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Carbon Pricing on the Electricity Grid

Prepared for Toronto Association of Business and Economics

March 31, 2021

Overview of Presentation

- What is a wholesale electricity market?
  - How are prices determined in a wholesale electricity market?
  - What are the common features of electricity markets across North America?

- Overview of the Ontario electricity market:
  - What types of resources operate in Ontario?
  - What makes Ontario unique to many other wholesale markets?
  - How will carbon prices impact wholesale electricity prices and investments signals?

- Overview of Alberta's electricity market:
  - What types of resources currently operate in Alberta?
  - What makes Alberta's wholesale market unique to other electricity markets?
  - How will carbon prices impact wholesale electricity prices and investments signals

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1. How Do Electricity Markets Work?

The Basics of the Wholesale Electricity Market

- A wholesale electricity market is a financial settlement process that establishes a price for the quantity of energy required to meet demand
  - Most electricity markets set the price on a 5-minute basis
  - Many jurisdictions do not have 5-minute electricity markets, with demand and supply balanced by a vertically integrated utility (Hydro Quebec and Manitoba Hydro for example)

- A wholesale electricity market "stacks" offers from generators and price-responsive loads until demand can be fully met
  - The stacking of offers is often referred to as the supply, offer or bid stack

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The Basics of the Wholesale Electricity Market

- The price paid by all consumers – known as the Market Clearing Price – is set by the last unit that is economically committed that can provide the next incremental unit of energy
  - This unit is typically referred to as the price-setting or marginal resource

- Once the price-setting unit is determined, all resources that were economically committed receive the Market Clearing Price for their output

- Resources participating in a wholesale electricity market typically offer at their marginal cost – i.e. the cost it takes for them to generate an additional unit of output

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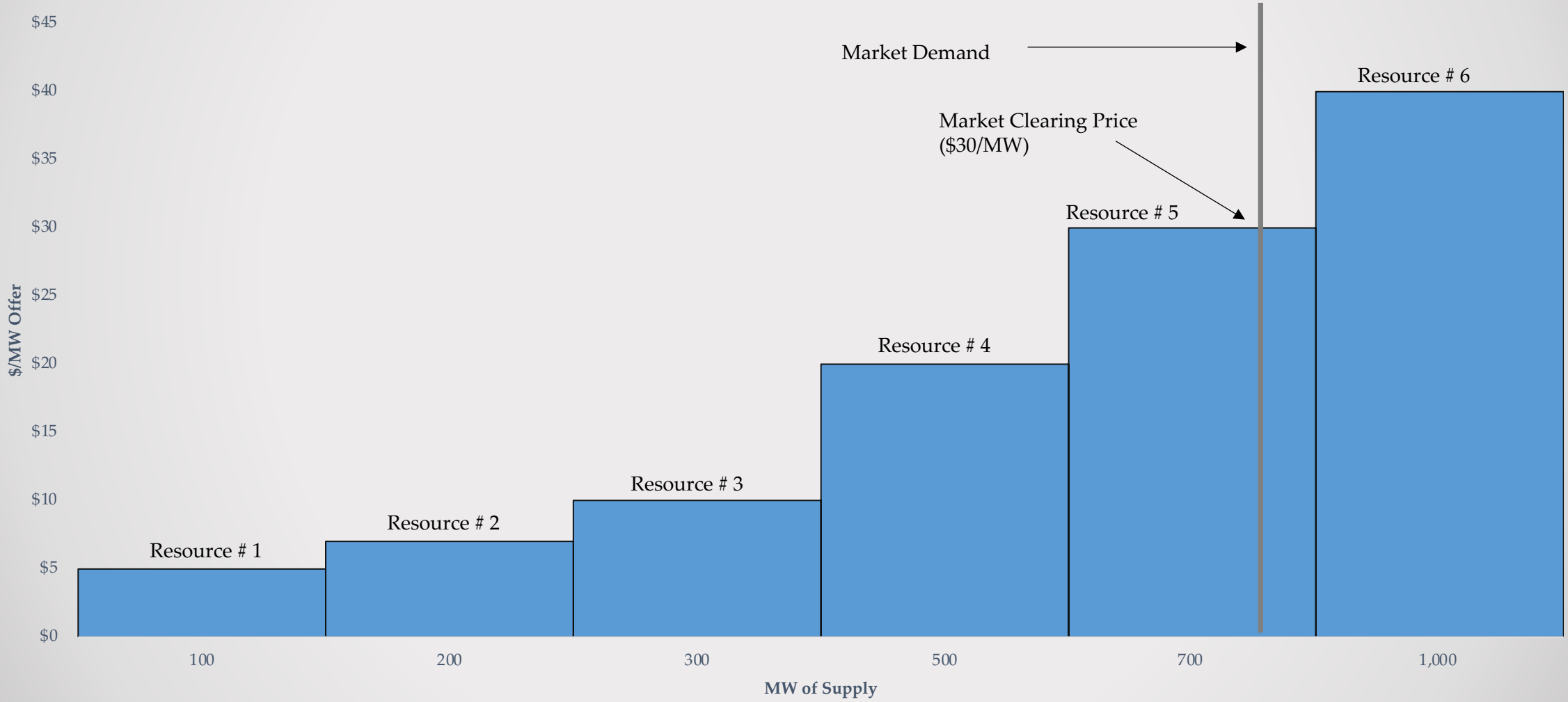
How the Supply Stack Works



Not all Wholesale Markets Are the Same

- Some wholesale energy markets have different material design features
  - "Energy-only" wholesale markets only pay generators when they actually generate electricity
  - "Capacity" markets provide generators with an additional payment to ensure availability during certain hours

Financially binding Day-Ahead Market

- Allow generators and consumers to sell or buy energy a day ahead of actual operation – providing price certainty for both

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Not all Wholesale Markets Are the Same

- Price Scarcity
  - Some markets allow for very high real-time prices to reflect scarcity on the grid
  - Other markets impose an administratively high price when certain reserve thresholds are crossed
  - High prices can solve the "missing money" problem in energy-only markets – allowing generators to recover fixed costs
- Market Power
  - Most electricity markets have market power thresholds, allowing them to administratively cap offers
  - Alberta has a very limited market power framework, allowing for high prices for an extended period of time

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2. A Closer Look at the Ontario Market and Carbon Pricing

