

Export Transmission Service (ETS) Charge Scenario Analysis

Draft Preliminary Report and Findings

**Prepared for
Independent Electricity System Operator**



INTERNATIONAL

June 25, 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) attributed to each ETS tariff option.
- Other implementation issues will be considered by the IESO, including potential reliability and operational impacts, regulatory and legal implications, and observed impacts on surplus base-load generation events.

General Conclusions

- Due to its portfolio of hydro, nuclear, wind, and gas, Ontario has more opportunity to export (to PJM/MISO) after North American carbon policy takes effect
- ETS options such as the *average network rate* and the modeled *reciprocal agreements* tend to increase consumer surplus and decrease producer surplus
 - The average network rate scenario involves a unilateral increase in the ETS charge, reducing external demand for Ontario power, and reducing the HOEP
 - Because Ontario has a lower export tariff than its neighbors, reciprocal tariff elimination reduces net exports from Ontario, decreases producer surplus, and increases consumer surplus
- ETS options such as *unilateral tariff elimination* tend to increase producer surplus and decrease consumer surplus
- ETS revenues increase in the scenarios that involve ETS charge increases
- Impacts on SO₂ and NO_x emissions are small because:
 - Ontario's CO₂ policy reduces those emissions well below their caps irrespective of the ETS charge scenario
 - The US CAIR policy restricts the emissions of both pollutants
 - But there is a small regional increase in emissions in the scenarios where the export tariffs are eliminated (in 2015)
- Under a North American cap-and-trade policy for CO₂ emissions, the ETS charge scenario has no effect on North American power system CO₂ emissions

Limitations of Analysis

- Contracted generator arrangements and obligations have generally been ignored
- Bidding behavior has generally been ignored
- Implications of changes in “uplift charge” revenue (and any associated impacts on rates) are not considered
- Limited understanding of hydropower output shape (Ontario, Quebec, New York)
- Transmission constraints inside of Ontario are not modeled

Outline

Key Assumptions for Calibration and Scenario Analysis

2007 Model Calibration Results

Scenario Definitions

Results by Scenario

Emissions Impacts by Scenario

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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.

Unit characteristics (2007) - other

Technology	Summer MW	Capacity-weighted Average Heat Rate (Btu/kWh)
Nuclear	11,504	10,500
Natural Gas Combined-Cycle	3,596	7,735
Natural Gas Combustion Turbine	397	12,257
Steam Turbine Gas/Oil	2,120	9,891
Hydroelectric	8,163	N/A
Wind Turbine	796	N/A
Other Renewables	93	N/A

Note: Non-coal units are aggregated in CRA's NEEM model. Combined-cycle units are grouped into three tiers and combustion turbines into two tiers based on heat rate and in-service year.

Sources: Ventyx Velocity Suite and IESO.

Defining assumptions

	Notes	2007	2010	2015
Load	Ontario electricity demand, in TWh	152	159	165
Peak Energy	Peak hour electricity demand, in MW	25,737	26,986	28,099
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	11.5
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

* In any given month, hydro output was assumed to be flat across the load blocks

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

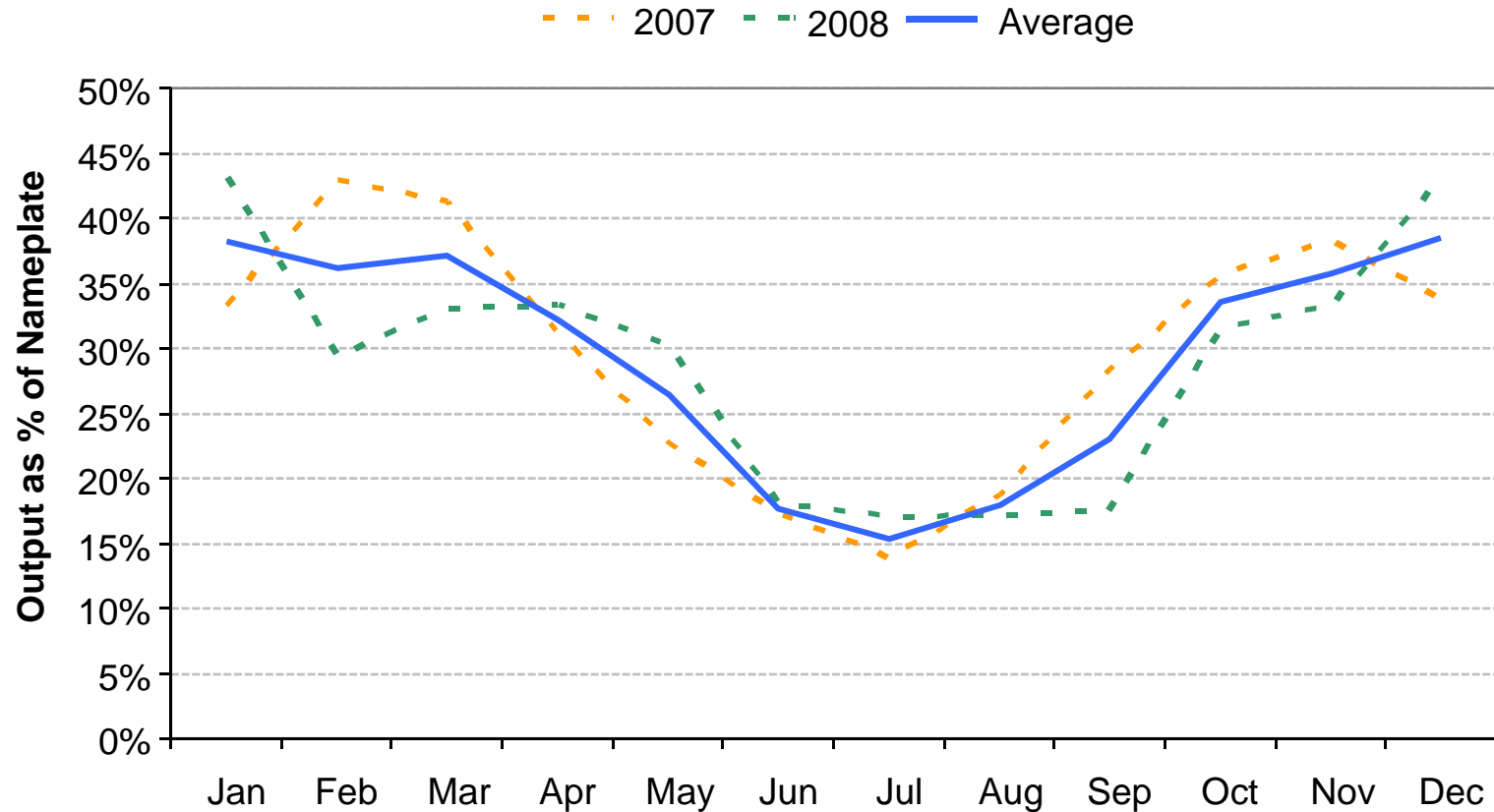
Forecasted hydro output by month was provided by the IESO

Month	MWh	
	2010	2015
Jan	2,934,620	3,230,845
Feb	2,661,792	2,995,066
Mar	2,950,537	3,303,194
Apr	3,114,072	3,379,253
May	3,680,026	3,835,571
Jun	3,247,366	3,410,776
Jul	3,057,440	3,220,447
Aug	2,862,262	2,988,861
Sep	2,699,030	2,839,254
Oct	3,038,747	3,178,484
Nov	3,209,319	3,377,889
Dec	3,278,952	3,465,199
TOTAL	36,734,162	39,224,839

Source: IESO

Within any month, hydro assumed to run flat across the load blocks.

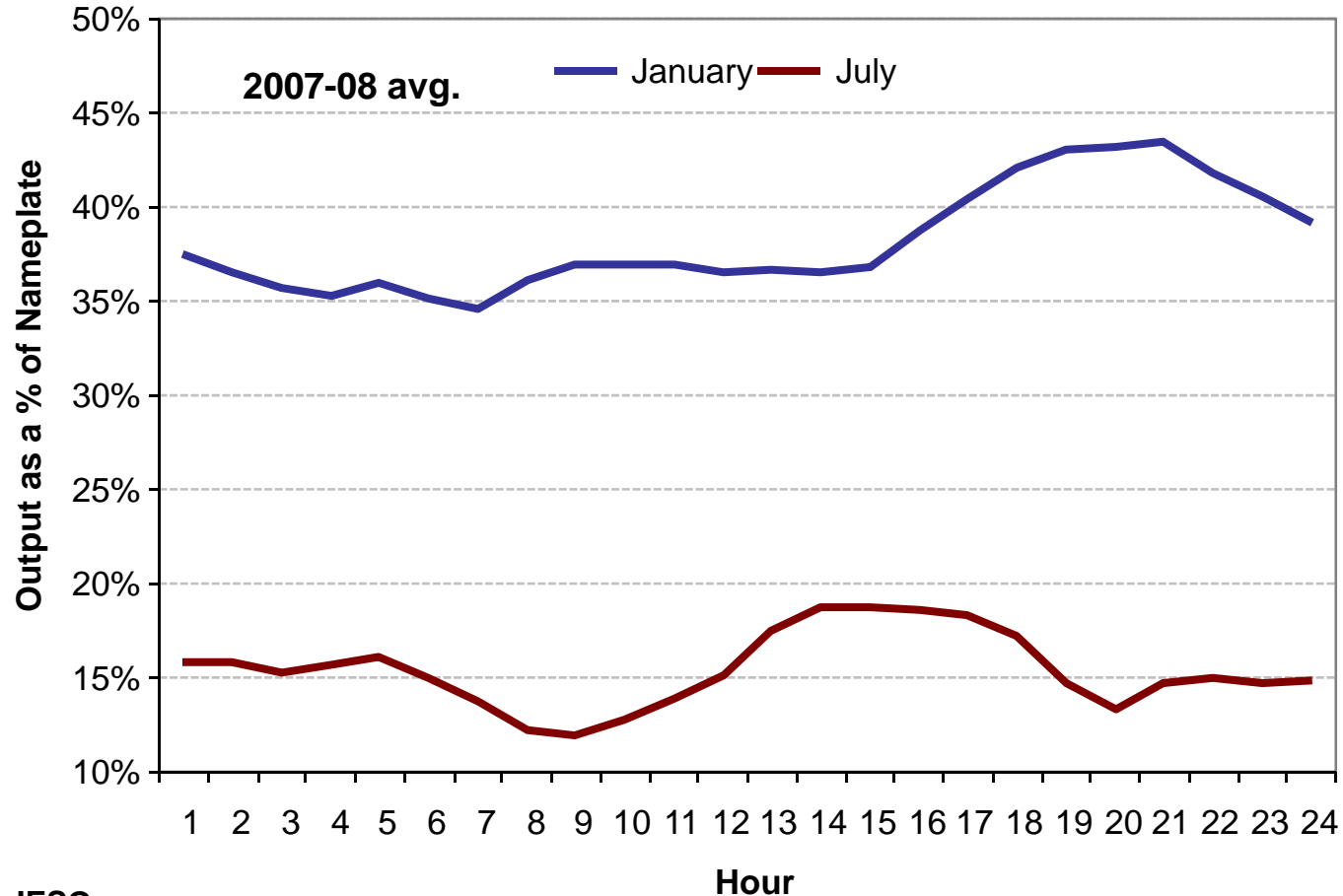
Wind output assumptions (monthly) are based on historical data



Source: IESO

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

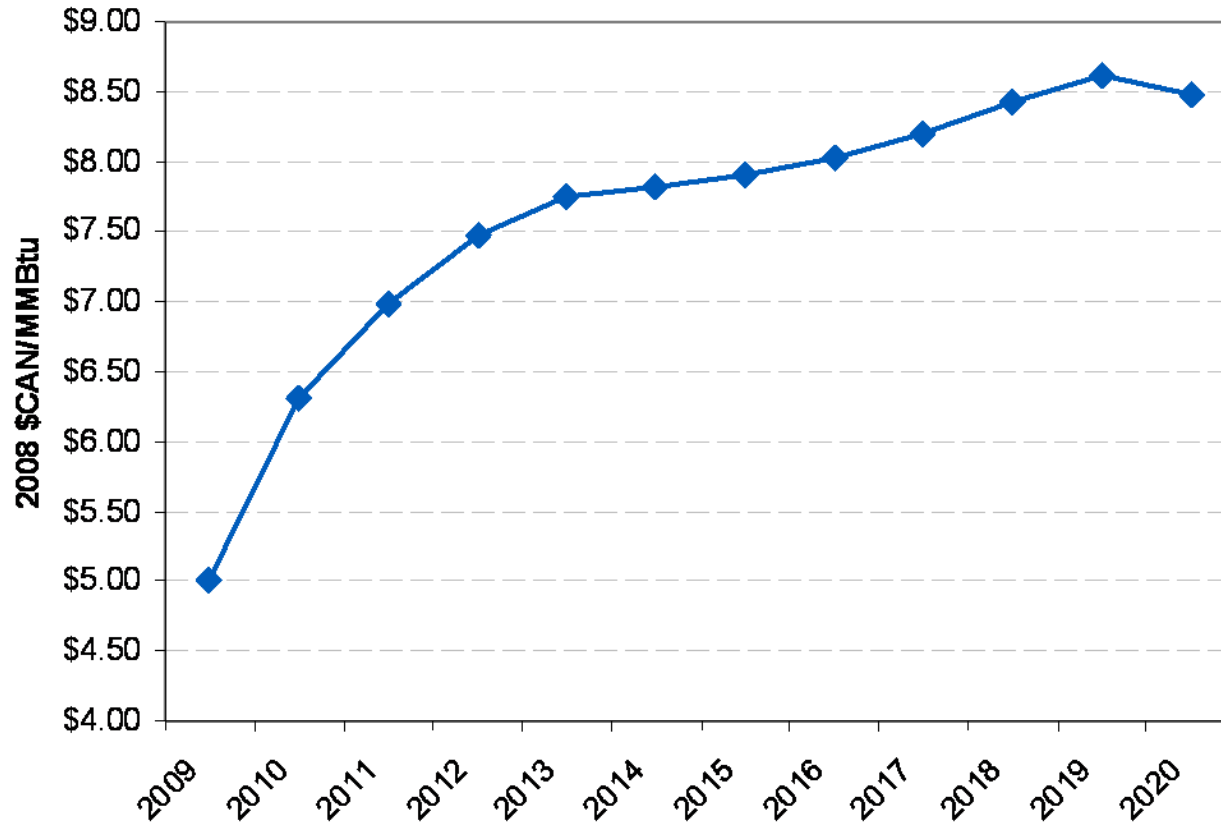
Wind output assumptions (diurnal variation in winter and summer)



Source: IESO

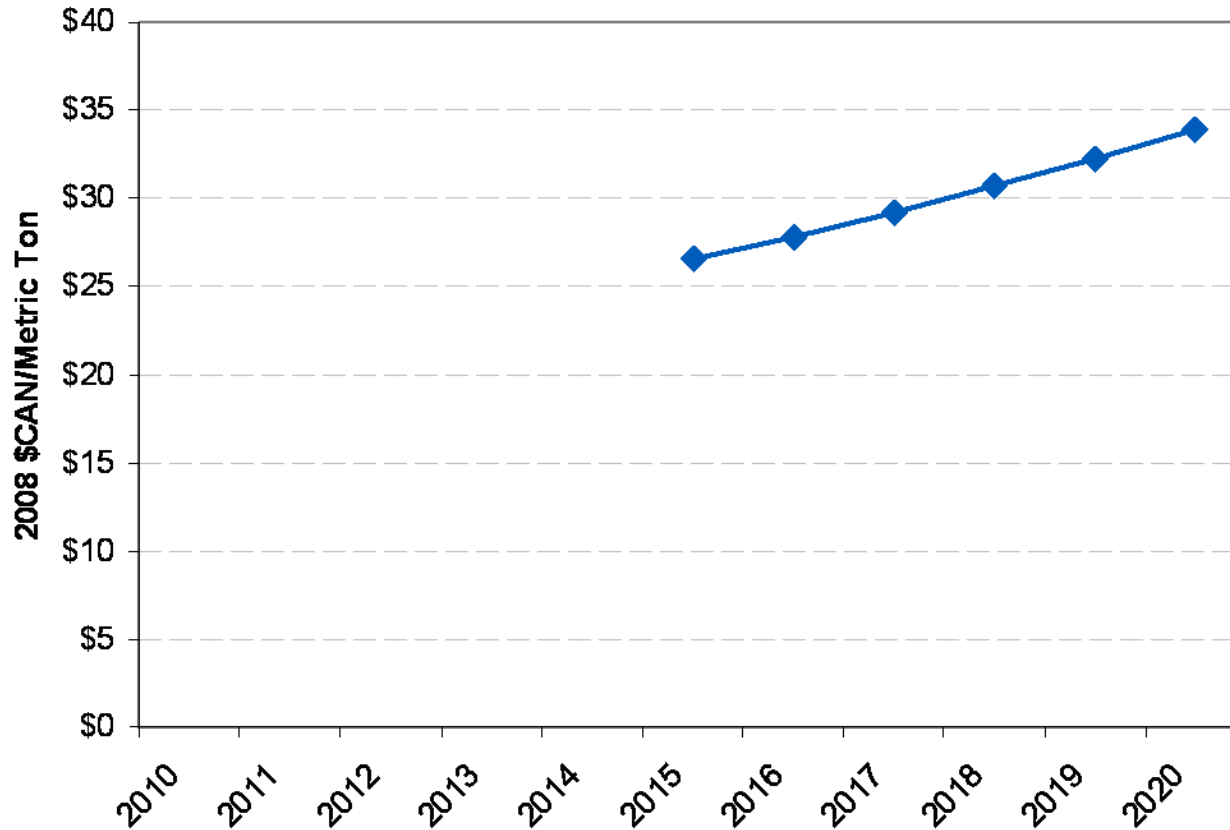
Summer and winter output levels and shapes are different.

Natural gas delivered prices to Ontario power plants



Henry hub prices based on a blend of NYMEX futures and EIA's AEO 2009 forecast. A regional basis differential adjusts this forecast to Ontario delivered prices.

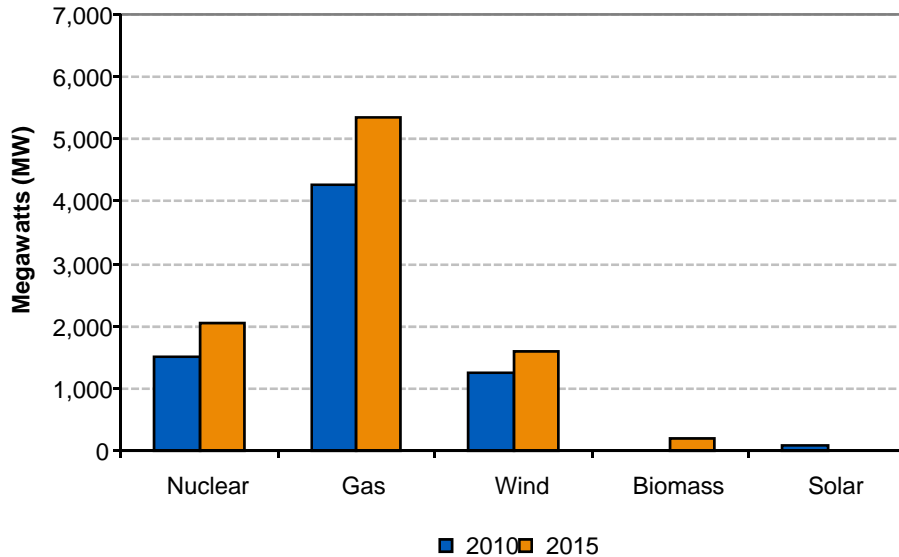
North-American CO2 policy affects 2015 assessment



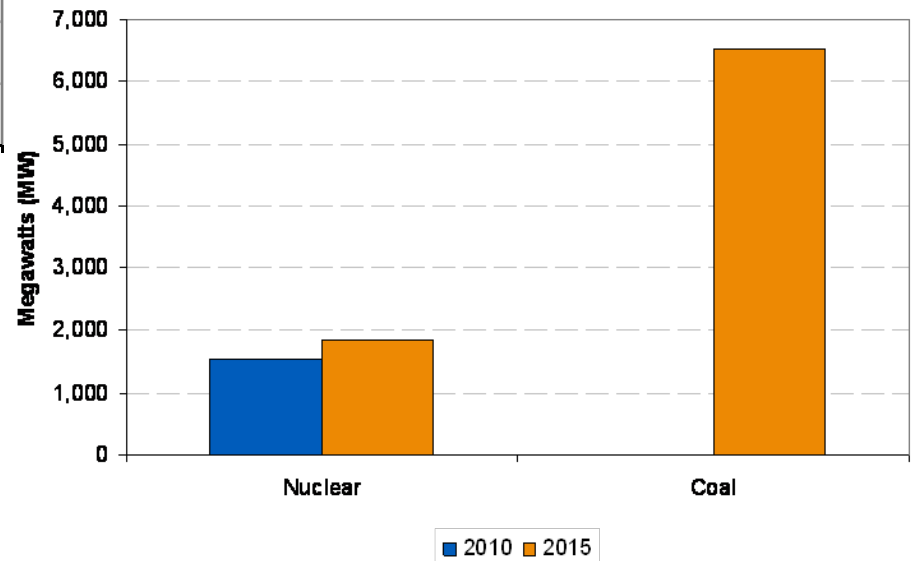
North-American carbon policy starts in 2015 at \$26.53/tonne (CAN\$), annual escalation is 5% real.

