The Role of Canadian LNG in Asia

Public Report

November 2022

Canadian Energy Centre

Wood Mackenzie
A Verisk Business

Report Overview

This report demonstrates **the impact of Canadian LNG in reducing emissions from the Asian energy mix** by 1) determining the potential Asian demand for Western Canada LNG; 2) modeling different scenarios for Canadian LNG supply and Asian natural gas demand to quantify the impact of Canadian LNG on Asian CO_2 emissions

To determine **the potential Asian demand for Western Canada LNG**, the report develops country-specific gas market overviews, including supply, demand, gas infrastructure, and market access for Canadian LNG; additionally, the report compares the cost competitiveness of Canadian LNG with other energy sources and forecasts Asian LNG demand

The impact of Canadian LNG on Asian CO_2 emissions was calculated by incorporating an emissions benchmark across energy sources and forecasts under different scenarios to determine what impact additional Canadian LNG supply will have on Asian CO_2 emissions

Source: Wood Mackenzie

Global energy demand continues to increase – especially in Asia – even as countries try to sharpen their focus on reducing emissions

Thesis Element	*Findings*	*Confidence Level*
Global energy demand will continue growing in the coming decades	**Renewable energy growth will be significant:** Renewables are projected to grow by almost 7% per annum from 2022 to 2050 globally, largely driven by wind and solar **However, fossil fuels will continue to play a large part in the energy landscape:** Hydrocarbons were 79% of the global energy mix in 2020, but are expected to fall to 65% in 2050, therefore coal, natural gas, and oil will still account for almost two-thirds of the global energy mix by mid-century **Natural gas will see the biggest growth among the fossil fuels:** Global gas demand is expected to grow at a rate of 0.6% annually from now until 2050, compared to an annual decrease of 1.6% for coal and 0.2% for oil **Asia will continue to see disproportionately large increases in its energy needs:** Asian gas demand is expected to have an annual growth rate of 1.6% from now through 2050, which is higher than the projected global average growth rate for gas	▪ High confidence in renewables growth ▪ Relative confidence in the projected share of hydrocarbons in the energy mix ▪ High confidence in global gas demand growth ▪ High confidence in Asian energy demand growth 
Countries need to reduce GHG emissions substantially to attain climate goals set out in the Paris Agreement	**Global energy-related emissions are expected to be about 18% less in 2050 compared to today:** Energy-related CO_2 emissions are expected to be 34.2 $GtCO_2e$ in 2022, compared to 27.9 $GtCO_2e$ expected in 2050 **Achieving global Net Zero Emissions by 2050 is possible, but requires a coordinated and sustained effort:** The greatest emissions reductions would likely need to come from the power sector, where natural gas could play a key role **Asia Pacific currently accounts for about half of global energy-related emissions:** Asia can reap large emissions reductions primarily from the power sector and secondarily from the industrial sector	▪ Low confidence in an aggressive reduction in global emissions ▪ Relative confidence in policy coordination among countries ▪ Relative confidence in Asian countries contributing with large emissions reductions 

Source: Wood Mackenzie

Natural gas is a great transition fuel, and this presents Canada with a tremendous opportunity to grow into a significant LNG exporter

Thesis Element	*Findings*	*Confidence Level*
Natural gas has many advantages, particularly for the power sector	**Natural gas has the lowest emissions amongst fossil fuels:** Gas produces less than half the emissions of coal when used in power generation **Natural gas can act as baseload as well as a peak shaver for power generation:** Along with coal and nuclear, gas is a baseload fuel that is reliable and dispatchable, especially as it can help to offset the intermittency of wind and solar power **Gas has numerous other advantages:** Natural gas is cost-competitive and there are large global reserves in many countries, including Canada. Furthermore, natural gas is used in various other industries aside from power generation	▪ High confidence in natural gas emissions intensity ▪ High confidence in natural gas reliability and dispatchability ▪ Relative confidence in natural gas cost-competitiveness 
Canada is well-positioned to capitalize on this unique opportunity	**Demand for LNG continues to grow, especially in Asia:** By 2030, there is a global demand gap for LNG of 51 mtpa. Even in a scenario where Canada aggressively ramps up its LNG exports (i.e., the unconstrained case), Asian demand will still be able to absorb the additional Canadian LNG on the global market through 2050 **Canada is well-positioned geographically:** Pipelines and LNG export infrastructure can be built in the western part of Canada to send higher volumes of LNG to Asia. Western Canadian LNG is much closer to Asia relative to US Gulf Coast LNG, which needs to be shipped through the Panama Canal to get to Asia **LNG from Canada would be cost-competitive for northeast Asian importers:** Although not as inexpensive as LNG from Qatar for Asian buyers, Canadian LNG is quite cost-competitive, due to its relatively low shipping and liquefaction costs. Compared to other global exporters of LNG, Western Canadian LNG is cost-competitive	▪ High confidence in Asian LNG demand growth ▪ High confidence in amount of Canadian natural gas reserves ▪ Relative confidence in Canadian LNG cost-competitiveness for buyers in NE Asia 

