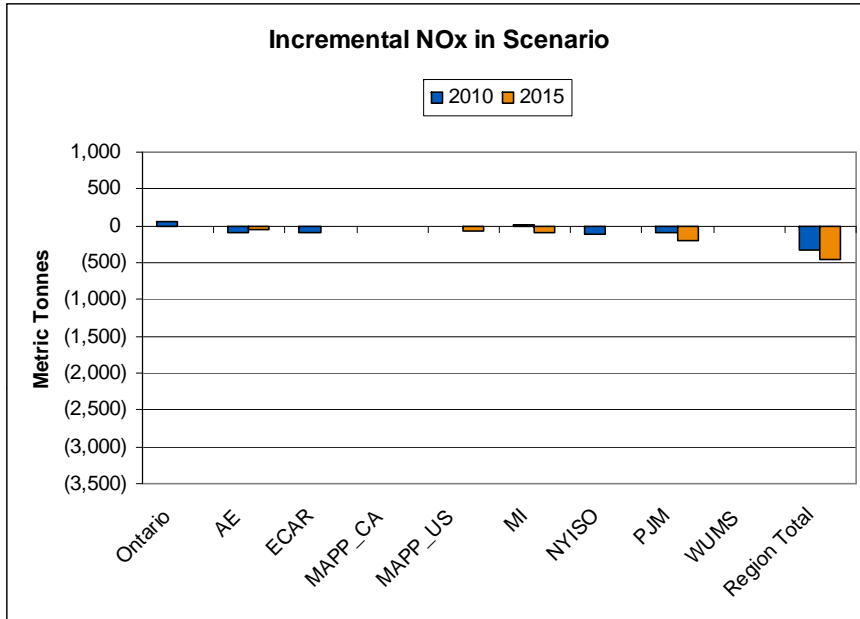
Option 3, Scenario 2 (reciprocal treatment, avg. embedded network cost)



Option 3, Scenario 2 – SO₂ and NO_x

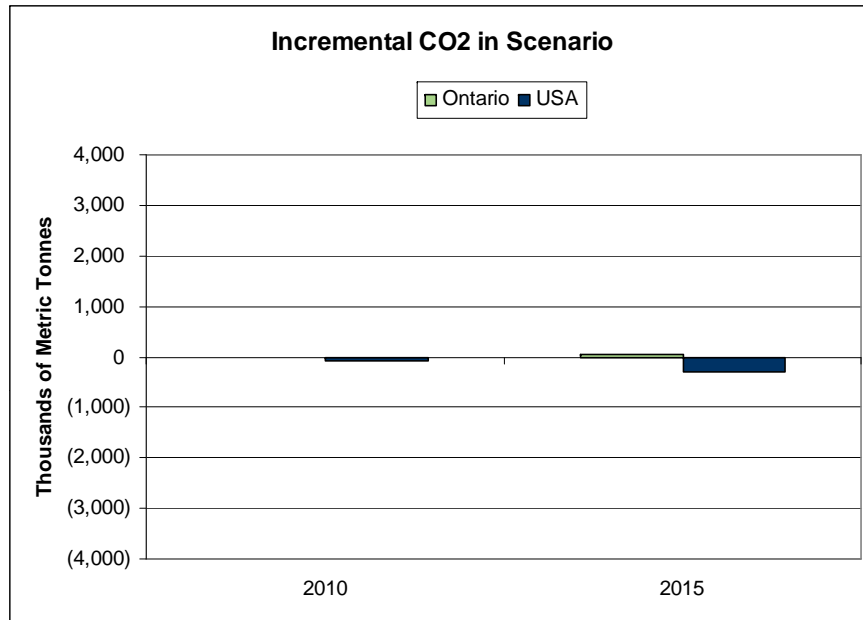
- Ontario SO₂ and NO_x emissions would be well under the caps in both Status Quo and Option 3, Scenario 2 (in 2010 and 2015) due to the consequential impacts of Ontario's CO₂ cap (and Ontario's policy to retire the coal-fired generation fleet by the end of 2014)
- Impacts on emissions are small in this scenario because the impact on net exports is small
- There is no change in SO₂ in Ontario in 2015 (versus status quo) because the coal-fired fleet is assumed to be retired by the end of 2014, and hence there are no SO₂ emissions
- SO₂ and NO_x emissions are relatively unchanged (versus status quo) in the U.S. because of US CAIR policy restrictions pertaining to both pollutants

Option 3, Scenario 2 (reciprocal treatment, avg. embedded network cost)

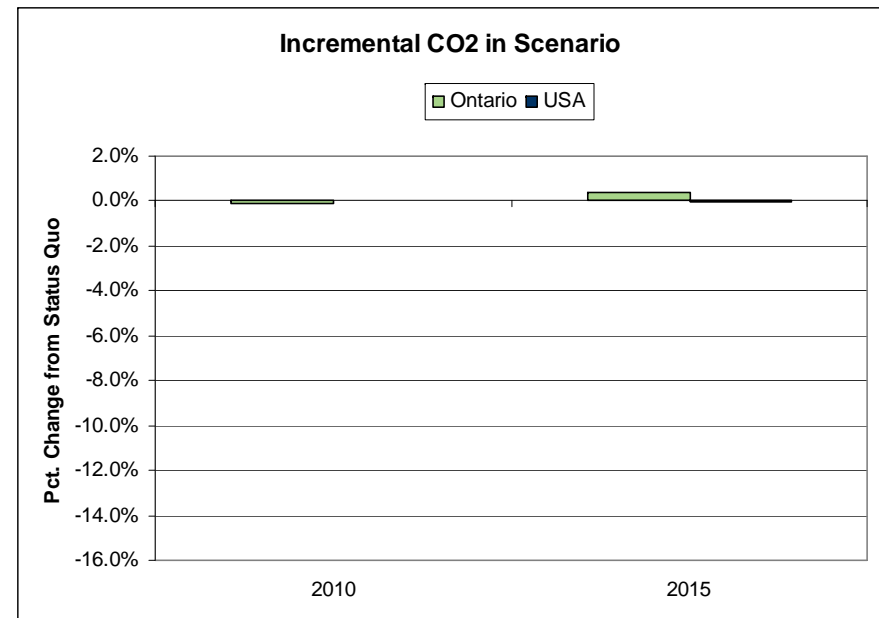


See Appendix C for a map of NEEM's regions.