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

Incremental Capacity Additions



Retirements



Notes: (1) NEEM model did not choose any economic additions 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

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* = $(\text{Price}_{\text{status quo}} - \text{Price}_{\text{scenario}}) * \text{block demand}$

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 (fuel, VOM, allowances, 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 = \$5,290 (Million 2008 CAN\$)**
- **2015 Producer Surplus = \$8,125 (Million 2008 CAN\$)**
- ***Status quo consumer surplus cannot be reported because load is fixed (demand is perfectly inelastic), so consumer surplus is infinite***

- **2010 ETS Revenue = \$19.7 (Million 2008 CAN\$)**
- **2015 ETS Revenue = \$31.8 (Million 2008 CAN\$)**

Key Assumptions for Calibration and Scenario Analysis

2007 Model Calibration Results

Scenario Definitions

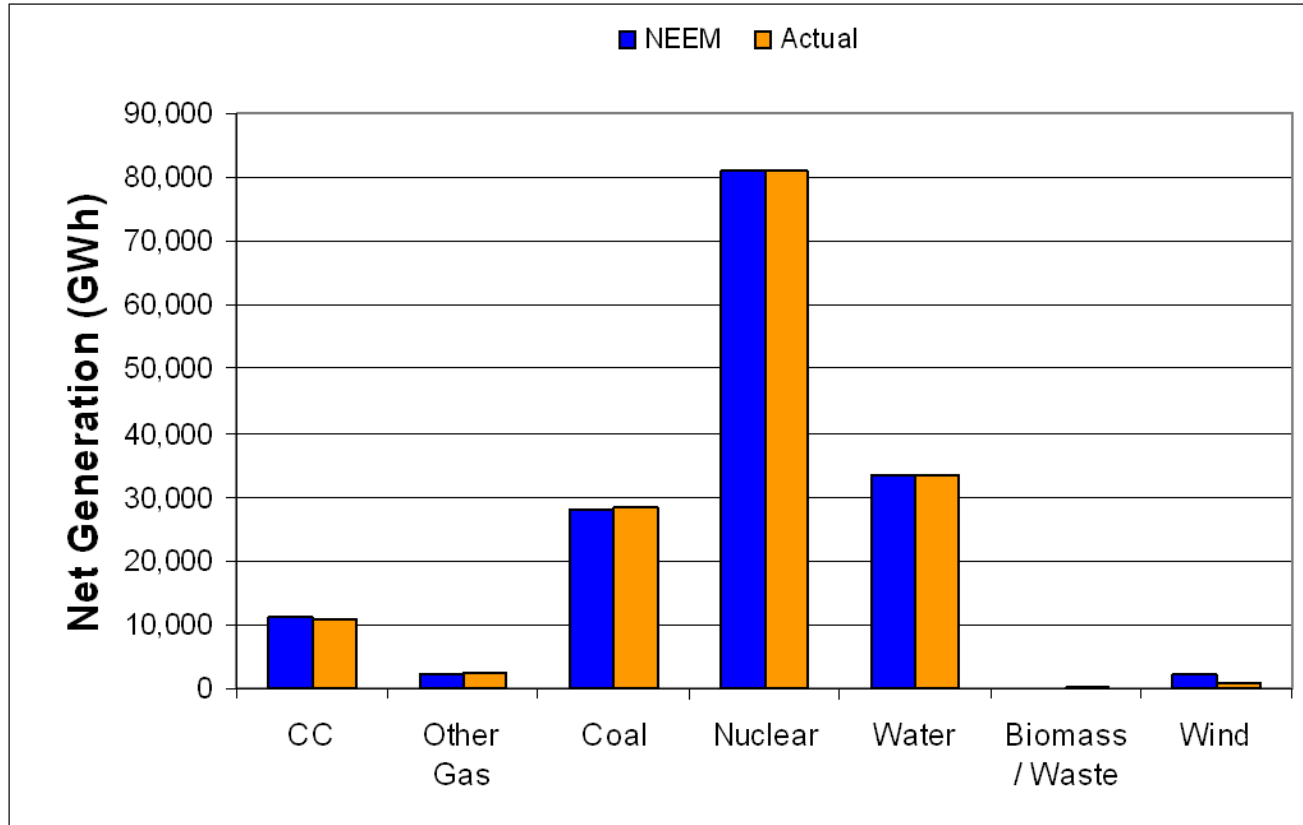
Results by Scenario

Emissions Impacts by Scenario

Conclusions

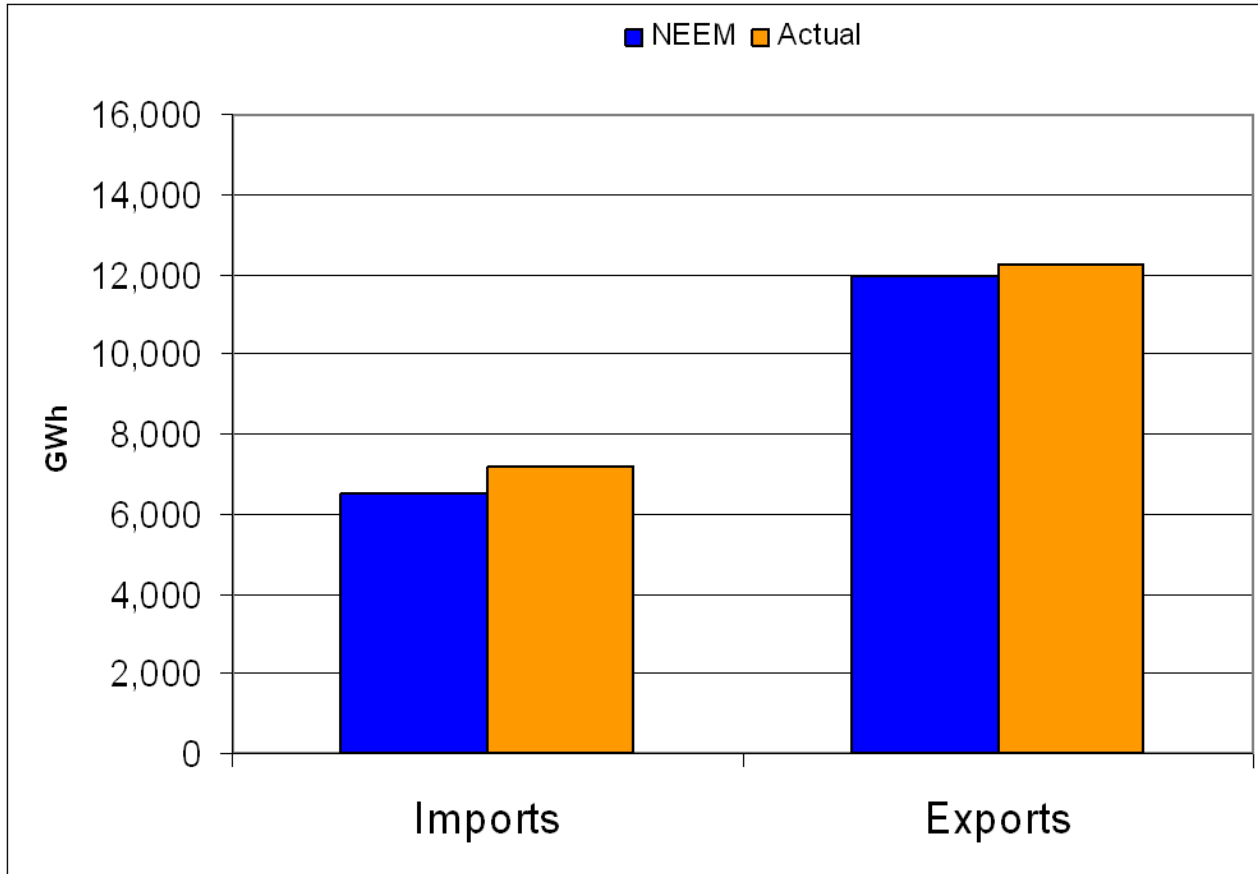
Appendix

Generation Calibration - 2007

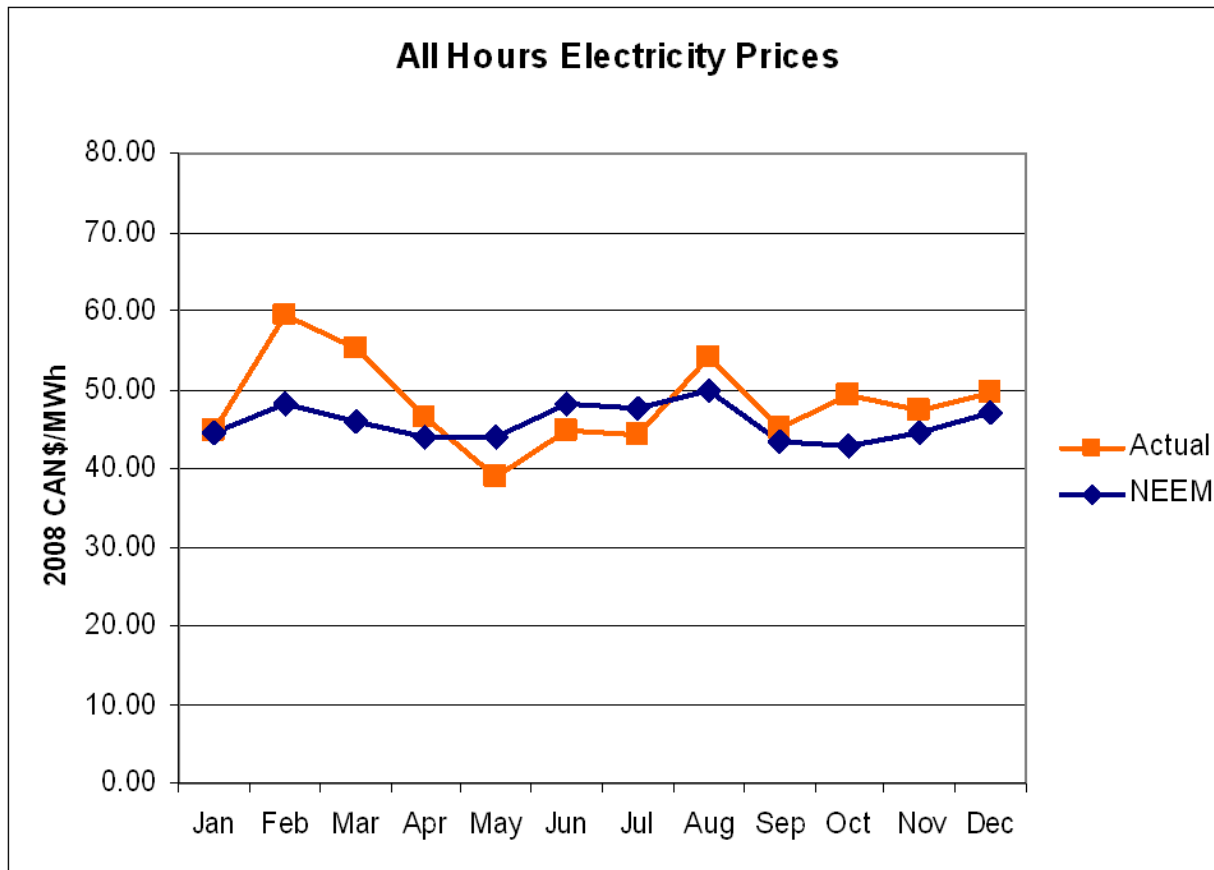


Gas and coal bids calibrated to roughly match annual output. Bids of combined-cycle gas were reduced roughly 15-25%. Bids on peak gas were also adjusted for the calibration, but those bid adjustments were removed in 2010 and 2015 because of pending contractual changes.

Import/Export Balance Calibration - 2007

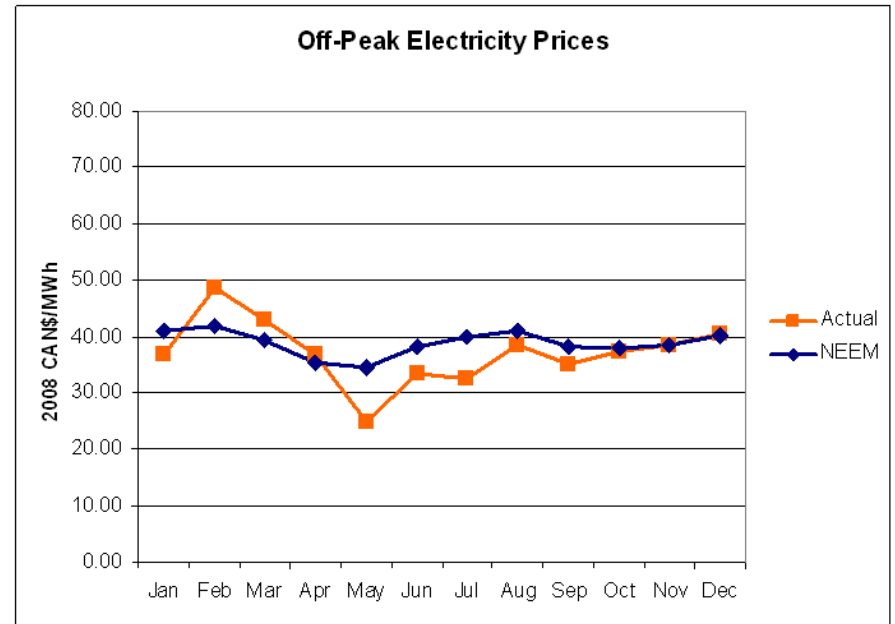
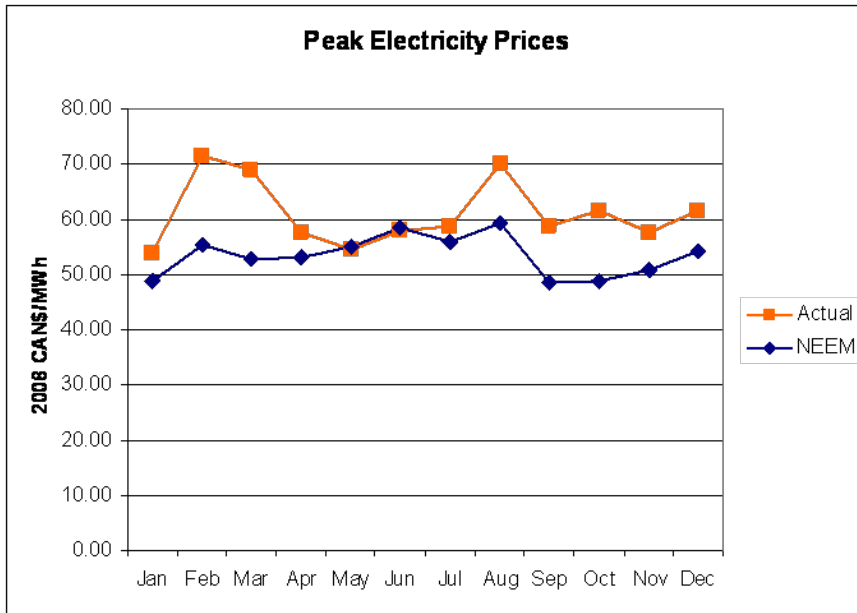


All-Hours Prices Calibration



NEEM-projected all-hours prices are quite close to actual (with the exception of February and March). In these two months, even though actual Ontario prices, 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) are typically lower than real-world peak prices. Production cost models do not make unit commitment errors (because they anticipate load and generator outages perfectly) and this biases on-peak prices downward.

Key Assumptions for Calibration and Scenario Analysis

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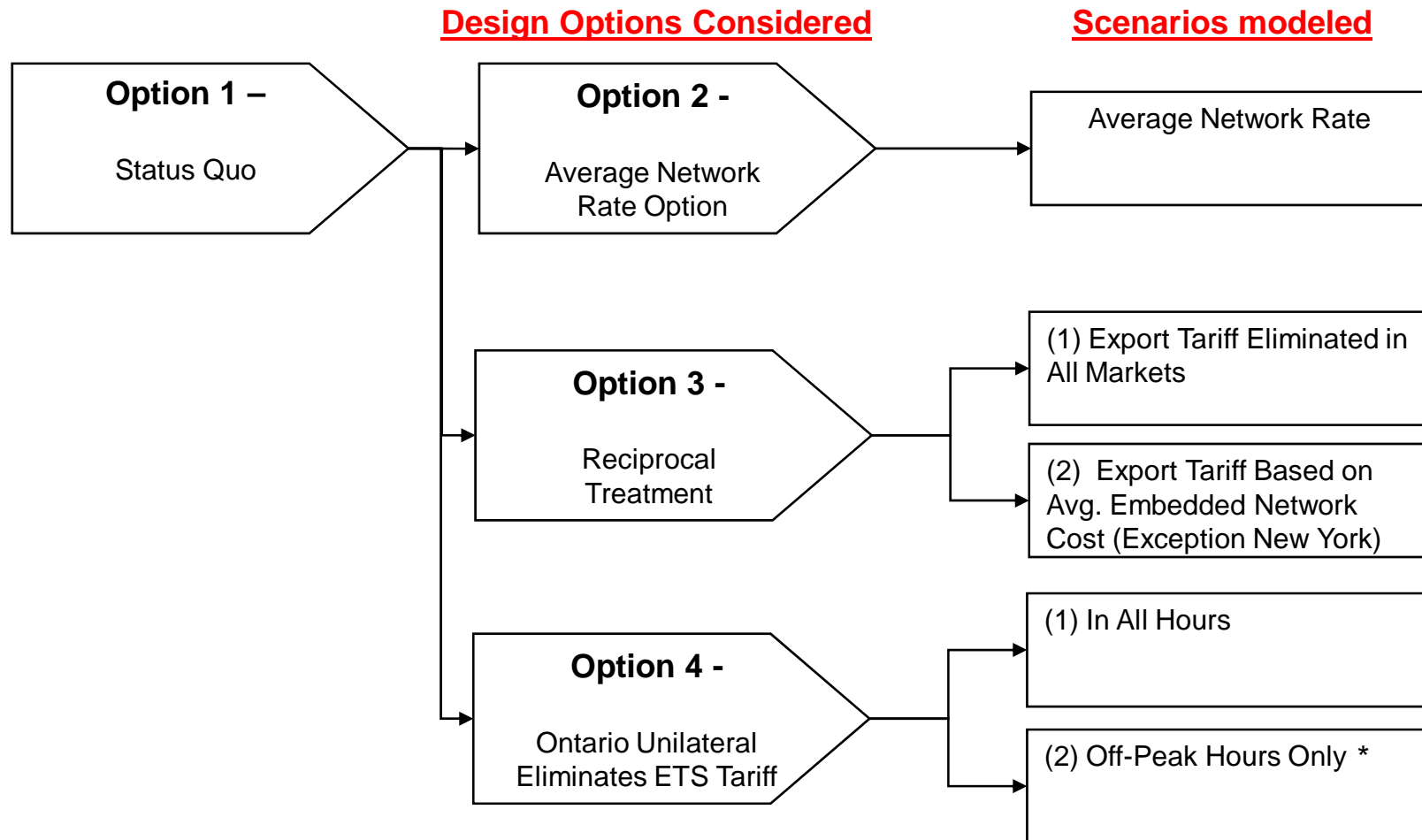
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ETS Tariff Design Options and Scenario Considered



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

See Appendix for More Detail on the Scenario Definitions.

Key Assumptions for Calibration and Scenario Analysis

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Scenario Definitions

Results by Scenario

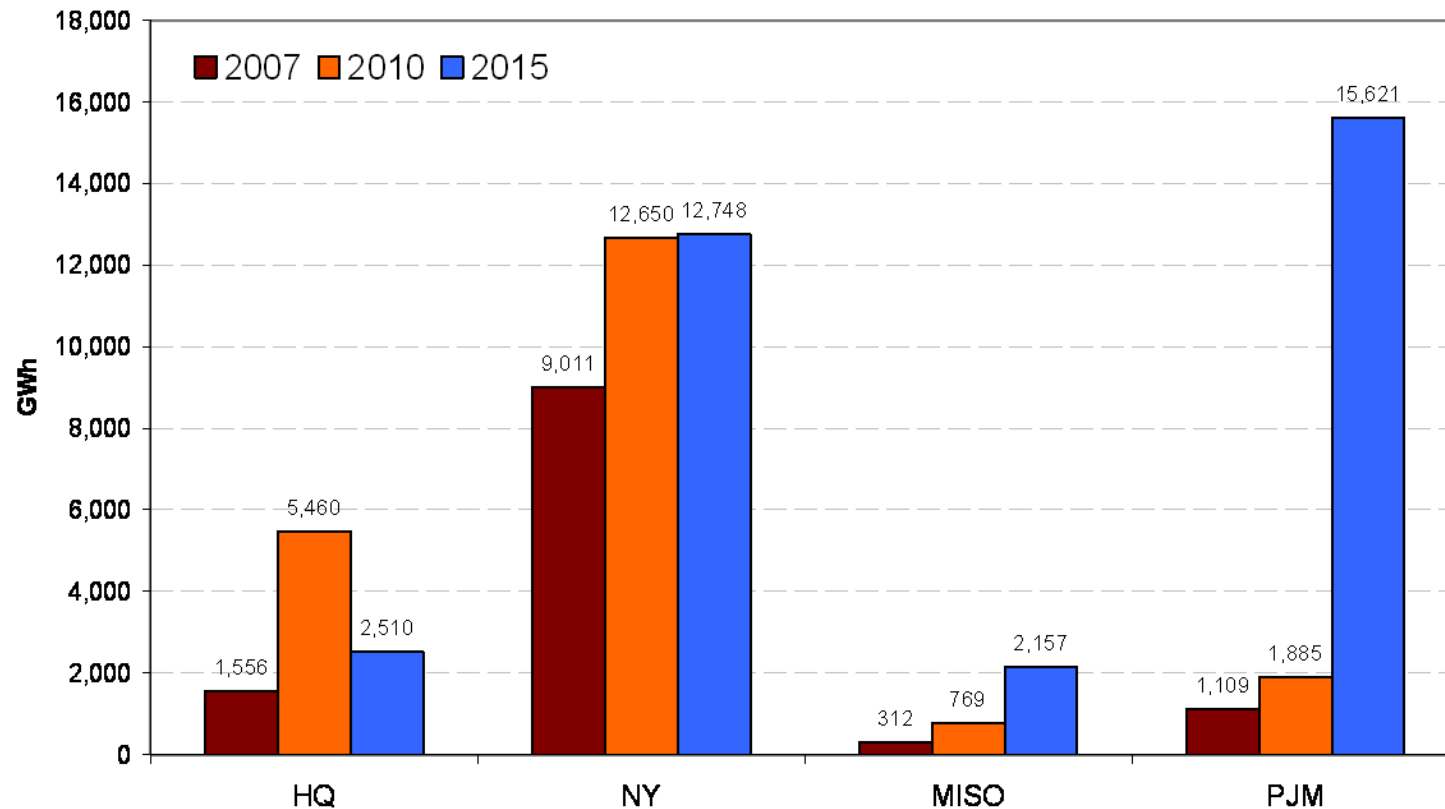
Emissions Impacts by Scenario

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Under Status Quo, the NEEM model suggests that Ontario will export significantly more power to PJM/MISO under North American carbon policy (in 2015)

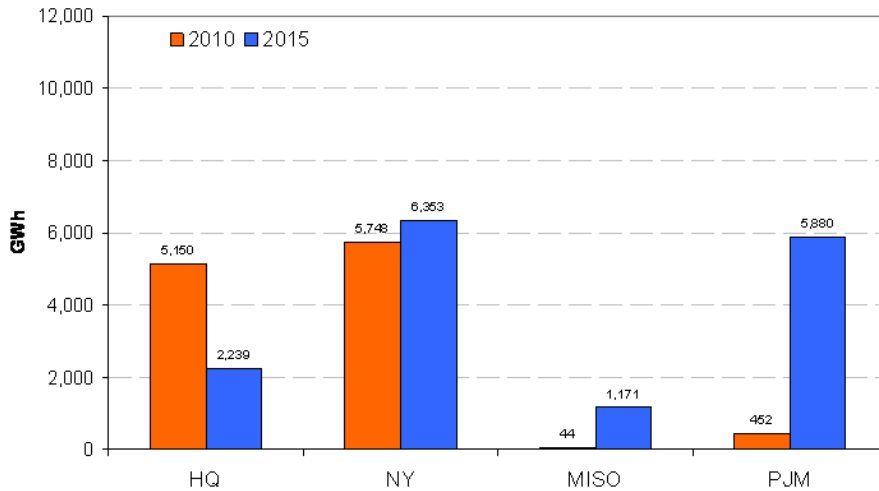
**Status Quo, All-Hours Flows
Ontario Exports**



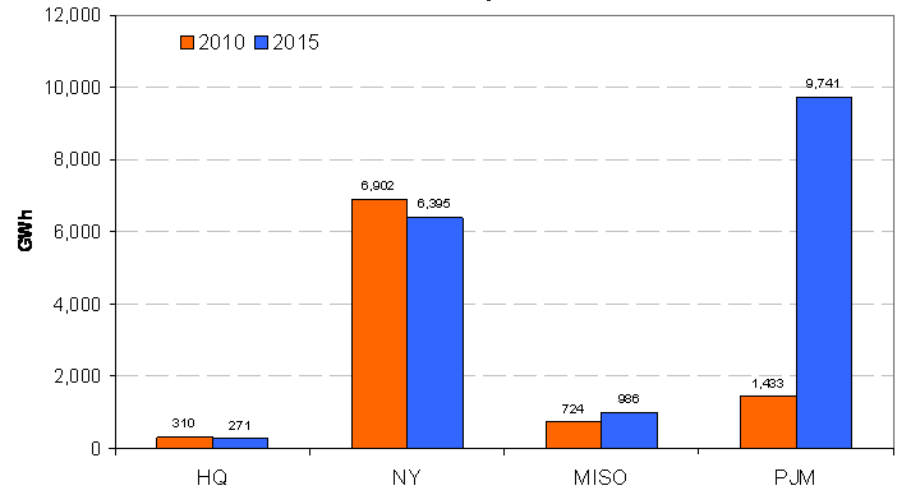
As a result, the incremental export impacts (of ETS changes) become larger in 2015 for PJM (and MISO).

