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A Spectra Energy Company

Enbridge Gas Distribution and Union Gas

Results from Aligned Cap & Trade Natural Gas Initiatives Analysis

November 2015

Ontario Energy Board Generic Community Expansion
Filed: 2016-04-22
EB-2016-0004
Exhibit S3.EGDI.OGA.3
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Outline

- Review of key assumptions defining Ontario Cap-and-Trade Scenarios
- Aligned Natural Gas Initiatives Assumptions
  - Renewable Natural Gas (RNG)
  - Combined Heat and Power (CHP)
  - Compressed/Liquefied Natural Gas (CNG/LNG)
  - Cap and Trade Energy Conservation (CTEC)
- Emissions Reduction Forecast and Initiatives Results
- Price Elasticity Demand Response
- Summary
- Appendix (separate file): Company-Specific Change in Natural Gas Demand

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Assumptions: Cap-and-Trade Policy

- Ontario's cap-and-trade program begins: **January 1, 2017**
- Link with Quebec and California: **January 1, 2018** (linkage not modeled)
- **Free allocation Scenario**: EITE industry and natural gas distributors
- **No free allocation Scenario**: transportation fuel distributors, electricity generators, and natural gas distributors
- **Cap**: -3.2% / year from 2017 to 2020 and -2.3% from 2020 to 2030
- **Offsets**: capped at 8%
- **Price floor**: aligned with Quebec and California (starting at $13 in 2017)
- **Reserve bank**: 3 tiers fixed at $50/$55/$60 in 2017 and increasing annually

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Assumptions: Activity Data

Business as usual

- Ontario's provincial forecast of GHG emissions
- Electricity sector aligned with Ontario's Long Term Energy Plan
- UG/EGD forecast of NG demand by customer segment out to 2030
- Beyond current DSM Plans no uptake of NG emission reducing opportunities

Cap-and-Trade Scenarios

- NG: RNG, CHP, CNG/LNG, CTEC
- Non-NG Transport: reduced activity, LCFS, and electrification

Model is populated with UG and EGD activity data and assumptions.

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Renewable Natural Gas

- Both UG and EGD provided annual forecast volume of RNG based on the Alberta Innovates (May 2011) Study.
- RNG production estimates derived from: anaerobic digestion (AD) and gasification.
- Introduction of RNG from various methods for AD and gasification sources as they relate to the availability of RNG supplies, the related technology maturity, scale and costs.

  *Actual market transformation will significantly depend on evolving policy and technology development support.

- Assumption is Ontario's cap-and-trade regulations permit the sourcing of RNG supplies from outside of provincial boundaries.

RNG Volume and Emissions Reductions Forecast	2017	2018	2019	2020	2021	2022	2023
Ontario Total Volume (million m^3/yr)	19	34	151	267	396	503	947
Ontario Emissions Reductions (Mt CO_2e/yr)	0.04	0.06	0.28	0.50	0.75	0.95	1.79

RNG Volume and Emissions Reductions Forecast	2024	2025	2026	2027	2028	2029	2030
Ontario Total Volume (million m^3/yr)	1,355	1,997	2,546	3,052	3,444	3,837	4,265
Ontario Emissions Reductions (Mt CO_2e/yr)	2.56	3.77	4.81	5.77	6.51	7.25	8.06

Notes: 1) RNG volume and emissions reduction estimates represent cumulative values.
2) Emissions reductions do not include offset volumes associated with RNG, please refer to Assumptions Book for offset potential associated with RNG.

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Combined Heat and Power

- CHP growth will total 1000 MW by 2030. Of this total, assume 40% is behind-the-meter CHP and 60% is grid-connected CHP delivering power into the wholesale electricity market.
- Assume a 50:50 market share for UG-EGD franchise areas for both behind-the-meter CHP and grid-connected CHP.

Provincial CHP Cumulative Capacity (Additional to Current Installed Capacity) and Emissions Reductions	2017	2018	2019	2020	2021	2022	2023
Ontario CHP (MW)	42	110	198	344	391	461	508
Ontario Emissions Reductions (Mt CO_2e/yr)	0.05	0.13	0.23	0.39	0.45	0.53	0.58

Provincial CHP Cumulative Capacity (Additional to Current Installed Capacity) and Emissions Reductions	2024	2025	2026	2027	2028	2029	2030
Ontario CHP (MW)	547	641	691	757	857	931	1,000
Ontario Emissions Reductions (Mt CO_2e/yr)	0.62	0.73	0.79	0.86	0.98	1.06	1.14

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Combined Heat and Power (continued)

- Calculation methodology from a CHP calculator developed by EGD, based on the principle of coincidence of load, was used.
  - Assumes operating hours of CHP (in both categories) are 100% coincident with the hours of grid-connected gas generation, and additional CHP operating hours are assumed to be coincident with zero-carbon grid generation
  - e.g. CHP operating for 7,500 hours per year displaces gas-fired generation for 7,000 hours in the year, and zero carbon emitting generation (i.e. nuclear, hydro) for 500 hours in the year (i.e. CHP wears full GHG emissions for hours it displaces non-emitting electricity)