Option 3, Scenario 2 (reciprocal treatment, avg. embedded network cost)

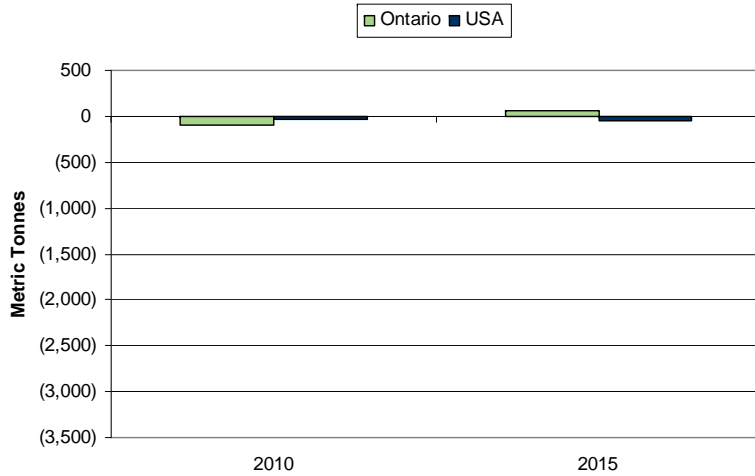


CO2 impacts are very small.

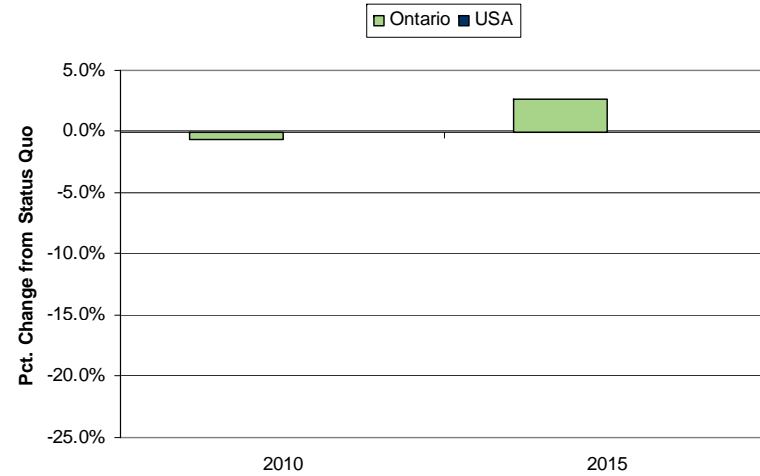


Option 4, Scenario 1 (unilateral tariff elimination in all hours)