CRA-NEEM projects the increase in exports (under Status Quo) to PJM/MISO to occur both on-peak and off-peak

Status Quo, Peak Flows
Ontario Exports

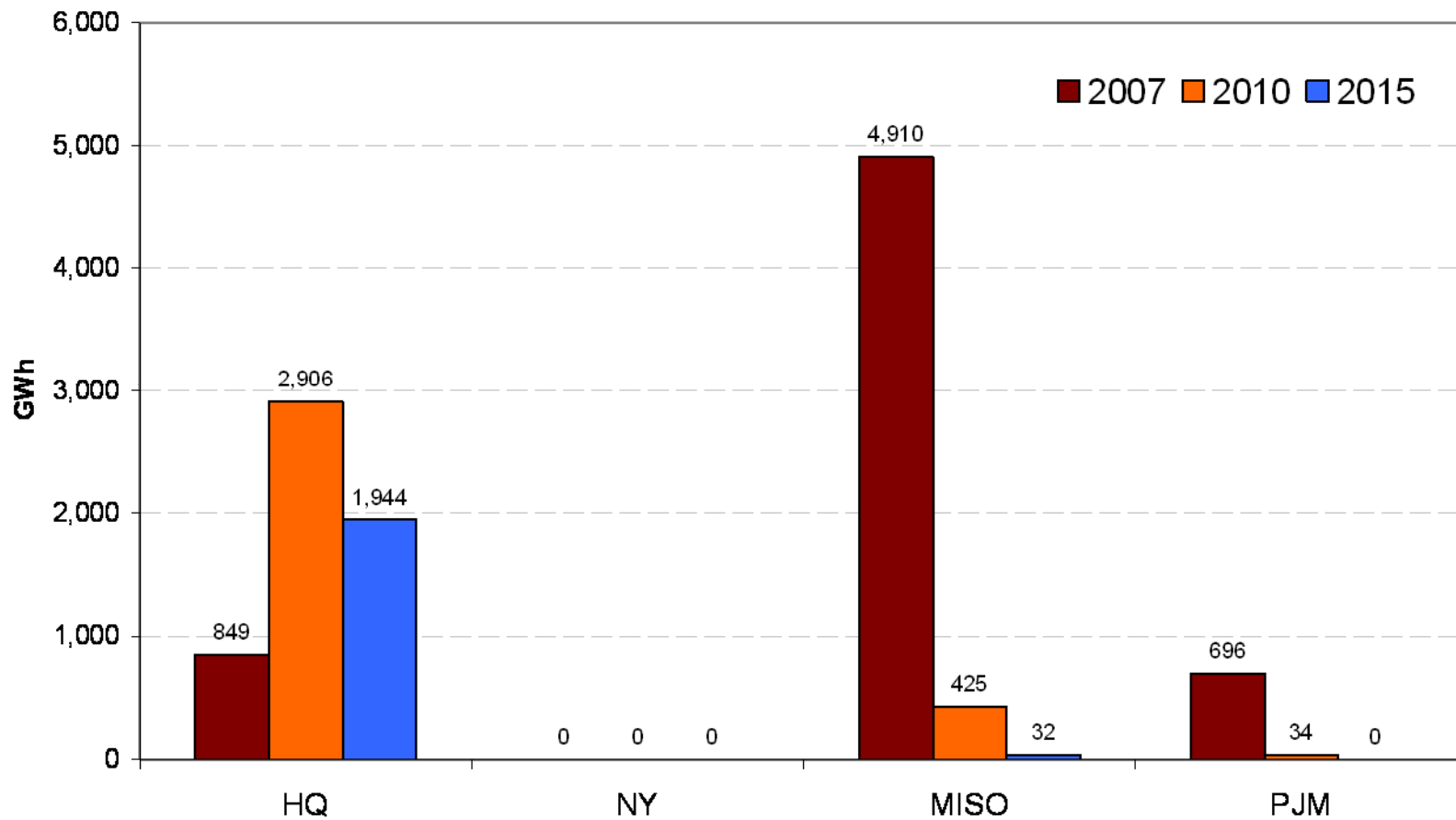


Status Quo, Off-Peak Flows
Ontario Exports

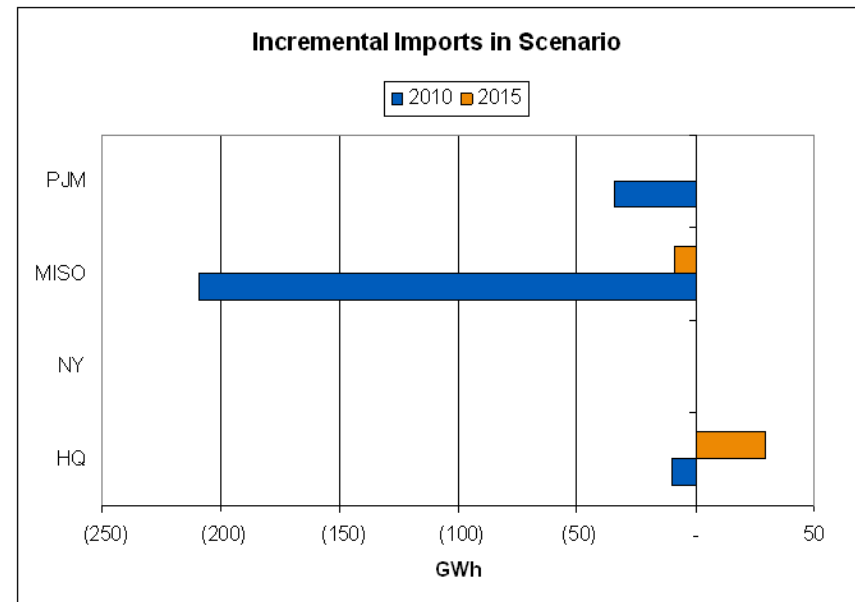
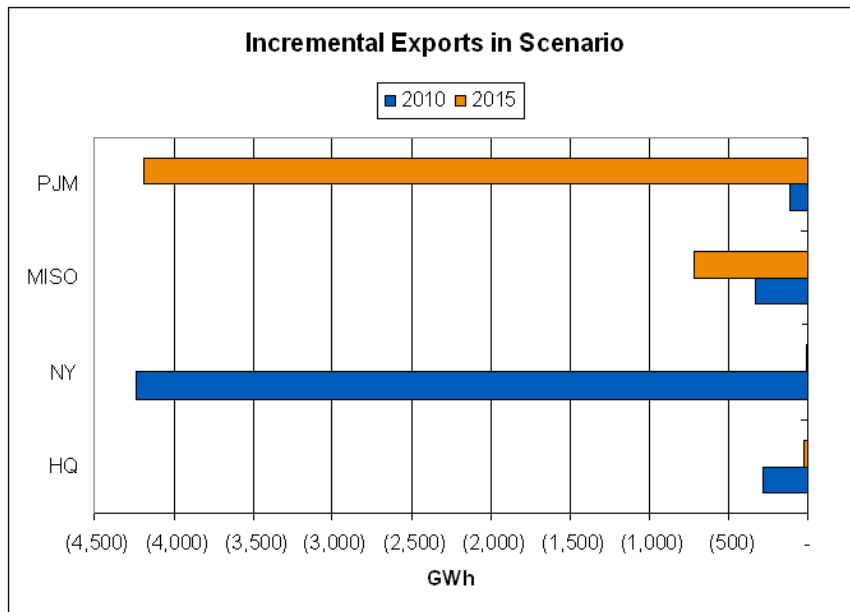


Ontario imports from PJM/MISO are forecasted by NEEM to decrease over time as Ontario adds capacity and CO2 policy is enacted

Status Quo, All-Hours Flows
Ontario Imports



Option 2 (average network rate option)

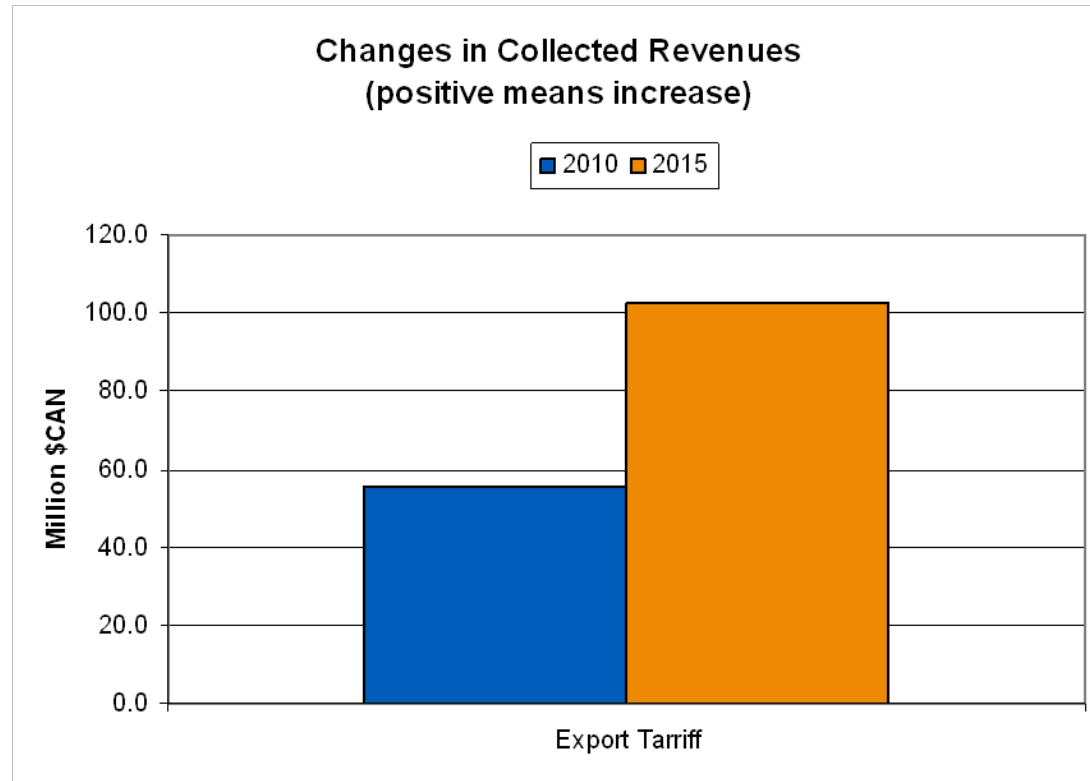


Year	Change in Exports from Status Quo	Change in Imports from Status Quo
2010	(24%)	(8%)
2015	(15%)	1%

Exports are reduced because of the increased ETS. Imports are less affected.

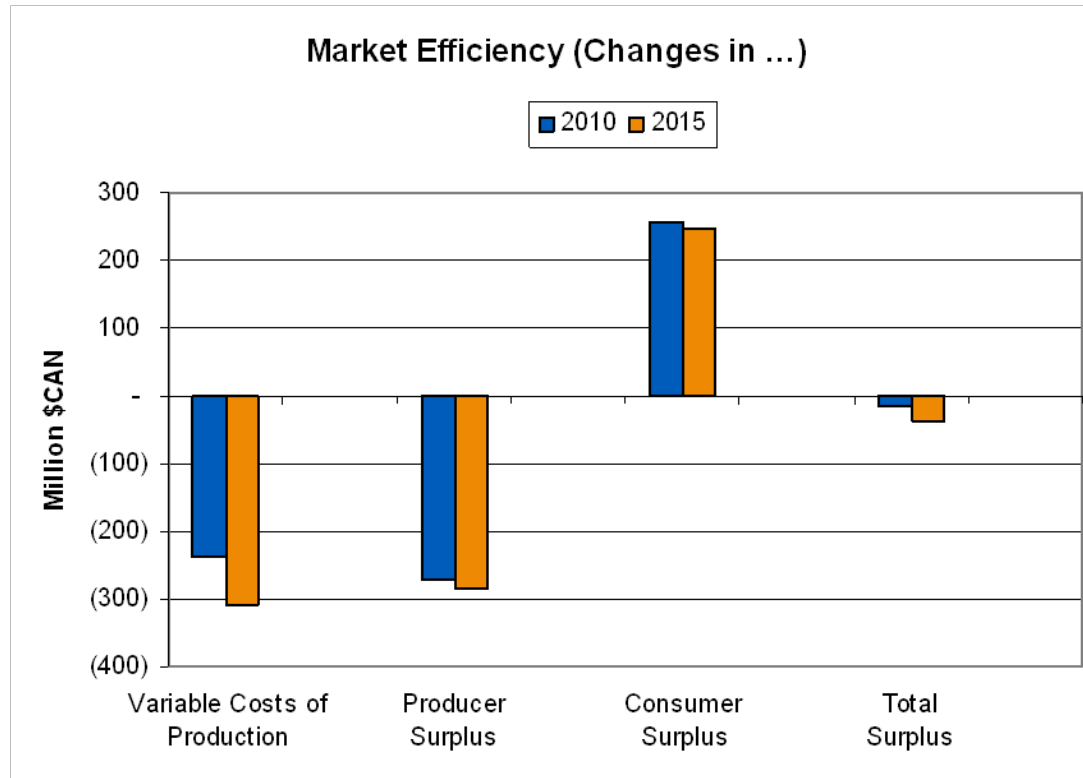
In 2015, the export reductions occur more to PJM/MISO rather than to NY. This is because there is a lot of power flowing to PJM/MISO in 2015 in status quo due to the North American carbon policy. These increased flows are both on-peak and off-peak.

Option 2 (average network rate option)



A fall in exports is more than offset by the high ETS, so revenues increase.

Option 2 (average network rate option)



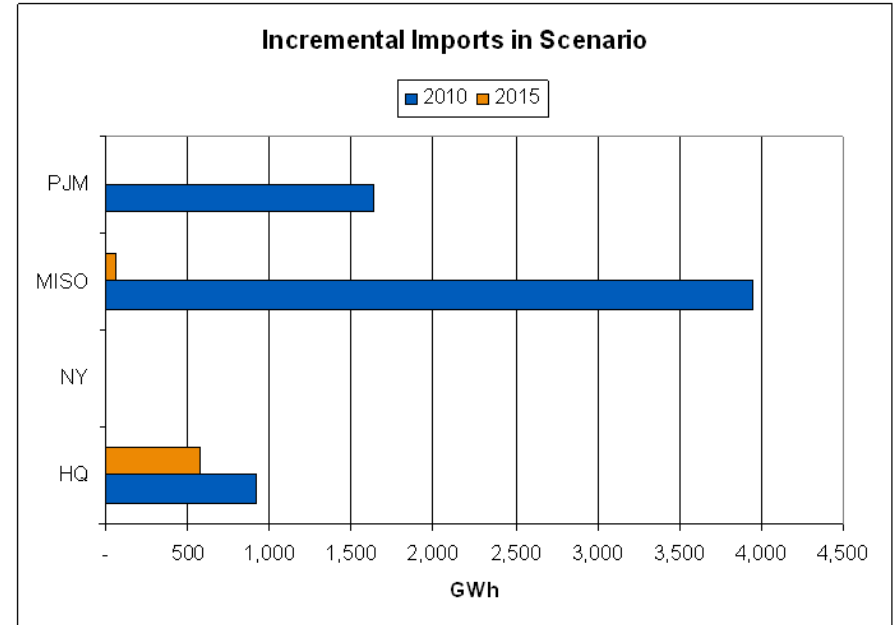
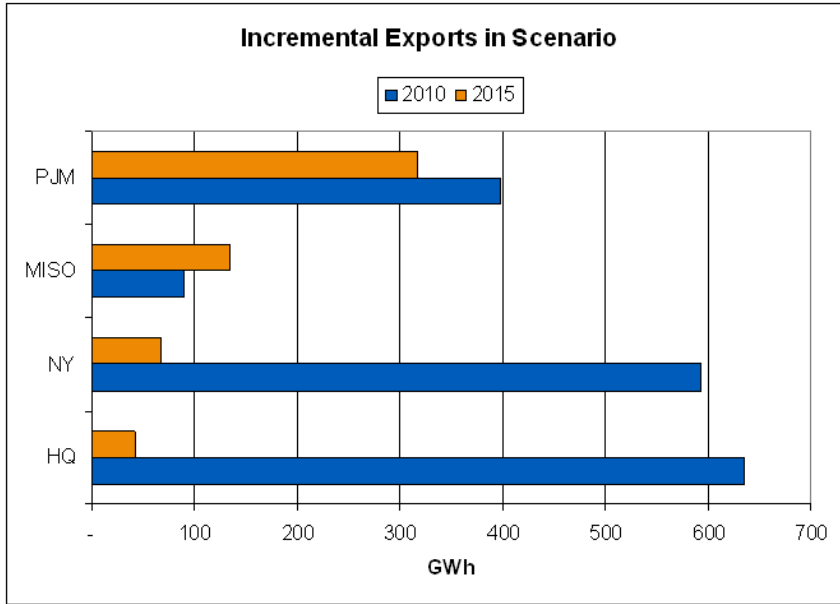
The unilaterally increased ETS reduces producer surplus (through reduced exports) but increases consumer surplus by lowering prices (prices are not pushed up as much by external demand).

Option 2 (average network rate option)

	Change in Electricity Prices Relative to Status Quo		
Year	All-Hours	Peak	Off-Peak
2010	(3.8%)	(2.1%)	(5.9%)
2015	(2.4%)	(2.6%)	(2.1%)

Prices are lower because the increased ETS dampens external demand.

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

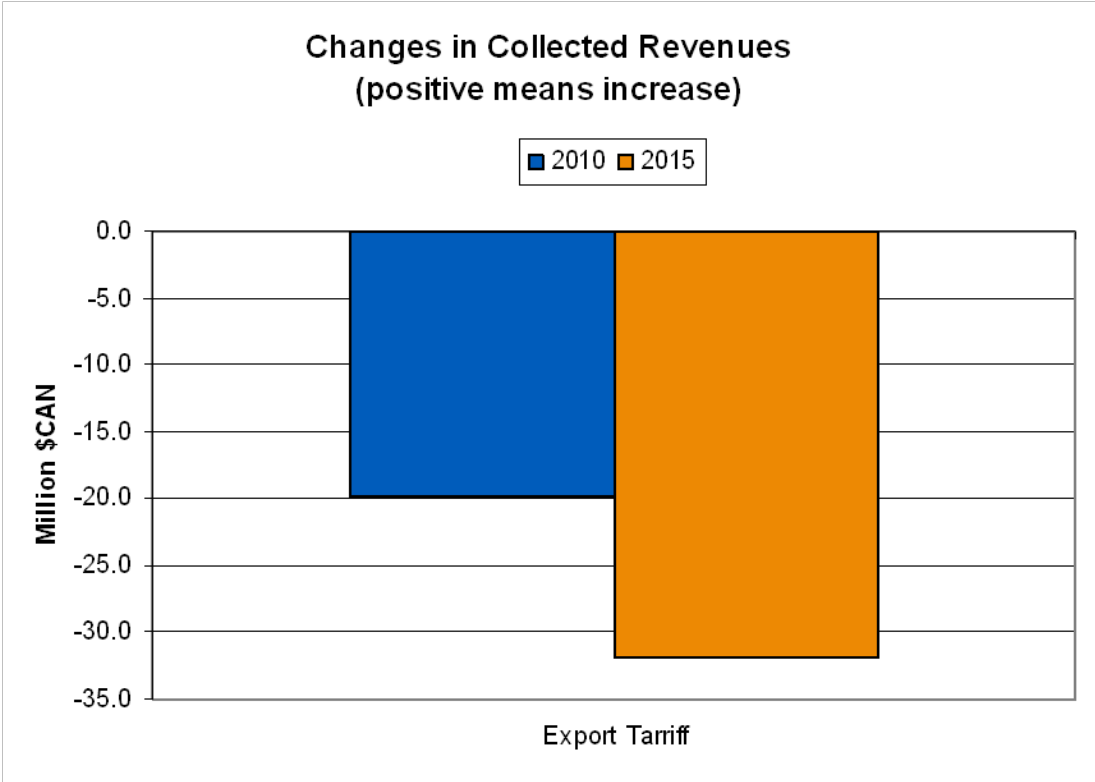


Year	Change in Exports from Status Quo	Change in Imports from Status Quo
2010	8%	193%
2015	1%	35%

Cutting Ontario’s ETS to zero has little impact on exports because the ETS is low in status quo. However, imports to Ontario are more affected because Ontario’s neighbors have higher export tariffs in status quo.