Overview of Ontario Market

- Ontario has what is known as a 'hybrid market' structure, with electricity prices derived from three components
  - Wholesale electricity market with 5-minute dispatch and Market Clearing Prices
  - Out-of-market supply contracts many generators
  - Rate-regulated for major nuclear and hydro assets of provincially owned Ontario Power Generation (OPG)
- The difference between wholesale market revenues and those guaranteed in contracts and rate-regulation are made up through what is known as the Global Adjustment (GA)
  - GA costs are recovered differently from small and large-volume consumers

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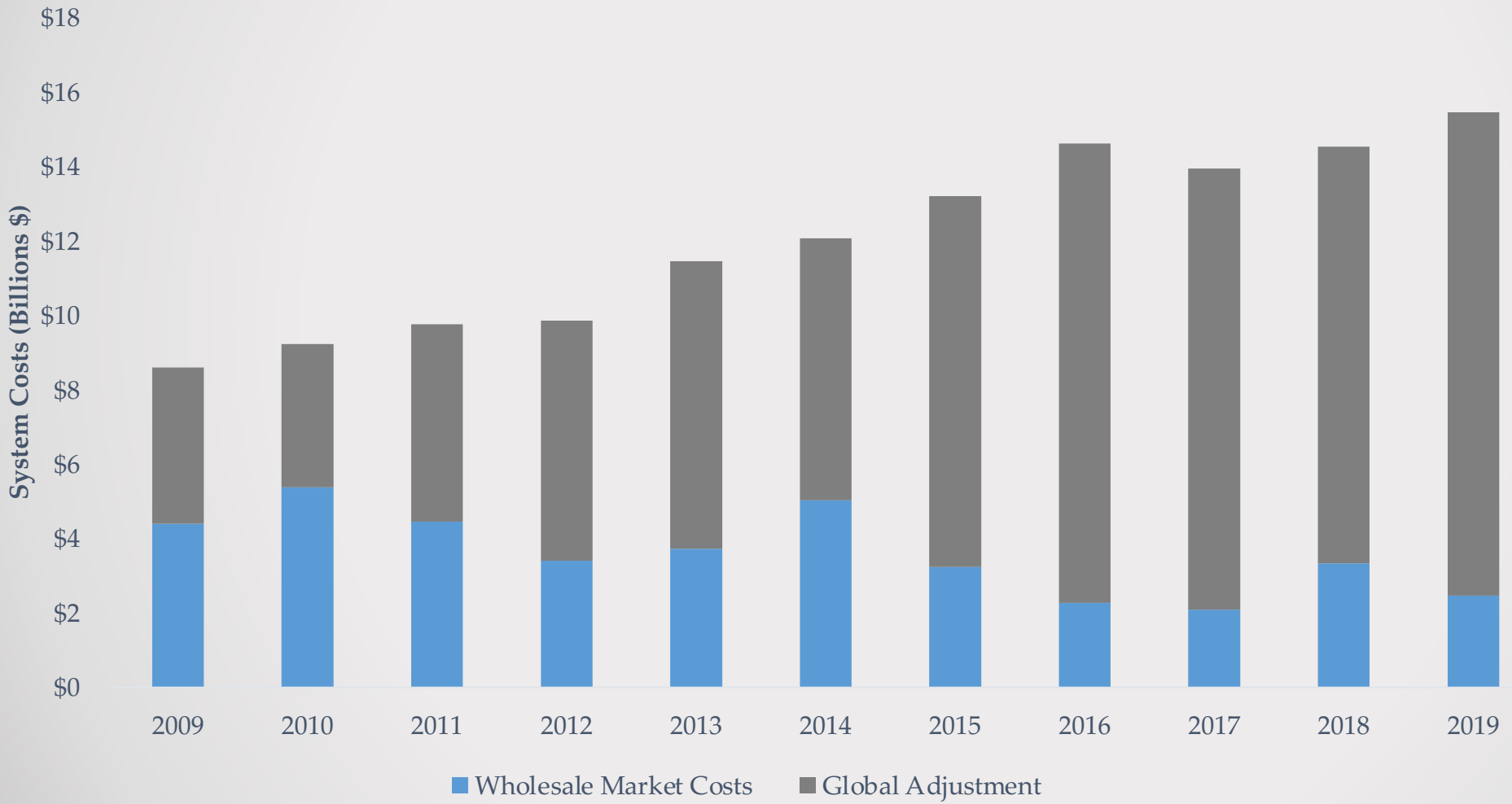
The Ontario Hybrid: Lower Wholesale Prices and Higher Fixed Costs



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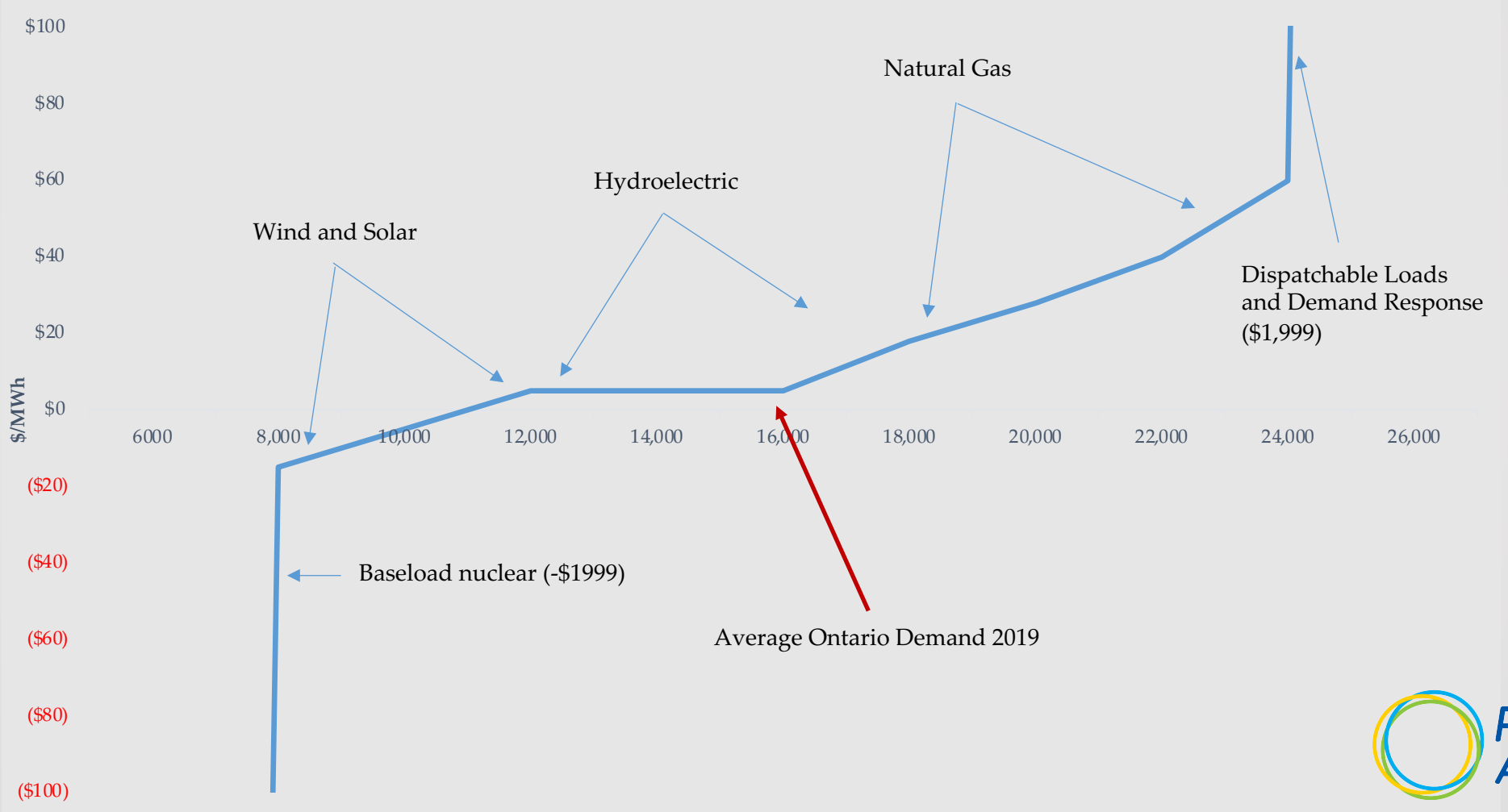
Typical Supply Stack in Ontario