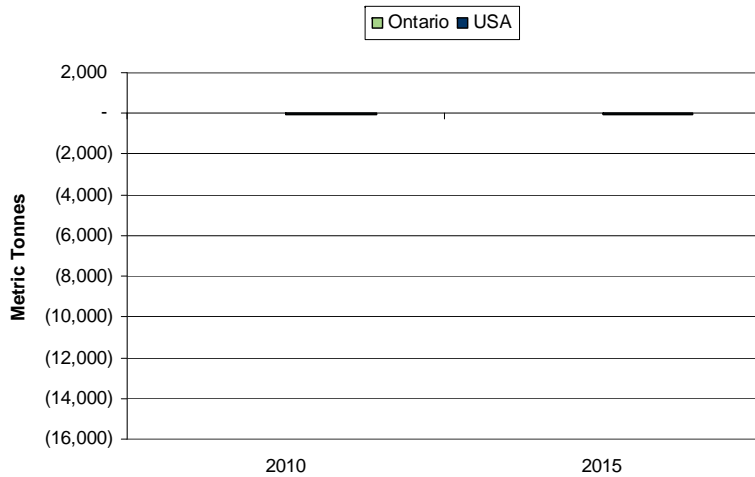
Incremental NOx in Scenario



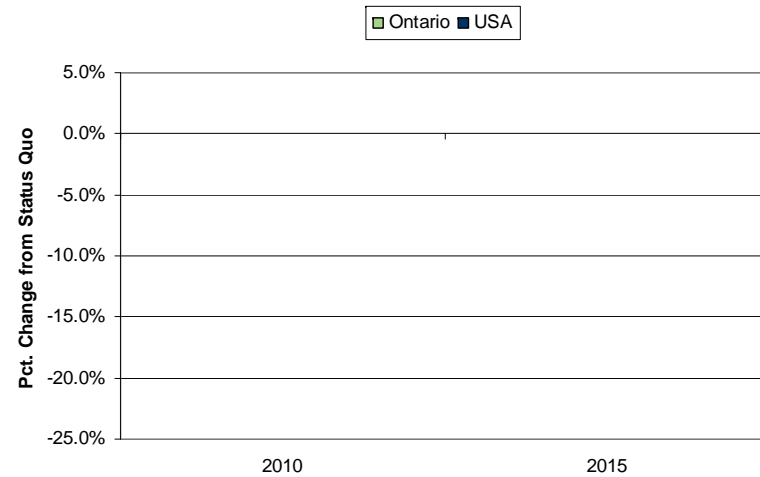
Incremental NOx in Scenario



Incremental SO2 in Scenario



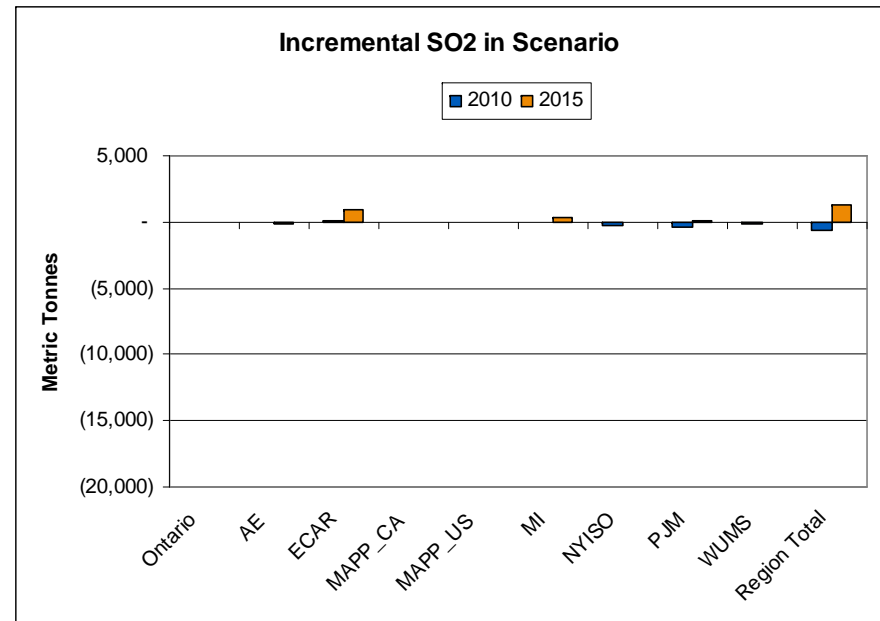
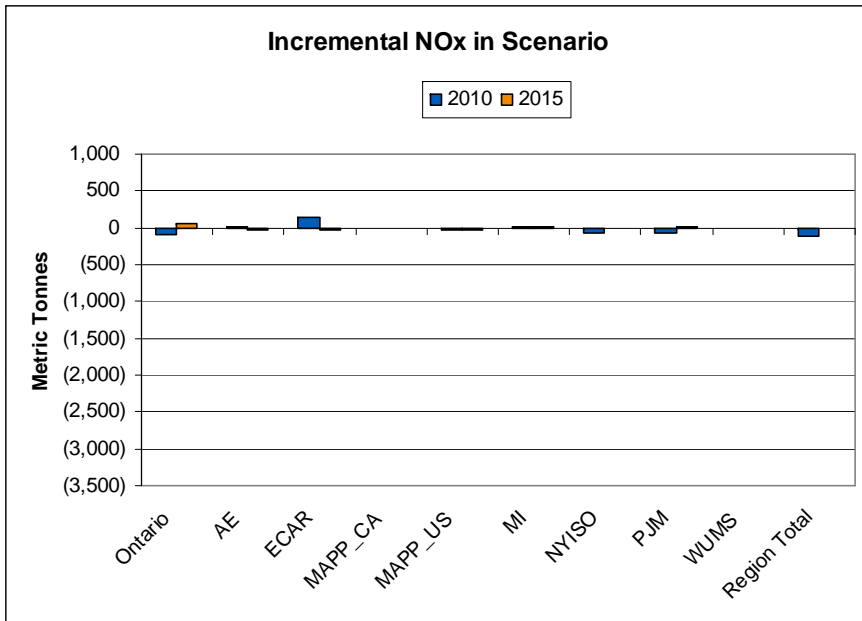
Incremental SO2 in Scenario



Option 4, Scenario 1 – SO₂ and NO_x

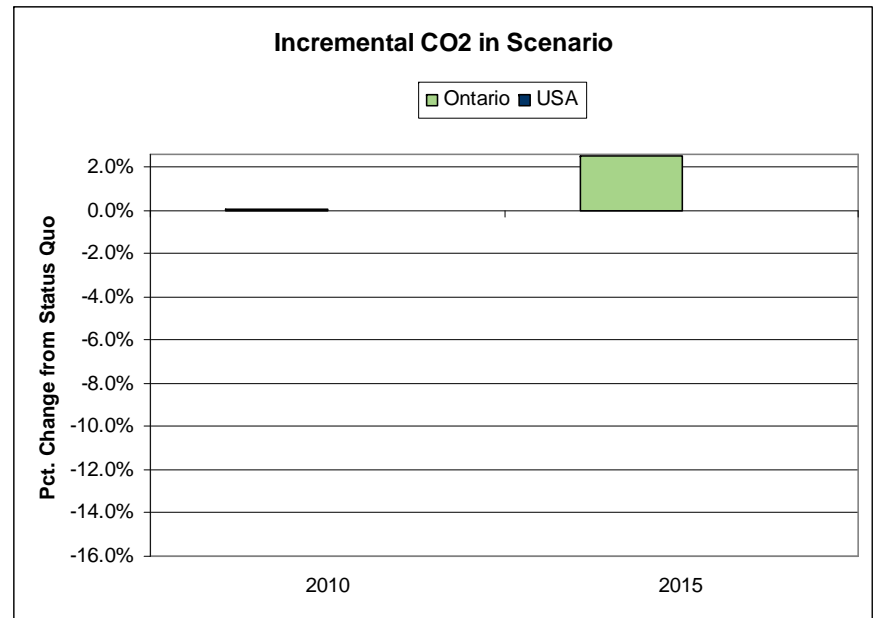
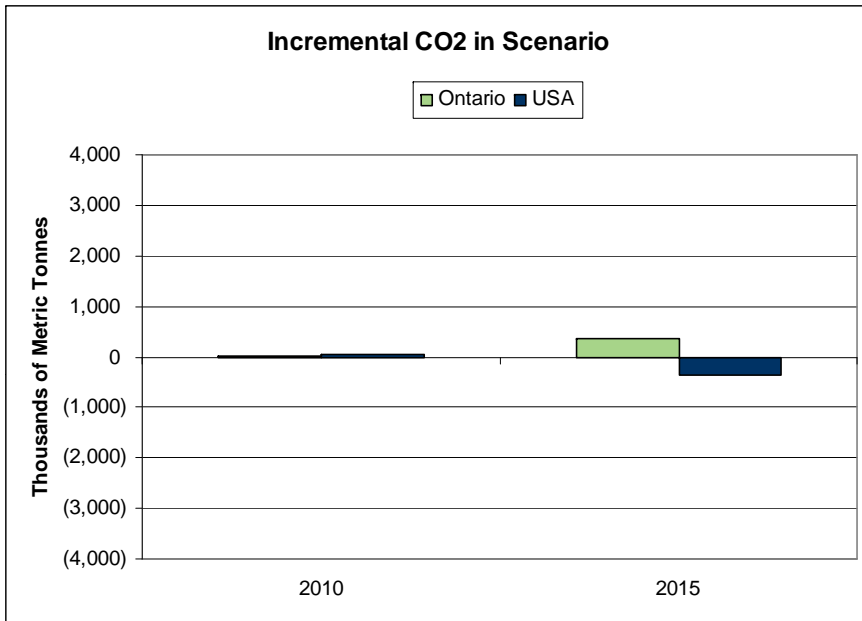
- Ontario SO₂ and NO_x emissions would be well under the caps in both Status Quo and Option 4, Scenario 1 (in 2010 and 2015) due to the consequential impacts of Ontario's CO₂ cap (and Ontario's policy to retire the coal-fired generation fleet by the end of 2014)
- Impacts on emissions are small in this scenario because the impact on net exports is small
- There is no change in SO₂ in Ontario in 2015 (versus status quo) because the coal-fired fleet is assumed to be retired by the end of 2014, and hence there are no SO₂ emissions
- SO₂ and NO_x emissions are relatively unchanged (versus status quo) in the U.S. because of US CAIR policy restrictions pertaining to both pollutants

