



# Long-Term Carbon Price Forecast Report

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Submitted to:  
Ontario Energy Board

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## Executive Summary

### Background and Objectives

Ontario's cap and trade program is a regulatory instrument aimed at meeting the provincial government's greenhouse gas (GHG) emissions reduction targets. Beginning in January 2017, the cap and trade program and resulting price on carbon will impact the price end users pay for transportation fuels, natural gas, and other fossil fuels.

The cap and trade program defines a compliance obligation for Ontario's natural gas distribution utilities to include:

- Facility-related obligations for facilities owned or operated by the utilities; and,
- Customer-related obligations for natural gas-fired generators, and residential, commercial and industrial customers who are not independently covered under the cap and trade program (i.e., that are not Large Final Emitters (LFEs) or voluntary participants).

The utilities' compliance obligations will require that they undertake cap and trade activities. The associated costs will need to be recovered from customers. Charged with regulating Ontario's natural gas and electricity sectors, including natural gas utility rates, the Ontario Energy Board (OEB) thus has a new role in assessing the cost consequences of the utilities' cap and trade activities for the purpose of approving cost recovery in rates.

The objective of this study is to provide the OEB with its first 10-year long-term carbon price forecast (LTCPF). The LTCPF is intended to inform the utilities during the development of their compliance plans and to assist the OEB in its evaluation of the cost-effectiveness of utilities' strategies for complying with the cap and trade program.

### Methodology and Assumptions

This report presents the LTCPF for the 2018-2028 period.

Overall, Ontario's cap and trade program design features are aligned with the WCI cap and trade programs already in place in California and Quebec. This alignment was intentional, as Ontario is expected to link with the WCI cap and trade market in 2018.

In developing the LTCPF, ICF used the floor price and ceiling price formulae as laid out in Ontario's Cap and Trade Regulation to develop minimum and maximum carbon price forecasts,<sup>1</sup> and then develop a mid-range trajectory in between. The mid-range forecast was developed drawing on ICF's knowledge of the WCI, Ontario's cap and trade program, and additional modeling and analyses.

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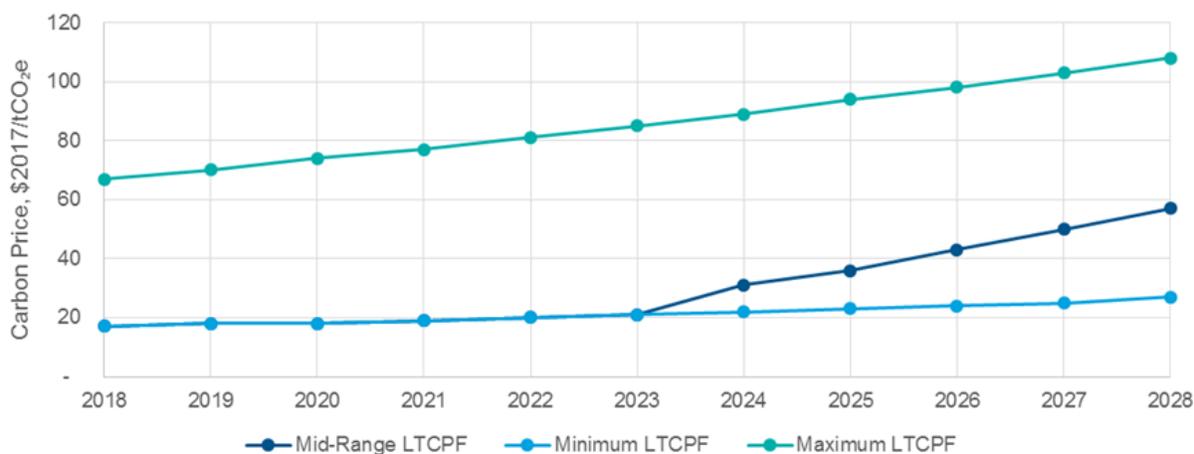
<sup>1</sup> Floor and ceiling price trajectories were used to account for current policy uncertainty associated with Ontario joining WCI and post-2020 program design, particularly in California.

## Summary of LTCPF Scenario Assumptions and Results

<b>Methodology &amp; Assumptions – all scenarios</b>	<ul style="list-style-type: none"> <li>No major changes to existing WCI-based rules Ontario, California or Quebec</li> <li>Ontario's cap and trade program will be deemed to meet the requirements of the federal carbon-pricing benchmark</li> <li>Exchange rate of 85 cents US to 1 dollar Canadian and inflation rate of 2.0% across all years, based on the Ontario Ministry of Finance's Long-Term Report on the Economy, Feb 2017 (Projections 2016-2040), note exception for minimum LTCPF which is set using California's floor price</li> </ul>		
<b>Methodology &amp; Assumptions – by scenario</b>	<b>Minimum LTCPF</b>	<b>Maximum LTCPF</b>	<b>Mid-Range LTCPF</b>
	<ul style="list-style-type: none"> <li>Ontario links with the joint WCI market in 2018</li> <li>Joint market allowance supply/demand stays in cumulative surplus through 2028</li> <li>Price follows the floor price as defined in Ontario Regulation</li> <li>California's floor price sets the joint WCI floor price as it is assumed to be higher than Quebec's, therefore California inflation rate of 1.8% used across all years</li> </ul>	<ul style="list-style-type: none"> <li>Ontario does not link with the joint WCI market</li> <li>Price is the highest price tier of allowances reserved for sale from the Cost Containment Reserve (CCR) as defined in Ontario Regulation</li> <li>Government would intervene to modify the design of the cap and trade program to hold the price of allowances at the top tier CCR price in order to avoid price shock or market failure</li> </ul>	<ul style="list-style-type: none"> <li>Ontario links with the joint WCI market in 2018</li> <li>Reflects carbon market under current outlook for complementary policies and economic growth and under existing market rules</li> <li>The California-Quebec joint market will see surplus to 2020, and will enter cumulative shortage in the mid-2020s under current market rules</li> <li>Ontario will join WCI with a shortage of allowances, which will cause the joint market to enter shortage sooner</li> </ul>
<b>Qualitative Results</b>	Price follows common auction reserve price (floor price), which grows annually at 5% plus inflation	Price follows top tier CCR, which grows annually at 5% plus inflation	Price follows the common auction reserve price (floor price) until 2024, at which point the joint WCI market is forecast to move from a long market (more than enough allowances available to cover emissions) to a short market (not enough allowances available to cover emissions)
<b>Quantitative Results (2017 Real CAD)</b>	2018: \$17/tonne 2020: \$18/tonne 2028: \$27/tonne	2018: \$67/tonne 2020: \$74/tonne 2028: \$108/tonne	2018: \$17/tonne 2020: \$18/tonne 2028: \$57/tonne

## LTCPF Results

Ontario Carbon Price Forecast Scenarios (Graph) Expressed in Real 2017 CAD \$/tCO<sub>2e</sub>



Ontario Carbon Price Forecast Scenario Results Expressed in Real 2017 CAD \$/tCO<sub>2e</sub>

	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028
<b>Mid-Range LTCPF</b>	17	18	18	19	20	21	31	36	43	50	57
<b>Minimum LTCPF</b>	17	18	18	19	20	21	22	23	24	25	27
<b>Maximum LTCPF</b>	67	70	74	77	81	85	89	94	98	103	108

Ontario Carbon Price Forecast Scenario Results Expressed in Real 2017 CAD \$/m<sup>3</sup>

	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028
<b>Mid-Range LTCPF</b>	0.032	0.034	0.034	0.036	0.037	0.039	0.058	0.067	0.081	0.09	0.11
<b>Minimum LTCPF</b>	0.032	0.034	0.034	0.036	0.037	0.039	0.041	0.043	0.045	0.047	0.051
<b>Maximum LTCPF</b>	0.13	0.13	0.14	0.14	0.15	0.16	0.17	0.18	0.18	0.19	0.20

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## 1. Introduction

### 1.1 Background

Ontario's cap and trade program is a regulatory instrument aimed at meeting the provincial government's greenhouse gas (GHG) emissions reduction targets. Beginning in January 2017, the cap and trade program and resulting price on carbon will impact the price end users pay for transportation fuels, natural gas, and other fossil fuels.