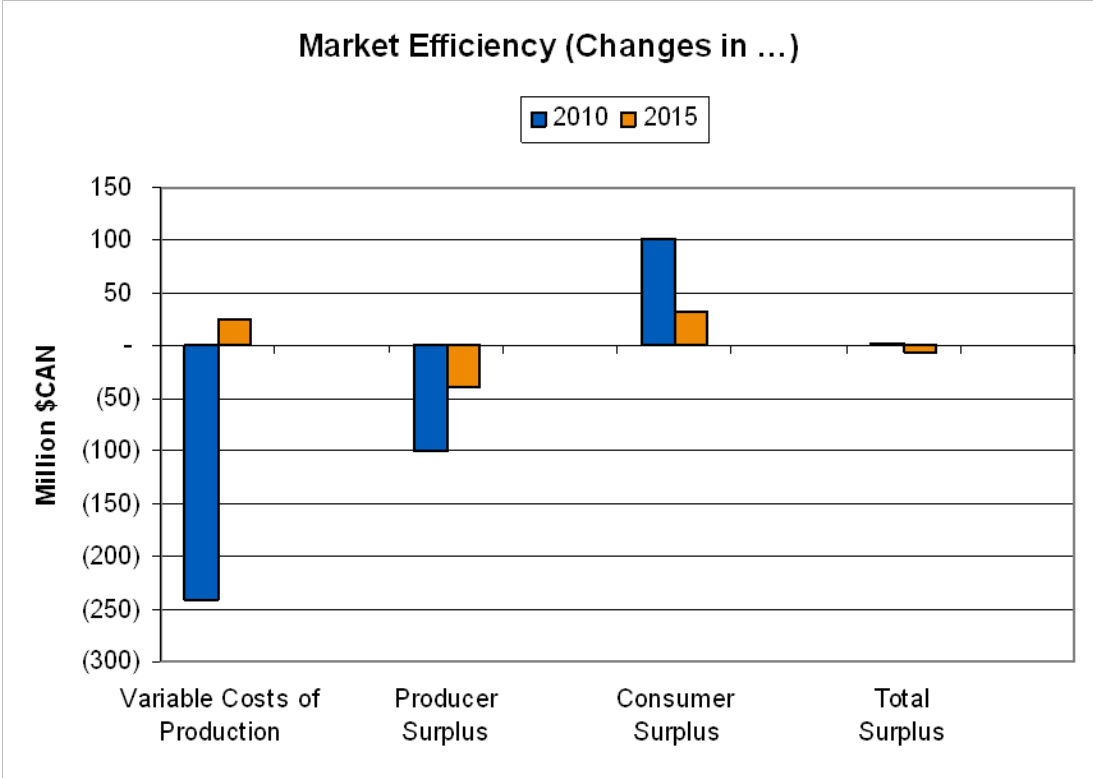
The incremental imports from PJM and MISO due to tariff reduction are sharply reduced in 2015 because the North American carbon policy has reduced imports from PJM and MISO in status quo.

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



The ETS revenue is completely lost when the ETS is eliminated.

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



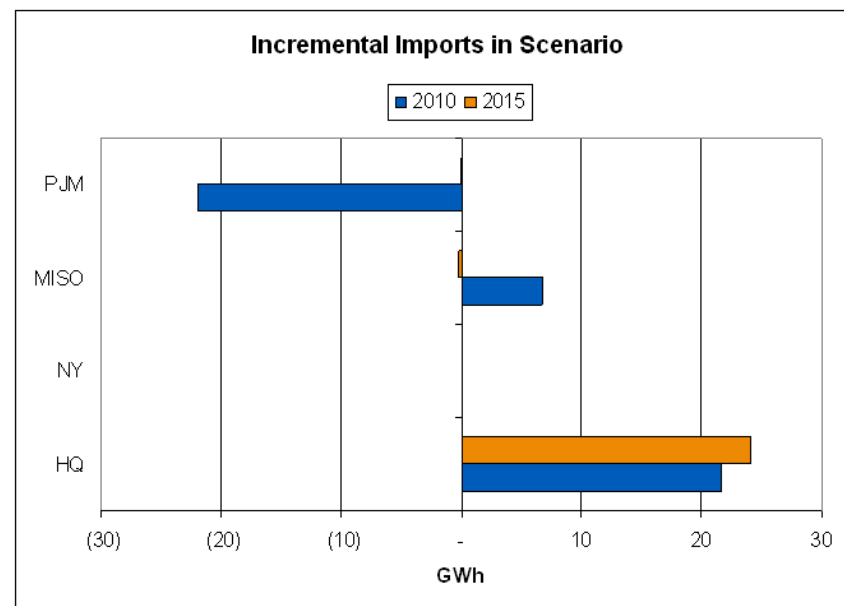
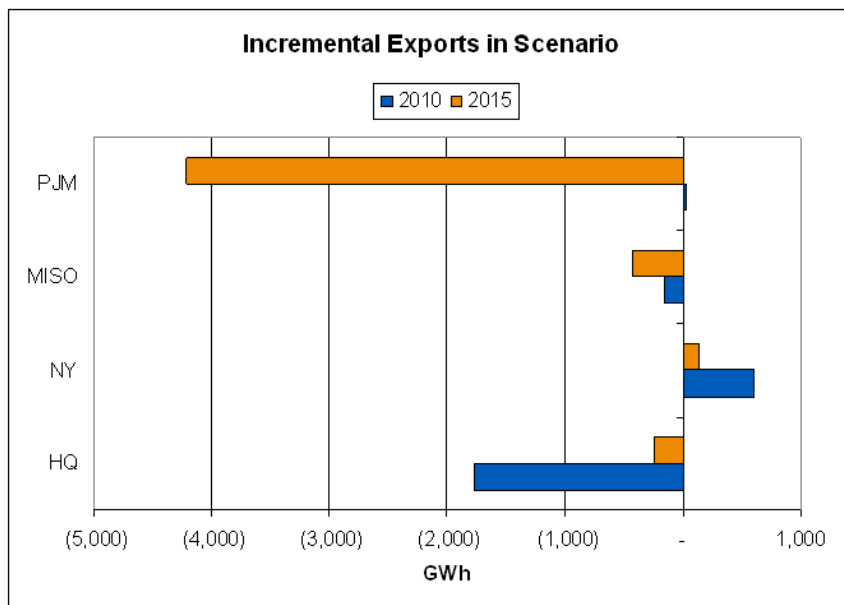
Since Ontario’s neighbors’ export charges are higher to begin with (in status quo), upon tariff elimination imports to Ontario increase and therefore producer surplus decreases. Consumer surplus increases as imports are subject to lower tariffs when exiting Ontario’s neighbors’ systems.

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

	Change in Electricity Prices Relative to Status Quo		
Year	All-Hours	Peak	Off-Peak
2010	(1.4%)	(1.5%)	(1.3%)
2015	(0.5%)	0.5%	(2.1%)

- Prices are generally reduced, but not by as much as in option 2.
- On-peak prices are slightly higher in 2015, as on-peak net exports have increased upon reciprocal tariff elimination.

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



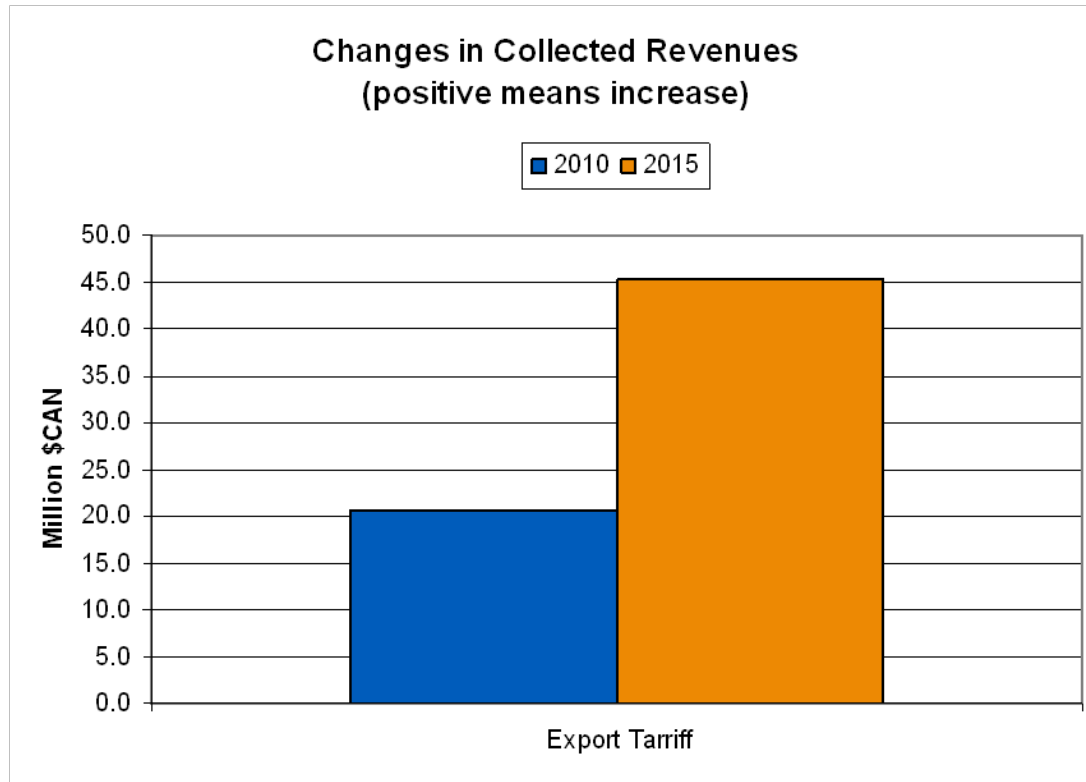
Year	Change in Exports from Status Quo	Change in Imports from Status Quo
2010	(6%)	0%
2015	(16%)	4%

Exports to NY increase because NY is the only neighbor to which the ETS is cut.

Exports to PJM are noticeably affected by the scenario in 2015 (and not 2010) because there are a lot more flows to PJM via MISO under carbon policy. The higher tariff to PJM via MISO reduces these exports.

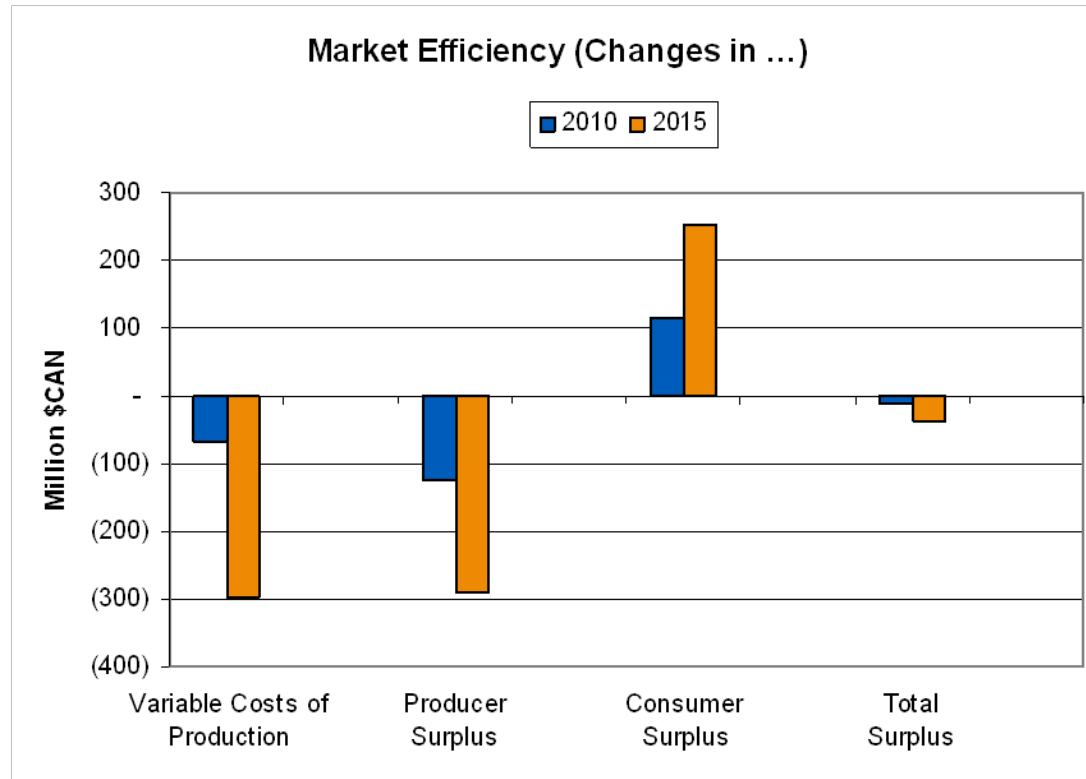
There are negligible impacts on imports.

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



Revenues increase despite a drop in exports because the ETS to some regions (HQ and MISO/PJM) is increased significantly.

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



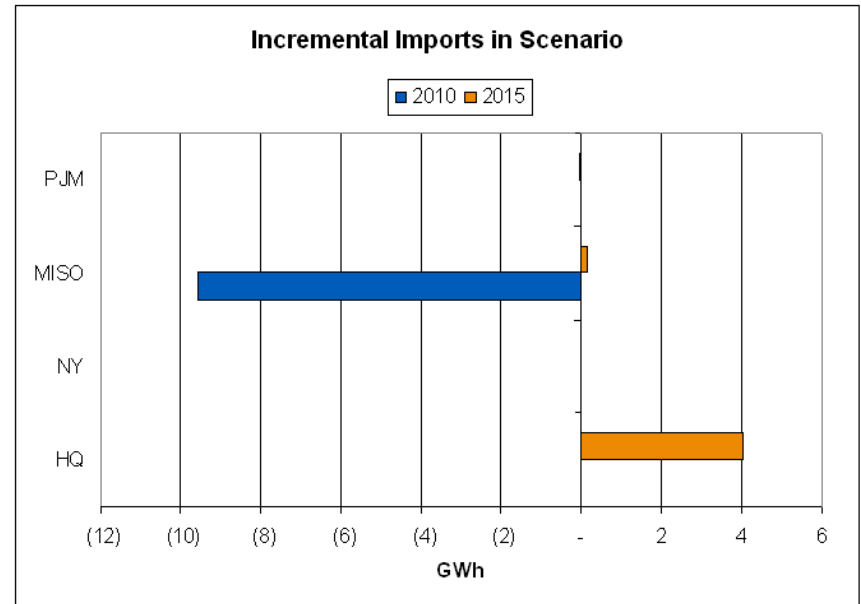
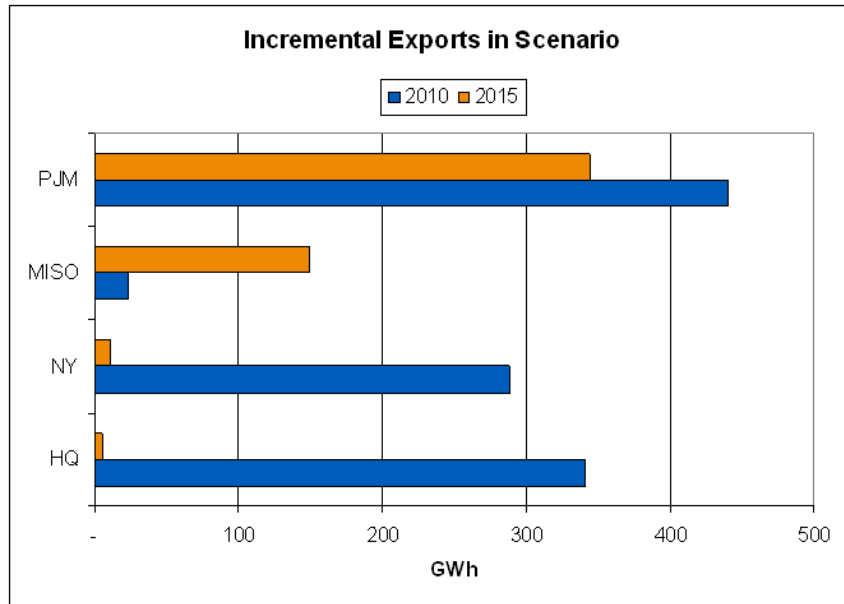
Increased ETS to non-NY neighbors reduces producer surplus (by reducing exports) but increases consumer surplus by lowering prices (prices are not pushed up as much by external demand).

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	(1.6%)	(0.9%)	(2.5%)
2015	(2.5%)	(2.6)%	(2.3%)

Prices are lower because the increased ETS dampens external demand.

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

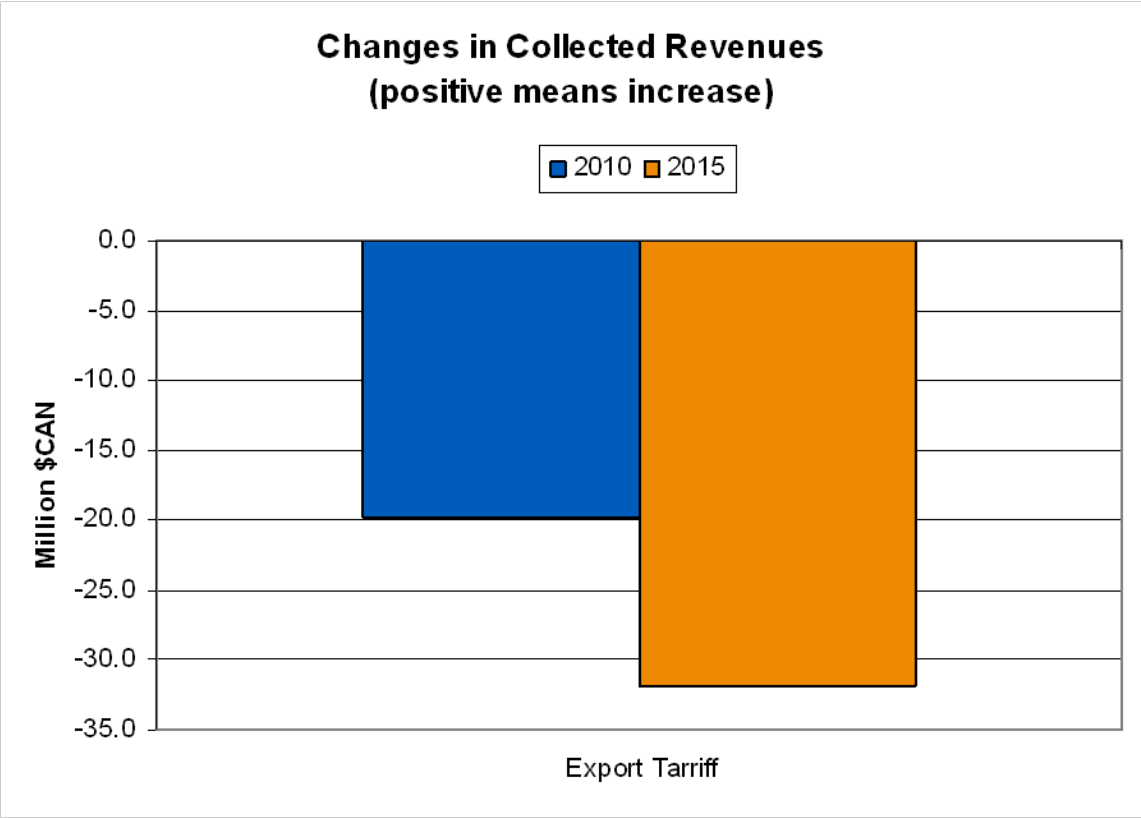


Year	Change in Exports from Status Quo	Change in Imports from Status Quo
2010	5%	0%
2015	2%	0%

Since the Ontario ETS is small, increases of exports are modest under the unilateral cut in the ETS.

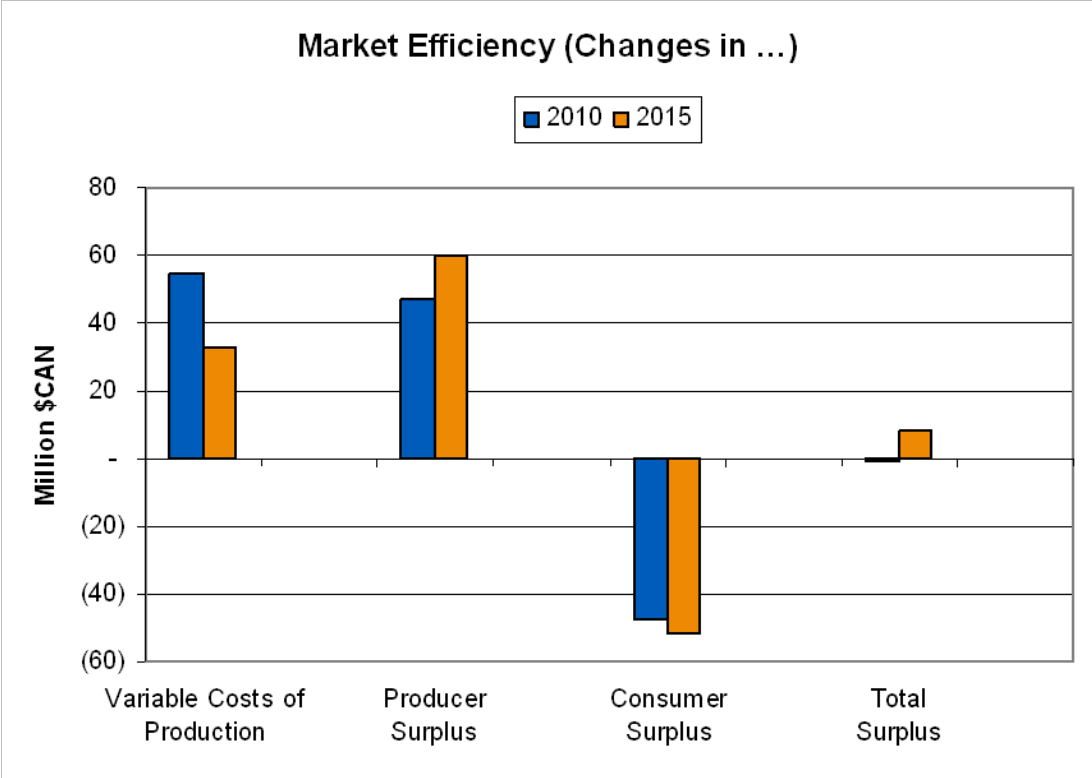
Impacts on imports are negligible.

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



The ETS revenue is completely lost under tariff elimination. The loss in ETS revenue is the same as Option 3 scenario 1.