Parameter	
Average Efficiency of Gas-fired Grid-connected Power Plants (HHV)	45%
Line Transmission and Distribution Losses	5%
Average Annual Grid-connected Gas Plant Operating Hours	7,000
Boiler Thermal Efficiency (HHV)	78%

Parameter	Behind-the-meter CHP[1]	Grid-connected CHP[2]
Electrical Efficiency	37.5%	48.1%
Heat-to-Power Ratio	1.2	0.8
Average Annual Operating Hours	7,500	4,200
Resulting Total System Efficiency (total power + thermal energy output/fuel consumed)	83%	87%

[1] Efficiency and heat-to-power ratio based on assumption that behind-the-meter CHP is likely to be a mix of small reciprocating engines (e.g. institutional buildings) and gas turbines (e.g. industrial sites with a requirement for steam). Operating hours based on assumption that CHP will run to meet thermal demands of process load or operation of a facility.

[2] Efficiency and heat-to-power ratio from manufacturer specifications for an illustrative large (8.5 MW) reciprocating engine, based on assumption that grid-connected CHP will be designed to maximize electrical power output. Operating hours based on typical operating hours for district energy-connected CHP with seasonal heat load, and the assumption that wholesale CHP runs only when the grid needs the electricity and can be approximated by the same annual operating hours as district energy-connected CHP.

CNG/LNG for Transportation

- EGD and UG provided volume of natural gas consumption based on current fuel consumption per target sector (does not include light-duty vehicles) and NG market capture estimates
  - UG/EGD provincial total assumed to be 50:50 market share
- Analysis uses a 22% emissions reduction factor for displacement of any BAU fuel (diesel, gasoline, fuel oil) with NG

Provincial NG Consumption for Transportation and Emissions Reductions	2017	2018	2019	2020	2021	2022	2023
Marine (million m^3/yr)	-	-	17	35	52	70	87
Rail (million m^3/yr)	-	-	33	65	98	130	163
On-Road Diesel (million m^3/yr)	20	86	216	388	560	862	1,422
On-Road Gasoline (million m^3/yr)	-	31	77	139	201	310	511
Ontario Total Volume (million m^3/yr)	**20**	**117**	**343**	**627**	**912**	**1,372**	**2,184**
Ontario Emissions Reductions (Mt CO_2e/yr)	0.01	0.06	0.18	0.33	0.49	0.73	1.16

Provincial NG Consumption for Transportation and Emissions Reductions	2024	2025	2026	2027	2028	2029	2030
Marine (million m^3/yr)	105	122	140	157	175	192	210
Rail (million m^3/yr)	195	228	260	293	325	342	342
On-Road Diesel (million m^3/yr)	2,241	3,233	3,664	3,879	4,009	4,052	4,095
On-Road Gasoline (million m^3/yr)	806	1,162	1,317	1,395	1,441	1,457	1,472
Ontario Total Volume (million m^3/yr)	**3,347**	**4,745**	**5,381**	**5,724**	**5,950**	**6,042**	**6,118**
Ontario Emissions Reductions (Mt CO_2e/yr)	1.78	2.53	2.87	3.05	3.17	3.22	3.26

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LNG for Stationary Combustion (Load Displacement)

- Analysis based on estimate of annual natural gas consumption volume forecasts from 2017 to 2030 agreed on by the EGD/UG working group
  - Forecast corresponds to an approximately 46% market capture by 2030 of 'current' Ontario consumption of relevant stationary fuel types
- Assume that 38% of the total volume displaces propane fuel use, and the remainder displaces diesel and oil use
- Assume that the stationary NG volumes are split 50:50 between Enbridge and Union
- Analysis uses a 22% emissions reduction factor for displacement of stationary diesel and fuel oil with LNG; or 16% emission reduction factor for displacement of propane with LNG

Provincial Stationary LNG Consumption and Emissions Reductions	2017	2018	2019	2020	2021	2022	2023
Ontario Total (million m^3/yr)	64	135	193	250	309	366	421
Ontario Emissions Reductions (Mt CO_2e/yr)	0.04	0.08	0.12	0.15	0.19	0.22	0.26

Provincial Stationary LNG Consumption and Emissions Reductions	2024	2025	2026	2027	2028	2029	2030
Ontario Total (million m^3/yr)	476	532	587	642	697	752	807
Ontario Emissions Reductions (Mt CO_2e/yr)	0.29	0.32	0.36	0.39	0.43	0.46	0.49

Cap and Trade Energy Conservation

- Cap and trade energy conservation (CTEC) quantification based on aggressive scenarios run by EGD in Navigant DSM model, and translated to UG's franchise by assuming the same proportional increase in budget and savings over the current OEB-approved DSM plan
- UG provided an estimate of additional 'large volumes' savings
- Initiative divided into two 'slices'
  - 'Slice 1' is a medium/constrained scenario corresponding to the highest modelled scenario that would be considered to have a 'reasonable yield' as a traditional DSM program
  - 'Slice 2' is the additional savings obtained in a high scenario, which is a modelled scenario where DSM incentives are set at 100% of capital costs for all currently economic measures. Traditional DSM may not be an effective policy tool to access these savings due to the high cost per m^3 savings.