Ontario's cap and trade program is based on the cap and trade program design of the Western Climate Initiative (WCI).<sup>2</sup> The government of Ontario has signaled its intention to link with the WCI Partner jurisdictions' (i.e., California and Quebec) joint cap and trade market in 2018.

The cap and trade program defines a compliance obligation for Ontario's natural gas distributors, including Union Gas Limited ("Union Gas"), Enbridge Gas Distribution Inc. ("Enbridge Gas Distribution") and Natural Resource Gas Ltd., collectively referred to as the "utilities". The utilities' compliance obligation includes:

- Facility-related obligations for facilities owned or operated by the utilities; and,
- Customer-related obligations for natural gas-fired generators, and residential, commercial and industrial customers who are not independently covered under the cap and trade program (i.e., that are not Large Final Emitters (LFEs) or voluntary participants).

The utilities' compliance obligations will require that they undertake cap and trade activities. The associated costs will need to be recovered from customers. Charged with regulating Ontario's natural gas and electricity sectors, including natural gas utility rates, the Ontario Energy Board (OEB) thus has a new role in assessing the cost consequences of the utilities' cap and trade activities for the purpose of approving cost recovery in rates.

The OEB issued a Regulatory Framework for the Assessment of Costs of Natural Gas Utilities' Cap and Trade Activities (the "Regulatory Framework") on September 26, 2016. The Regulatory Framework describes the OEB's expectation for each utility to develop cap and trade Compliance Plans that include robust information regarding compliance strategies. The Regulatory Framework also outlined the OEB's approach for assessing the cost consequences of proposed cap and trade activities. In the Regulatory Framework, the OEB indicated it will provide a long-term carbon price forecast (LTCPF) for the purpose of undertaking assessment of longer term costs.

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<sup>2</sup> The WCI is a group of American states and Canadian provinces that decided to adopt a common approach toward addressing climate change, in particular by developing and implementing a program for capping and trading GHG emissions. Currently, two jurisdictions (California and Quebec) have a functional joint WCI market created by linking their cap and trade programs. For more information, see <http://www.mddelcc.gouv.qc.ca/changements/carbone/WCI-en.htm>

## 1.2 Study Scope and Objectives

The objective of this study is to provide the OEB with its first 10-year LTCPF (2018-2028). The LTCPF is intended to be used to inform the utilities during the development of their compliance plans and to assist the OEB in its evaluation of the cost-effectiveness of utilities' strategies for complying with the cap and trade program. The LTCPF will be updated annually and issued in May.

In developing the LTCPF, ICF used the floor price and ceiling price formulae as laid out in Ontario's Cap and Trade Regulation to develop minimum and maximum carbon price forecasts,<sup>3</sup> and then develop a mid-range trajectory in between. The mid-range forecast was developed drawing on ICF's knowledge of the WCI, Ontario's cap and trade program, and additional modeling and analyses.

The approach and methodology is explained in more detail in Section 3, Methodology, Data, and Assumptions.

## 1.3 Report Organization

This report presents the LTCPF for the 2018-2028 period. It is organized into the next four sections as follows:

- Section 2 provides context for the study and a description of key factors affecting the price of carbon going forward, including a description of Ontario's cap and trade program and the WCI market.
- Section 3 presents the methodology, data, and assumptions used by ICF to develop the LTCPF minimum, maximum, and mid-range scenarios.
- Section 4 presents the LTCPF scenario results and includes a comparison of assumptions across the forecasts.
- Appendix A provides additional background information on various topics addressed throughout the report.

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<sup>3</sup> Floor and ceiling price trajectories were used to account for current policy uncertainty associated with Ontario joining WCI and post-2020 program design, particularly in California.

## 2. Key Factors Affecting the Price of Carbon

The price of carbon will be determined by Ontario's cap and trade program as well as the cap and trade programs of WCI Partner jurisdictions. This section provides an overview of these programs including key market design features.

### 2.1 Overview of Cap and Trade

There are a variety of policy mechanisms available to regulators to address climate change and carbon emissions, including carbon pricing programs such as cap and trade and carbon taxation. Cap and trade is a market-based mechanism that establishes a limit, or "cap", on the amount of GHG emissions permitted within a jurisdiction and puts a price on those GHG emissions.

Under a cap and trade program, the government determines who is covered under the program and what the overall GHG emissions caps will be. The government then creates tradable emissions permits, which can be distributed freely or sold to emitters. GHG emitters in a cap and trade program have options. They can reduce their GHG emissions by offering customer-related conservation programs or undertaking projects to reduce their facility-related emissions, or they can purchase permits. Because participants have the ability to trade permits, cap and trade programs create a secondary market where permits can be traded amongst participants.

The carbon price is determined by the market price of permits, which is influenced by supply and demand. The design of the program also affects how the market operates and therefore also influences the price of permits. The greatest influences on the price of permits are the GHG emissions limit set by the government, the availability of permits, and the abatement opportunities available to emitters. The price of carbon can therefore vary significantly.

To provide the basis for the development of the LTCPFs presented in this report, this section examines Ontario's cap and trade program as well as the WCI program, as the government has announced its intent to link to the joint-WCI cap and trade market in 2018.

### 2.2 WCI Regional Cap and Trade Program Overview

In 2007, the WCI began as a collaboration of independent US and Canadian jurisdictions working together to identify, evaluate, and implement emissions trading policies, such as cap and trade, to tackle climate change. Currently, two Partner jurisdictions, California and Quebec, have implemented cap and trade programs and have linked their programs to create the joint WCI market. As mentioned, Ontario has signaled its intent to join this market in 2018.

Under the WCI cap and trade program, each Partner jurisdiction's government establishes its cap which represents that jurisdiction's emissions limit. The cap decreases over time in order to meet emissions reduction targets. Each Partner jurisdiction must have a target that is at least as stringent as the WCI regional emissions reduction target of 15% below 2005 levels by 2020. A new Partner jurisdiction may enter the WCI regional cap and trade program if their emissions reduction target meets this requirement and existing Partner jurisdictions agree to the addition.

This cap is then translated into permits, called “allowances,” which are distributed freely<sup>4</sup> or sold by the government. One allowance is equal to a permit to emit one tonne of GHG emissions (CO<sub>2</sub>e<sup>5</sup>).

In the WCI program, there are no caps for individual emitters. The only requirement is that each covered emitter must acquire enough allowances to equal their total GHG emissions.

Capped emitters across WCI Partner jurisdictions include entities that emit more than 25,000 tonnes CO<sub>2</sub>e per year, as well as electricity generators<sup>6</sup> and fuel suppliers. The WCI scheme establishes three year compliance periods during which emitters must procure enough allowances to match their GHG emissions. At the end of a compliance period, emitters must surrender the allowances to the government.

Joint cap and trade auctions are held quarterly between California and Quebec, and allowances from both jurisdictions are fully tradable for use towards compliance in both California and Quebec.

The WCI cap and trade program also incorporates various market design features as described below.

### 2.2.1 Establishment of Floor and Ceiling Prices

WCI cap and trade programs use floor and ceiling prices designed to stabilize the market.

The WCI Partner jurisdictions set a minimum price, also referred to as the floor price, for the sale of allowances at auctions. The auction floor price is set annually and is based on a 2012 starting price of \$10/tonne CO<sub>2</sub>e (CAD or USD), and escalates annually at 5% plus inflation.<sup>7</sup> The precise floor price methodologies differ slightly between each jurisdiction – descriptions for California and Quebec are provided in Appendix A.