Option 4, Scenario 1 (unilateral tariff elimination in all hours)



See Appendix C for a map of NEEM's regions.

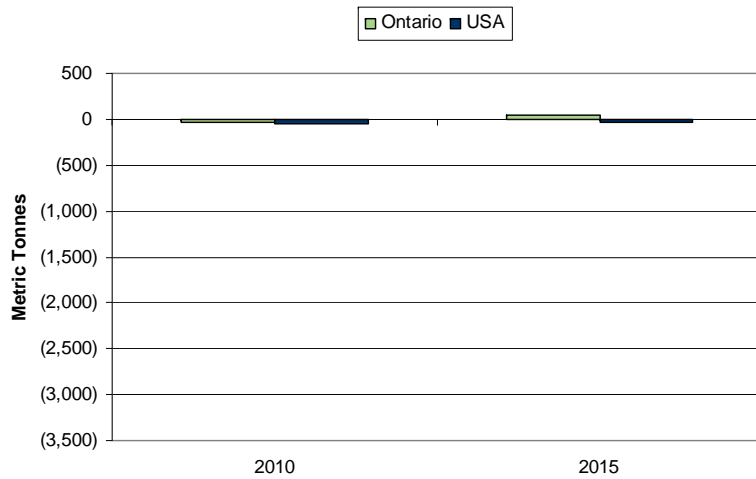
Option 4, Scenario 1 (unilateral tariff elimination in all hours)



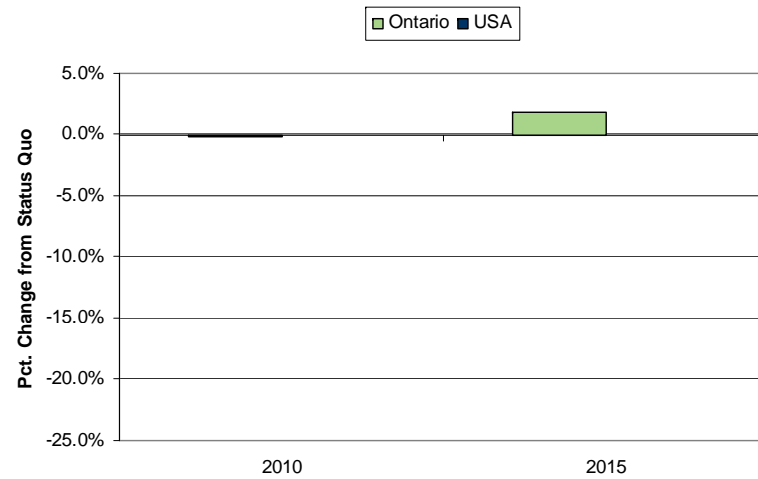
CO2 impacts are small.

Option 4, Scenario 2 (unilateral tariff elimination, off-peak hours only)