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



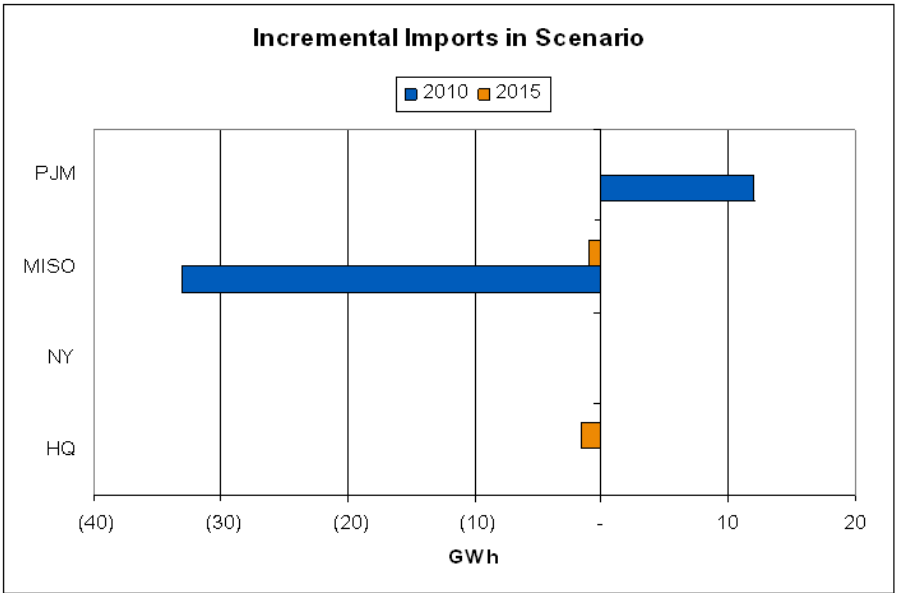
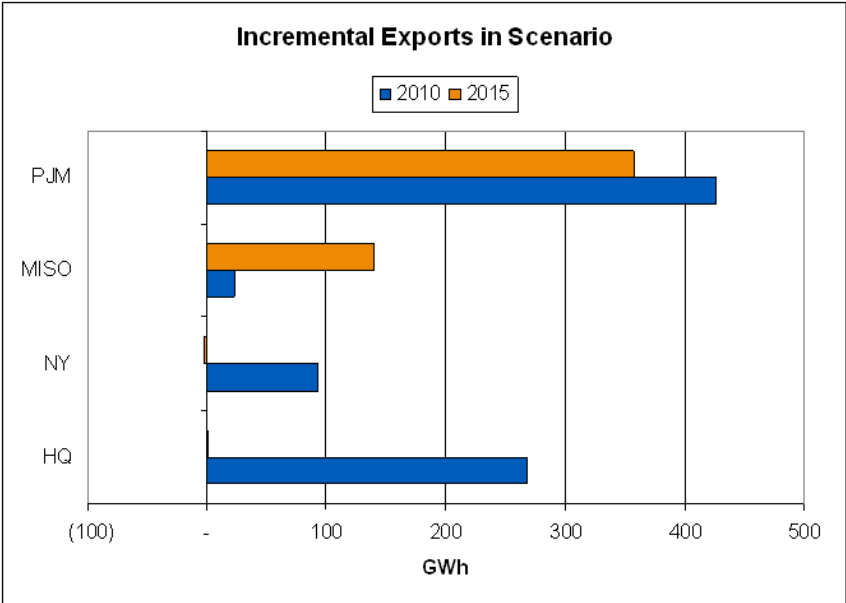
When the ETS is removed unilaterally, exports increase and prices increase. This increases producer surplus and reduces consumer surplus. Total surplus is significantly positive in 2015 because carbon policy has increased external demand for Ontario’s cleaner power.

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

	Change in Electricity Prices Relative to Status Quo		
Year	All-Hours	Peak	Off-Peak
2010	0.7%	0.4%	1.0%
2015	0.5%	0.7%	0.2%

Reducing the ETS unilaterally increases prices because external demand increases.

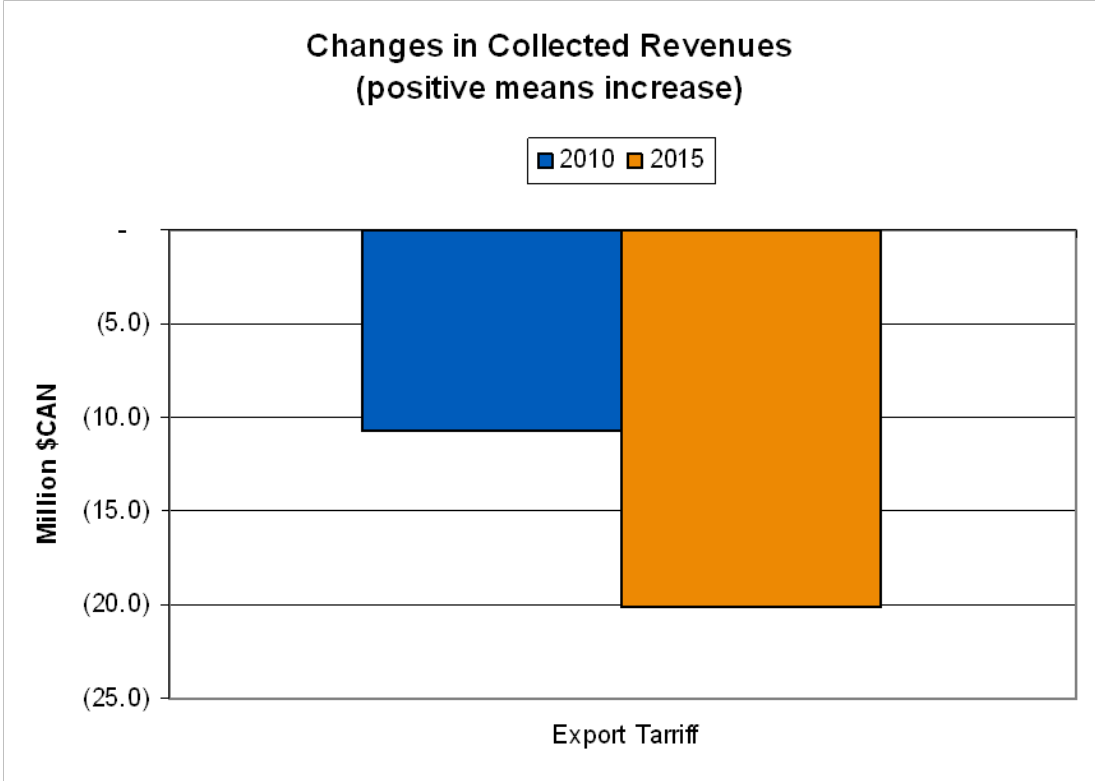
Option 4, Scenario 2 (unilateral tariff elimination, off-peak only)



Year	Change in Exports from Status Quo	Change in Imports from Status Quo
2010	4%	(1%)
2015	2%	0%

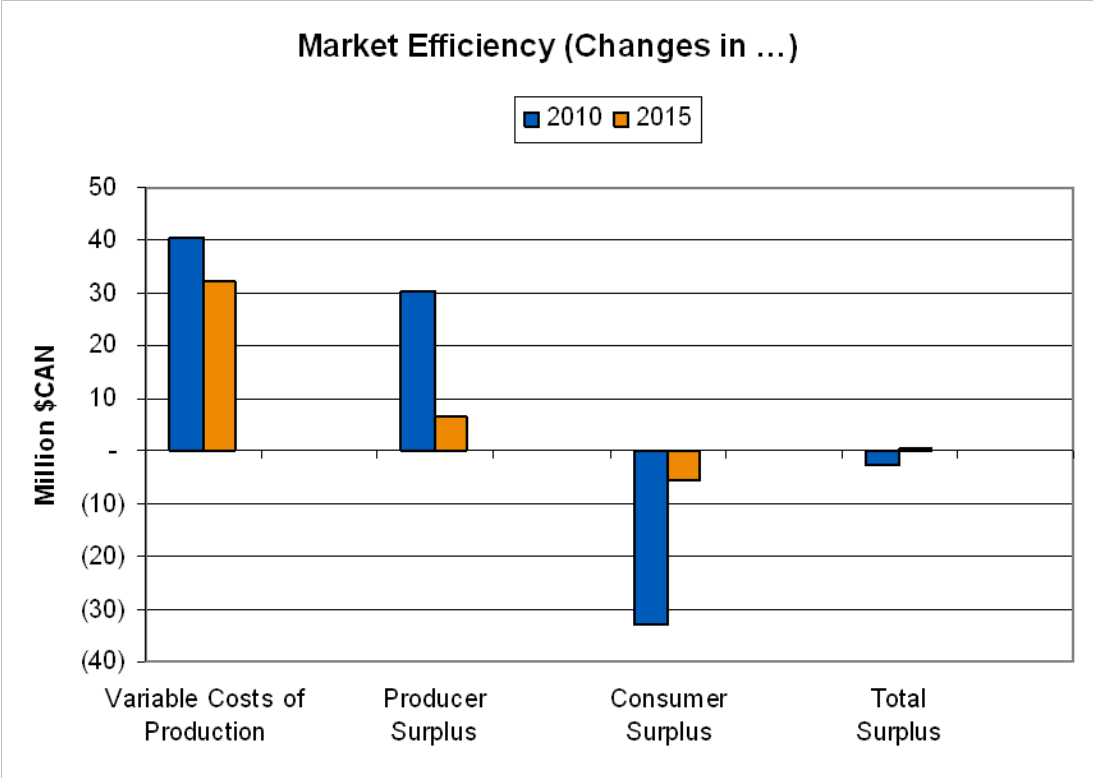
This is similar to Option 4, Scenario 1. The Ontario ETS is small, so impacts are small.

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



There is a lower impact on ETS revenue than scenario 1 because the ETS is retained on-peak and that revenue is collected.

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



Compared to scenario 1, the 2015 increase in producer surplus (and decrease in consumer surplus) is significantly reduced. This is because scenario 2 does not cut the on-peak ETS.

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%	0.0%	1.2%
2015	0.1%	0.0%	0.1%

Reducing the ETS unilaterally increases prices because external demand increases. For scenario 2, this only occurs during the off-peak hours in which the ETS is cut.

Key Assumptions for Calibration and Scenario Analysis

2007 Model Calibration Results

Scenario Definitions

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Emissions Impacts by Scenario

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Appendix

Changes in Net Exports (these generally drive emissions impacts)

Change in Net Exports - 2010
GWh

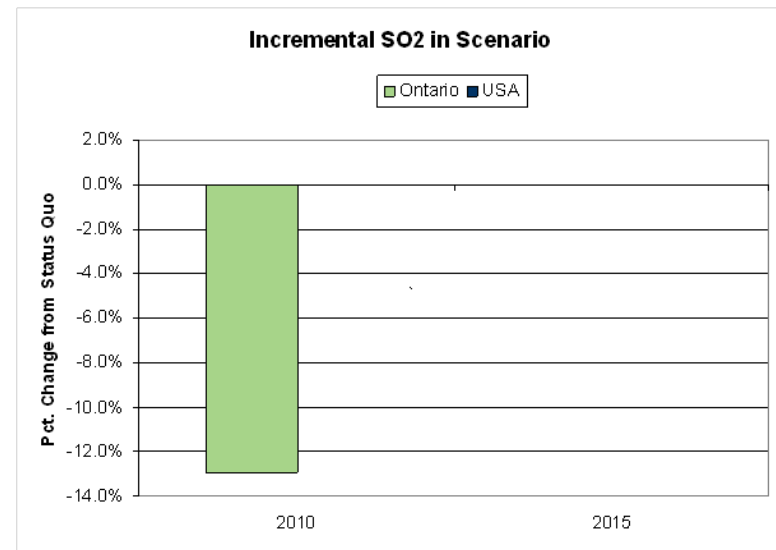
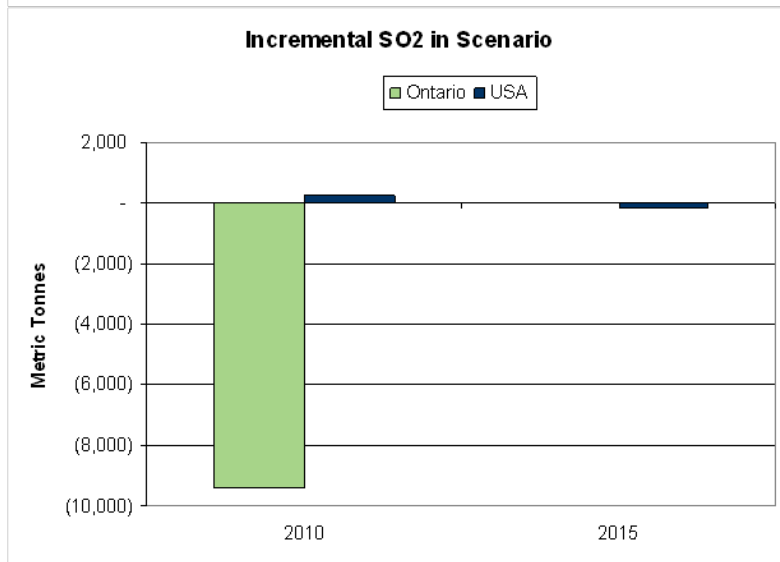
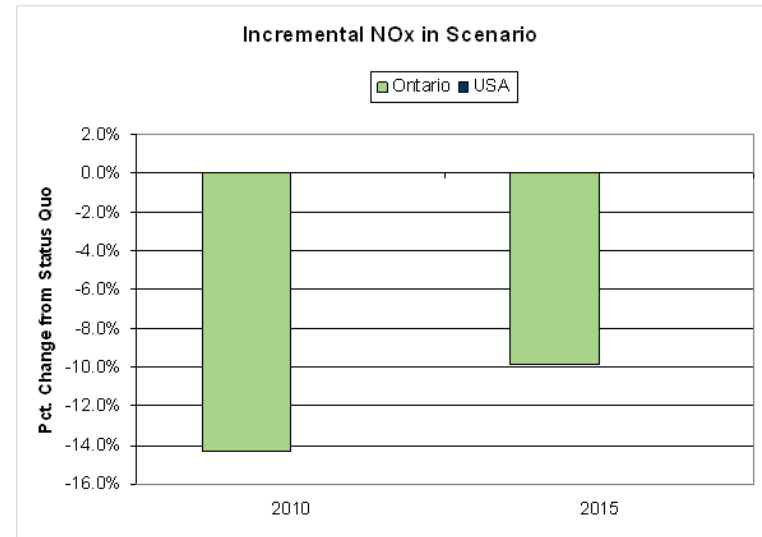
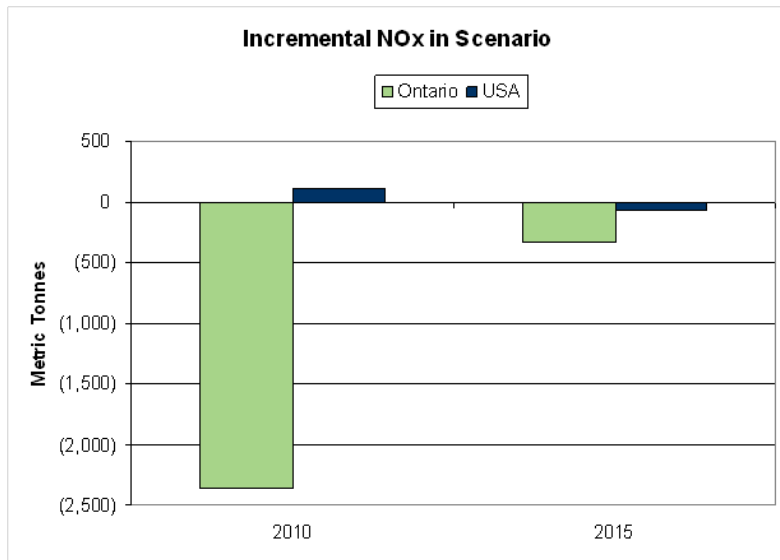
Option	Scenario	Destination				Total
		PJM	MISO	NY	HQ	
Option 2		(88)	(123)	(4,236)	(274)	(4,722)
Option 3	Scenario 1	(1,235)	(3,861)	593	(286)	(4,789)
Option 3	Scenario 2	49	(163)	604	(1,786)	(1,297)
Option 4	Scenario 1	439	33	288	341	1,100
Option 4	Scenario 2	414	56	93	267	831

Change in Net Exports - 2015
GWh

Option	Scenario	Destination				Total
		PJM	MISO	NY	HQ	
Option 2		(4,181)	(710)	(7)	(55)	(4,954)
Option 3	Scenario 1	318	79	68	(536)	(71)
Option 3	Scenario 2	(4,208)	(434)	136	(276)	(4,781)
Option 4	Scenario 1	344	149	11	2	506
Option 4	Scenario 2	358	141	(2)	3	499

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

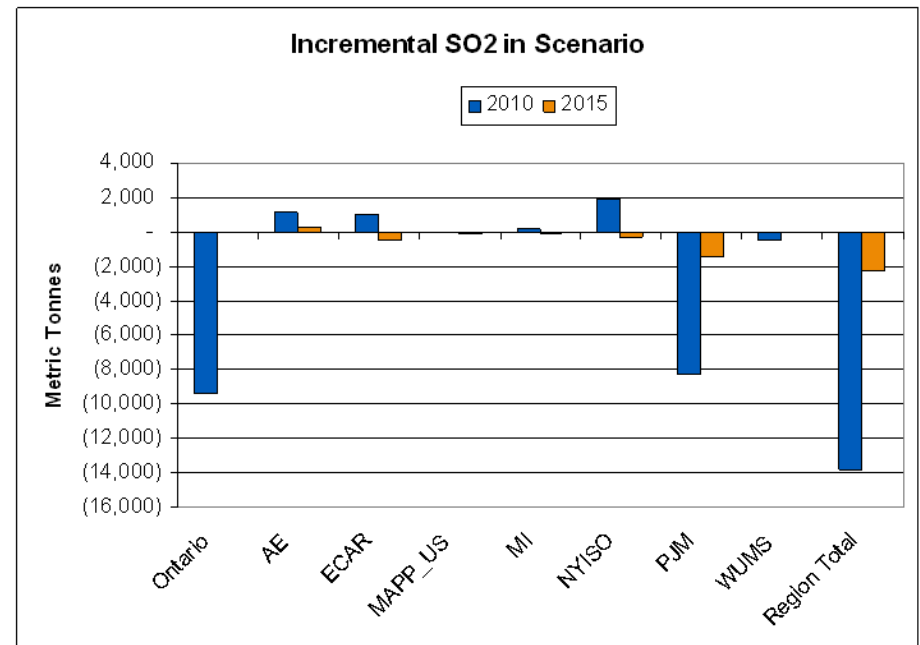
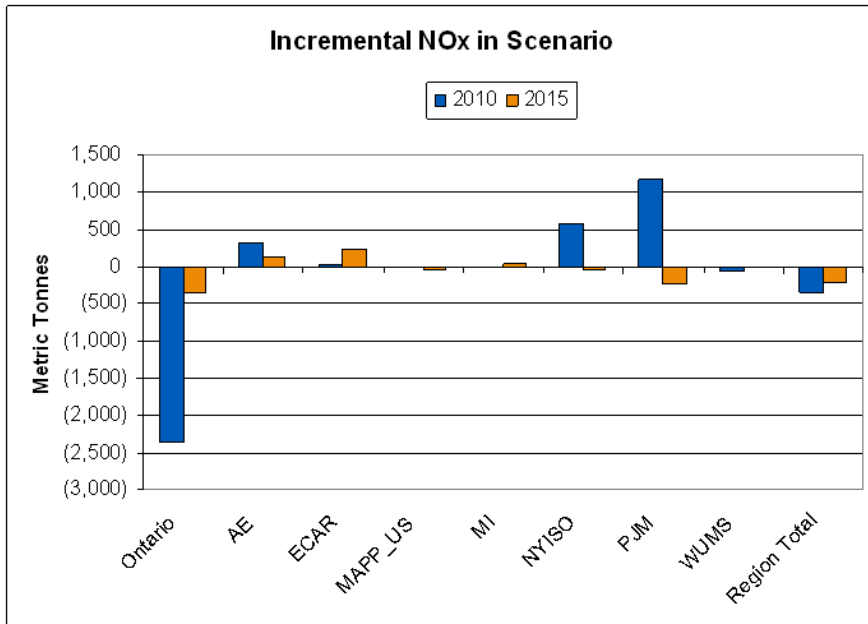
Option 2 (average network rate option)



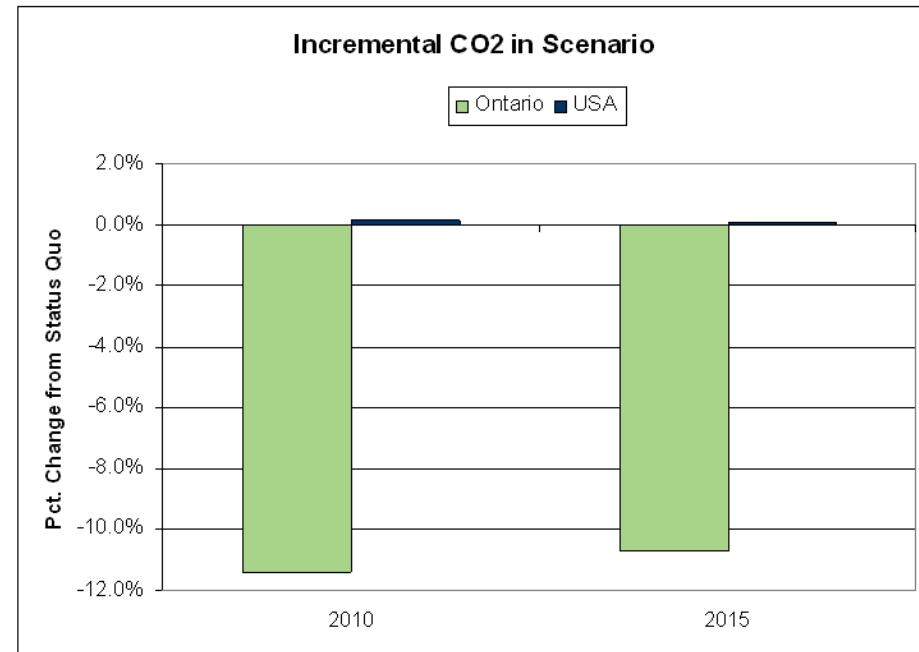
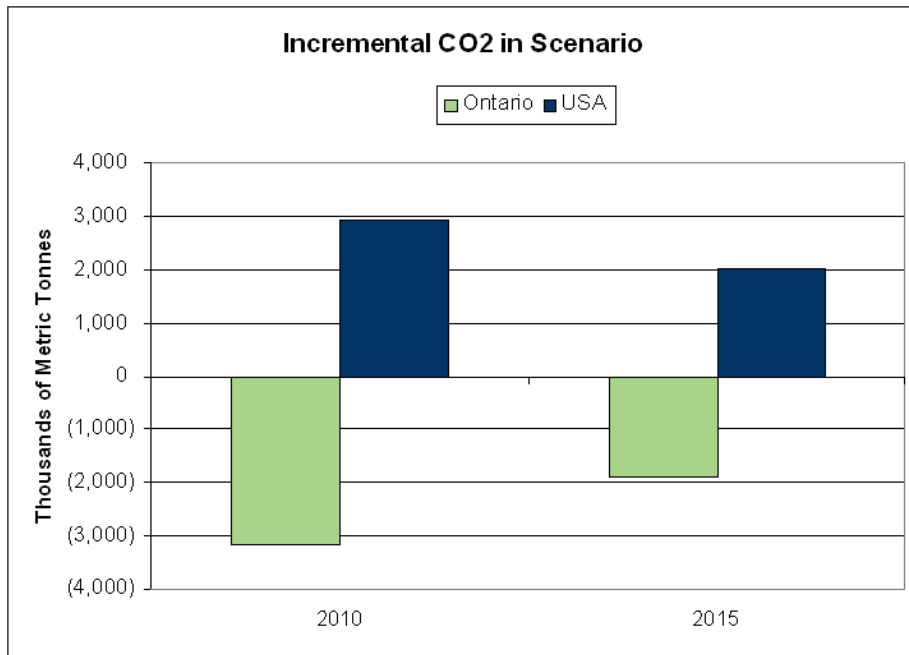
Option 2 - SO₂ and NO_x