While there is no “hard” ceiling (i.e., no absolute upper limit on the price of an allowance), the WCI program provides for a “soft” price ceiling in the form of a Reserve Account. Each year, a certain percentage of the total amount of allowances created within a jurisdiction’s cap are set

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<sup>4</sup> In both California and Quebec, free allowances are provided to emissions-intensive trade-exposed (EITE) industries that are at risk of carbon leakage to ensure industry and global competitiveness. Although California and Quebec have each selected different methodologies for free distribution, both jurisdictions use free allocation of allowances to lessen the financial burden of cap and trade on some sectors of the economy.

<sup>5</sup> Tonnes CO<sub>2</sub>e (tCO<sub>2</sub>e) refers to metric tonnes of ‘carbon dioxide equivalent’ – a measure of total GHG emissions that is calculated by multiplying the tonnes of each greenhouse gas by its “global warming potential” (GWP) compared to CO<sub>2</sub>. The time period usually used for GWPs is 100 years. For example, methane is a more potent GHG than carbon dioxide, and has a GWP of 21 over 100 years as defined by Ontario’s GHG Reporting Regulation.

<sup>6</sup> First jurisdictional deliverers of electricity, including generators, retail providers and marketers, are covered under WCI.

<sup>7</sup> The rate of inflation is unique to each Partner jurisdiction. The floor price for any given auction is the highest of the Quebec or California price using the current exchange rate. Given the current strength of the USD compared to the CAD, the floor price is expected to be set by California throughout the 2018-2028 period defined as the focus of this LTCPF.

aside and put into the Reserve Account, and are therefore not available at auction. The allowances in the Reserve Account are organized into pre-determined fixed price tiers that are significantly higher than auction prices. If the auction price and/or the market price of allowances approaches or exceeds a Reserve price tier, the jurisdiction's government holds a Reserve sale, which is a separate sale<sup>8</sup> of allowances at pre-determined prices, during which program participants can purchase allowances at that price.

### 2.2.2 Offsets

In addition to allowances, the WCI cap and trade program currently allows emitters to use another type of permit, called an offset credit to cover their GHG emissions. Offset credits are permits created by GHG emissions reduction projects in sectors of activity outside of those subject to cap and trade compliance obligations. For example, an offset credit may be issued for a project to capture methane from a landfill.

In order to ensure that a majority of GHG emissions reductions occur within the sectors that must comply with cap and trade, emitters in the WCI program must limit the use of offset credits to 8% of their total compliance obligation.

Partner jurisdictions develop offset credit protocols that establish offset eligibility rules and GHG calculation methodologies to create compliance-caliber offset credits.

### 2.2.3 Complementary Measures

Complementary measures are emissions reduction activities that are implemented or enabled by government, in addition to the cap and trade program, to assist each jurisdiction in meeting its overall GHG emissions reduction targets. Complementary measures are typically funded at least in part through proceeds from the sale of allowances. For example, a complementary measure could be an investment in infrastructure for electric vehicles.

*See Appendix A for further information.*

## 2.3 Ontario Cap and Trade Program Overview

On May 19, 2016, the government released Ontario Regulation 144/16 *The Cap and Trade Program* (the Cap and Trade Regulation) under the *Climate Change Mitigation and Low-Carbon Economy Act, 2016*. The Cap and Trade Regulation took effect July 1, 2016, and imposes a compliance obligation on over 80% of emissions sources in the province as of January 1, 2017.

Overall, Ontario's cap and trade program design features are aligned with the WCI cap and trade programs already in place in California and Quebec. This alignment was intentional, as Ontario is expected to link with the joint WCI cap and trade market in 2018.

This section identifies key details of Ontario's cap and trade program relevant to developing the LTCPF.

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<sup>8</sup> Reserve sales are not held at the same time as auctions, and are governed by a different set of market rules. Allowances sold in Reserve sales can only be purchased in the jurisdiction holding the sale, i.e. Reserve sales are not joint WCI market sales.

### 2.3.1 GHG Emissions Reduction Targets

Ontario has committed to three provincial GHG emissions reduction targets (caps) which are in line with those set by Quebec and California. As shown in Exhibit 1, the 2020 target is set at 15% below 1990 emissions levels, the 2030 target is set at 37% below 1990 emissions levels, and the 2050 target of 80% below 1990 levels.

Exhibit 1 WCI Partner Jurisdiction Targets

Jurisdiction	1990 (Mt CO <sub>2</sub> e)	Target by 2020	Target by 2030	Target by 2050	2020 (Mt CO <sub>2</sub> e)	2030 (Mt CO <sub>2</sub> e)	2050 (Mt CO <sub>2</sub> e)
Quebec	~84	20% below 1990	37.5% below 1990	80-95% below 1990	~67	~53	~17-4
California	~431	To 1990 levels	40% below 1990	80% below 1990	~431	~259	~86
Ontario	~177	15% below 1990	37% below 1990	80% below 1990	~150	~112	~35

The cap for 2017 aligns with the Ontario Ministry of Environment and Climate Change's (MOECC) forecast of GHG emissions for capped emitters for the year 2017. From 2017 to 2020, the cap declines at a rate that will enable Ontario to achieve its 2020 target. This results in a cap decline of approximately 4.3% per year.

### 2.3.2 Emissions Coverage and Point of Regulation

Ontario's cap and trade program has broad economy coverage to ensure the greatest amount of emissions reductions. Capped emitters include:

- Mandatory participants:
  - Industrial, large commercial, and institutional facilities with emissions exceeding 25,000 tCO<sub>2</sub>e annually,<sup>9</sup> also referred to as Large Final Emitters (LFEs);
  - Fuel distributors (including transportation fuel and other fossil-derived fuels)
  - Natural gas distributors
  - Electricity importers
- Voluntary participants:
  - Facilities with emissions of 10,000 – 25,000 tCO<sub>2</sub>e annually that voluntarily opt-in to the program

Fuel and natural gas distributors are required to purchase allowances on behalf of their customers who are not LFEs or voluntary participants. These customers will pay a consumption-based carbon price charged by distributors.

See Appendix A for further notes.

<sup>9</sup> Includes both combustion emissions and fixed process emissions as described in the Ontario GHG Reporting Regulations and associated Reporting Guidelines

### 2.3.3 Ontario's Floor Price

Aligned with WCI rules, Ontario's cap and trade program sets a minimum price, also referred to as the floor price. The floor price of an allowance at an Ontario auction is set annually, and is the highest of the Quebec floor price or the California floor price converted to Canadian currency based on the current exchange rate.<sup>10</sup>

### 2.3.4 Ontario's Ceiling Price

Similar to WCI Partner jurisdictions, while there is currently no "hard" ceiling price, Ontario's cap and trade program has a "soft" ceiling price established by the Cap and Trade Regulation using a Reserve account, called the Cost Containment Reserve (CCR). As with the WCI Partner jurisdictions, CCR Reserve allowances are sold at three price tiers that are significantly higher than the auction price, that align with WCI, and that escalate by 5% plus inflation<sup>11</sup> each year.

Each year, five percent of the total amount of allowances available in Ontario are set aside and put into the CCR, and are therefore not available at auction. If the auction and/or the market price of allowances approaches or exceeds a CCR price tier, the government holds a Reserve sale during which program participants in Ontario can purchase allowances at the specified tier price.

### 2.3.5 Complementary Measures

In addition to the cap and trade program, the Ontario government has committed to complementary measures to reduce GHG emissions, to be funded through proceeds from the sale of allowances, to help Ontario meet its GHG emissions reduction targets. The government's five-year plan to reinvest cap and trade revenue, called the Climate Change Action Plan (CCAP), was published in June 2016. Ontario's CCAP for 2016 to 2020 outlines up to \$8.3 billion for emissions reduction measures between 2017 and 2020 that are estimated to deliver a total of 9.8 Mt CO<sub>2</sub>e of emissions reductions by 2020. The CCAP describes a list of potential emissions reduction actions in the transportation, buildings, land-use planning, industrial, indigenous communities, research & development, government, agriculture and forestry sectors.