Source: Wood Mackenzie

Canadian LNG would ultimately help to lower emissions in Asia

Thesis Element	*Findings*	*Confidence Level*
Canadian LNG going to NE Asia will have a significant impact on reducing emissions	**If Canada does not export as much LNG as anticipated to NE Asia, the region would need to rely on LNG from elsewhere that has a higher emissions intensity:** LNG from Canada going into NE Asia has lower emissions than LNG coming from many other global LNG exporters **Asia will not be able to produce enough natural gas domestically to meet its escalating demand, therefore Canadian LNG is a compelling alternative:** With its high environmental standards and stewardship, Canada would be a great partner to fill the LNG demand gap in Asia	▪ High confidence in Canadian LNG emissions intensity competitiveness to NE Asia ▪ High confidence in Canadian LNG being a competitive alternative for NE Asia
Imported Canadian LNG has lower emissions than domestic coal in NE Asia for power generation	**Since the power sector has the greatest potential for emissions reductions in Asia, switching from coal-fired to gas-fired power plants will be critical:** A compelling opportunity exists in Asia to retrofit or replace coal-fired power plants with gas-fired ones that have lower emissions. If countries such as China, Japan, and South Korea ramp up coal to gas switching, Canadian LNG can help meet the increased energy demand while at the same time lowering emissions. Note that a much bigger impact on emissions comes from switching from coal-fired to gas-fired power plants, whereas the precise source of the natural gas (Qatar vs Canada vs the United States, for instance) has less of an impact on overall emissions **Imported Canadian LNG into Northeast Asia would emit fewer carbon emissions than domestically produced coal in that region when used in the power sector:** If Canada aggressively ramps up its LNG exports (i.e., the unconstrained case) and NE Asia adopts more natural gas for power generation in place of coal, this has the potential to significantly reduce emissions in NE Asia by offsetting the use of coal. Under this scenario, the emissions displaced from Canadian LNG would total 5.5 $GtCO_2e$ from 2022 to 2050 or 181 $MtCO_2e$ on average per year, which is equivalent to removing all Canadian cars from the road (41 million cars)	▪ High confidence in emissions reduction from coal to gas switching in power plants ▪ Medium confidence in aggressive Canadian ramp-up of natural gas production and LNG infrastructure build-out as well as NE Asian adoption of natural gas in place of coal