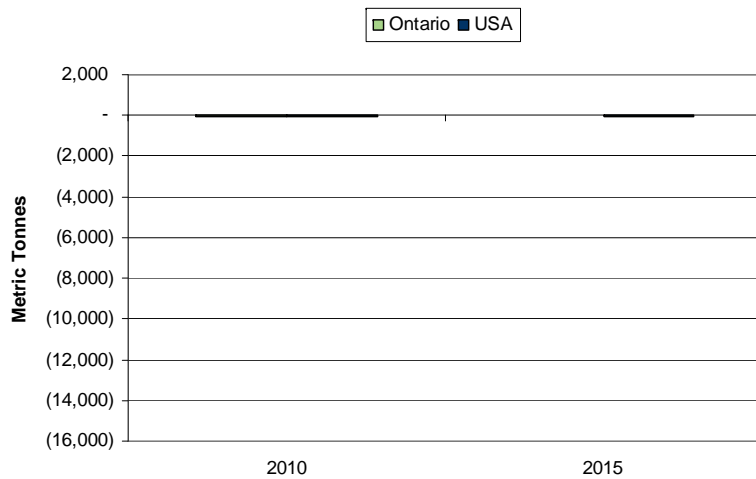
Incremental NOx in Scenario



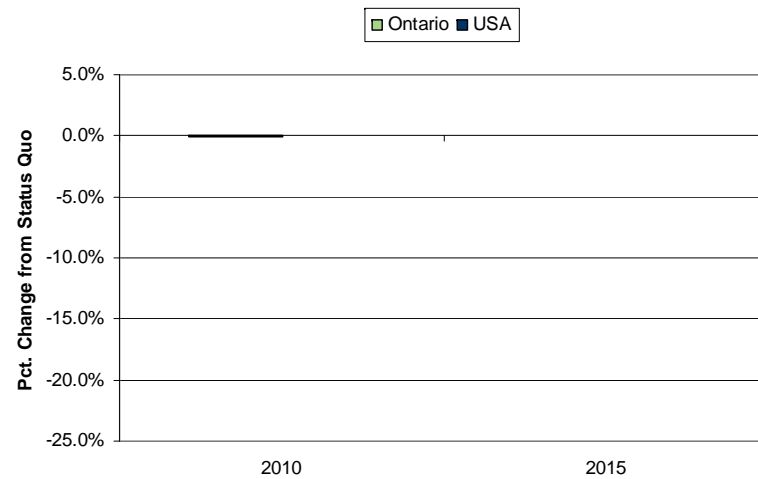
Incremental NOx in Scenario



Incremental SO2 in Scenario



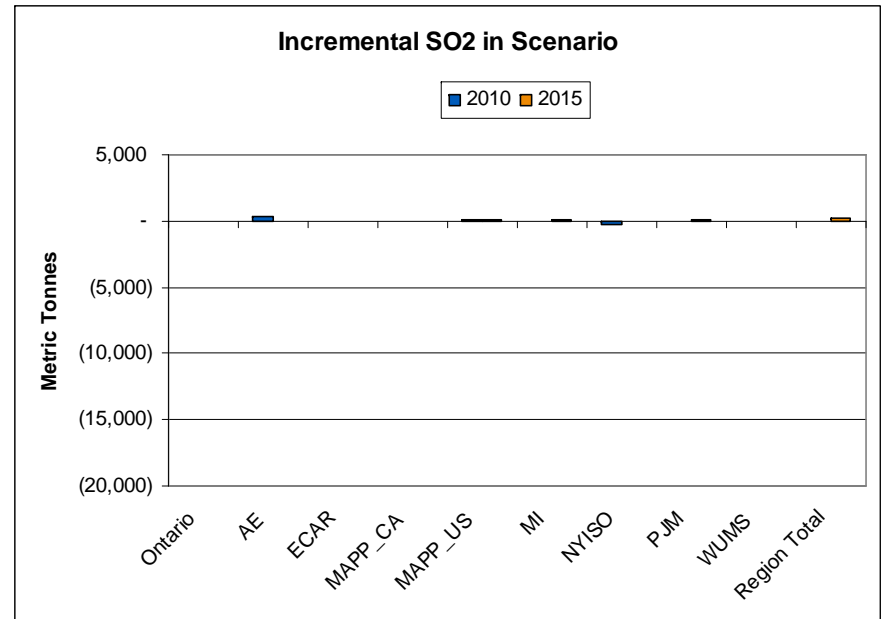
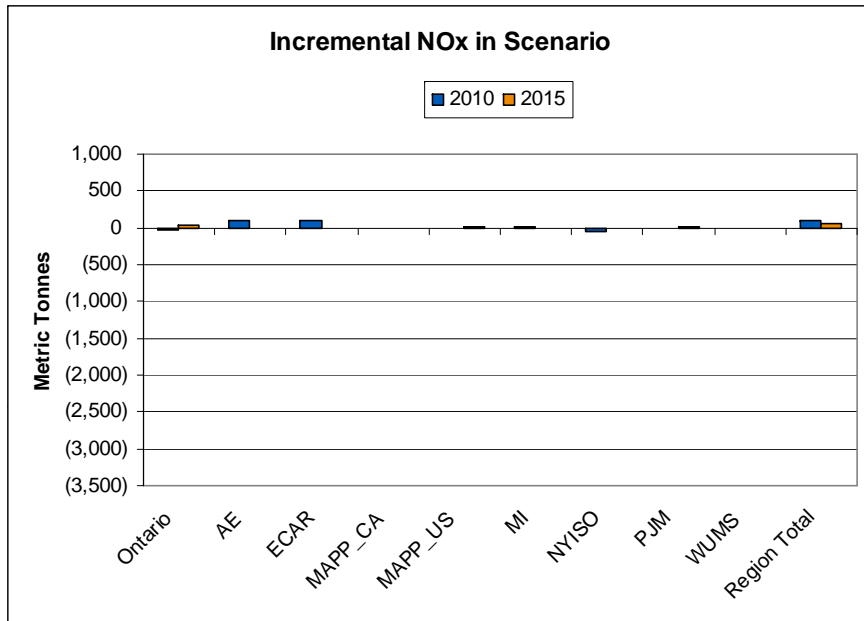
Incremental SO2 in Scenario



Option 4, Scenario 2 – SO₂ and NO_x

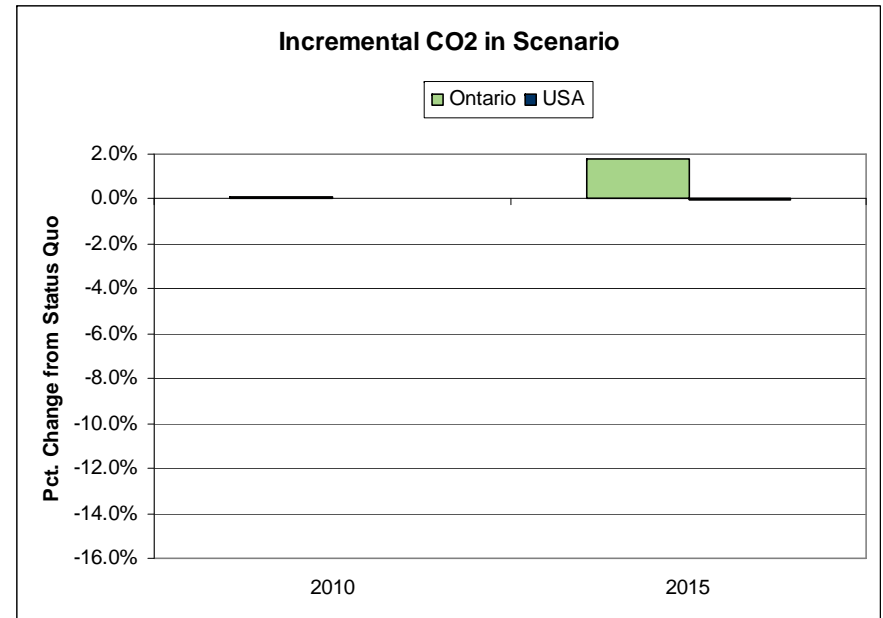
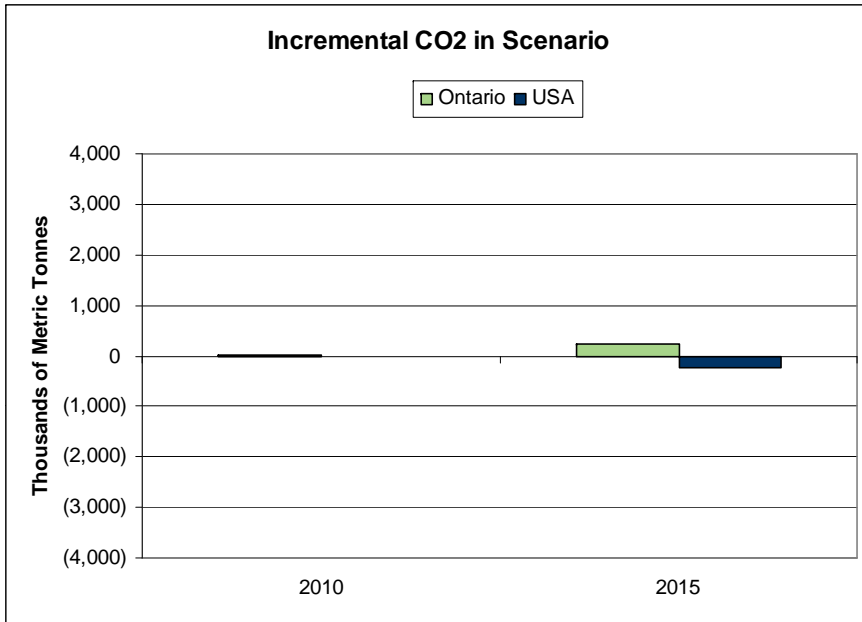
- Ontario SO₂ and NO_x emissions would be well under the caps in both Status Quo and Option 4, Scenario 2 (in 2010 and 2015) due to the consequential impacts of Ontario's CO₂ cap (and Ontario's policy to retire the coal-fired generation fleet by the end of 2014)
- Impacts on emissions are small in this scenario because the impact on net exports is small
- There is no change in SO₂ in Ontario in 2015 (versus status quo) because the coal-fired fleet is assumed to be retired by the end of 2014, and hence there are no SO₂ emissions
- SO₂ and NO_x emissions are relatively unchanged (versus status quo) in the U.S. because of US CAIR policy restrictions pertaining to both pollutants