Successfully implemented complementary measures would reduce the province's forecasted emissions, which could exert downward pressure on demand for allowances and prices would decrease accordingly. Likewise, failure to successfully implement complementary measures would have the opposite effect, driving demand for allowances and the carbon price higher.

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<sup>10</sup> Section 71 of the Cap and Trade Regulation

<sup>11</sup> The inflation rate used to calculate the Reserve allowance prices for Ontario was 2% (*Ontario Ministry of Finance, Long-Term Report on the Economy, Table 2.6 Price - Consumer Price Index, February 2017*)

### 3. Methodology, Data and Assumptions

This section describes the methodology, data, analyses and assumptions used to generate the LTCPF based on the WCI and Ontario cap and trade context described in Section 2. Given that there are numerous sources of uncertainty<sup>12</sup> associated with carbon pricing for Ontario, this study takes the approach of defining three carbon price forecasts: a minimum forecast aligned with the cap and trade floor price, a maximum forecast aligned with the ceiling price, and a mid-range forecast. These forecasts draw from knowledge of WCI and Ontario market fundamentals, understanding of the Ontario cap and trade program, and anticipated impact of Ontario's linkage with the joint WCI market.

#### 3.1 Ontario Linkage with the Joint WCI Market

Development of the forecasts includes an understanding of the implications of Ontario's linkage with the WCI market. As previously discussed, Ontario intends to link to WCI in 2018, within Ontario's first compliance period. If linking with California and Quebec is achieved as expected, the joint WCI market carbon price will apply across all Partner jurisdictions, including Ontario, as of 2018.

The Ontario floor price is already defined as equal to the California and Quebec joint auction floor price. The Reserve prices (soft ceiling prices) are jurisdiction specific, but the price methodologies defined in Ontario's regulation align with the other jurisdictions.

In order to forecast what a joint WCI market including Ontario might look like, it is necessary to understand the cumulative allowance surpluses or shortages (rather than only the annual supply/demand balance) that exists in today's joint California and Quebec market. Once this is established, it is then possible to extrapolate the effect of Ontario linking with the joint California and Quebec market.

In this section ICF draws on data and analysis from several studies to understand the implications of Ontario's linkage to the WCI program: ICF internal WCI modelling (3.1.1), EnviroEconomics Modeling Study (3.1.2) and ICF Cap and Trade Supply & Demand Model (3.1.3).

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<sup>12</sup> Sources of uncertainty that affect the LTCPF include:

- Timing and details of Ontario's linkage with joint WCI market (California and Quebec)
- Infancy of Ontario cap and trade program and potential for modification
- Ontario cap and trade program rules not yet defined past 2020
- Lack of clarity regarding Ontario emissions abatement
- Potential for policy changes to cap and trade program in partner jurisdictions (e.g. California could scale back GHG emissions reduction targets or eliminate the use of offsets)
- WCI rule revisions and market changes, including potential addition of other partner jurisdictions
- Factors impacting emissions profile of Partner jurisdictions, including economic growth, availability and price of abatement options and policy measures

### 3.1.1 ICF Internal WCI Modelling (California/Quebec WCI market)

The supply and demand forecast for the joint WCI California and Quebec market underpinning this study is informed by ICF's internal WCI market modelling and a number of other sources and studies that forecast the California and Quebec joint market will have an annual surplus of allowances to 2020, with annual supply expected to tighten in the mid-2020s. It is important to note that these analyses evaluate the WCI joint market under existing market rules, complementary policies and economic outlook, and assume full auction subscription, including the associated auction revenue to fund the complementary measures.

Based on the assumption that annual demand for allowances at auction in California and Quebec is expected to exceed supply around 2020 or shortly thereafter, an annual shortage is expected in subsequent years. There is still expected to be an overall surplus of allowances available to the market due to the cumulative surplus built up from annual surpluses in the years preceding 2020. This cumulative surplus is expected to keep allowance prices at or near the floor price until it is depleted, at which time the market price is expected to rise higher than the floor price. The cumulative surplus is expected to be depleted in the mid-2020s at which point a cumulative shortage will occur, which will trigger an increase in price off the floor. Conceptually, this corresponds to the point where there are not enough allowances available to cover emissions, so the allowance price rises until it drives enough abatement in the joint market to meet the cap.

*See Appendix A for note regarding unsold California allowances.*

### 3.1.2 EnviroEconomics Modeling Study (Ontario)

In 2015, MOECC commissioned EnviroEconomics to complete a modeling study<sup>13</sup> to analyze the economic implications and competitiveness outcomes of alternative cap and trade design options for Ontario, including a carbon price forecast to 2020.

The EnviroEconomics study found that the Ontario cap and trade program will be short to 2020 (i.e., demand for allowances will outpace supply). The study found that 2.8 Mt of abatement is forecast to occur in Ontario as a direct response to the allowance price. Therefore the forecast of covered emissions is 22.2 Mt higher than the 2020 cap. The study assumed that the 22.2 Mt gap will be met by a combination of offsets, complementary emissions reduction measures, and allowance imports from other WCI jurisdictions. It is important to note that the emissions reductions expected through full deployment of the complementary measures outlined in CCAP would not be enough to meet the 22.2 Mt gap.

The EnviroEconomics study forecasted an allowance price for two scenarios: an Ontario-only cap and trade program under current rules which saw the price for an allowance reach \$157/tonne by 2020; and a scenario in which Ontario links with the joint WCI market. As shown in Exhibit 2, the allowance price forecast scenario for Ontario's linkage to WCI was based on an average of third party WCI forecasts for 2017-2020,<sup>14</sup> and closely follows the floor price.

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<sup>13</sup> Impact Modelling and Analysis of Ontario Cap and Trade Program, presented by Dave Sawyer, EnviroEconomics, on May 17, 2016, commissioned by the Government of Ontario and posted at <http://www.enviroeconomics.org/#!/insight/c19sr>

<sup>14</sup> Prices quoted in Exhibit 3 are in Canadian dollars.

Exhibit 2 EnviroEconomics: Average Allowance Prices from 2017-2020 in a Joint WCI Market (including Ontario)

**Allowance Price: Average of Third-party forecasts\***

	2017	2018	2019	2020
Nominal (~2% inflation)	\$18.09	\$18.10	\$18.82	\$19.86
Real \$2016	\$17.74	\$17.40	\$17.73	\$18.33

\*Assumes Ontario does not substantially impact the WCI allowance price

**3.1.3 ICF Internal Cap and Trade Supply & Demand Model (for Ontario)**

ICF used an in-house provincial cap and trade supply/demand model for Ontario, based on sector-level forecasts and program details of Ontario’s cap and trade program. ICF engaged with current/past clients, the MOECC, and other stakeholders to validate content included within the model. In addition, ICF deployed this model to conduct a provincial GHG abatement potential study with Union Gas and Enbridge Gas Distribution. Through this engagement, the ICF model was calibrated using data and assumptions vetted by the two utilities.