Provincial CTEC Cumulative Savings and Emissions Reductions	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Medium/Constrained Scenario (Slice 1) (million m^3/yr)	263	513	756	989	1,215	1,432	1,637	1,835	2,033	2,232	2,430	2,628	2,826	[illegible]
Ontario Emissions Reductions (Mt CO_2e/yr)	0.50	0.97	1.43	1.87	2.30	2.71	3.09	3.47	3.84	4.22	4.59	4.97	[illegible]	[illegible]
High Scenario (Slice 1 + Slice 2) (million m^3/yr)	364	714	1,053	1,376	1,688	1,985	2,264	2,533	2,801	3,070	3,338	3,607	[illegible]	[illegible]
Ontario Emissions Reductions (Mt CO_2e/yr)	0.69	1.35	1.99	2.60	3.19	3.75	4.28	4.79	5.29	5.80	6.31	6.82	7.32	7.83

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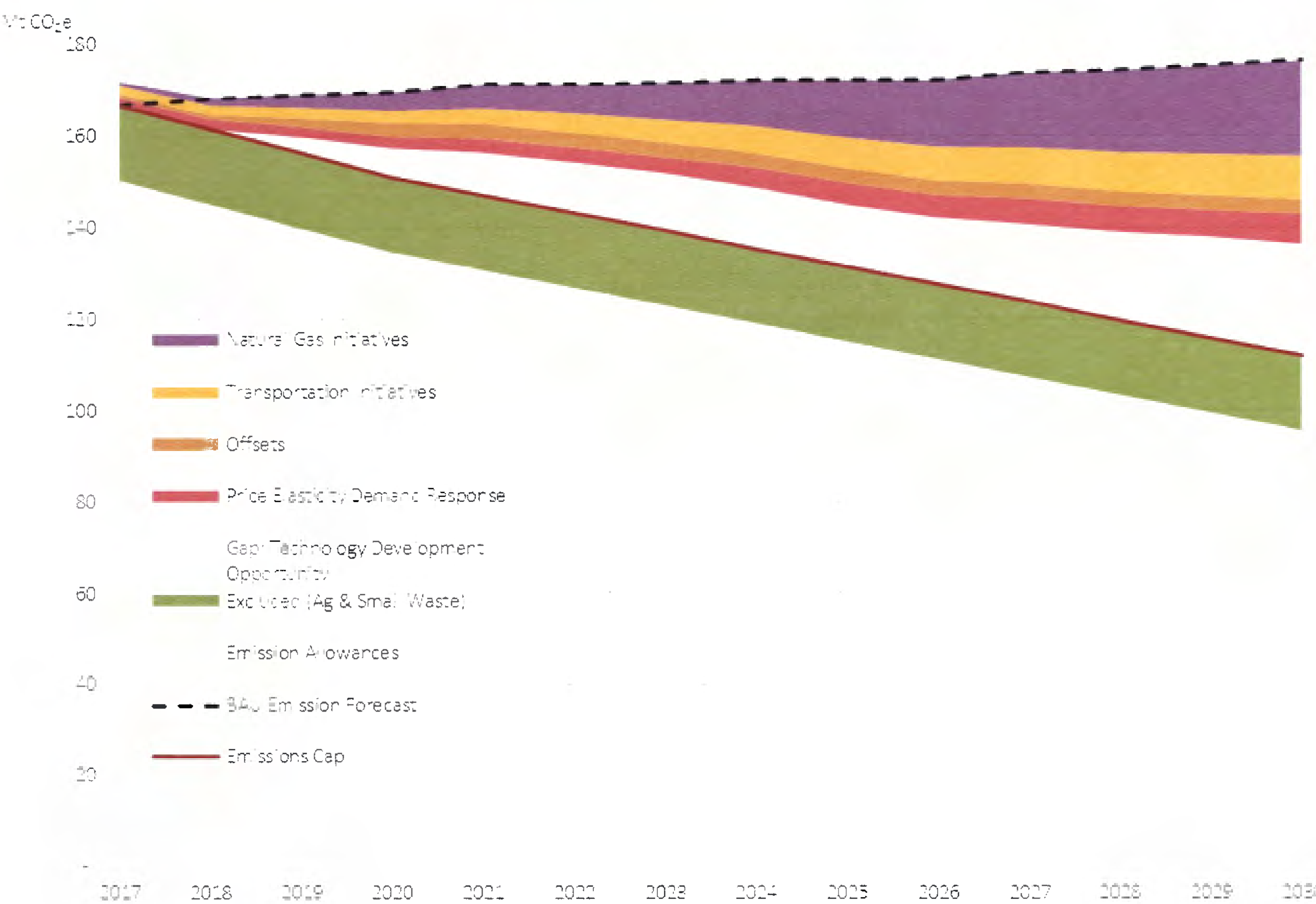
Assumptions: Non-NG Transportation Initiatives