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Ontario Goes Clean

- Ontario has made significant investments in the electricity grid in an effort to reduce GHG emissions
  - Wind and Solar capacity grew from nearly 0 MW in 2005 to more than 5,000 and 2,500 MW in 2020, respectively and retired more than 7,000 MW of coal capacity
  - Non-emitting resources (nuclear, hydro, wind and solar) accounted for 93% of all generation in 2020.
  - Emissions in electricity sector have declined by more than 80% over the last two decades
- Cleaning the electricity grid was not without drawbacks
  - Costs for consumers increased dramatically over the last decade
  - A number of high-cost long-term contracts signed prior to significant cost improvements
  - Out-of-market contracts mitigated the impact of price signals in the wholesale market

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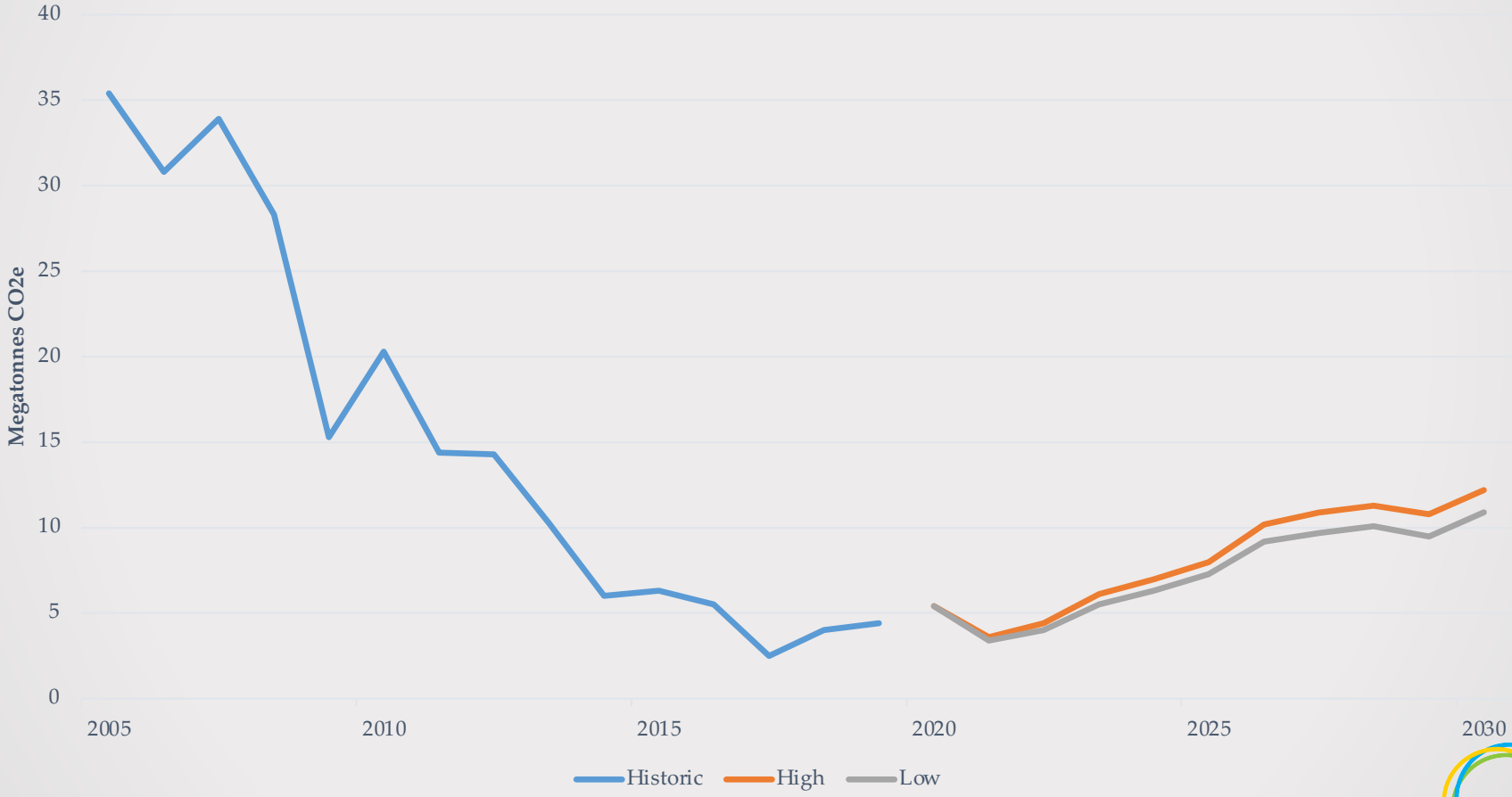
Emissions in Ontario's Grid



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You (Ontario) Can Go Your Own Way