- Ontario SO₂ and NO_x emissions would be well under the cap in both status quo and option 2 (in 2010 and 2015) because of carbon policy's impacts on the Ontario fleet and its operation
- Option 2 reduces Ontario emissions relative to status quo because Ontario has unilaterally increased its export tariff and therefore its net exports decrease
- There is no change in SO₂ inside Ontario in 2015 because the coal has retired
- US emissions are relatively unchanged because the US CAIR policy restricts emissions of both pollutants

Option 2 (average network rate option)

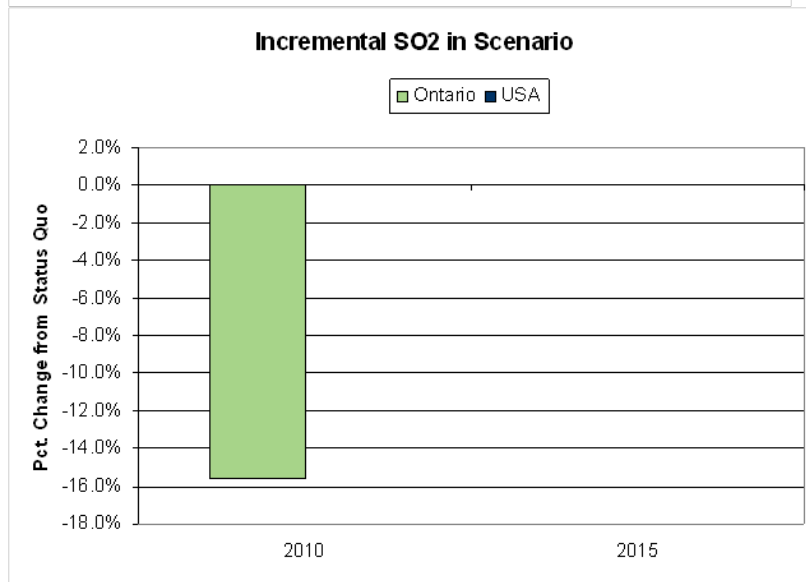
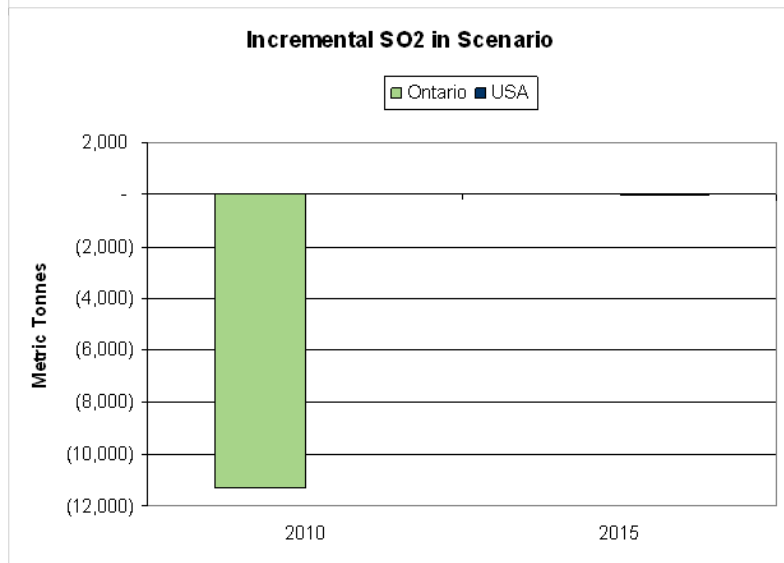
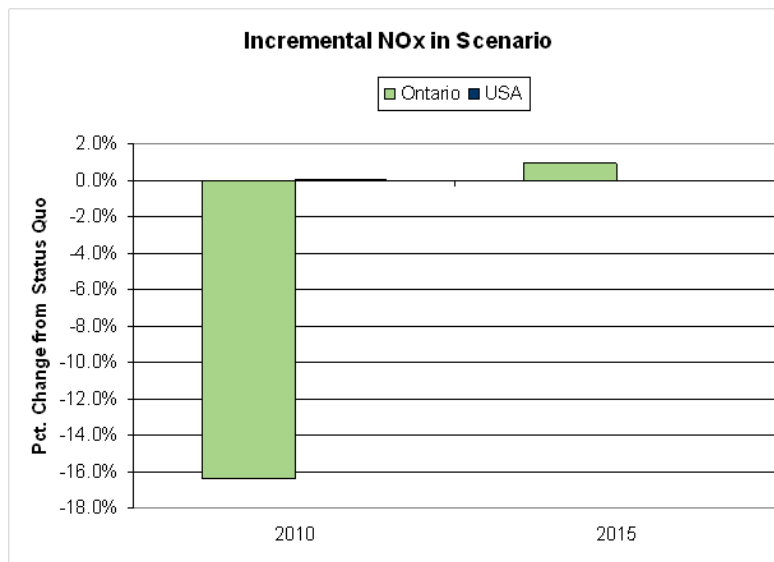
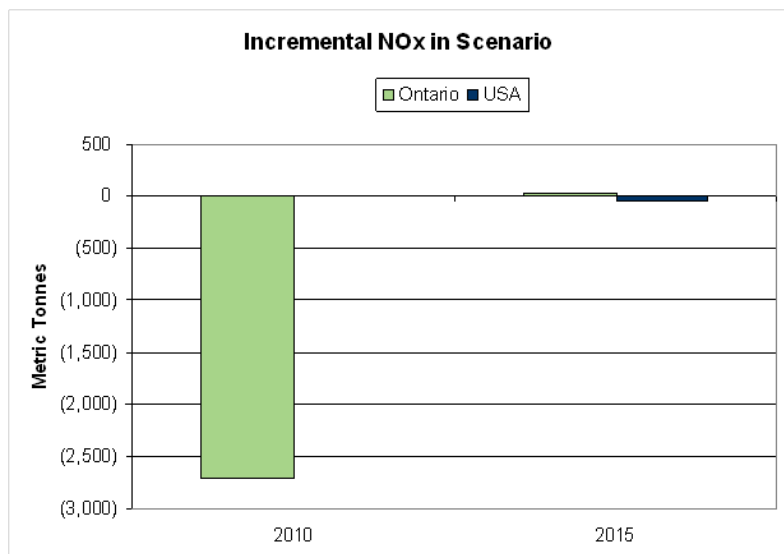


Option 2 (average network rate option)



CO2 impacts are small and offsetting.

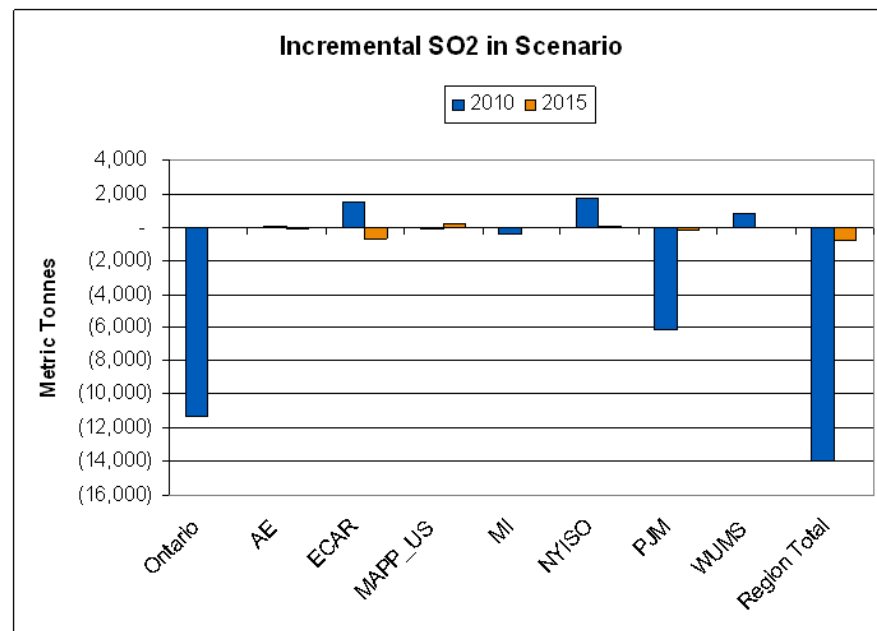
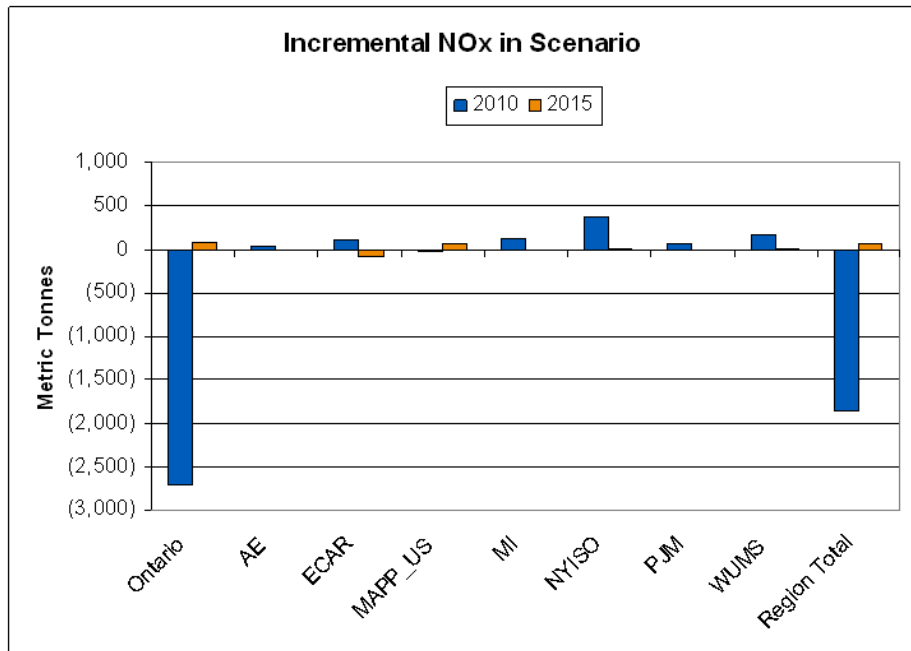
Option 3, Scenario 1 (reciprocal treatment, tariff eliminated)



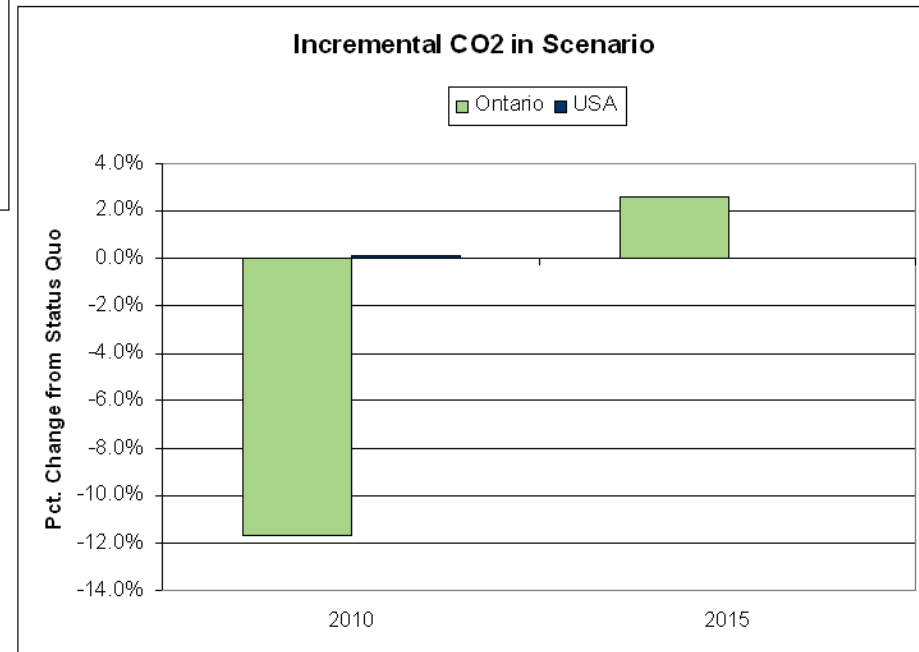
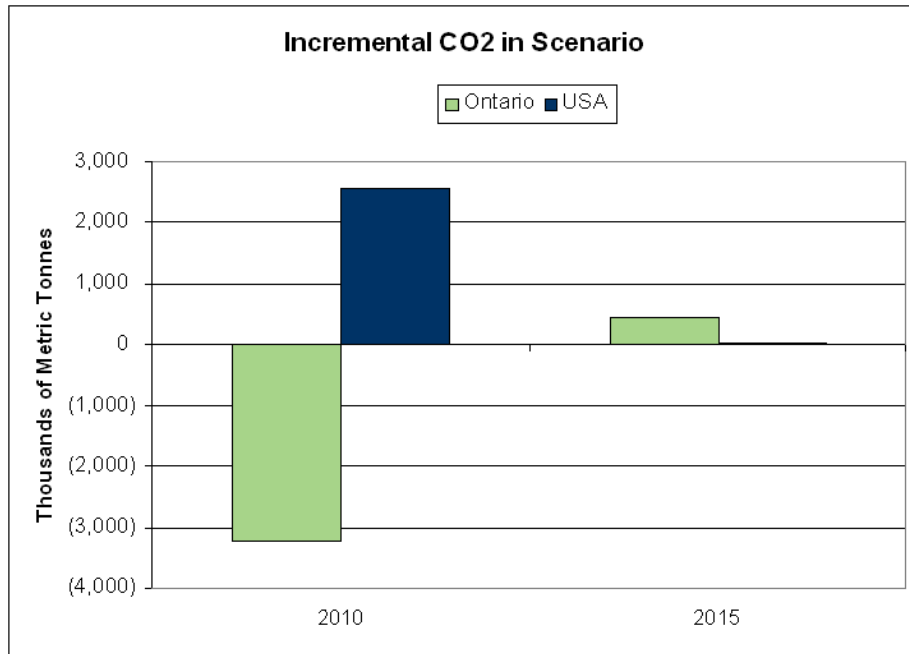
Option 3, Scenario 1 – SO₂ and NO_x

- Ontario SO₂ and NO_x emissions would be well under the cap in both status quo and option 3 scenario 1 (in 2010 and 2015) because of carbon policy's impacts on the Ontario fleet and its operation
- Option 3 scenario 1 generally reduces Ontario emissions relative to status quo because Ontario's net exports are decreased (because Ontario's neighbors' tariffs are cut more)
- There is no change in SO₂ inside Ontario in 2015 because the coal has retired
- US emissions are relatively unchanged because the US CAIR policy restricts emissions of both pollutants

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

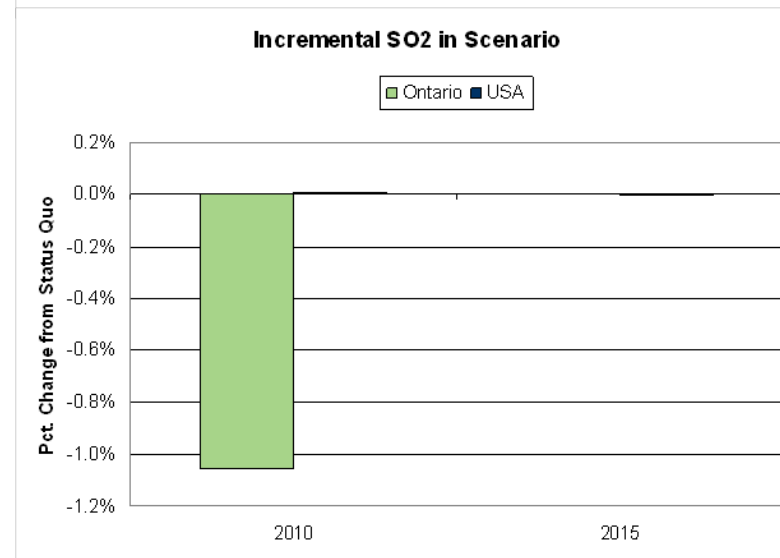
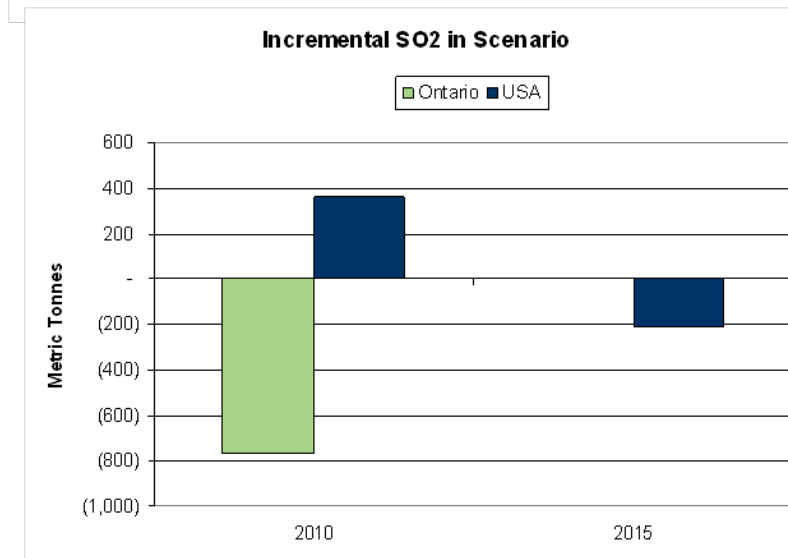
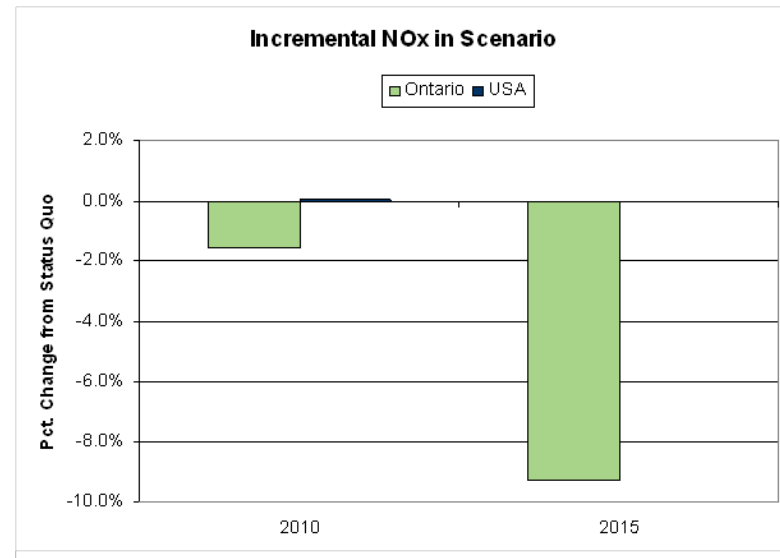
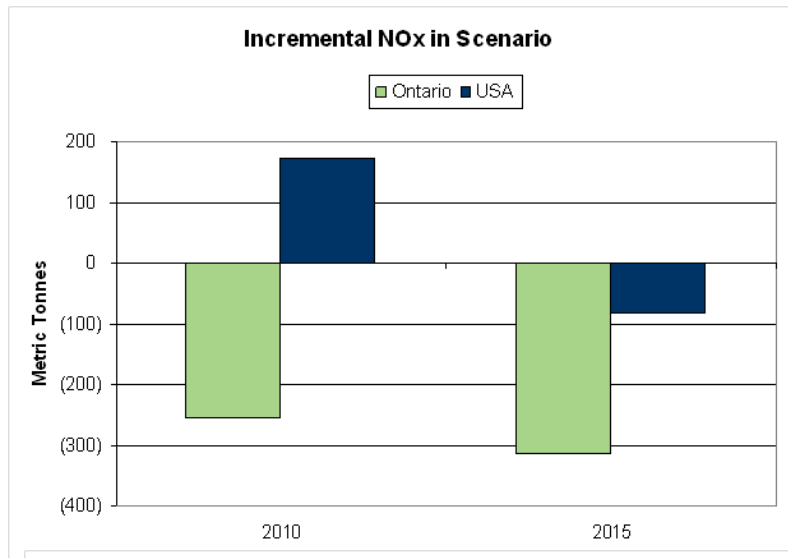


Option 3, Scenario 1 (reciprocal treatment, tariff eliminated)



CO2 impacts are small and nearly offsetting.