- Electrification of light-duty vehicles
  - 1.5 million electric vehicles (EVs) by 2030
  - Assumed rapid penetration of EVs as a result of government incentive
  - 4.1 MWh/year required per EV for annual travel of 20,000 km
  - Non-emitting electricity generation used to power EVs
- Zero Emission Vehicle mandate modelled on the California ZEV mandate, beginning in 2017
- Reduce Vehicle Kilometres travelled, considers potential impact of transit programs incremental to the Big Move
- Low Carbon Fuel Standard modelled on the California LCFS, beginning in 2017 and following the same schedule for increased stringency
  - Accounts for existing renewable fuel mandates in Ontario

Ontario Emissions Reduction Forecast: With Free Allocation to Natural Gas Distributors



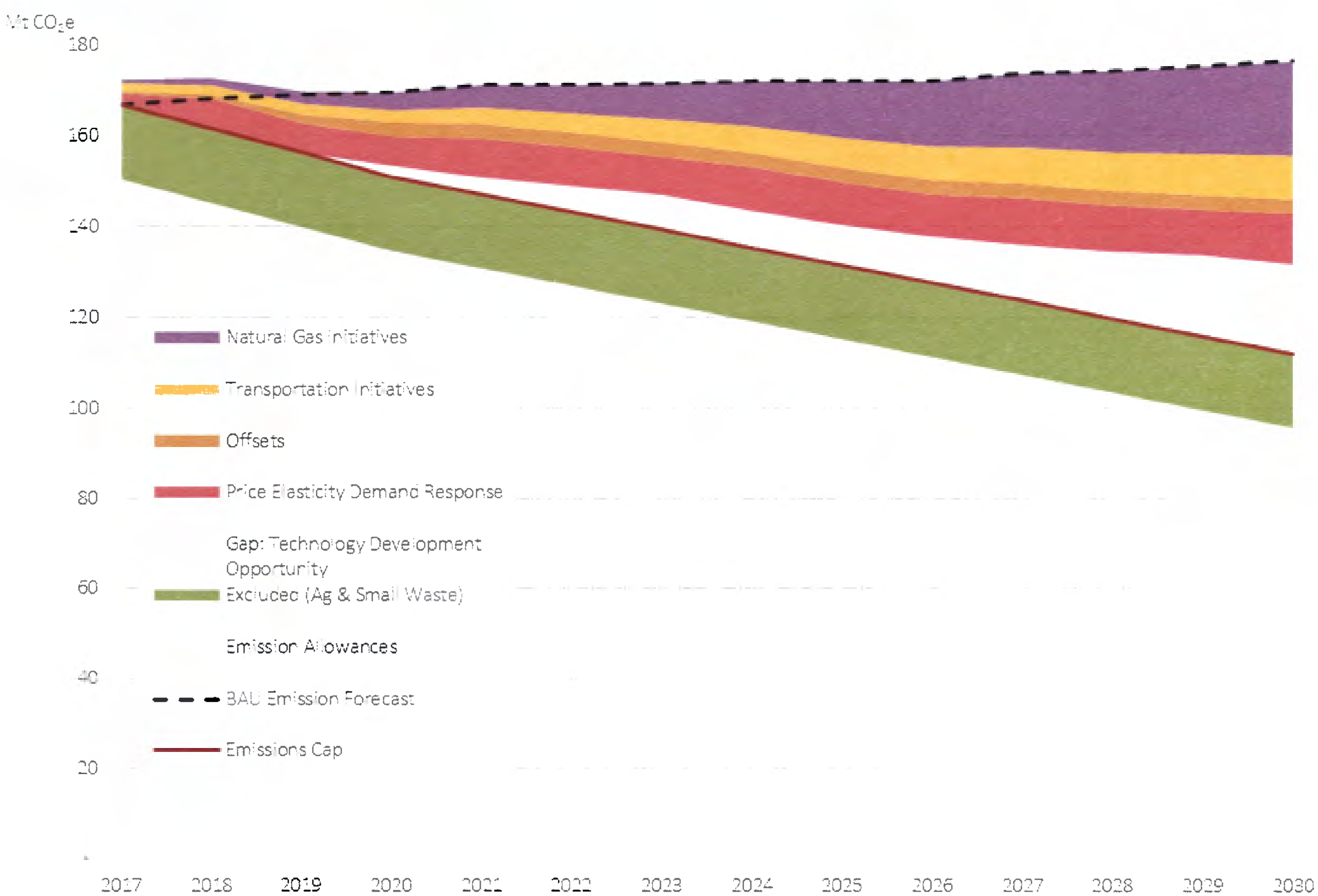
C&T scenario with free allocation informed by UG/EGD activity data and assumptions.

By 2030

- NG related initiatives **reduce emissions by 21 Mt CO_2e**, the largest GHG reduction potential in the study timeframe.
- Non-NG transport initiatives **reduce emissions by 10 Mt CO_2e**.
- Elasticity demand response to increasing fuel prices results in **reductions of 7 Mt CO_2e**.
- Gap; Technology Development Opportunity of **24 Mt CO_2e**

Cumulative allowance shortage of **161 Mt CO_2e** from 2017-2030.