- The Federal government prices carbon through its Output-Based Pricing System (OBPS)
  - OBPS applies a price to emissions at facilities that exceed an pre-established industry benchmark
  - When facilities are below the benchmark, they generate compliance instruments
  - For electricity generators, the federal benchmark is 370 tonnes of carbon per GWh of output and carbon price is $40/tonne with announcement of $170/tonne by 2030
- Ontario introduced its own carbon policy, known as the Emissions Performance Standard (EPS)
  - EPS shares many of the same features of the OBPS
  - Notable difference is the benchmark under EPS is 420 tonnes of carbon per GWh of output
  - The higher threshold results in most gas-fired generators being below the threshold and exempt from carbon pricing impacts (discussed below)

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Ontario Solution Mitigates Impact of Carbon Prices

- The current EPS regime in Ontario largely exempts the entire gas-fired generating fleet carbon price
  - Most generators will not pay a carbon price or pay a fuel charge
  - A typical gas-fired generator with a 30% capacity factor can earn around $2.2 million annually in Environmental Attributes (i.e. credits) when the carbon price is $50/tonne in 2022
- The benchmark for existing generators is expected to remain at 420 tonnes of carbon per GWh of output, though the province has not provided details
  - This provides an incentive to keep existing, less efficient plants in operation
- The benchmark disrupts an economically efficient supply stack by foregoing the cost of carbon in marginal price offers
  - Lessens the opportunity for non-emitting resources to compete in the wholesale market

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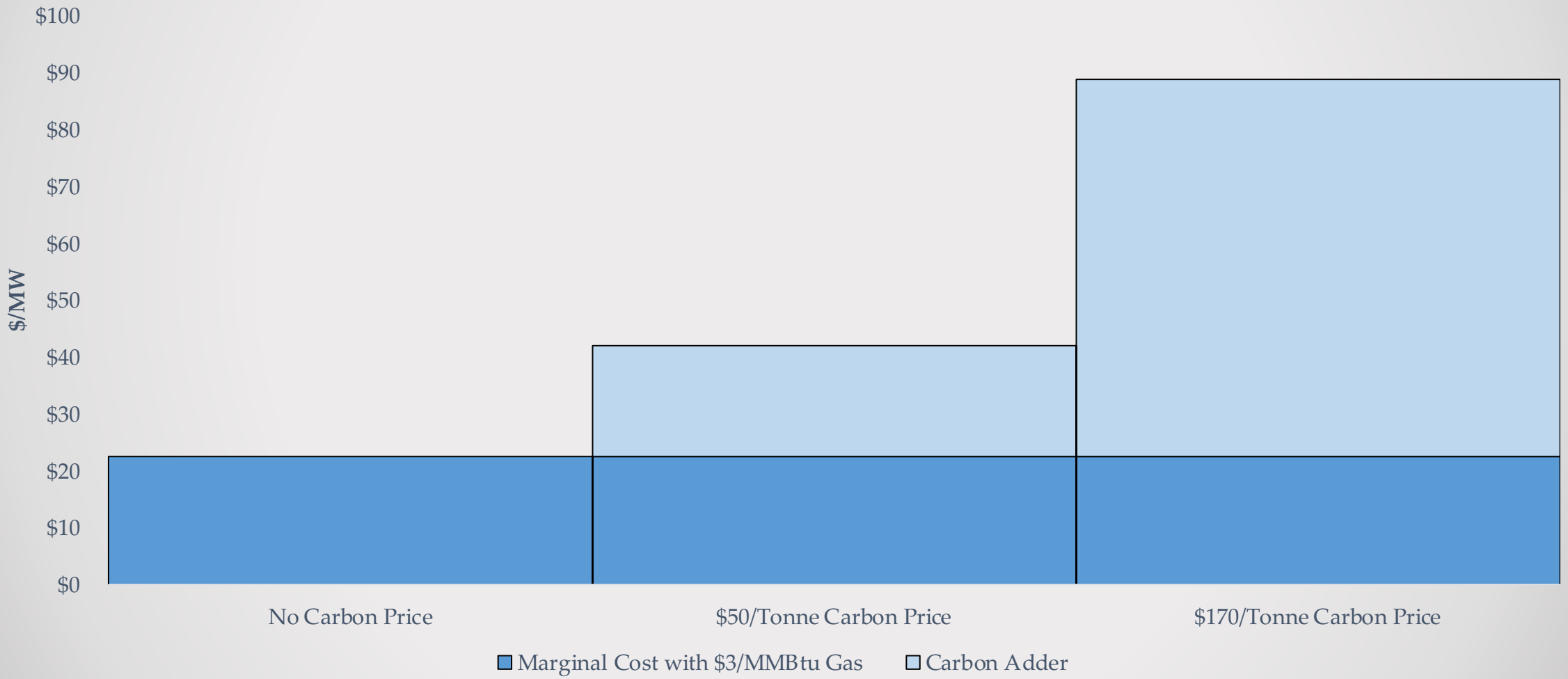
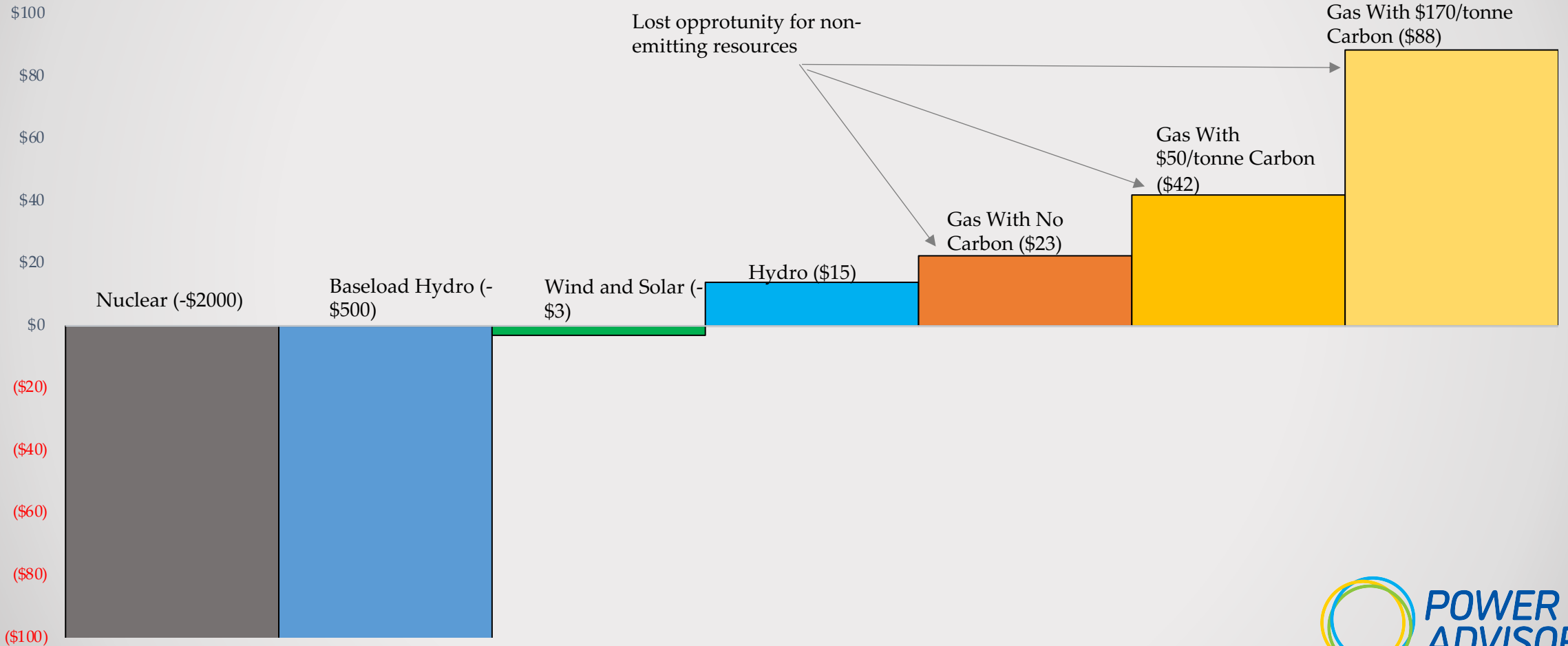
Marginal Offers With and Without a Full Carbon Price