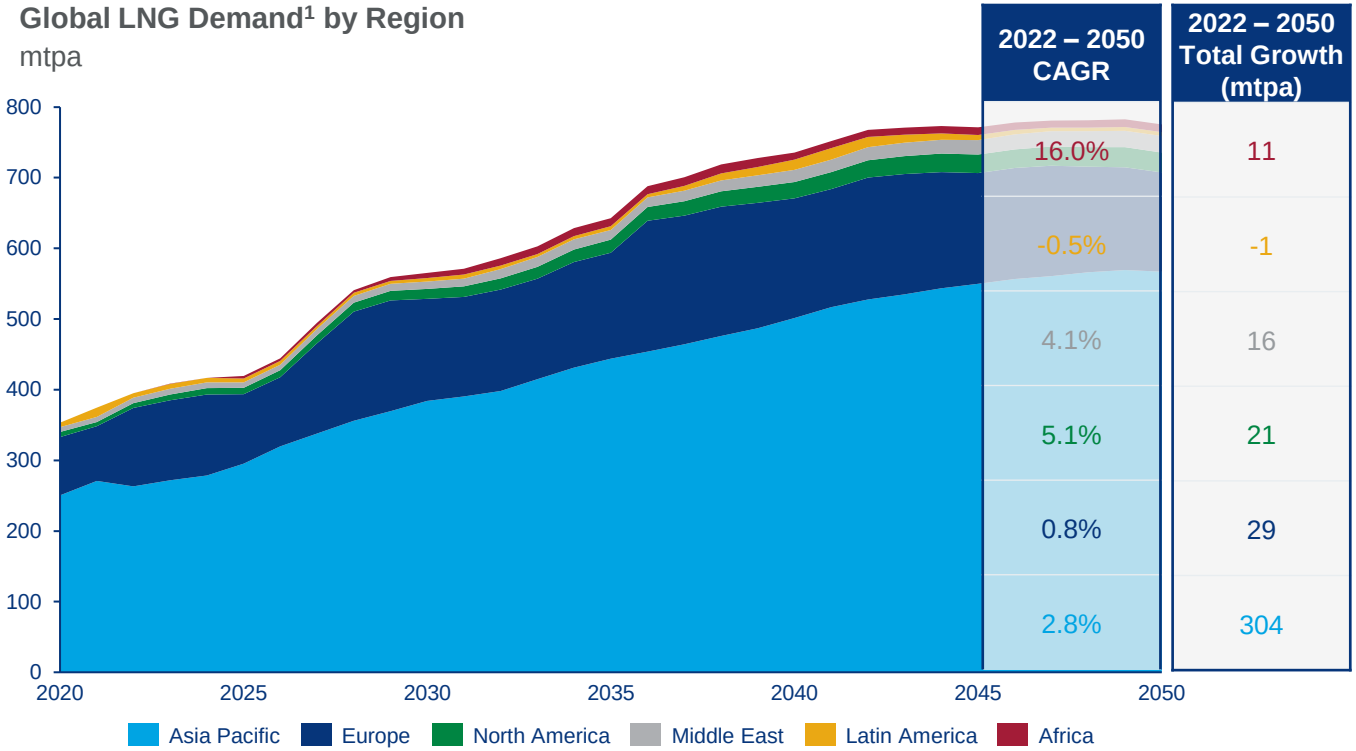
Source: Wood Mackenzie

Asia amounts to 67% of the actual global LNG demand and continues growing

Western Canada LNG has strategic positioning to supply part of the Asian increasing demand

Global LNG Demand[1] by Region

mtpa



- Asian LNG demand is expected to grow over 300 mtpa towards 2050, representing 73% of global consumption
- **Asian LNG imports will continue to increase** driven by:
  - Power decarbonization
  - More electricity demand given economic and population growth
  - The need to replace the declining domestic supply
- **Western Canada LNG geographic position is ideal** for supplying the main Asian demand centers: China, Japan, South Korea and Southeast Asia