Ontario Emissions Reduction Forecast: No Free Allocation to Natural Gas Distributors



C&T scenario assuming no free allocation informed by UG/EGD activity data and assumptions.

By 2030

- NG related initiatives **reduce emissions by 21 Mt CO_2e**, the largest GHG reduction potential in the study timeframe
- Non-NG transport initiatives **reduce emissions by 10 Mt CO_2e**.
- Elasticity demand response to increasing fuel prices results in **reductions of 11 Mt CO_2e**.
- Gap; Technology Development Opportunity of **20 Mt CO_2e**.

Cumulative allowance shortage of **100 Mt CO_2e** from 2017-2030.

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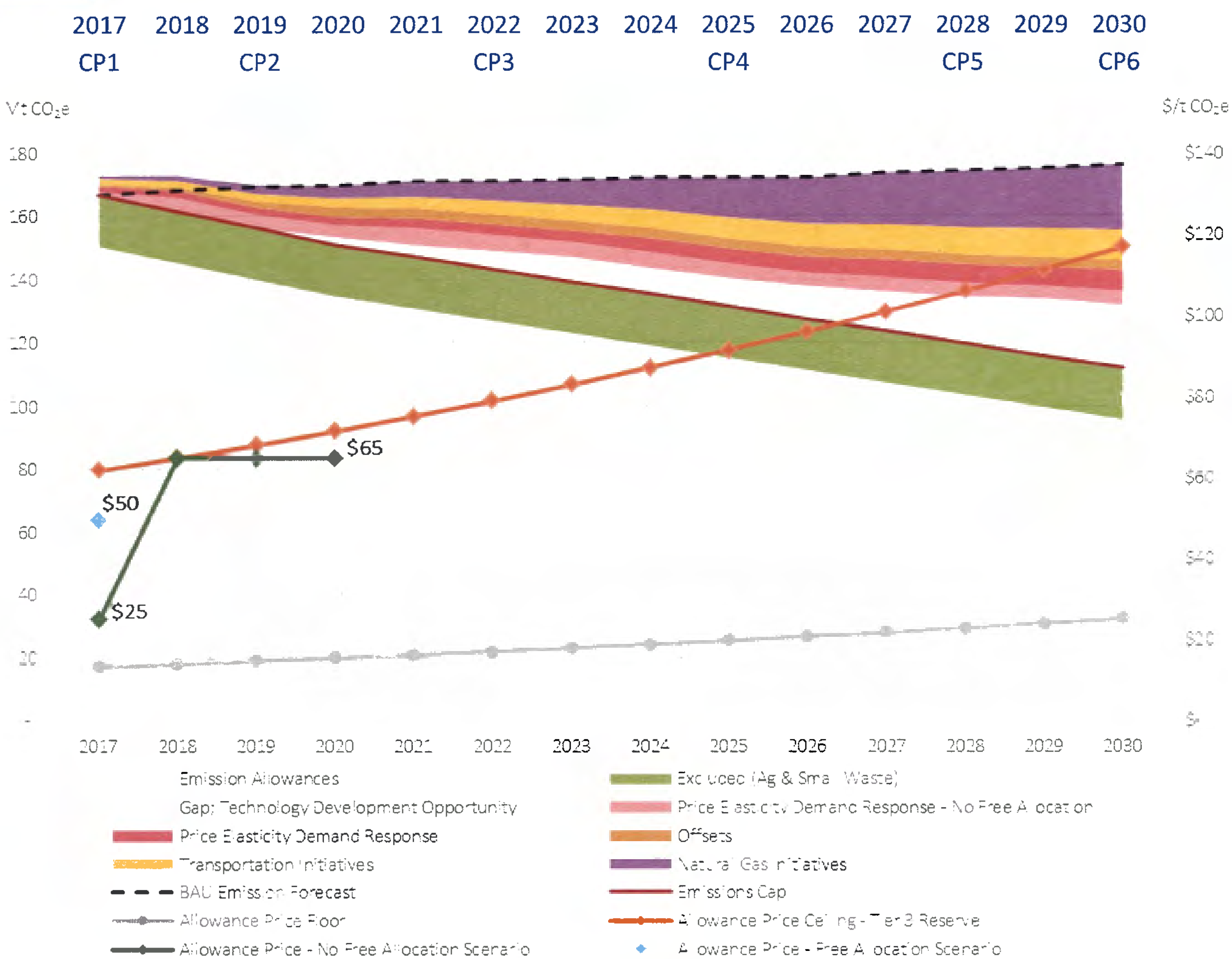
Ontario Emissions Reduction Forecast: Potential for Complementary Initiatives

- Based on modeled results, Ontario cannot meet its GHG reduction objectives solely from within its own domestic market – will need to purchase allowances from other WCI jurisdictions, or close the gap with complementary initiatives targeting technology developments/innovation that achieve deeper GHG reductions (e.g. natural gas heat pumps, etc.).
- Serious consideration should be given to the ensuring auction proceeds are reinvested to achieve maximum emissions reductions for the province.
- It is important to establish complementary initiatives (for example - a natural gas technology fund) early in the cap-and-trade program development process to ensure technology solutions are commercialized early enough to deliver the needed GHG reductions, or cumulative allowance shortages will grow.