Lack of Robust Carbon Price Distorts Supply Stack



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3. A Closer Look at the Alberta Market and Carbon Pricing

Overview of AB Market

- AB has an 'energy only' market design
  - Relatively rare market design – Australia and ERCOT are the other examples
- No central planning function in AB
  - Generation investments are made purely as a function of price signals – including the carbon tax
  - Entry into the market as a generator is open with few barriers (beyond capital cost and price risk)
- Historically AB has had prices average $60 with high levels of year to year volatility
- There is retail competition with typical prices at the $55/MWh for large industrial customers and $65/MWh for small customers
- Carbon reduction targets are the #1 current issue – AB has a carbon intense grid based on coal and gas
  - Generation mix is rapidly shifting with AB expected to move from 60% of energy from coal in 2017 to 0% of energy from coal in 2023

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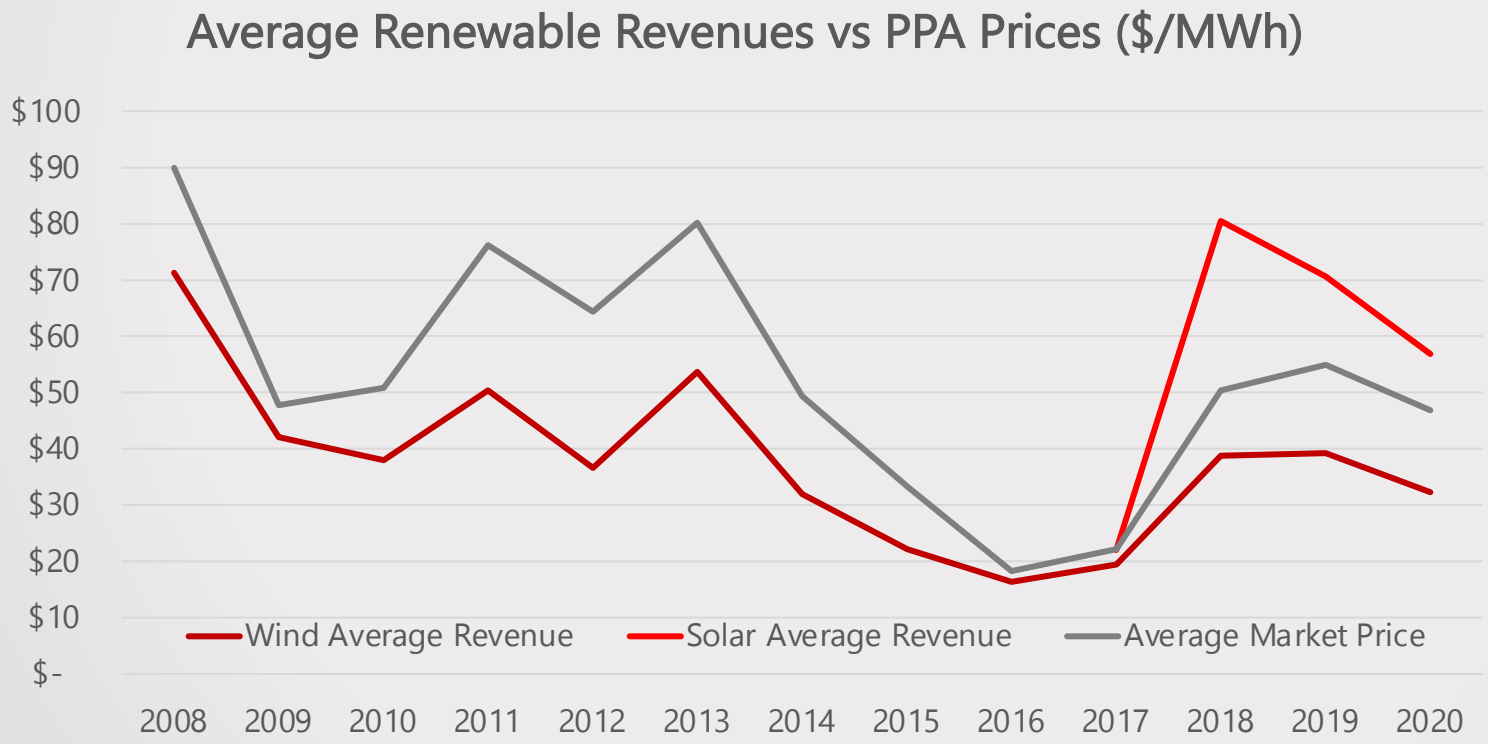
Alberta Historical Prices vs Revenues

- AB electricity GHG emissions were about 50 MT in 2016, 36 MT in 2018 and estimated at 30 MT in 2020
- Simple story – the carbon tax works very effectively in AB electricity to reduce emissions