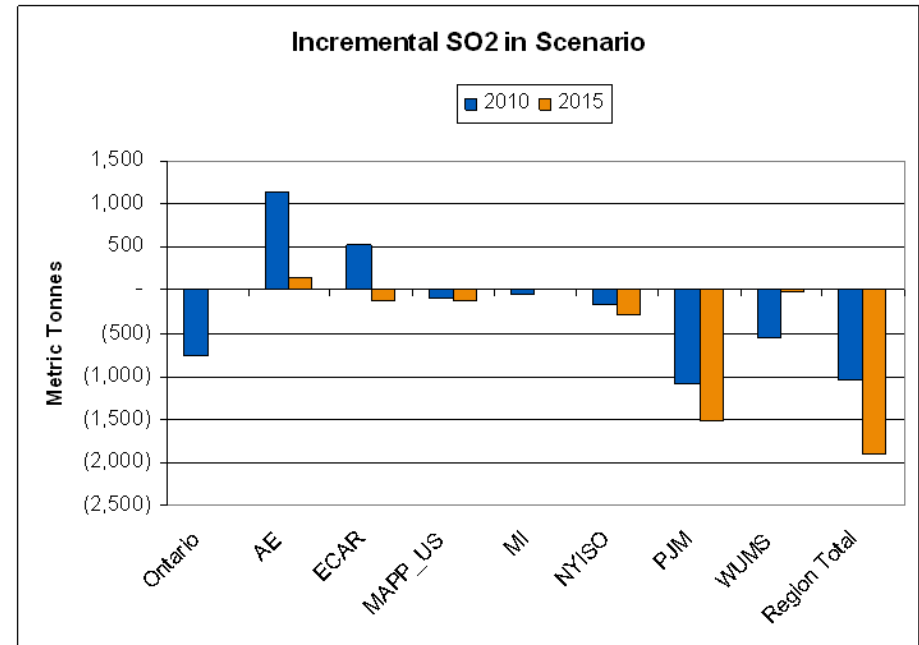
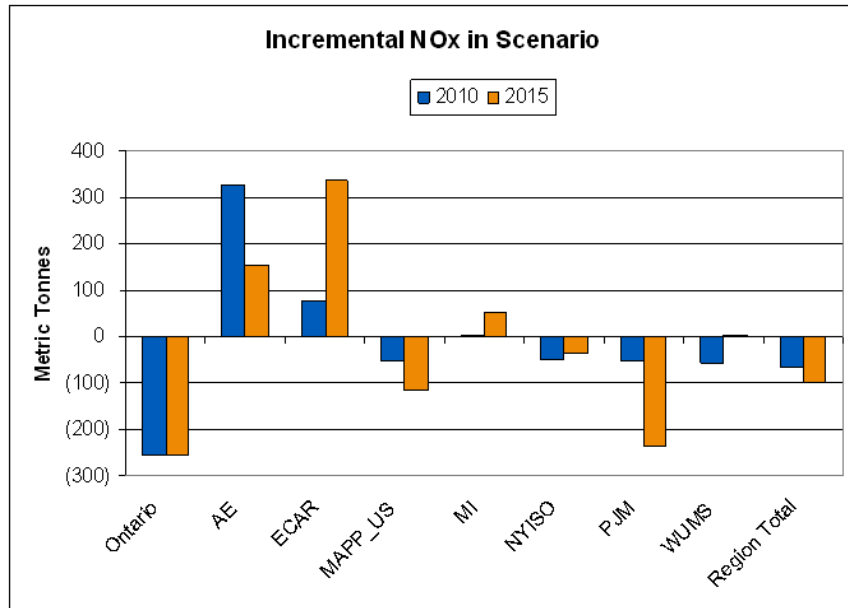
Option 3, Scenario 2 (reciprocal treatment, avg. embedded network cost)



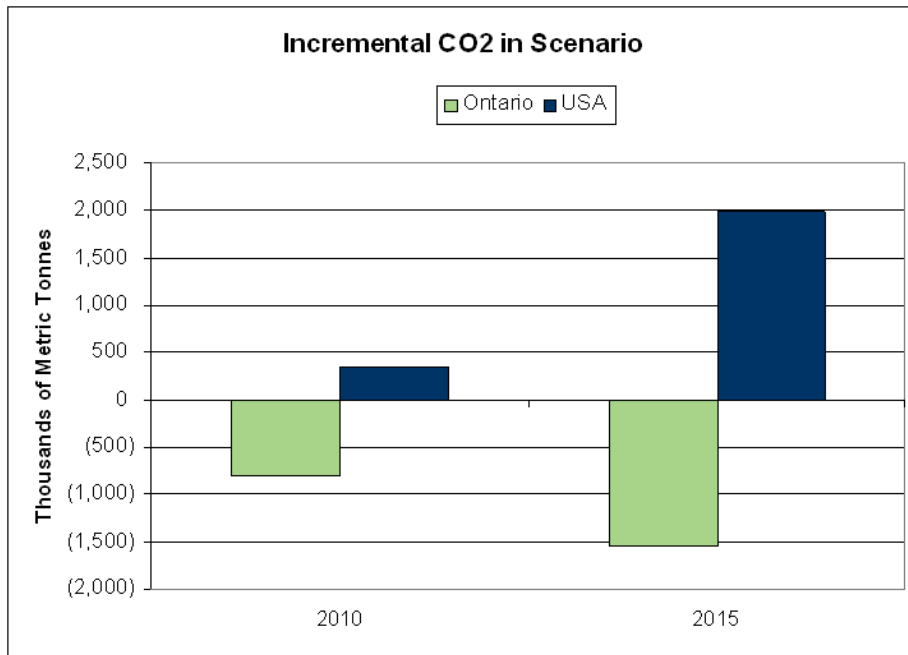
Option 3, Scenario 2 – SO₂ and NO_x

- Ontario SO₂ and NO_x emissions would be well under the cap in both status quo and option 3 scenario 2 (in 2010 and 2015) because of carbon policy's impacts on the Ontario fleet and its operation
- Option 3 scenario 2 generally reduces Ontario and regional emissions relative to status quo
- This scenario reduces net exports from Ontario, so Ontario emissions generally decline
- There is no change in SO₂ inside Ontario in 2015 because the coal has retired
- US emissions are relatively unchanged because the US CAIR policy restricts emissions of both pollutants

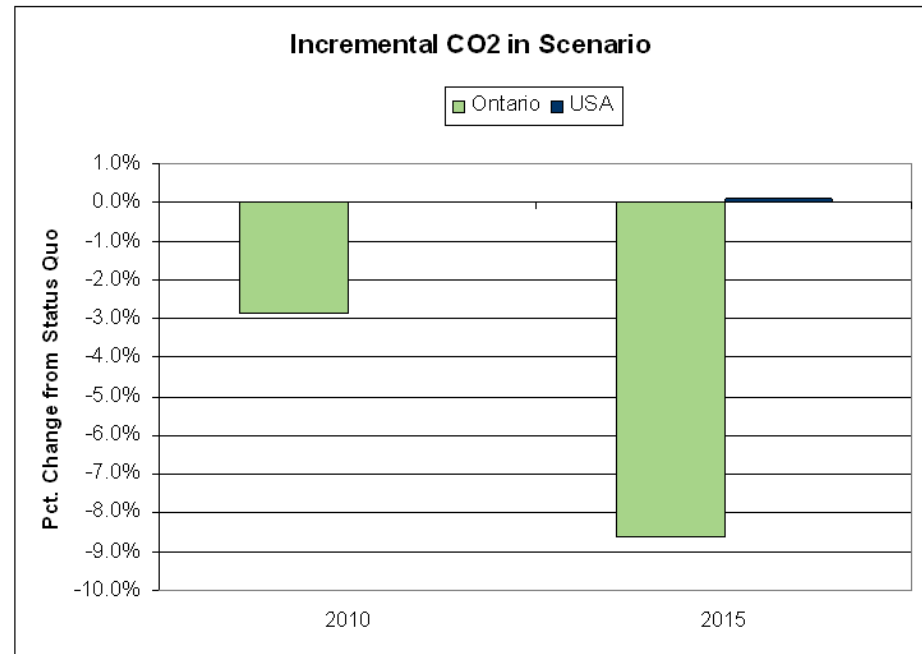
Option 3, Scenario 2 (reciprocal treatment, avg. embedded network cost)



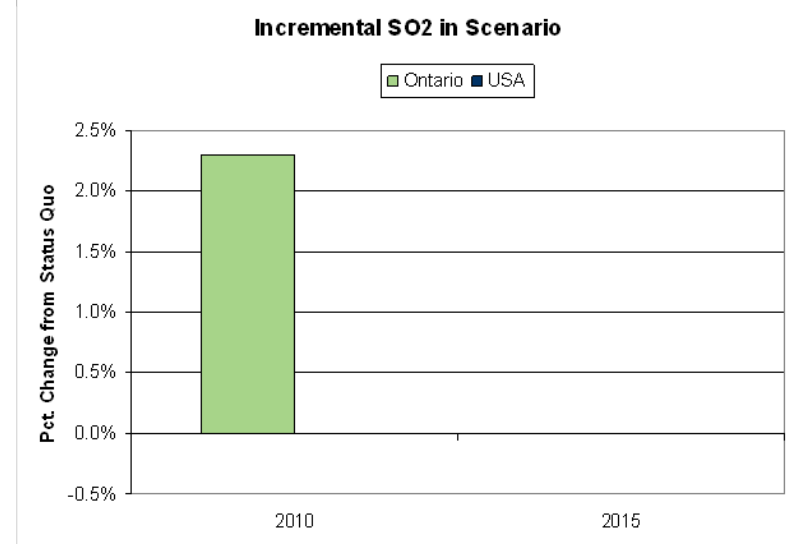
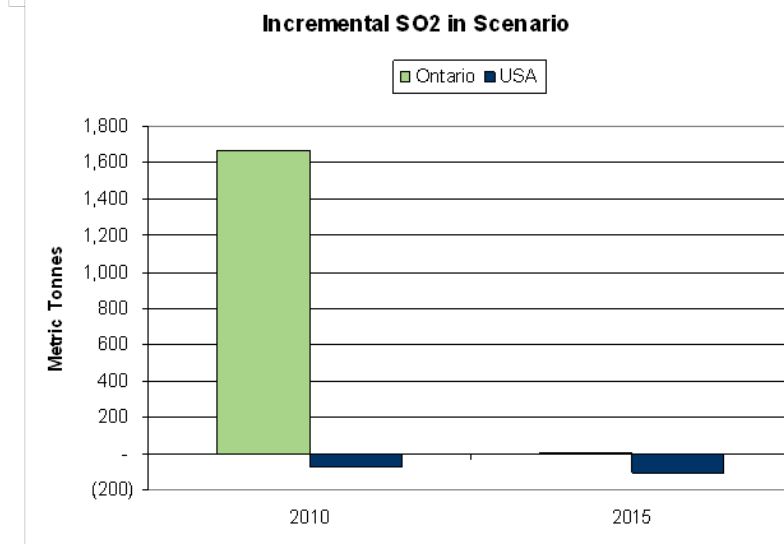
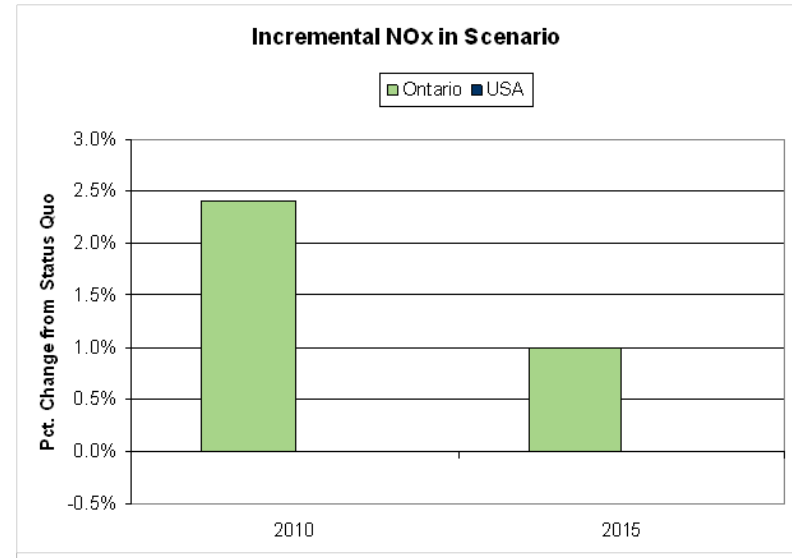
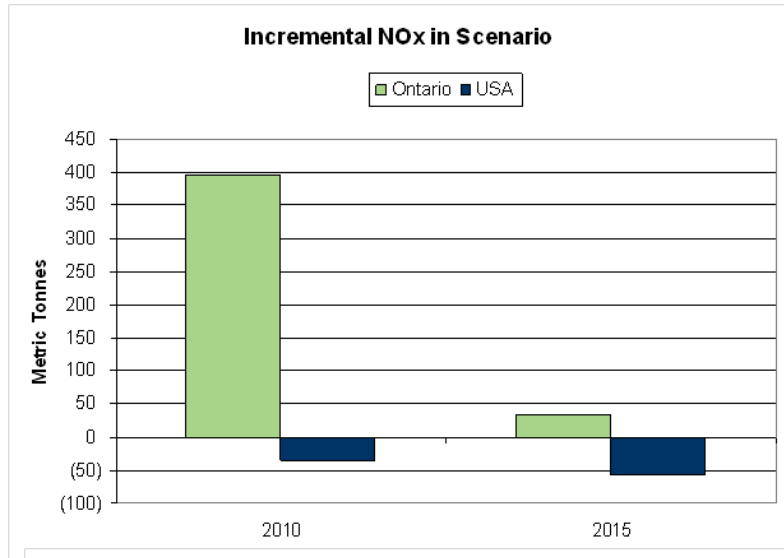
Option 3, Scenario 2 (reciprocal treatment, avg. embedded network cost)



CO2 impacts are small and nearly offsetting.



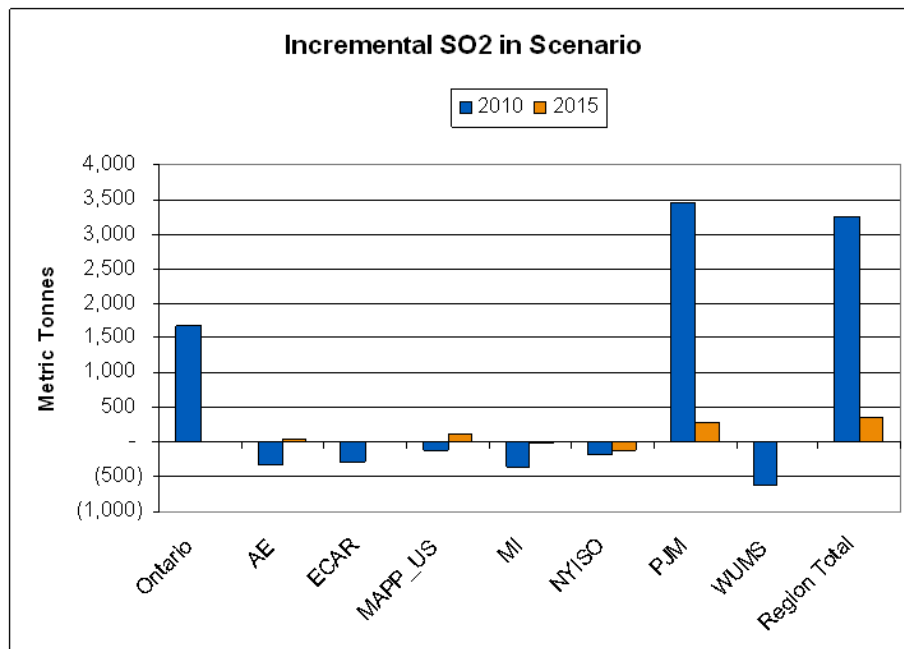
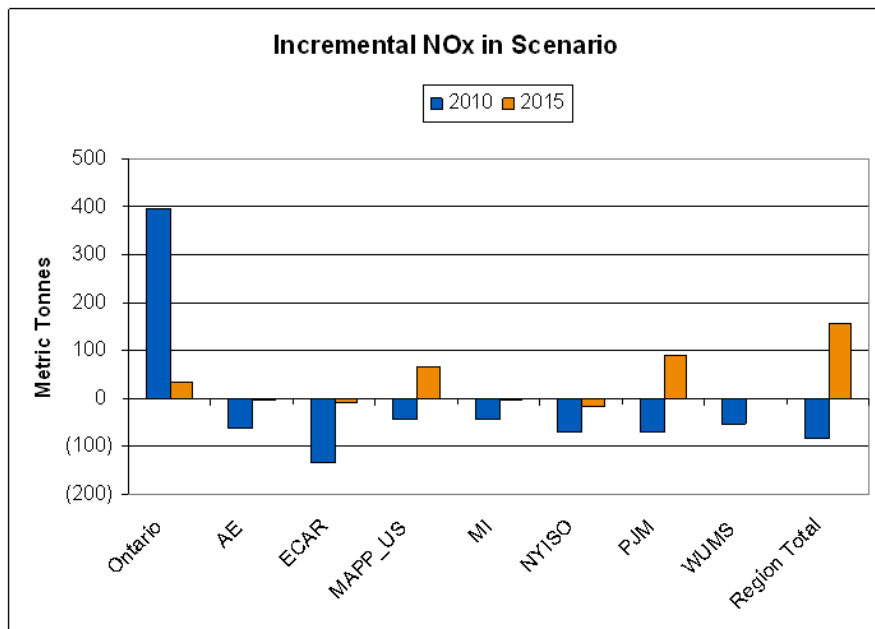
Option 4, Scenario 1 (unilateral tariff elimination in all hours)



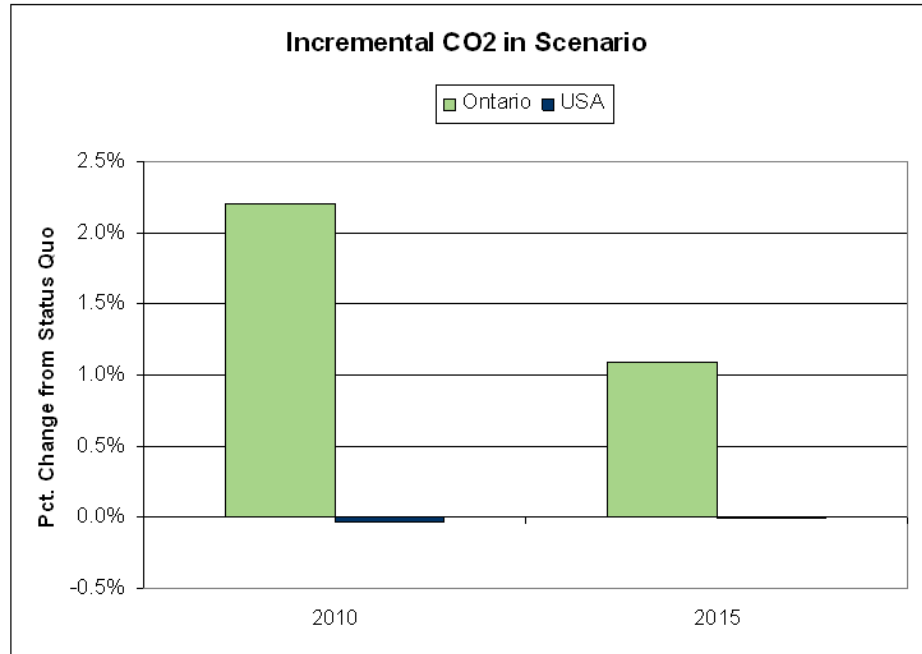
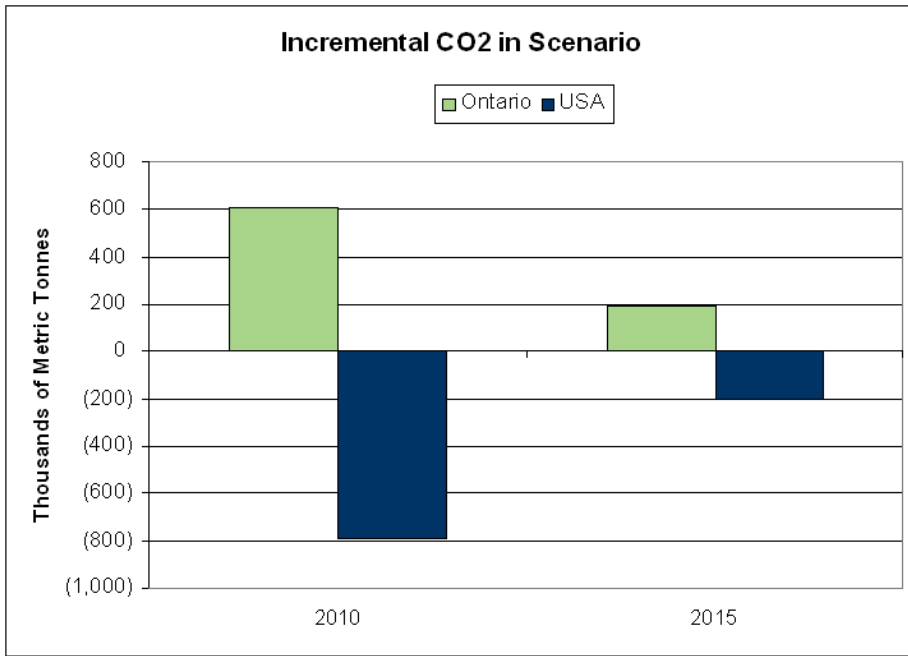
Option 4, Scenario 1 – SO₂ and NO_x

- Ontario SO₂ and NO_x emissions would be well under the cap in both status quo and option 4, Scenario 1 (in 2010 and 2015) because of carbon policy's impacts on the Ontario fleet and its operation
- Option 4, Scenario 1 (generally) slightly increases Ontario emissions relative to status quo because unilateral elimination of the export tariff increases Ontario net exports
- There is no change in SO₂ inside Ontario in 2015 because the coal has retired
- US emissions are relatively unchanged because the US CAIR policy restricts emissions of both pollutants

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

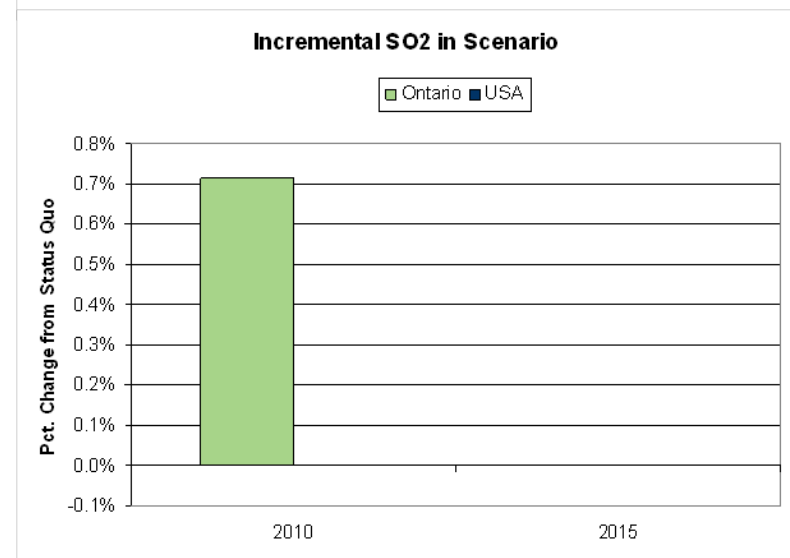
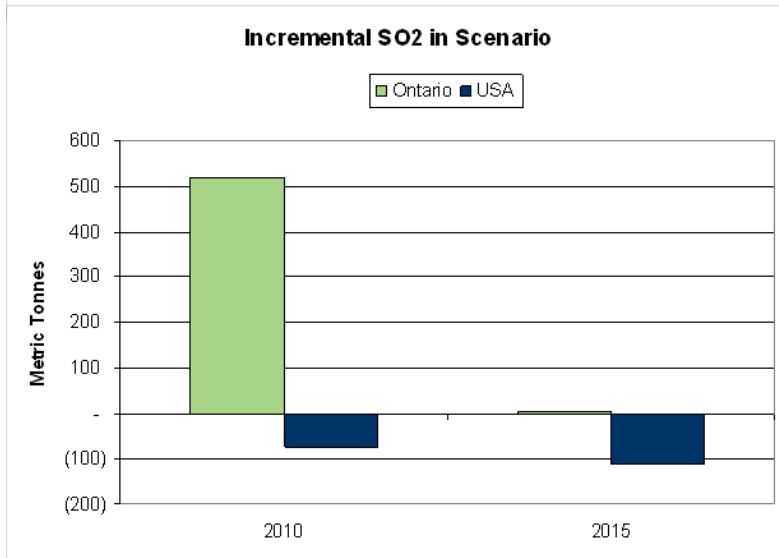
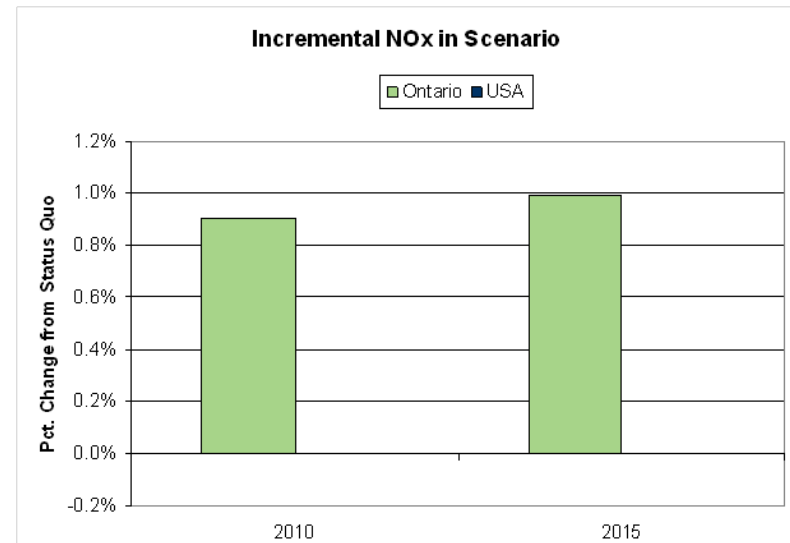
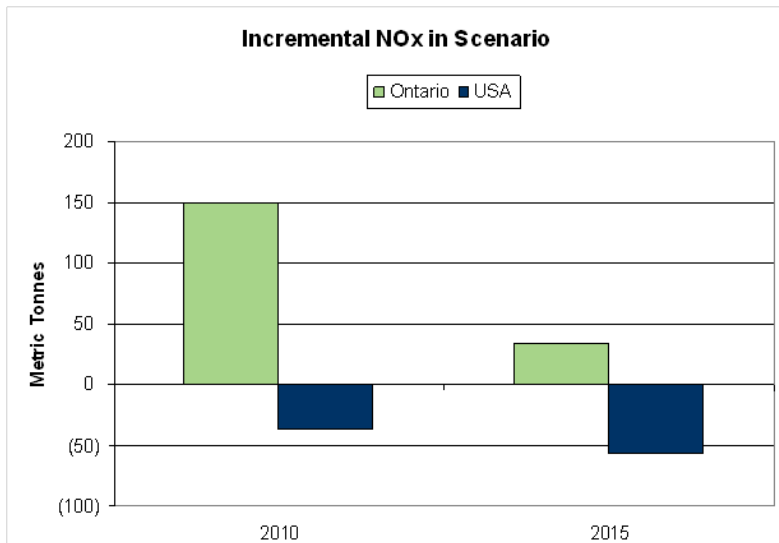


Option 4, Scenario 1 (unilateral tariff elimination in all hours)



CO2 impacts are small and nearly offsetting.