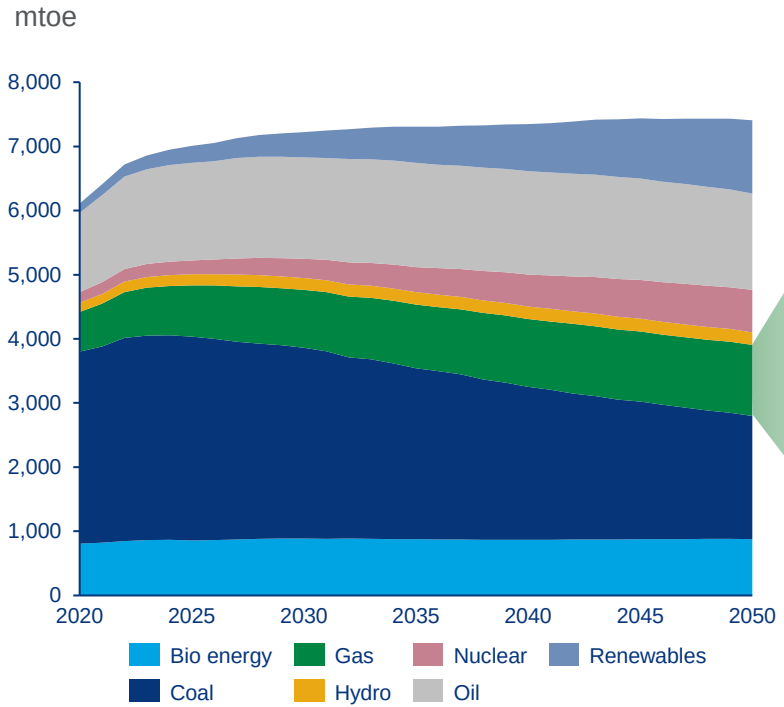
1) Demand excludes global boil-off

Source: Wood Mackenzie

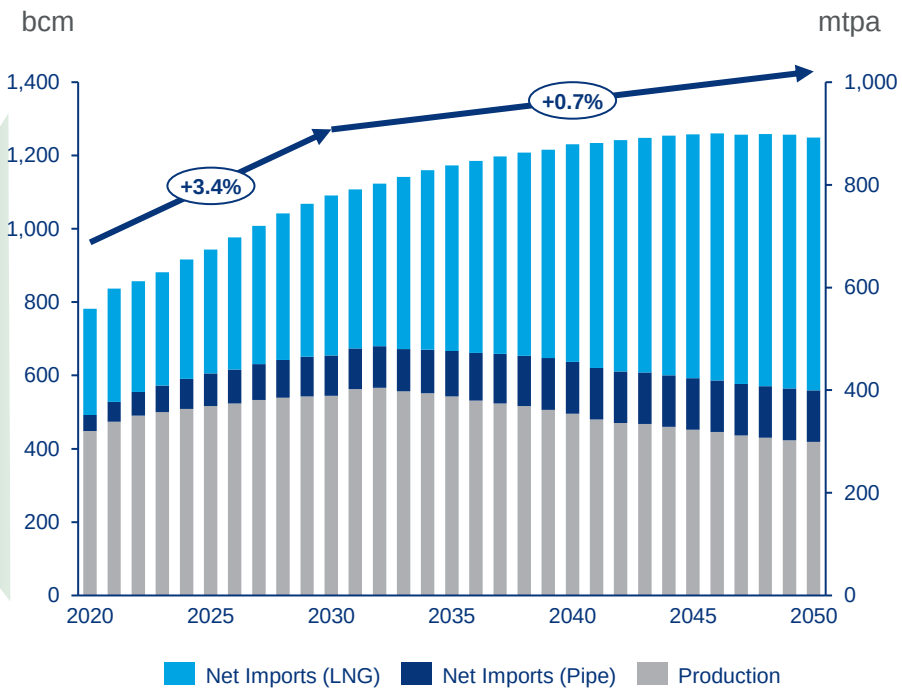
In Asia, natural gas will be a key ‘transition fuel’ in the global energy environment, with LNG as a critical solution to meet demand