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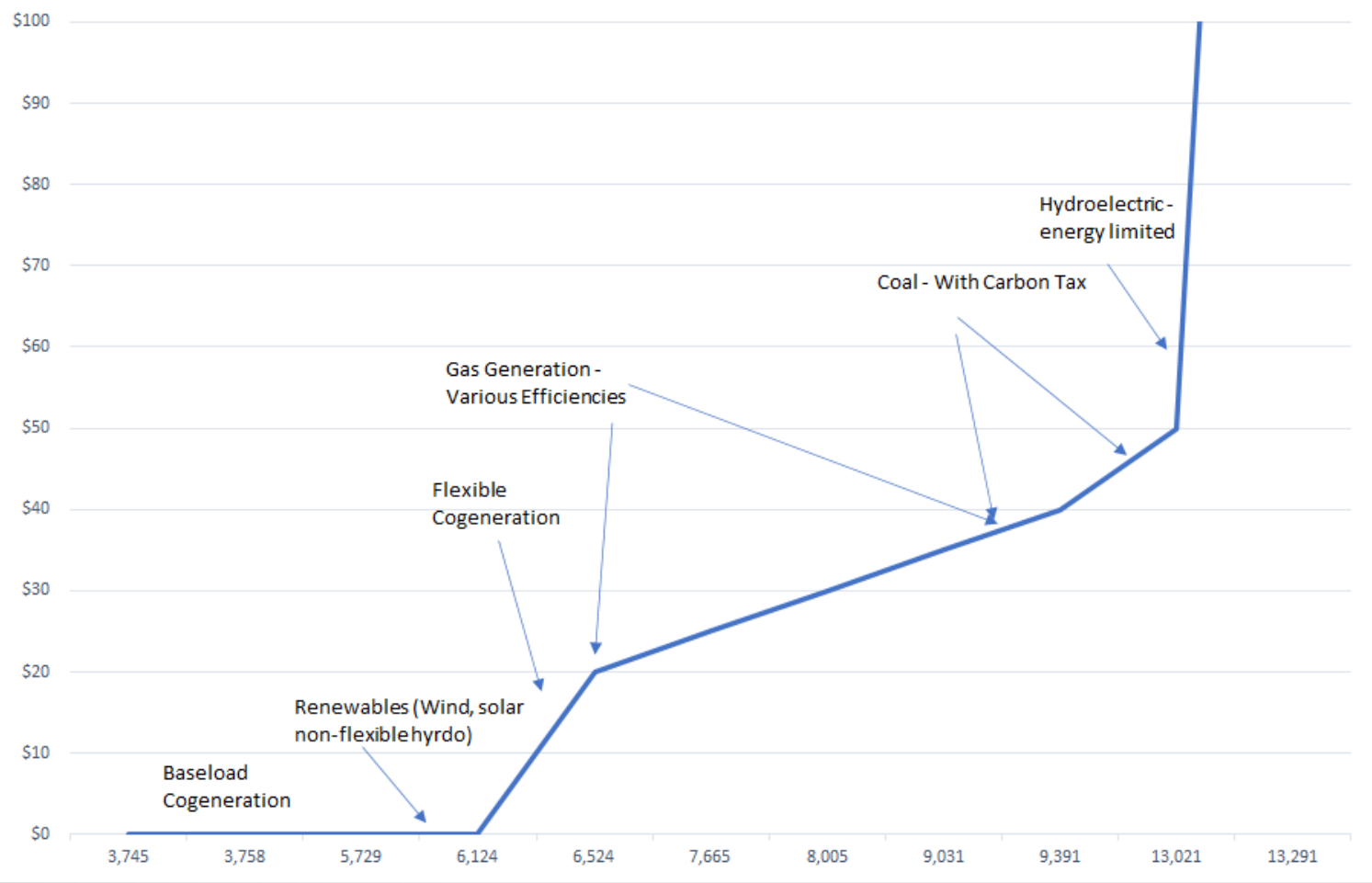
Typical Supply Stack in Alberta



- Carbon tax resulted in coal becoming a high variable cost generator
- Carbon tax incented existing coal plants to switch to natural gas fired and/or repower as more efficient generators
- Renewable investment is incented based on a cost advantage
- Carbon capture and/or firing with hydrogen expected long-term

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Alberta Carbon Emissions

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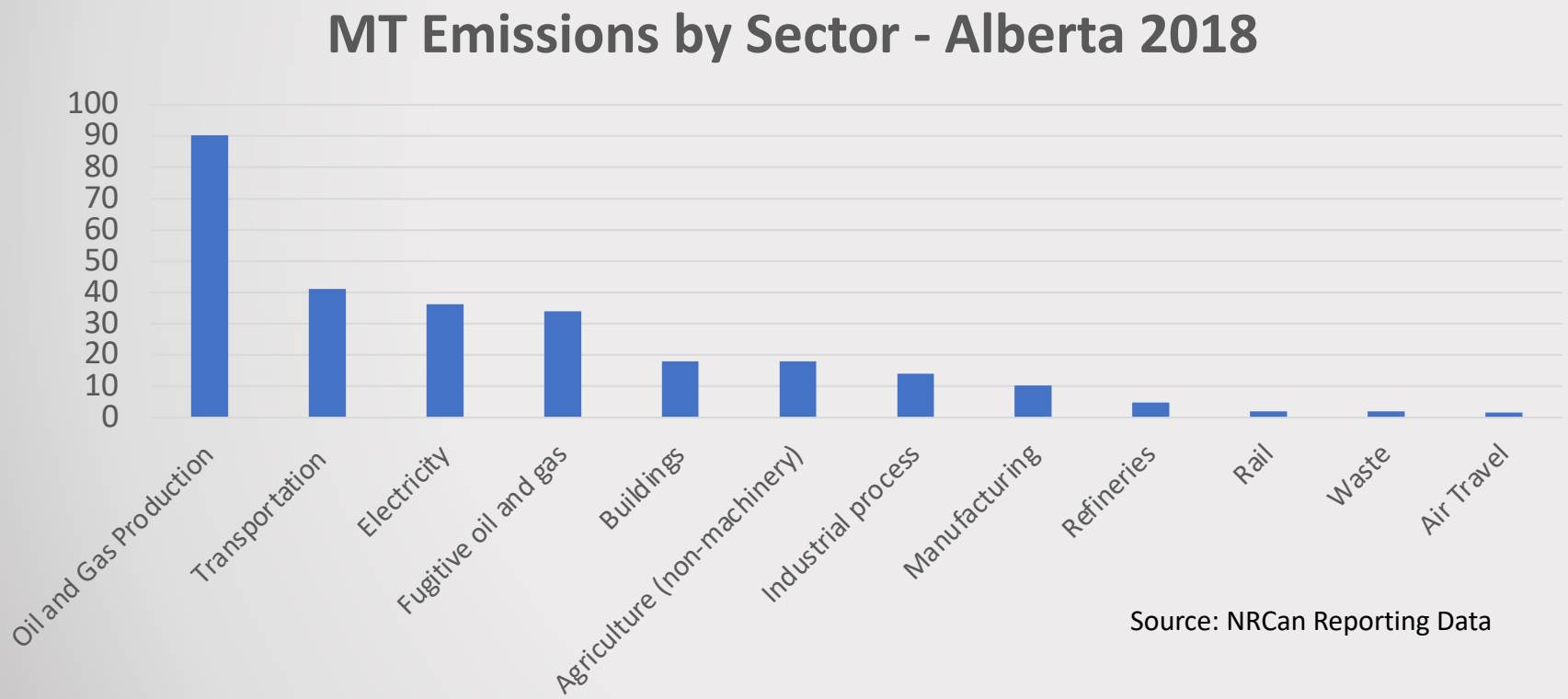