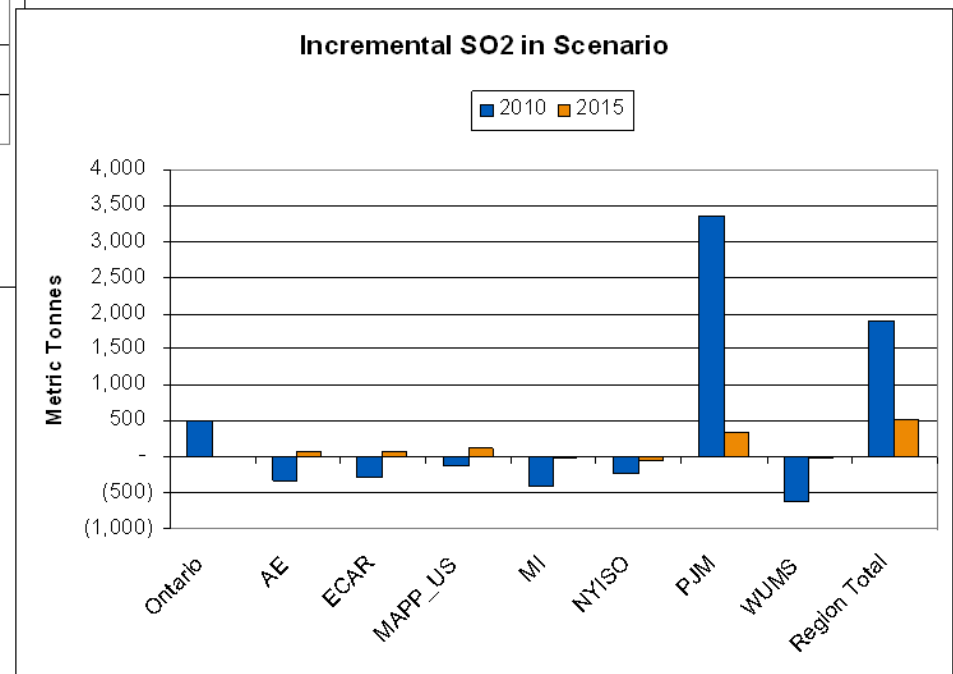
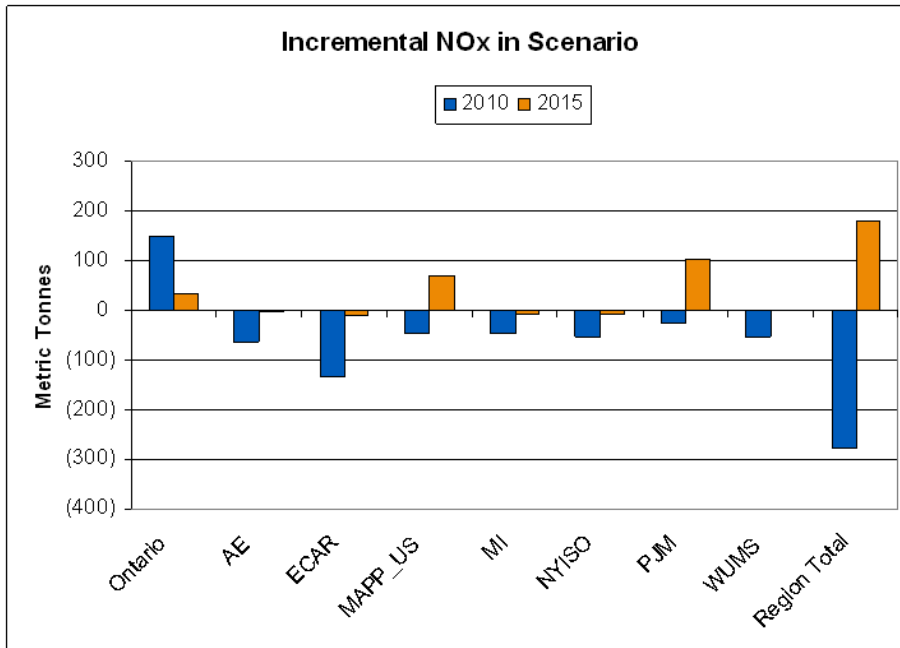
Option 4, Scenario 2 (unilateral tariff elimination, off-peak hours only)



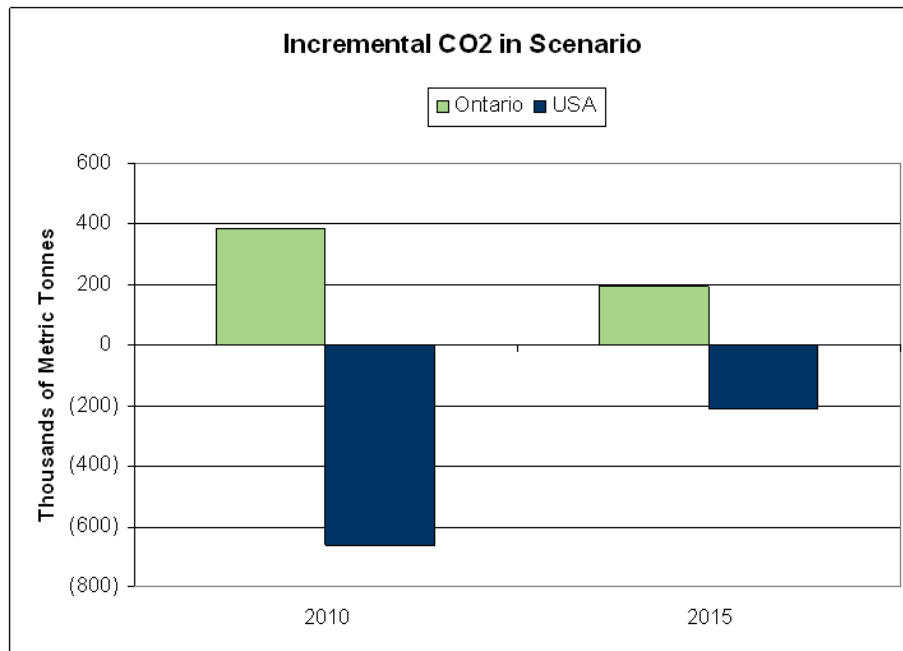
Option 4, Scenario 2 – SO₂ and NO_x

- Ontario SO₂ and NO_x emissions would be well under the cap in both status quo and option 4, Scenario 2 (in 2010 and 2015) because of carbon policy's impacts on the Ontario fleet and its operation
- Option 4, Scenario 2 (generally) slightly increases Ontario emissions relative to status quo because unilateral elimination of the export tariff increases Ontario net exports
- There is no change in SO₂ inside Ontario in 2015 because the coal has retired
- US emissions are relatively unchanged because the US CAIR policy restricts emissions of both pollutants

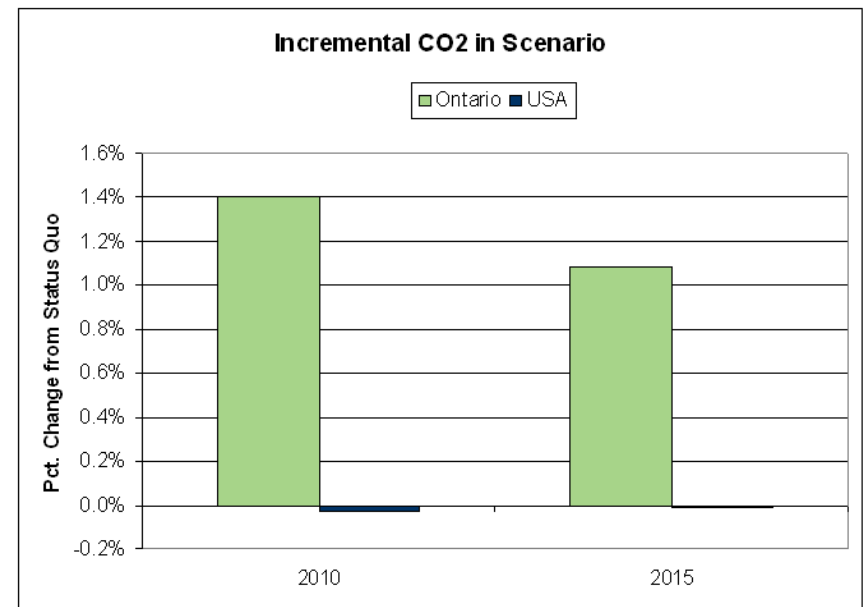
Option 4, Scenario 2 (unilateral tariff elimination, off-peak only)



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



CO2 impacts are small and nearly offsetting.



Key Assumptions for Calibration and Scenario Analysis

2007 Model Calibration Results

Scenario Definitions

Results by Scenario

Emissions Impacts by Scenario

Conclusions

Appendix

Economic Impacts

- Due to its portfolio of hydro, nuclear, wind, and gas, Ontario has more opportunity to export (to PJM/MISO) after North American carbon policy takes effect
- Option 2 (average network rate) and option 3 (reciprocal agreements) increase consumer surplus and decrease producer surplus
- 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 revenue. All other options decrease ETS 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 because of Ontario carbon policy
- Impacts on U.S. SO₂ and NO_x will be relatively small because of CAIR. Regionally, and in 2015, SO₂ and NO_x emissions will increase a bit under option 3, Scenario 1 (reciprocal tariff elimination) and under option 4, Scenarios 1 and 2 (unilateral tariff elimination)
- 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

Conclusions

Appendix

Appendix A: Results Tables

Impacts on Ontario Exports

Incremental Exports - 2010

GWh

Option	Scenario	Destination				Total
		PJM	MISO	NY	HQ	
Option 2		(122)	(333)	(4,236)	(284)	(4,976)
Option 3	Scenario 1	398	90	593	636	1,717
Option 3	Scenario 2	27	(156)	604	(1,764)	(1,290)
Option 4	Scenario 1	439	23	288	340	1,091
Option 4	Scenario 2	426	23	93	267	810

Incremental Exports - 2015

GWh

Option	Scenario	Destination				Total
		PJM	MISO	NY	HQ	
Option 2		(4,182)	(719)	(7)	(25)	(4,933)
Option 3	Scenario 1	318	134	68	42	563
Option 3	Scenario 2	(4,208)	(434)	136	(252)	(4,757)
Option 4	Scenario 1	344	149	11	6	510
Option 4	Scenario 2	358	140	(2)	1	497

Impact on Ontario Imports

Incremental Imports - 2010

GWh

Option	Scenario	PJM	MISO	Origin NY	HQ	Total
Option 2		(34)	(209)	-	(10)	(254)
Option 3	Scenario 1	1,633	3,951	-	922	6,506
Option 3	Scenario 2	(22)	7	-	22	7
Option 4	Scenario 1	-	(10)	-	(0)	(10)
Option 4	Scenario 2	12	(33)	-	-	(21)

Incremental Imports - 2015

GWh

Option	Scenario	PJM	MISO	Origin NY	HQ	Total
Option 2		(0)	(9)	(0)	30	21
Option 3	Scenario 1	0	55	0	578	633
Option 3	Scenario 2	(0)	(0)	-	24	24
Option 4	Scenario 1	(0)	0	(0)	4	4
Option 4	Scenario 2	(0)	(1)	(0)	(2)	(3)

ETS Revenue and Market Efficiency Impacts

Change in ETS Revenue

Million \$CAN

Option	Scenario	2010	2015
Option 2		55.7	102.8
Option 3	Scenario 1	(19.7)	(31.8)
Option 3	Scenario 2	20.7	45.3
Option 4	Scenario 1	(19.7)	(31.8)
Option 4	Scenario 2	(10.7)	(20.1)

Market Efficiency Impacts - 2010

Million \$CAN

Option	Scenario	Sum Variable Costs	Producer Surplus	Consumer Surplus	Total Surplus
Option 2		(238)	(271)	256	(15)
Option 3	Scenario 1	(242)	(99)	101	2
Option 3	Scenario 2	(67)	(124)	113	(11)
Option 4	Scenario 1	55	47	(47)	(0)
Option 4	Scenario 2	41	30	(33)	(2)

Market Efficiency Impacts - 2015

Million \$CAN

Option	Scenario	Sum Variable Costs	Producer Surplus	Consumer Surplus	Total Surplus
Option 2		(308)	(284)	246	(38)
Option 3	Scenario 1	25	(39)	32	(6)
Option 3	Scenario 2	(297)	(293)	254	(39)
Option 4	Scenario 1	33	60	(52)	8
Option 4	Scenario 2	32	6	(6)	1

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		(2,357)	313	16	(9)	7	569	1,173	(54)	(342)	113
Option 3	Scenario 1	(2,705)	21	109	(22)	133	376	73	165	(1,851)	2
Option 3	Scenario 2	(257)	325	76	(54)	2	(50)	(53)	(56)	(67)	171
Option 4	Scenario 1	397	(64)	(133)	(45)	(45)	(71)	(71)	(52)	(84)	(35)
Option 4	Scenario 2	149	(65)	(134)	(47)	(48)	(55)	(25)	(52)	(278)	(37)

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		(334)	124	240	(33)	46	(33)	(235)	3	(222)	(69)
Option 3	Scenario 1	30	(9)	(50)	71	(5)	(15)	123	1	146	(43)
Option 3	Scenario 2	(315)	138	215	(91)	48	(37)	(235)	1	(275)	(82)
Option 4	Scenario 1	34	(4)	(11)	67	(5)	(17)	91	1	155	(57)
Option 4	Scenario 2	34	(3)	(9)	69	(6)	(7)	102	(1)	181	(56)

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		(9,375)	1,139	1,069	10	202	1,913	(8,243)	(495)	(4,855)	233
Option 3	Scenario 1	(11,293)	83	1,471	(144)	(423)	1,680	(6,151)	798	(13,979)	11
Option 3	Scenario 2	(765)	1,132	519	(85)	(44)	(175)	(1,081)	(544)	(1,044)	358
Option 4	Scenario 1	1,669	(321)	(291)	(113)	(346)	(183)	3,458	(613)	3,260	(73)
Option 4	Scenario 2	518	(325)	(291)	(115)	(404)	(226)	3,354	(615)	1,896	(75)

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		-	247	(459)	(147)	(102)	(261)	(1,478)	(1)	(2,202)	(170)
Option 3	Scenario 1	-	20	(128)	169	31	(98)	498	11	502	(63)
Option 3	Scenario 2	-	185	(746)	(70)	(9)	(271)	(1,414)	(26)	(2,352)	(213)
Option 4	Scenario 1	-	45	15	136	(18)	(118)	296	4	364	(104)
Option 4	Scenario 2	-	68	82	128	(31)	(43)	336	(11)	534	(111)

CO2 Emissions Impacts

Incremental CO2 Emissions

000 Tonnes

Option	Scenario	2010 Ontario	2010 USA	2015 Ontario	2015 USA
Option 2		(3,148)	2,926	(1,913)	2,033
Option 3	Scenario 1	(3,221)	2,568	177	(144)
Option 3	Scenario 2	(794)	348	(1,834)	1,907
Option 4	Scenario 1	610	(790)	195	(201)
Option 4	Scenario 2	387	(664)	194	(215)

Incremental CO2 Emissions

% Change

Option	Scenario	2010 Ontario	2010 USA	2015 Ontario	2015 USA
Option 2		-11.4%	0.1%	-10.7%	0.1%
Option 3	Scenario 1	-11.7%	0.1%	1.0%	0.0%
Option 3	Scenario 2	-2.9%	0.0%	-10.3%	0.1%
Option 4	Scenario 1	2.2%	0.0%	1.1%	0.0%
Option 4	Scenario 2	1.4%	0.0%	1.1%	0.0%

Appendix B: All-In Export Costs and ETS

Status Quo

2010								
All-In Export Costs (2008 \$CAN/MWh)		To						
		ON	HQ	PJM		NY	MISO	
				Via MISO	Via NY			
From	ON		16.22	4.92	12.66	4.27	4.27	
	HQ	11.95				11.95		
	PJM	Via MISO	6.01				4.15	0.58
		Via NY	11.17					
	NY	7.02	18.97		8.39			
	MISO	5.43			0.65			

2010	
Export Tariff out of Ontario (2008 \$CAN/MWh)	
HQ	0.95
NY	0.95
MISO	0.95

2015								
All-In Export Costs (2008 \$CAN/MWh)		To						
		ON	HQ	PJM		NY	MISO	
				Via MISO	Via NY			
From	ON		16.29	4.95	12.69	4.30	4.30	
	HQ	12.00				12.00		
	PJM	Via MISO	6.01				4.15	0.58
		Via NY	11.17					
	NY	7.02	19.02		8.39			
	MISO	5.43			0.65			

2015	
Export Tariff out of Ontario (2008 \$CAN/MWh)	
HQ	0.96
NY	0.96
MISO	0.96

Appendix B: All-In Export Costs and ETS

Option 2 – Average Network Rate

2010								
All-In Export Costs (2008 \$CAN/MWh)		To						
		ON	HQ	PJM		NY	MISO	
				Via MISO	Via NY			
From	ON		20.05	8.75	16.49	8.10	8.10	
	HQ	11.95				11.95		
	PJM	Via MISO	6.01					
		Via NY	11.17				4.15	0.58
	NY	7.02	18.97		8.39			
	MISO	5.43			0.65			

2010	
Export Tariff out of Ontario (2008 \$CAN/MWh)	
HQ	4.78
NY	4.78
MISO	4.78

2015								
All-In Export Costs (2008 \$CAN/MWh)		To						
		ON	HQ	PJM		NY	MISO	
				Via MISO	Via NY			
From	ON		20.12	8.78	16.52	8.12	8.12	
	HQ	12.00				12.00		
	PJM	Via MISO	6.01					
		Via NY	11.17				4.15	0.58
	NY	7.02	19.02		8.39			
	MISO	5.43			0.65			

2015	
Export Tariff out of Ontario (2008 \$CAN/MWh)	
HQ	4.79
NY	4.79
MISO	4.79

Appendix B: All-In Export Costs and ETS

Option 3, Scenario 1 – Reciprocal Tariff 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		15.27	3.97	11.71	3.32	3.32	HQ	0	
	HQ	4.23				11.95		NY	0	
	PJM	Via MISO	1.23				4.15	0.58	MISO	0
		Via NY	7.53							
	NY	3.38	18.97		8.39					
	MISO	0.65			0.65					

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		15.33	3.99	11.73	3.33	3.33	HQ	0	
	HQ	4.26				12.00		NY	0	
	PJM	Via MISO	1.23				4.15	0.58	MISO	0
		Via NY	7.53							
	NY	3.38	19.02		8.39					
	MISO	0.65			0.65					

Appendix B: All-In Export Costs and ETS

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		22.98	8.75	11.71	3.32	8.10	HQ	7.71	
	HQ	11.95				11.95		NY	0	
	PJM	Via MISO	6.01				4.15	0.58	MISO	4.78
		Via NY	7.53							
	NY	3.38	18.97		8.39					
	MISO	5.43			0.65					
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		23.07	8.76	11.73	3.33	8.11	HQ	7.74	
	HQ	12.00				12.00		NY	0	
	PJM	Via MISO	6.01				4.15	0.58	MISO	4.78
		Via NY	7.53							
	NY	3.38	19.02		8.39					
	MISO	5.43			0.65					

Appendix B: All-In Export Costs and ETS

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		15.27	3.97	11.71	3.32	3.32	HQ	0	
	HQ	11.95				11.95		NY	0	
	PJM	Via MISO	6.01				4.15	0.58	MISO	0
		Via NY	11.17							
	NY	7.02	18.97		8.39					
	MISO	5.43			0.65					

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		15.33	3.99	11.73	3.33	3.33	HQ	0	
	HQ	12.00				12.00		NY	0	
	PJM	Via MISO	6.01				4.15	0.58	MISO	0
		Via NY	11.17							
	NY	7.02	19.02		8.39					
	MISO	5.43			0.65					

Appendix C: Map of NEEM Regions



Michigan is a separate region.