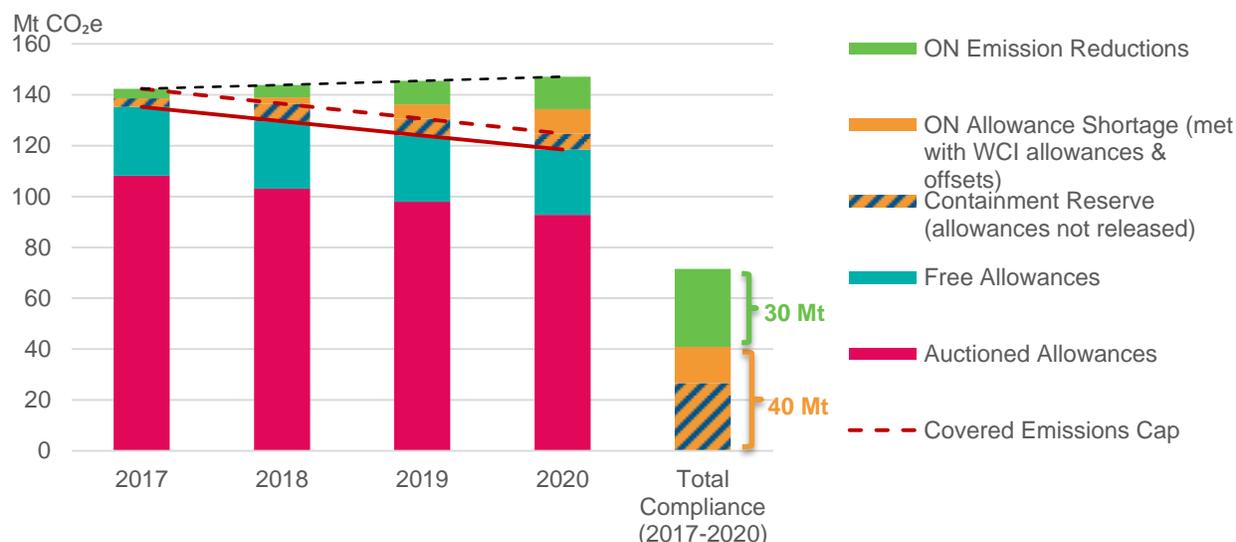
In its model, ICF considered the availability of allowances at auction. For the year 2017, the Ontario government set the provincial cap to equal the expected amount of provincial emissions (142.3 Mt CO<sub>2</sub>e), and created allowances to match that amount. However, as discussed above, 5 percent of total allowances have been set aside and put into Ontario’s Reserve (the CCR). This means that over 7 Mt CO<sub>2</sub>e of allowances will not be available at auctions in 2017, and would only be released from the CCR at prices of \$50-\$60. The government of Ontario also stated that approximately 30 Mt CO<sub>2</sub>e allowances will be distributed freely to qualified participants, leaving approximately 100 Mt CO<sub>2</sub>e of allowances available for auction.

By the end of the first compliance period in Ontario (2017-2020), ICF expects a cumulative compliance gap of around 70 Mt between business-as-usual emissions and available Ontario allowances. Aside from minimal demand response resulting from the cap and trade program, forecast through ICF’s modeling and consistent with the EnviroEconomics study, further abatement may be achieved through complementary measures as presented in the CCAP.<sup>15</sup> Assuming successful implementation of these measures, ICF forecasts a cumulative shortage of approximately 40 Mt CO<sub>2</sub>e by 2030, after available allowances, offset credits, and emissions reductions are accounted for. This results in a compliance gap that would need to be met by allowances and offset credits from WCI partner jurisdictions.

Exhibit 3, presented below, illustrates the forecast for Ontario allowance supply and distribution, alongside expected covered sector emissions.

<sup>15</sup> CCAP complementary measures may include policies/programs to encourage emissions reductions through, for example, low emissions fuels in the transportation sector, electrification of vehicles, reduced consumption of natural gas through energy efficiency, and uptake of renewable natural gas

Exhibit 3 Ontario Covered Emissions and Compliance Forecast<sup>16</sup>



### 3.2 Common Assumptions for all Forecasts

In addition to understanding the implications of Ontario’s linkage with the joint WCI market, development of the LTCPFs involves determining the assumptions upon which the forecasts will be predicated. All three forecasts (maximum, minimum and mid-range) are underpinned by assumptions, some of which are common to all three forecasts.

All three forecasts are based on the assumption that there are no major changes to the existing WCI-based rules within Ontario, California or Quebec (including use of offset credits, limited to 8% of an emitter’s compliance obligation, the caps of the Partner jurisdictions, Reserve account rules, floor price formulae and market rules). All three forecasts also assume that Ontario’s cap and trade program will not be significantly modified, and will be deemed to meet the stringency requirements of the federal carbon-pricing benchmark, and thus the federal Government’s minimum carbon prices<sup>17</sup> will not apply in Ontario.

All forecasts also have a common exchange rate of 85 cents US to 1 dollar Canadian and an inflation rate of 2.0%<sup>18</sup> across all years, based on the Ontario Ministry of Finance’s *Long-Term Report on the Economy*, 8 Feb 2017 (Projections 2016-2040).

### 3.3 Minimum LTCPF Assumptions

The minimum LTCPF tracks the floor price established in the Cap and Trade Regulation. The minimum carbon price forecast is based on the assumption that Ontario links to the joint WCI

<sup>16</sup> Data Sources: MOECC Ontario GHG forecasts; EnviroEconomics modeling commissioned by MOECC; independent ICF analysis

<sup>17</sup> In federal carbon pricing plan, carbon pollution (tCO<sub>2</sub>e) will cost a minimum of \$10 per tonne in 2018 and rise by \$10 a year to reach \$50 per tonne in 2022.

<sup>18</sup> Exception used for minimum LTCPF scenario development, see Section 3.3 for explanation.

market in 2018. For the purposes of this forecast, it is assumed that the current floor price formulae will apply through to 2028.

As discussed in Section 2.2.1, the floor price for a given WCI joint auction is the highest of the Quebec price or the California price converted to CAD using a current exchange rate. The joint auction floor price has been set by the California price for the past couple of years, based on the relative strength of the USD compared to the CAD. To develop the minimum LTCPF, ICF used a California inflation rate of 1.8% across all future years,<sup>19</sup> because ICF assumes the USD will continue to be strong, and therefore California will set the minimum floor price.

Because the California and Quebec joint market has been in a cumulative surplus position to date, the market price has settled at or near the floor price in almost every WCI auction. There are several scenarios under which a joint WCI market including Ontario could continue to remain in a cumulative surplus position until 2028 and thus continue to solve at the floor price. Any major slowdown in economic growth, for example, would reduce demand for allowances, and thus push the date of reaching cumulative shortage further forward, beyond 2028.

Another plausible scenario is one in which California reduces the stringency of its emissions reduction target (i.e., increases its cap) due to sustained US federal and major trade jurisdictions' inaction on carbon pricing policy. This would increase the supply of WCI allowances, which would again extend the period of time during which the joint WCI market is expected to be in a cumulative surplus position, with price settling at or near the floor.

Equally, if constraints governing the use of offset credits under the WCI program were lifted, this could also materially increase supply of compliance instruments. Increased availability of offset credits would likely reduce demand for allowances, which would keep the cost of allowances low.

Alternatively, very successful deployment of complementary measures could lower GHG emissions to the point of reducing demand for allowances.

Overall, the minimum LTCPF reflects a scenario in which Ontario links to the joint WCI market, and the cumulative allowance surplus continues beyond 2028 due to a combination of the above factors. This would cause the allowance price to continue to settle around the floor price to 2028.

### 3.4 Maximum LTCPF Assumptions

There are two basic assumptions underlying the maximum LTCPF. The first assumption is that Ontario does not link to the joint WCI market. The second is that in the event that the price of allowances exceeded the highest price tier of the "soft ceiling" created by the CCR, the government would intervene by holding the price of allowances at the top CCR price tier to prevent market failure and to avoid price shock.

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<sup>19</sup> California inflation rate was based on the 10 year historical average of the metric used to determine California's floor price, the U.S. Bureau of Labor Statistics' Consumer Price Index (All Urban Consumers, U.S. city average, all items, not seasonally adjusted).

The Ontario carbon price would follow an entirely different trajectory for an Ontario-alone market versus a linked WCI market. As discussed, EnviroEconomics' modeling found a 2020 carbon price of \$18/t under a linked WCI program compared to \$157/t for an Ontario-alone market (\$2016 CAD). This is because Ontario is expected to be short of allowances from early in the program if Ontario emitters are unable to buy emissions units (allowances and offset credits) from WCI partner jurisdictions.