Option 4, Scenario 2 (unilateral tariff elimination, off-peak only)



See Appendix C for a map of NEEM's regions.

Option 4, Scenario 2 (unilateral tariff elimination, off-peak only)



CO2 impacts are small.

Key Assumptions for Calibration and Scenario Analysis

2007 Model Calibration Results

Scenario Definitions

Results by Scenario

Emissions Impacts by Scenario

General Conclusions

Appendices

Economic Impacts

- Option 2 (average embedded network rate) and Option 3 (reciprocal treatment) tend to increase consumer surplus and decrease producer surplus (the small decrease in consumer surplus in Option 3, scenario 2 in 2010 is the exception)
- Option 4, scenarios 1 and 2 increase producer surplus, but scenario 2 less so. Option 4, scenarios 1 and 2 decrease consumer surplus, but scenario 2 less so. (These are the unilateral tariff elimination options - Scenario 2 involves tariff elimination only in the off-peak hours)
- Option 2 and Option 3, scenario 2 increase ETS tariff revenue. These are the options that involve an increase in the ETS tariff. The increase in Option 3, scenario 2 is small because tariffs are both increased and decreased (depending on the recipient of the exports). All other options decrease ETS tariff revenue.

Emissions Impacts

- Overall emissions impacts are small
- Ontario SO₂ and NO_x will be well below their caps regardless of the export tariff scenario due to the consequential effects of Ontario's CO₂ cap (and Ontario's policy to retire the coal-fired generation fleet by the end of 2014)
- North American cap-and-trade policy for CO₂ would control any CO₂ leakage associated with export tariff changes
 - If all power sector CO₂ emissions in North America were subject to cap-and-trade, North American CO₂ emissions would not be affected by the choice of export tariff scenario
 - Since we modeled the North American policy as a CO₂ price and allowed emissions to change, we see small net changes in CO₂ emissions

Key Assumptions for Calibration and Scenario Analysis

2007 Model Calibration Results

Scenario Definitions

Electric Power Results by Scenario

Emissions Impacts Sector Results by Scenario

General Conclusions

Appendices

Appendix A: Summary Results Tables

Impacts on Ontario Exports

Incremental Exports - 2010

GWh

Option	Scenario	Destination				Total
		PJM	MISO	NY	HQ	
Option 2		(184)	(3)	(3,380)	(493)	(4,060)
Option 3	Scenario 1	478	55	3,320	601	4,453
Option 3	Scenario 2	(323)	(19)	1,290	(839)	109
Option 4	Scenario 1	56	2	657	132	847
Option 4	Scenario 2	13	8	195	152	368

Incremental Exports - 2015

GWh

Option	Scenario	Destination				Total
		PJM	MISO	NY	HQ	
Option 2		(312)	(17)	(5,105)	(591)	(6,025)
Option 3	Scenario 1	560	148	1,664	698	3,070
Option 3	Scenario 2	(283)	(44)	1,367	(1,215)	(175)
Option 4	Scenario 1	(2)	25	868	360	1,251
Option 4	Scenario 2	(9)	13	494	237	735

Impact on Ontario Imports

Incremental Imports - 2010

GWh

Option	Scenario	PJM	MISO	Origin NY	HQ	Total
Option 2		(107)	(1,613)	(0)	(87)	(1,808)
Option 3	Scenario 1	2,515	4,392	0	2,681	9,588
Option 3	Scenario 2	237	(60)	0	(3)	174
Option 4	Scenario 1	291	370	0	128	791
Option 4	Scenario 2	91	194	0	19	304

Incremental Imports - 2015

GWh

Option	Scenario	PJM	MISO	Origin NY	HQ	Total
Option 2		0	(1,718)	(1)	(123)	(1,840)
Option 3	Scenario 1	1,005	6,505	177	625	8,313
Option 3	Scenario 2	(0)	(173)	4	(114)	(284)
Option 4	Scenario 1	0	282	1	23	307
Option 4	Scenario 2	0	68	0	4	72