Source: NRCan Reporting Data

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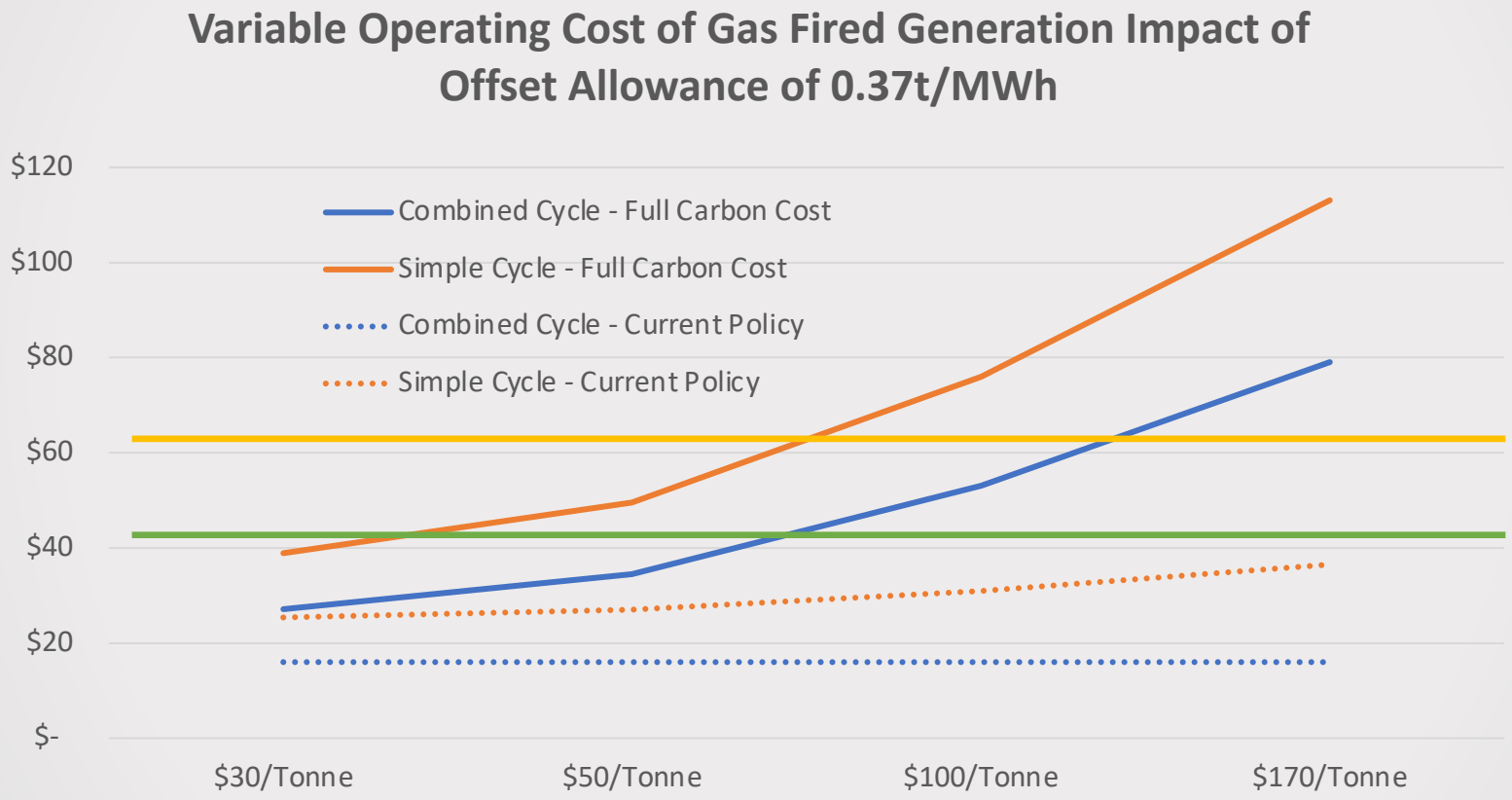
Market Distortion?