For the maximum LTCPF, it is assumed that in an Ontario-only market, where demand exceeds supply early on, the government would intervene to modify the design of the cap and trade program to prevent price shock and market failure. For the purposes of this forecast, it is assumed that the government would not allow the price of allowances to exceed the top price tier of the CCR. In order to hold the price at the CCR price, the government could issue new allowances into the Reserve, could implement a 'hard ceiling price' or could undertake other measures to stabilize the market. For example, California has proposed amendments to address the threat of depletion of its own Allowance Price Containment Reserve that would enable the sale and early use of 'future vintage' allowances.

Note that although the Maximum LTCPF represents the top tier CCR price as the "maximum price", this does not actually represent the highest price an entity might pay for an allowance. Even if the government were to intervene and hold the maximum price at the top tier CCR price, the secondary market price could exceed this price.

### 3.5 Mid-Range LTCPF Scenario Assumptions

The previously described uncertainty regarding long-term carbon market dynamics makes it impractical to define a precise 'expected' long-term forecast. ICF has instead developed a mid-range forecast which reflects a scenario based on the assumptions and data sources described below.

ICF's approach to developing the mid-range long-term carbon price forecast is fundamentally based on the assumption that Ontario will link to the joint WCI market in early 2018. This scenario also assumes:

- No major changes to the existing WCI-based rules, including the offset compliance limit, and that all three participating jurisdictions stay in the joint WCI market;<sup>20</sup>
- No major economic shifts in the participating jurisdictions;
- No new joint WCI market entrants;
- No change in emissions reduction targets to 2030;
- Complementary measures deliver abatement in line with expectations; and
- Minimal reductions from demand response due to relatively inelastic emissions sectors driving compliance demand (as described in Sections 3 and 3.4).

These assumptions are consistent with the data sources and the supply and demand forecasts described in Sections 3.1.1 and 3.1.3.

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<sup>20</sup> This includes the assumption that the 2015 California proposed an amendment about unsold allowances is not approved. See Appendix A for discussion regarding unsold California allowances.

The mid-range forecast draws on the WCI supply/demand scenario view described in Section 3.1.1, which tracks the emissions reduction targets currently in place for California and Quebec under a business-as-usual economic growth demand scenario. This forecast assumes full auction subscription, including the associated auction revenue to fund complementary measures. Although the joint WCI auctions through 2016 and into 2017 have been under-subscribed and the revenue to fund complementary emissions reductions programs has been lower than expected, the mid-range LTCPF has not been adjusted. The issue of under-subscription is expected to cease once Ontario joins the market (at the start of the LTCPF timeframe in 2018).

The current joint WCI market will see an annual shortage of allowances after 2020 and, when the cumulative surplus of banked allowances is depleted, a cumulative shortage will occur in the mid-2020s timeframe which would trigger an increase in price off the floor. ICF combined the supply and demand forecasts described in Section 3.1.1 for California and Quebec and in Section 3.1.3 for Ontario to develop a supply and demand forecast for a joint WCI market including Ontario.

In ICF's forecast the addition of Ontario to the existing joint WCI market will cause the market to move from an annual surplus to an annual shortage of allowances in 2019, with a cumulative shortage starting in the year 2024. The impact of Ontario joining the WCI market in a short position increases the rate at which the joint WCI market eliminates its cumulative surplus of allowances, resulting in the overall cumulative shortage for the joint WCI market, including Ontario, beginning earlier than California and Quebec alone.

The resulting mid-range carbon price forecast is defined by the common auction reserve price (floor price) until 2024, at which point the joint WCI market is forecast to move from a long market (i.e. more than enough allowances available to cover emissions) to a short market (i.e. not enough allowances available to cover emissions).

## 4. Results

Exhibit 4 and Exhibit 5 outline the long-term carbon price forecast in real CAD per tonne CO<sub>2</sub>e over the 2018-2028 study timeframe. The price forecasts are converted into the corresponding long-term carbon price forecast in real CAD per cubic metre of natural gas for illustrative purposes in Exhibit 6.

Exhibit 9 and Exhibit 10 in Appendix A show the long-term carbon price forecast in nominal CAD per tonne CO<sub>2</sub>e over the 2018-2028 study timeframe. Exhibit 11 in Appendix A displays long-term carbon price forecast in nominal CAD per cubic metre of natural gas.

Exhibit 12 in Appendix A presents a comparison of the mid-range LTCPF developed using the flat exchange rate referenced in Section 3.2 (based on the Ontario Ministry of Finance, average for 2016-2040) versus the Ontario Ministry of Finance's exchange rate by year. Using the yearly exchange rate resulted in a higher carbon price of up to \$1.15 at the start of the study timeframe, no impact of the carbon prices in the middle of the study timeframe, and a lower carbon price by \$0.66 at the end of the study timeframe. Since these differences are small, no changes were made to the mid-range forecast based on the flat exchange rate.

Exhibit 4 Ontario Carbon Price Forecast Scenarios (Graph) Expressed in Real 2017 CAD \$/tCO<sub>2</sub>e

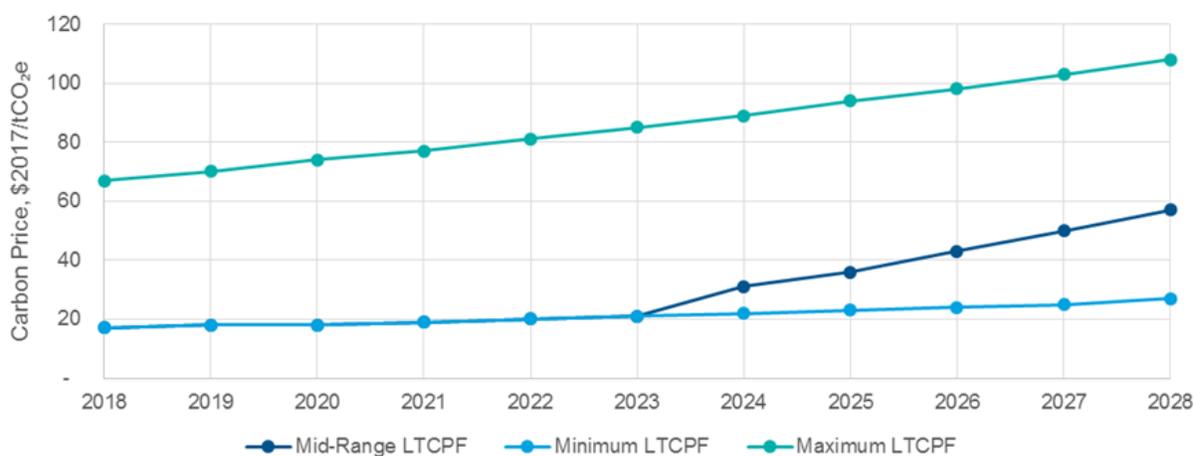


Exhibit 5 Ontario Carbon Price Forecast Scenario Results Expressed in Real 2017 CAD \$/tCO<sub>2</sub>e

	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028
<b>Mid-Range LTCPF</b>	17	18	18	19	20	21	31	36	43	50	57
<b>Minimum LTCPF</b>	17	18	18	19	20	21	22	23	24	25	27
<b>Maximum LTCPF</b>	67	70	74	77	81	85	89	94	98	103	108

Exhibit 6 Ontario Carbon Price Forecast Scenario Results Expressed in Real 2017 CAD \$/m<sup>3</sup>

	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028
<b>Mid-Range LTCPF</b>	0.032	0.034	0.034	0.036	0.037	0.039	0.058	0.067	0.081	0.09	0.11
<b>Minimum LTCPF</b>	0.032	0.034	0.034	0.036	0.037	0.039	0.041	0.043	0.045	0.047	0.051
<b>Maximum LTCPF</b>	0.13	0.13	0.14	0.14	0.15	0.16	0.17	0.18	0.18	0.19	0.20

\* conversion factor from tonne CO<sub>2</sub> to m<sup>3</sup> natural gas: 0.001863 (Table 400-2, Guideline for Greenhouse Gas Emissions Reporting 2015)

These results correspond to the scenario assumptions described in Section 3, which are summarized below in Exhibit 7. As discussed, the results are sensitive to a multitude of sources of uncertainty. A significant number of factors could affect the LTCPF for Ontario from an Ontario-alone unlinked market, to any number of changes to post-2020 cap and trade program rules (e.g., approval of California amendment removing unsold allowances would drive up demand and carbon price, but loosening of the restriction on use of offsets for compliance to greater than 8% would have the opposite effect on allowance prices, by reducing demand and the associated price), to poor success of complementary measures (delivering less reductions than expected thus driving demand for reductions up as well as the corresponding carbon price). The relatively broad deviation between the minimum and maximum scenarios (a factor of >3) reflects the sensitivity of the carbon price to assumptions around these sources of uncertainty.