ETS Tariff Revenue and Market Efficiency Impacts

Change in ETS Revenue
Million 2008\$CAN

Option	Scenario	2010	2015
Option 2		27.4	22.5
Option 3	Scenario 1	(12.0)	(13.5)
Option 3	Scenario 2	2.2	1.7
Option 4	Scenario 1	(12.0)	(13.5)
Option 4	Scenario 2	(8.9)	(9.8)

Market Efficiency Impacts - 2010
Million 2008\$CAN

Option	Scenario	Sum Variable Costs	Producer Surplus	Consumer Surplus	Total Surplus
Option 2		(126)	(214)	207	(7)
Option 3	Scenario 1	(272)	(299)	297	(1)
Option 3	Scenario 2	9	(14)	(5)	(19)
Option 4	Scenario 1	16	102	(111)	(9)
Option 4	Scenario 2	6	35	(36)	(1)

Market Efficiency Impacts - 2015
Million 2008\$CAN

Option	Scenario	Sum Variable Costs	Producer Surplus	Consumer Surplus	Total Surplus
Option 2		(325)	(187)	176	(10)
Option 3	Scenario 1	(403)	(198)	192	(6)
Option 3	Scenario 2	10	(53)	46	(7)
Option 4	Scenario 1	76	59	(56)	3
Option 4	Scenario 2	53	20	(18)	2

Impacts on the HOEP

Appendix A – Summary Results Table

Impacts on the HOEP
% Change

Option	Scenario	2010	2015
Option 2		-2.5%	-1.4%
Option 3	Scenario 1	-3.7%	-1.6%
Option 3	Scenario 2	-0.2%	-0.4%
Option 4	Scenario 1	1.3%	0.4%
Option 4	Scenario 2	0.5%	0.2%

NOx Emissions Impacts

Incremental NOx Emissions - 2010

Tonnes

Option	Scenario	Ontario Ontario	Neighbor AE	Neighbor ECAR	Neighbor MAPP_US	Neighbor MI	Neighbor NYISO	Neighbor PJM	Neighbor WUMS	Region Total	USA Total
Option 2		(1,077)	(242)	(227)	(65)	(18)	173	456	3	(999)	48
Option 3	Scenario 1	(3,189)	476	(137)	16	202	(102)	(319)	(92)	(3,143)	101
Option 3	Scenario 2	55	(95)	(82)	(4)	17	(111)	(98)	(8)	(327)	24
Option 4	Scenario 1	(93)	12	143	(28)	6	(73)	(68)	(11)	(112)	(37)
Option 4	Scenario 2	(32)	93	99	(13)	16	(53)	(7)	0	103	(43)

Incremental NOx Emissions - 2015

Tonnes

Option	Scenario	Ontario Ontario	Neighbor AE	Neighbor ECAR	Neighbor MAPP_US	Neighbor MI	Neighbor NYISO	Neighbor PJM	Neighbor WUMS	Region Total	USA Total
Option 2		(276)	(272)	(643)	(49)	(101)	195	102	(8)	(1,052)	(63)
Option 3	Scenario 1	(339)	35	182	(1)	446	(20)	(5)	(11)	287	58
Option 3	Scenario 2	(5)	(44)	(17)	(72)	(94)	(14)	(201)	(1)	(449)	309
Option 4	Scenario 1	64	(22)	(33)	(21)	7	(17)	12	2	(9)	(57)
Option 4	Scenario 2	43	3	(9)	17	3	(3)	15	(1)	68	(29)

See Appendix C for a map of NEEM's regions.

Appendix A – Summary Results Table

SO2 Emissions Impacts

Incremental SO2 Emissions - 2010

Tonnes

Option	Scenario	Ontario Ontario	Neighbor AE	Neighbor ECAR	Neighbor MAPP_US	Neighbor MI	Neighbor NYISO	Neighbor PJM	Neighbor WUMS	Region Total	USA Total
Option 2		(4,853)	(751)	(2,358)	(126)	(33)	334	2,306	(66)	(5,547)	34
Option 3	Scenario 1	(13,576)	1,871	3,838	75	276	(108)	(6,485)	(896)	(15,004)	162
Option 3	Scenario 2	718	(314)	(204)	(31)	(62)	(432)	(478)	(103)	(905)	(8)
Option 4	Scenario 1	17	(9)	98	(18)	(6)	(264)	(349)	(126)	(657)	(21)
Option 4	Scenario 2	(61)	303	12	76	(4)	(275)	(26)	(3)	22	(39)

Incremental SO2 Emissions - 2015

Tonnes

Option	Scenario	Ontario Ontario	Neighbor AE	Neighbor ECAR	Neighbor MAPP_US	Neighbor MI	Neighbor NYISO	Neighbor PJM	Neighbor WUMS	Region Total	USA Total
Option 2		-	(881)	(695)	(100)	(875)	12	625	(30)	(1,941)	(260)
Option 3	Scenario 1	-	195	(3,753)	27	2,077	(25)	(115)	(86)	(1,678)	276
Option 3	Scenario 2	-	(208)	2,790	(203)	(754)	(7)	(1,009)	(3)	606	661
Option 4	Scenario 1	-	(94)	976	19	281	(12)	154	23	1,347	(54)
Option 4	Scenario 2	-	(41)	(15)	58	129	1	113	(1)	244	(55)

See Appendix C for a map of NEEM's regions.

CO2 Emissions Impacts

Appendix A – Summary Results Table

Incremental CO2 Emissions
Thousand Tonnes

Option	Scenario	2010 Ontario	2010 USA	2015 Ontario	2015 USA
Option 2		(1,420)	795	(1,548)	1,423
Option 3	Scenario 1	(3,603)	2,721	(1,967)	2,358
Option 3	Scenario 2	(27)	(66)	51	(293)
Option 4	Scenario 1	19	46	358	(367)
Option 4	Scenario 2	23	(0)	249	(230)

Incremental CO2 Emissions
% Change

Option	Scenario	2010 Ontario	2010 USA	2015 Ontario	2015 USA
Option 2		-5.8%	0.0%	-11.0%	0.1%
Option 3	Scenario 1	-14.8%	0.1%	-13.9%	0.1%
Option 3	Scenario 2	-0.1%	0.0%	0.4%	0.0%
Option 4	Scenario 1	0.1%	0.0%	2.5%	0.0%
Option 4	Scenario 2	0.1%	0.0%	1.8%	0.0%