Model Output Allowance Price *NOT an allowance price forecast



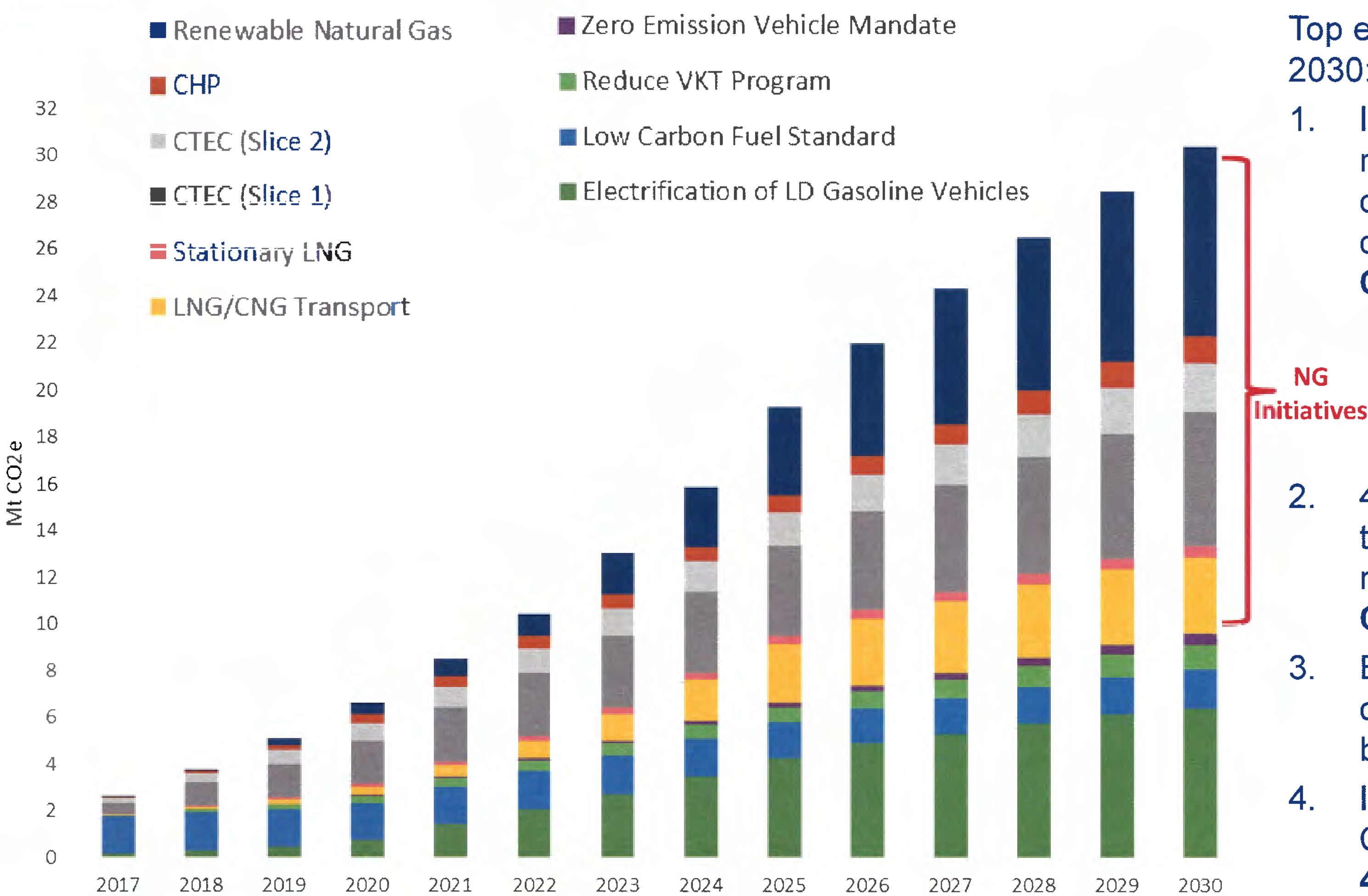
Model Assumptions:

- Ontario in a vacuum
  - No link to QC/CA allowance markets
- Price is solved per WCI compliance period (CP)
- Price is constrained between the WCI floor and ceiling
  - Assume the top tier reserve price is a hard ceiling price for modelling purposes
- If price exceeds ceiling, model stops solving

Model Results:

- ➢ The price exceeds ceiling after CP1 or CP2 for the free and no free allocation scenario, respectively
- ➢ There are insufficient emission reductions in Ontario to meet the reduction targets within these price constraints