Exhibit 7 Summary of Scenario Assumptions and Results

<p><b>Methodology &amp; Assumptions – all scenarios</b></p>	<ul style="list-style-type: none"> <li>No major changes to the existing WCI-based rules within Ontario or California and Quebec</li> <li>Ontario's cap and trade program will be deemed to meet the requirements of the federal carbon-pricing benchmark</li> <li>Exchange rate of 85 cents US to 1 dollar Canadian and inflation rate of 2.0% across all years, based on the Ontario Ministry of Finance's Long-Term Report on the Economy, Feb 2017 (Projections 2016-2040), note exception for minimum LTCPF which is set using California's floor price</li> </ul>		
<p><b>Methodology &amp; Assumptions – by scenario</b></p>	<p><b>Minimum LTCPF</b></p> <ul style="list-style-type: none"> <li>Ontario links with the joint WCI market in 2018</li> <li>Joint market allowance supply/demand stays in cumulative surplus through 2028</li> <li>Price follows the floor price as defined in Ontario Regulation</li> <li>California's floor price sets the joint WCI floor price as it is assumed to be higher than Quebec's, therefore California inflation rate of 1.8% used across all years</li> </ul>	<p><b>Maximum LTCPF</b></p> <ul style="list-style-type: none"> <li>Ontario does not link with the joint WCI market</li> <li>Price is the highest price tier of allowances reserved for sale from the Cost Containment Reserve (CCR) as defined in Ontario Regulation</li> <li>Government would intervene to modify the design of the cap and trade program to hold the price of allowances at the top tier CCR price in order to avoid price shock or market failure</li> </ul>	<p><b>Mid-Range LTCPF</b></p> <ul style="list-style-type: none"> <li>Ontario links with the joint WCI market in 2018</li> <li>Reflects carbon market under current outlook for complementary policies and economic growth and under existing market rules</li> <li>The California-Quebec joint market will see surplus to 2020, and will enter cumulative shortage in the mid-2020s under current market rules             <ul style="list-style-type: none"> <li>Ontario will join WCI with a shortage of allowances, which will cause the joint market to enter shortage sooner</li> </ul> </li> </ul>
<p><b>Qualitative Results</b></p>	<p>Price follows common auction reserve price (floor price), which grows annually at 5% plus inflation</p>	<p>Price follows top tier CCR, which grows annually at 5% plus inflation</p>	<p>Price follows the common auction reserve price (floor price) until 2024, at which point the joint WCI market is forecast to move from a long market (more than enough allowances available to cover emissions) to a short market (not enough allowances available to cover emissions)</p>
<p><b>Quantitative Results (2017 Real CAD)</b></p>	<p>2018: \$17/tonne 2020: \$18/tonne 2028: \$27/tonne</p>	<p>2018: \$67/tonne 2020: \$74/tonne 2028: \$108/tonne</p>	<p>2018: \$17/tonne 2020: \$18/tonne 2028: \$57/tonne</p>

## Appendix A.

This Appendix contains further information related to various topics addressed throughout the report. The information is organized by sub-heading and cross-referenced to the main body of the report.

### **Establishment of Floor and Ceiling Price** (Cross-ref [2.2.1](#))

#### *California Regulation:*

*Section 95911 “Auction Reserve Price in U.S. dollars shall be the U.S. dollar Auction Reserve Price for the previous calendar year increased annually by 5 percent plus the rate of inflation as measured by the most recently available twelve months of the Consumer Price Index for All Urban Consumers.” The rate of inflation used to calculate California’s 2017 Auction Reserve Price is 1.64 percent.*

#### *Quebec Regulation:*

*Article 49 of the Quebec Cap-and-Trade Regulation stipulates that “The minimum price of the emission units is set at:*

*(1) \$10 per emission unit, for auctions conducted in 2012;*

*(2) for auctions conducted in any year after 2012, the price set in subparagraph 1 increased annually by 5 percent and adjusted in the manner provided for in section 83.3 of the Financial Administration Act (chapter A-6.001).” (section 83.3: “Fees are adjusted by operation of law on 1 January of each year by a rate corresponding to the annual change in the overall average Quebec consumer price index without alcoholic beverages and tobacco products for the 12-month period ending on 30 September of the year preceding the year for which the fee is to be adjusted. The Minister publishes the rate without delay on the Minister’s website and in the Gazette officielle du Quebec.”)*

### **Complementary Measures** (cross-ref to [2.2.3](#))

California’s cap and trade program is part of AB32, The California Global Warming Solutions Act of 2006. In addition to market-based approaches (i.e. cap and trade), the AB32 Scoping Plan and Update describes strategies, including regulations, voluntary measures, policies, and other emissions reduction programs. These complementary measures are intended to help California meet its state-wide GHG emissions reduction target. California State-owned allowance proceeds are deposited into the Greenhouse Gas Reduction Fund (GGRF) and available for appropriation to support State GHG emissions reduction goals. For 2014-2015, \$832 million was appropriated from GGRF to State agencies and programs.

Quebec developed the 2013-2020 Climate Change Action Plan (2013-2020 CCAP) to address climate change. One of the priorities in the plan is the cap and trade program. The other initiatives can be considered complementary measures that will help Quebec meet its provincial GHG emissions reduction target. Quebec’s proceeds from the quarterly auctions are paid to the

Green Fund (Fonds vert) and reinvested in full for the implementation of the Climate Change Action Plan. As of February 22, 2017, \$1.46 billion had been paid to the Green Fund.

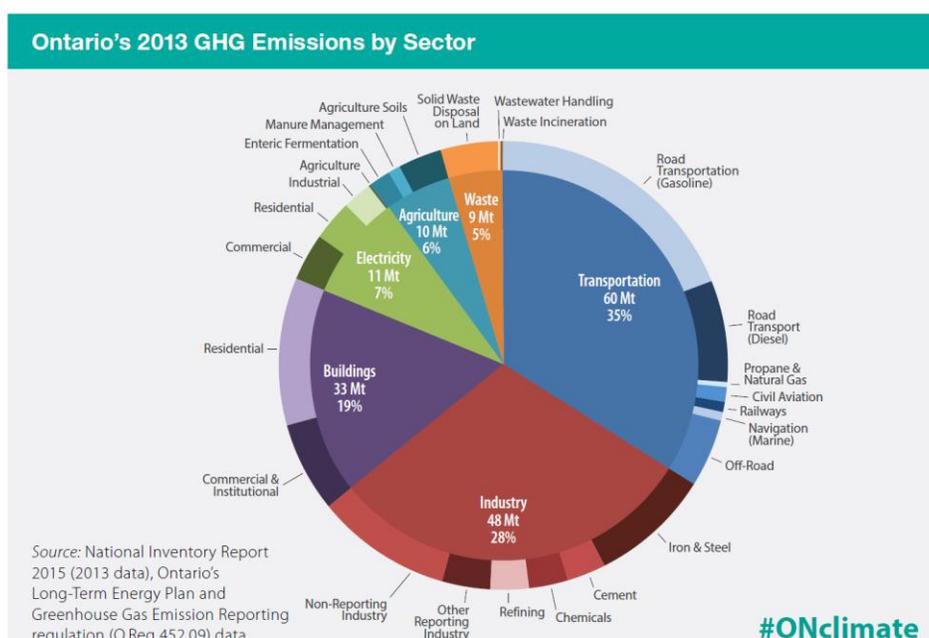
### Ontario Cap and Trade Targets (cross-ref to 2.3.1)

In 2007 Ontario set a GHG emission reduction goal of 6% below 1990 levels by 2014. This goal was achieved through a variety of policy measures including the closure of Ontario's coal fired electricity generating stations, increased renewable energy through the Green Energy Plan, and smart growth planning. As a result, the electricity sector in Ontario has already significantly lowered its carbon intensity relative to the baseline year (1990).