Canadian LNG could have a key role to play to serve the growing Asian LNG demand

Asia Pacific Energy Demand by Fuel – Base Case



Asian Gas Balance

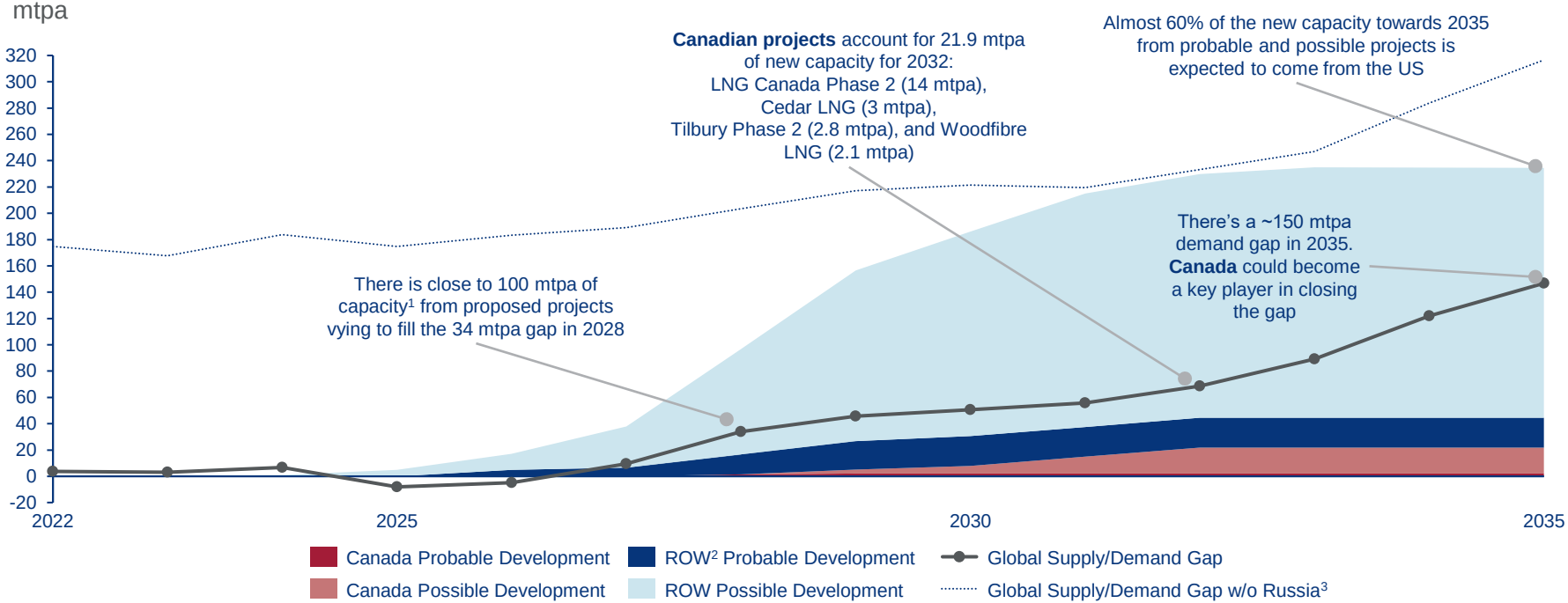


Source: Wood Mackenzie

Although there is a growing LNG demand gap, the world is ready to fill it with new capacity

Canadian projects could contribute significantly to meet future demand requirements

LNG Demand Gap vs. Proposed Projects by Status



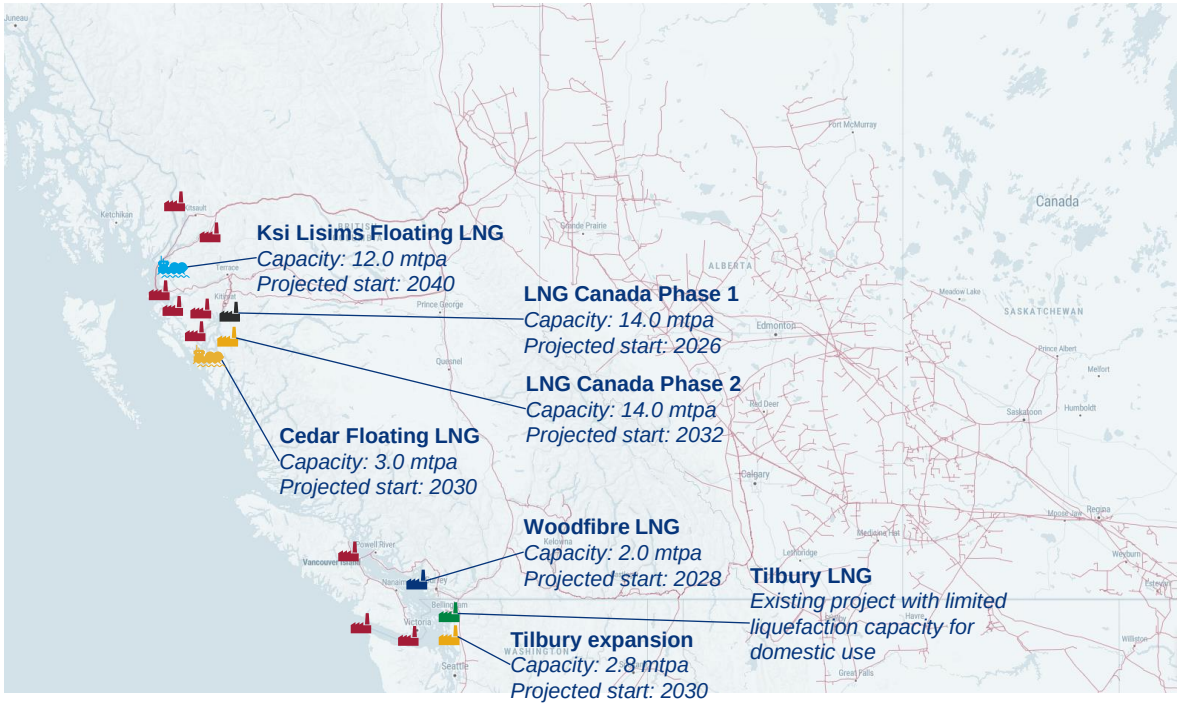
1) 100 mtpa of proposed capacity is not an exhaustive number. This includes projects deemed credible by Wood Mackenzie global analysts
2) Rest of the World (excluding Canada)
3) Global supply/demand gap if there is no supply of Russian piped gas or LNG (hypothetical scenario)