Summary of Aligned Initiatives Results

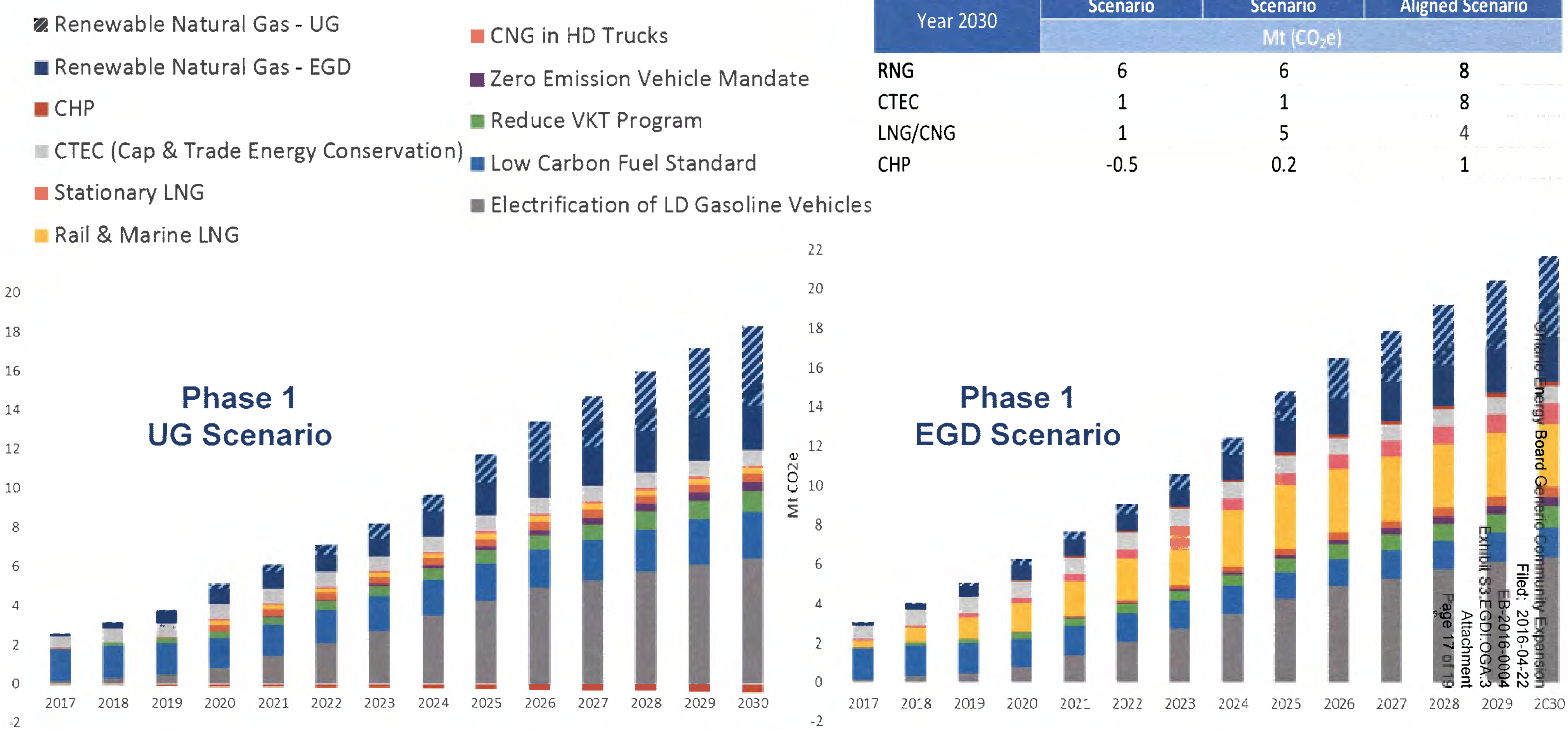


Top emission reduction initiatives in 2030:

1. In total, NG energy efficiency reduces emissions by **8 Mt CO_2e** due to 4.1 billion m^3 of CTEC demand destruction and **1 Mt CO_2e** due to 1,000 MW of CHP.
   – Highest modelled CTEC scenario with 'reasonable yield' as traditional DSM program (Slice 1) reduces emissions by 6 Mt CO_2e due to 3.0 billion m^3 demand destruction.
2. 4.3 billion m^3 of RNG (~15% of total provincial NG consumption) reduces emissions by **8 Mt CO_2e**.
3. Electrification of 1.5 million light-duty vehicles reduces emissions by **6 Mt CO_2e**.
4. In total, 6.9 billion m^3 of CNG/LNG reduces emissions by **4 Mt CO_2e**.