Solar average cost

Wind average cost

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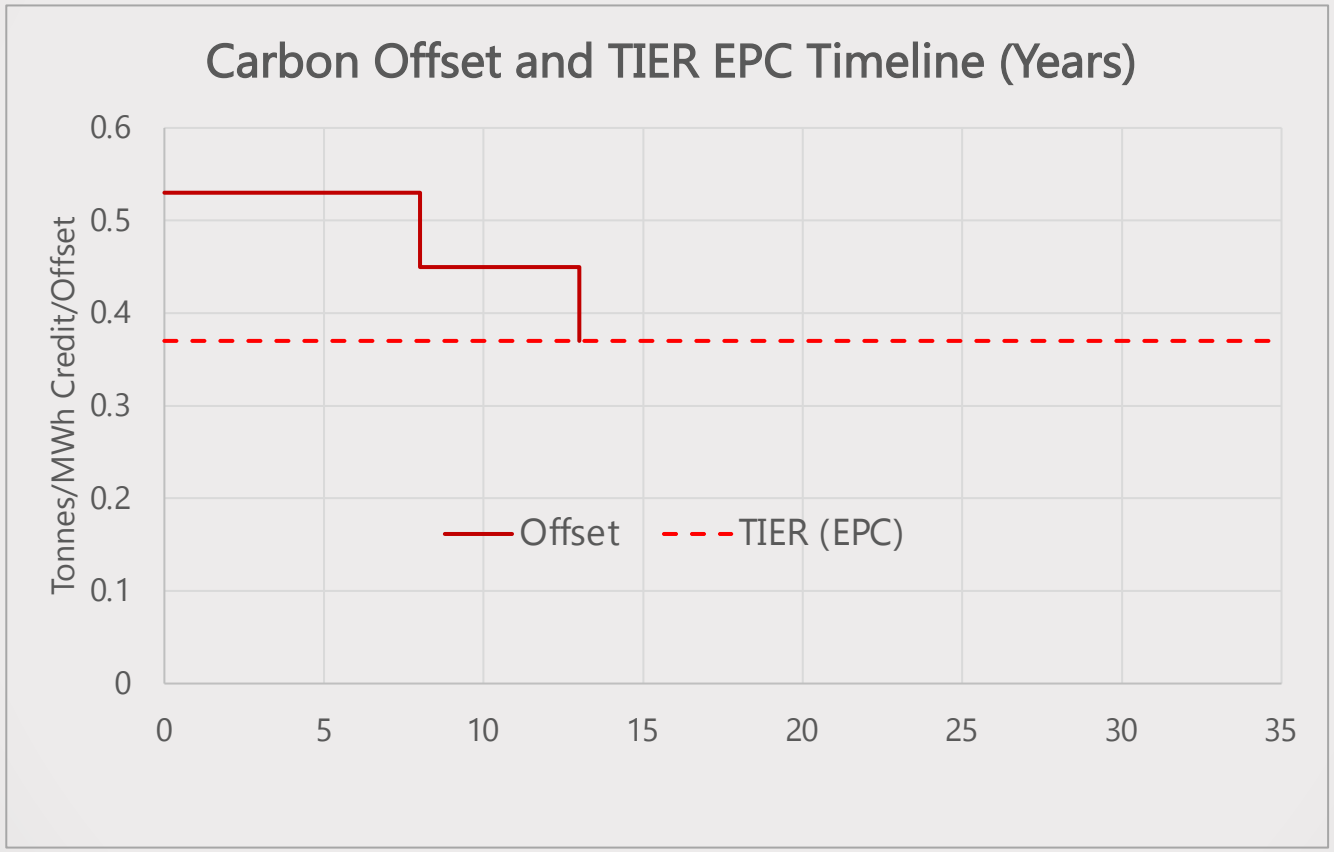
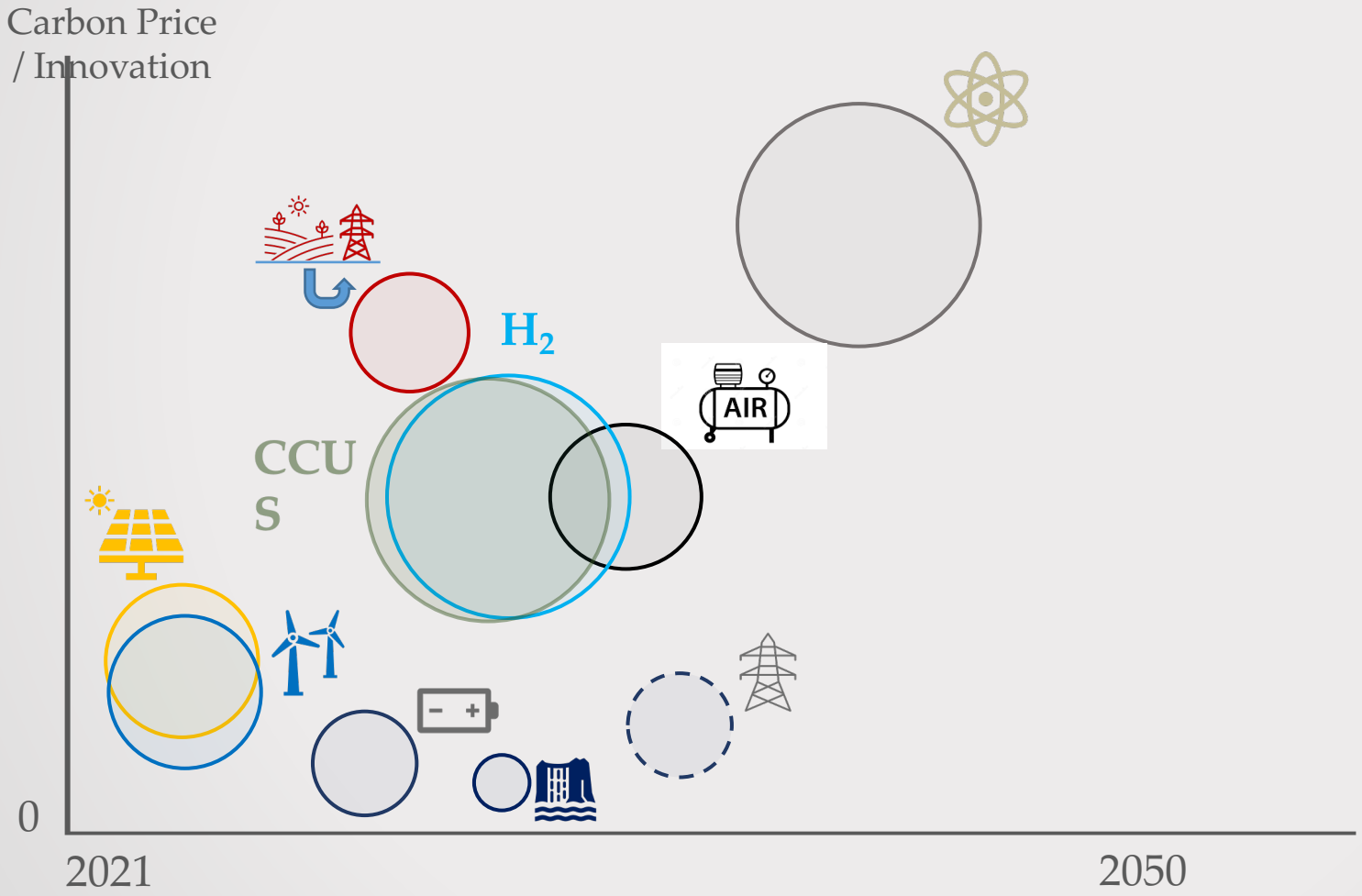
AB Policy Solution



Beyond Renewables – Decarbonization Options



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Thank You

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