Source: Wood Mackenzie

Pipelines transport natural gas produced in the Western Canadian Basin gas fields to British Columbia's emerging coastal natural gas liquefaction industry

Canada has 23+ proposed conventional and floating LNG liquefaction facilities

Map of West Canada natural gas pipelines and LNG liquefaction facilities



- Natural gas piped from Western Canadian Sedimentary Basin (WCSB) fields becomes LNG on the West Coast
- Tilbury is Canada's only existing liquefaction facility, producing LNG for domestic natural gas customers and marine bunkering
- Cancelled projects may be reconsidered to supply growing East Asian demand for LNG

- Existing
- Under construction[1]
- Probable[1]
- Possible[1]
- Speculative
- Cancelled[2]

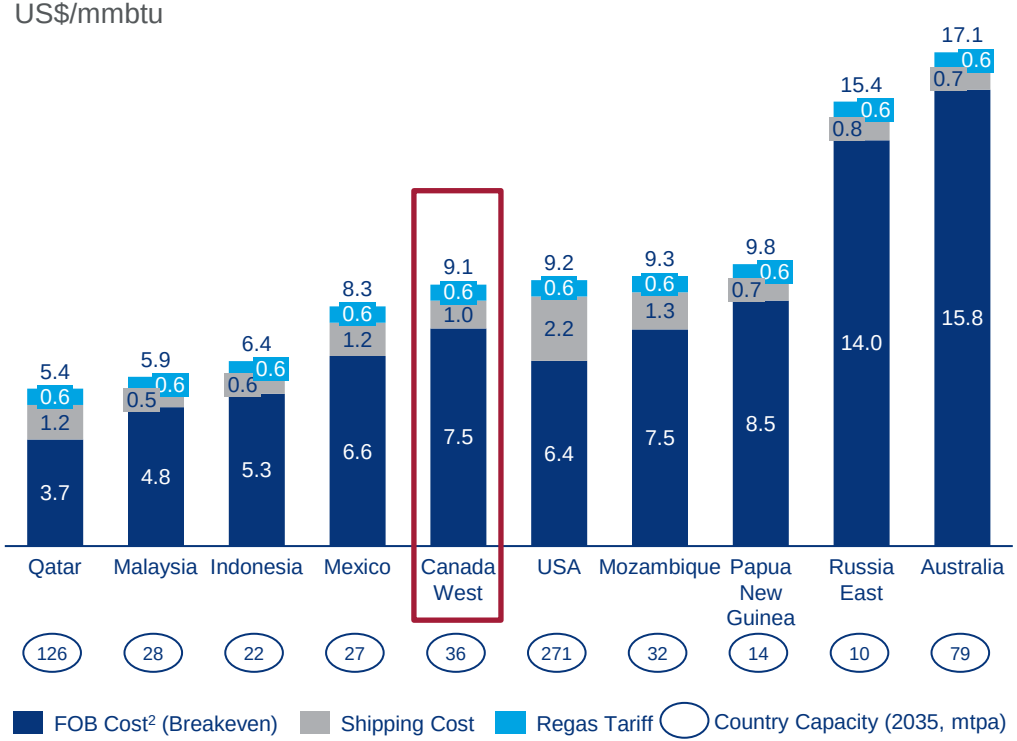
1) Included in base case scenario
2) Cancelled projects: **Kitimat LNG, Aurora LNG, WCC LNG**, Douglas Channel LNG, Pacific Northwest LNG, Prince Rupert LNG, Kitsault Energy, Triton LNG, Stewart LNG Phase 1, Stewart LNG Phase 2, Grassy Point LNG, Kwispaa LNG Phase 1, Kitimat LNG Train 3, Malahat LNG, Discovery LNG, Orca LNG, NewTimes LNG among others

Source: Wood Mackenzie

Canadian LNG remains cost-competitive delivering to Asian markets compared with the largest exporter (US), given lower transportation costs

Average Delivered Full Life Cycle Cost to Northeast Asia[1] from Competing LNG Supply Countries