Previous Initiatives Results

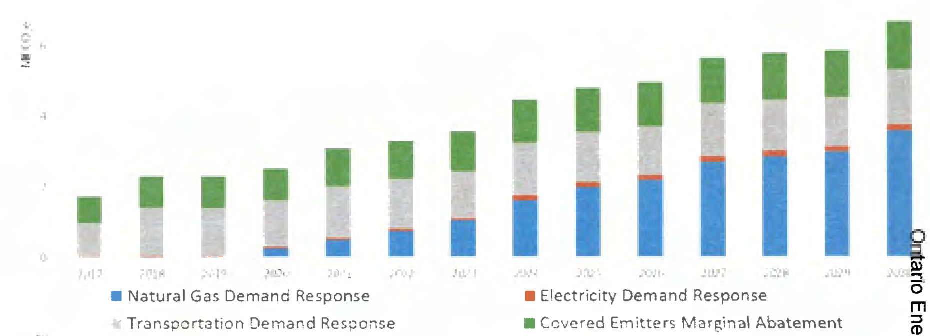
Provincial Totals Year 2030	Phase 1 UG Scenario	Phase 1 EGD Scenario	Phase 2 UG/EGD Aligned Scenario
	Mt (CO_2e)		
RNG	6	6	8
CTEC	1	1	8
LNG/CNG	1	5	4
CHP	-0.5	0.2	1



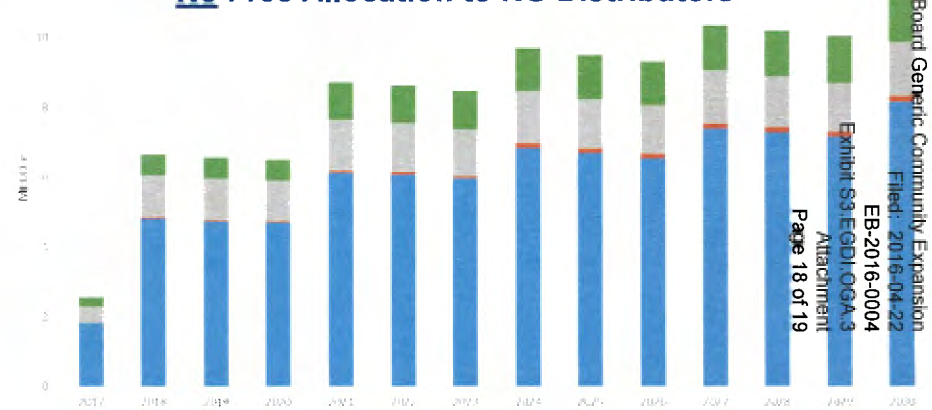
End users respond to high price of allowance / energy by reducing usage

- Price elasticity assumptions informed by **limited available research**.
  - Natural Gas: *The Likely Effect of Carbon Pricing on Energy Consumption in Canada*. Dr. D. Ryan & Noha Abdel Razek, University of Alberta, May 2012.
  - Transportation Fuels & Electricity: ICF expert opinion
- No physical constraint imposed in the model.
  - e.g. in reality, NG demand destruction would be limited by a minimum space heating requirement for Ontario's climate
- Price elasticity applied to prices consumers pay for:
  - Electricity
  - Transportation – light duty gasoline & diesel only
  - Natural Gas – residential, commercial & small industrial sub-sectors
- Industrial marginal abatement costs based on research for industry sector or sub-sector and ICF expert opinions.
  - Adjusted to avoid double counting EE abatement in complementary initiatives
- NG demand destruction would be reduced through free allocation to NG distributors (vs. no free allocation).

Free Allocation to NG Distributors



No Free Allocation to NG Distributors



Aggressive 2030 targets and C&T policy will reduce demand for NG in Ontario

NG Initiatives (RNG, CNG/LNG, CTEC and CHP) have the potential to maximize Ontario's GHG reductions in the 2017-2030 timeframe, but policy and regulatory support will be key to achieving this potential. NG can contribute broad spectrum and cost-effectively as a foundational fuel to a low carbon economy:

- NG is critical for re-fueling heavy transport.
- RNG (decarbonized CH_4) is critical to leveraging existing energy infrastructure for GHG reductions and as a means of limiting consumer cost-pressures under cap-and-trade. Policy/regulatory support for some new infrastructure required for delivery, but this could be a modest investment compared to alternatives.
- Deeper energy efficiency and conservation understood as contributors to the solution - EGD/UG delivery of programs necessary for success.
- CHP efficiency benefits are well understood, and represent the most efficient use of NG for power generation in the near-term, and the use of RNG in the future.

However, there are caveats:

- NG for transport requires thinking through the role of NG Distributors in establishing the refueling infrastructure required to achieve early market adoption.
- RNG potential availability: EGD and UG are relying on preliminary market assessments. Policy/regulatory signals are needed to prioritize this before the understanding of market and technology potential can improve.
- Deeper energy efficiency and conservation must be considered beyond the lens of traditional DSM programs (complicated by OEB mandate).
- CHP may be the victim of unintended consequences in cap-and-trade design.

Short term (2017-2030):

- Opportunity for UG/EGD: price (vs. electricity) and infrastructure.
- Challenge for UG/EGD: regulator mandate, rate design considerations, money and time to deploy new infrastructure vs. 2030 target.
- NG demand destruction limited by minimum space heating needs and consumer resistance (cost) to electrifying building heating. ~~Early~~ start on NG technology innovation needed as an energy cost control measure, and as a means of preserving low-carbon electricity for electrification of ~~light-duty transportation~~.

Long term (2030-2050):

- Demand destruction vs. BAU is inevitable. Technology innovation and green gas supplies needed for the economy to have access to cost-effective energy by pipeline.