Appendix B – ETS Tariff and All-In Costs

Status Quo

2010								2010		
All-In Export Costs (2008 \$CAN/MWh)		To						Export Tariff out of Ontario (2008 \$CAN/MWh)		
		ON	HQ	PJM		NY	MISO			
				Via MISO	Via NY					
From	ON		17.47	5.31	13.64	4.60	4.60	HQ	1.02	
	HQ	12.87				12.87		NY	1.02	
	PJM	Via MISO	6.48				4.47	0.63	MISO	1.02
		Via NY	12.04							
	NY	7.57	20.44		9.04					
	MISO	5.85			0.70					

2015								2015		
All-In Export Costs (2008 \$CAN/MWh)		To						Export Tariff out of Ontario (2008 \$CAN/MWh)		
		ON	HQ	PJM		NY	MISO			
				Via MISO	Via NY					
From	ON		17.55	5.33	13.67	4.63	4.63	HQ	1.04	
	HQ	12.93				12.93		NY	1.04	
	PJM	Via MISO	6.48				4.47	0.63	MISO	1.04
		Via NY	12.04							
	NY	7.57	20.49		9.04					
	MISO	5.85			0.70					

Appendix B – ETS Tariff and All-In Costs

Option 2 – Average Embedded Network Rate

2010								2010		
All-In Export Costs (2008 \$CAN/MWh)		To						Export Tariff out of Ontario (2008 \$CAN/MWh)		
		ON	HQ	PJM		NY	MISO			
				Via MISO	Via NY					
From	ON		21.60	9.43	17.77	8.72	8.72	HQ	5.15	
	HQ	12.87				12.87		NY	5.15	
	PJM	Via MISO	6.48				4.47	0.63	MISO	5.15
		Via NY	12.04							
	NY	7.57	20.44		9.04					
	MISO	5.85			0.70					

2015								2015		
All-In Export Costs (2008 \$CAN/MWh)		To						Export Tariff out of Ontario (2008 \$CAN/MWh)		
		ON	HQ	PJM		NY	MISO			
				Via MISO	Via NY					
From	ON		21.68	9.46	17.79	8.75	8.75	HQ	5.16	
	HQ	12.93				12.93		NY	5.16	
	PJM	Via MISO	6.48				4.47	0.63	MISO	5.16
		Via NY	12.04							
	NY	7.57	20.49		9.04					
	MISO	5.85			0.70					

Appendix B – ETS Tariff and All-In Costs

Option 3, Scenario 1 – Reciprocal Tariff Joint Elimination

2010								2010		
All-In Export Costs (2008 \$CAN/MWh)		To						Export Tariff out of Ontario (2008 \$CAN/MWh)		
		ON	HQ	PJM		NY	MISO			
				Via MISO	Via NY					
From	ON		16.45	4.28	12.62	3.58	3.58	HQ	0	
	HQ	4.56				12.87		NY	0	
	PJM	Via MISO	1.33				4.47	0.63	MISO	0
		Via NY	8.11							
	NY	3.64	20.44	9.04						
	MISO	0.70		0.70						

2015								2015		
All-In Export Costs (2008 \$CAN/MWh)		To						Export Tariff out of Ontario (2008 \$CAN/MWh)		
		ON	HQ	PJM		NY	MISO			
				Via MISO	Via NY					
From	ON		16.52	4.30	12.63	3.59	3.59	HQ	0	
	HQ	4.59				12.93		NY	0	
	PJM	Via MISO	1.33				4.47	0.63	MISO	0
		Via NY	8.11							
	NY	3.64	20.49	9.04						
	MISO	0.70		0.70						

Appendix B – ETS Tariff and All-in Costs

Option 3, Scenario 2 – Reciprocal Treatment, Avg. Embedded Network Cost**

2010								2010		
All-In Export Costs (2008 \$CAN/MWh)		To						Export Tariff out of Ontario (2008 \$CAN/MWh)		
		ON	HQ	PJM		NY	MISO			
				Via MISO	Via NY					
From	ON		24.76	9.43	12.62	3.58	8.72	HQ	8.31	
	HQ	12.87				12.87		NY	0	
	PJM	Via MISO	6.48				4.47	0.63	MISO	5.15
		Via NY	8.11							
	NY	3.64	20.44	9.04						
	MISO	5.85		0.70						

2015								2015		
All-In Export Costs (2008 \$CAN/MWh)		To						Export Tariff out of Ontario (2008 \$CAN/MWh)		
		ON	HQ	PJM		NY	MISO			
				Via MISO	Via NY					
From	ON		24.85	9.44	12.63	3.59	8.74	HQ	8.34	
	HQ	12.93				12.93		NY	0	
	PJM	Via MISO	6.48				4.47	0.63	MISO	5.15
		Via NY	8.11							
	NY	3.64	20.49	9.04						
	MISO	5.85		0.70						

**Note: Except between New York where the ETS tariff is deemed to be eliminated.

Appendix B – ETS Tariff and All-In Costs

Option 4, Scenario 1 and 2 – Unilateral Tariff Elimination (note: *Scenario 2 is status quo on-peak*)

2010								2010		
All-In Export Costs (2008 \$CAN/MWh)		To						Export Tariff out of Ontario (2008 \$CAN/MWh)		
		ON	HQ	PJM		NY	MISO			
				Via MISO	Via NY					
From	ON		16.45	4.28	12.62	3.58	3.58			
	HQ	12.87				12.87			0	
	PJM	Via MISO	6.48							
		Via NY	12.04				4.47	0.63		
	NY	7.57	20.44		9.04					
	MISO	5.85			0.70					0

2015								2015		
All-In Export Costs (2008 \$CAN/MWh)		To						Export Tariff out of Ontario (2008 \$CAN/MWh)		
		ON	HQ	PJM		NY	MISO			
				Via MISO	Via NY					
From	ON		16.52	4.30	12.63	3.59	3.59			
	HQ	12.93				12.93			0	
	PJM	Via MISO	6.48							
		Via NY	12.04				4.47	0.63		
	NY	7.57	20.49		9.04					
	MISO	5.85			0.70					0

Map of NEEM Regions



Michigan is a separate region.