US$/mmbtu



- **Qatari LNG** is the most competitive from a cost perspective and is increasingly GHG focused. **Malaysia and Indonesia** are also competitive given short distances and low FOB costs
- **Canadian** new LNG projects will face lower FOB costs due to existing common infrastructure and workforce buildup, along with modular solutions for specific projects
- The **US**, although competitive, has the highest shipping costs
- **Mozambique's** projects face a considerable degree of development uncertainty
- **Australian** projects have a wide range of FOB costs and have incurred cost overruns in the past
- Economic competitiveness is key to securing off-takers, but **other aspects are considered** when assessing contracts with pre-FID LNG projects, for example:
  - Some LNG buyers have concerns about becoming overly dependent on Qatari or Russian LNG
  - US LNG is facing growing scrutiny due to carbon emissions
  - Contract terms such as duration, flexibility and indexation are also increasingly important to securing offtake agreements

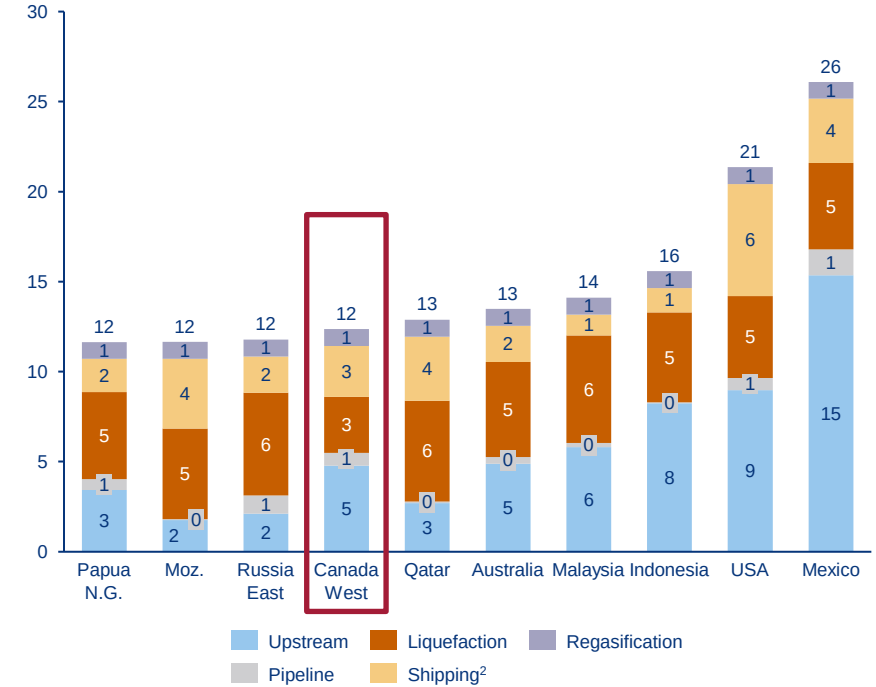
1) Supply capacity weighted average of costs to the main import terminal for each region: Shanghai (China), Ohgishima (Japan), and Incheon (South Korea)
2) FOB Cost at a 12% discount rate

Source: Wood Mackenzie

After including a carbon tax, Canadian LNG becomes even more competitive against countries like the US and Mexico due to lower emissions

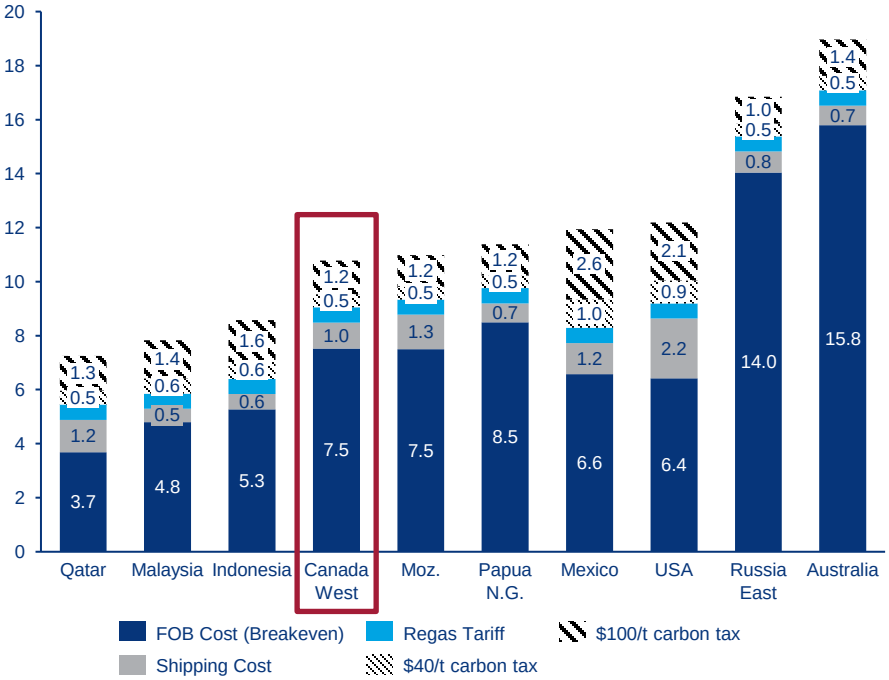
LNG Facility Emissions Intensity to Northeast Asia