### Emissions Coverage and Point of Regulation (cross-ref to 2.3.2)

Exhibit 8 illustrates Ontario's GHG emissions profile – the cap covers over 80% of Ontario's emissions. The largest 'uncovered' sectors are agriculture, forestry and waste. Other uncovered emissions include a portion of the non-reporting industry category.

Exhibit 8 Ontario's 2013 GHG Emissions Profile<sup>21</sup>



Program participants in Ontario will include more than 100 large industrial emitters, who will be required to have allowances to match their GHG emissions at the end of the compliance period. At present, most large industrial emitters will receive free allocated allowances. However, the natural gas utilities and fuel distributors (Suncor/PetroCanada, ESSO/Imperial, Shell, etc.) will not receive free allowances and will need to procure these at government auctions and/or in the secondary market.

<sup>21</sup> Ontario's Climate Change Strategy 2015, Ministry of the Environment and Climate Change. National Inventory Report 2014 (2013 data); O.Reg. 452.09 data

Natural gas and transport fuel usage dominate Ontario's emissions profile, and are forecast to represent over 95% of Ontario allowance purchases in the first compliance period due to free allocation of allowances to all large final emitters covered under the program.

**Note Regarding Unsold California Allowances** (cross-ref to 3.1.1)

During 2016, the joint WCI auctions were undersubscribed and only 58% of allowances put up for auction were sold. This was primarily attributed to uncertainty created by legal and political proceedings, including a lack of certainty that the California cap and trade program will continue post-2020. Under current market rules, this would be unlikely to have a long-term impact on the supply/demand balance, because unsold allowances are eventually returned to the market once demand picks up. Specifically, unsold allowances are made available in the next current auction following two consecutive fully subscribed auctions, in an amount up to 25% of the total allowances auctioned in any individual auction.

In 2015 California proposed an amendment which would transfer unsold allowances into the allowance price containment reserve (APCR) after 24 months – as a result, these unsold allowances would be permanently removed from market supply unless/until they are accessed through Reserve sales at the ceiling price. ICF's base case scenario does *not* assume that this amendment comes into effect because it has been close to two years, and it is still only 'a proposal'. If the amendment were adopted by California, and it applied retrospectively to unsold allowances from pre-2020 auctions, the current cumulative surplus of the joint California-Quebec market would be substantially reduced. As a result, price would rise off the floor sooner than in this base case forecast. However, the impact of this specific change would not cause ICF's estimate of the base case price scenario to reach the ceiling by 2028, all other things equal.

**Results Expressed in Nominal CAD**

Exhibit 9 Ontario Carbon Price Forecast Scenarios (Graph) Expressed in Nominal CAD \$/tCO<sub>2</sub>e

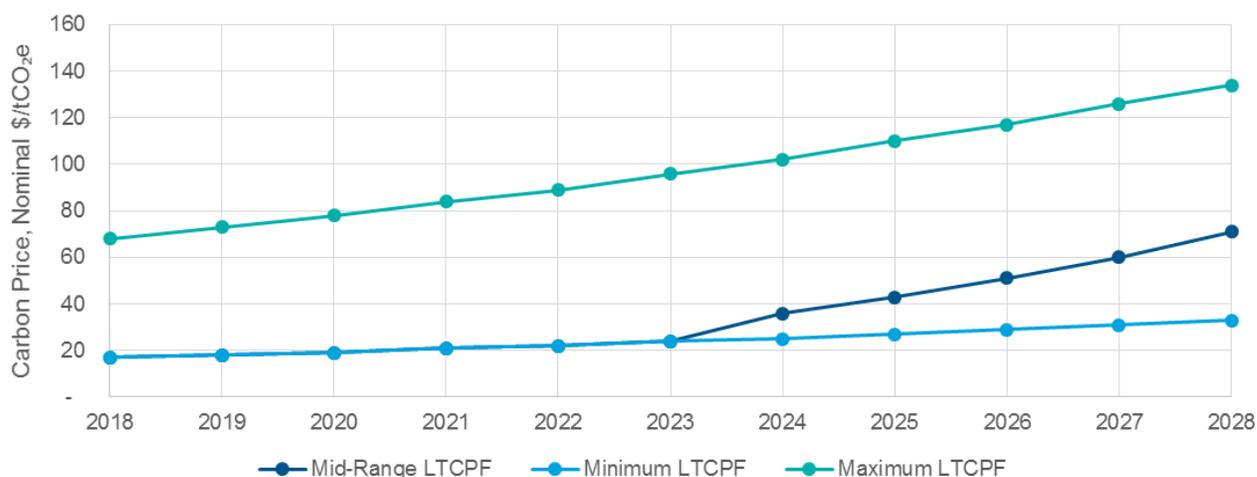


Exhibit 10 Ontario Carbon Price Forecast Scenario Results Expressed in Nominal CAD \$/tCO<sub>2</sub>e

	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028
<b>Mid-Range LTCPF</b>	17	18	19	21	22	24	36	43	51	60	71
<b>Minimum LTCPF</b>	17	18	19	21	22	24	25	27	29	31	33
<b>Maximum LTCPF</b>	68	73	78	84	89	96	102	110	117	126	134

Exhibit 11 Ontario Carbon Price Forecast Scenario Results Expressed in Nominal CAD \$/m<sup>3</sup>

	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028
<b>Mid-Range LTCPF</b>	0.032	0.034	0.036	0.039	0.041	0.045	0.067	0.08	0.10	0.11	0.13
<b>Minimum LTCPF</b>	0.032	0.034	0.036	0.039	0.041	0.045	0.047	0.051	0.054	0.058	0.062
<b>Maximum LTCPF</b>	0.13	0.14	0.15	0.16	0.17	0.18	0.19	0.21	0.22	0.24	0.25

\* conversion factor from tonne CO<sub>2</sub> to m<sup>3</sup> natural gas: 0.001863 (Table 400-2, Guideline for Greenhouse Gas Emissions Reporting 2015)

Exhibit 12 Comparison of Ontario Mid-Range LTCPF Using Two Ontario Ministry of Finance Exchange Rates (Expressed in Real 2017 CAD \$/tCO<sub>2</sub>e)

	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028
<b>MoF Exchange Rate, using simple average</b>	0.85	0.85	0.85	0.85	0.85	0.85	0.85	0.85	0.85	0.85	0.85
<b>Mid-Range LTCPF</b>	17	18	18	19	20	21	31	36	43	50	57
<b>MoF Exchange Rate, by vintage (alternate exch. rate)</b>	0.80	0.80	0.80	0.85	0.85	0.85	0.85	0.85	0.86	0.86	0.86
<b>Mid-Range LTCPF (based on alternate exchange rate)</b>	18	19	19	19	20	21	31	36	42	49	56
<b>Difference Based on Alternate Exchange Rate (Real 2017 CAD \$/tCO<sub>2</sub>e)</b>	1.05	1.09	1.15	-	-	-	-	-	(0.50)	(0.58)	(0.66)
<b>Difference Based on Alternate Exchange Rate (%)</b>	6.2%	6.2%	6.2%	0.0%	0.0%	0.0%	0.0%	0.0%	-1.2%	-1.2%	-1.2%