$KgCO_2e/mmbtu$



Supply Costs Delivering to Northeast Asia[1] with Carbon Tax

US$/mmbtu



1) Supply capacity weighted average of costs to the main import terminal for each region: Shanghai (China), Ohgishima (Japan), and Incheon (South Korea)
2) Shipping assumptions: Propulsion Technique: Dual Fuel Diesel Electric; Vessel Size: 174,000 m^3, Route Details: Round Trip, Standard Speed

Source: Wood Mackenzie

Wood Mackenzie developed 2 additional scenarios to analyze the impact of Canadian LNG supply on global gas and energy markets

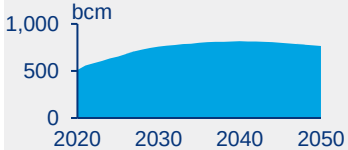
1 Wood Mackenzie **BASE CASE**

Wood Mackenzie's integrated view of the global energy and natural gas landscape with LNG supply from existing, potential and speculative projects

Methodology

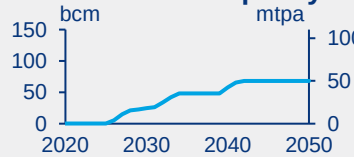
Least cost modelling for piped gas and LNG supply to meet natural gas demand considering cost competitiveness, distance and transport capacity

Natural Gas Demand (NE Asia)



2022: **580** bcm
2050: **764** bcm
CAGR: **1.0%**

Canadian LNG Capacity



2022: **0** mtpa
2050: **50** mtpa

Projects:
LNG Canada Phase 1 & 2, Woodfibre LNG, Cedar LNG, 14 mtpa generic additional capacity from 2040

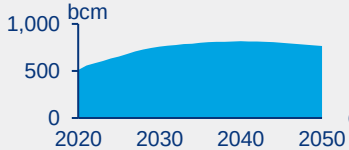
2 **LIMITED** Canadian LNG

Wood Mackenzie's view of the Canadian LNG market if only a limited number of LNG projects begin production

Methodology

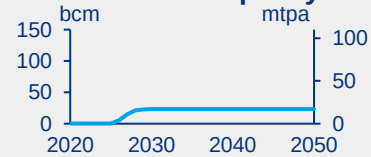
Remove LNG Canada Phase 2 and other speculative projects from the project pipeline
Keep base case demand fixed

Natural Gas Demand (NE Asia)



2022: **580** bcm
2050: **764** bcm
CAGR: **1.0%**

Canadian LNG Capacity



2022: **0** mtpa
2050: **17** mtpa

Projects:
LNG Canada Phase 1, Woodfibre LNG

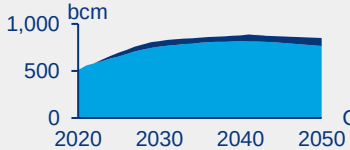
3 **UNCONSTRAINED** Canadian LNG

Wood Mackenzie's upside view of the Canadian LNG market with most of Canada's domestic gas production liquefied for export

Methodology

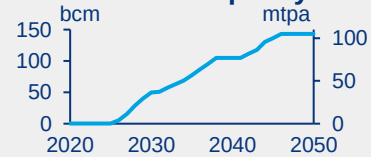
Accelerate coal-to-gas switch in China power
Accelerate and increase Canadian liquefaction capacity to upstream capacity
Increase Qatar and US liquefaction capacity

Natural Gas Demand (NE Asia)



2022: **580** bcm
2050: **852** bcm
CAGR: **1.4%**

Canadian LNG Capacity



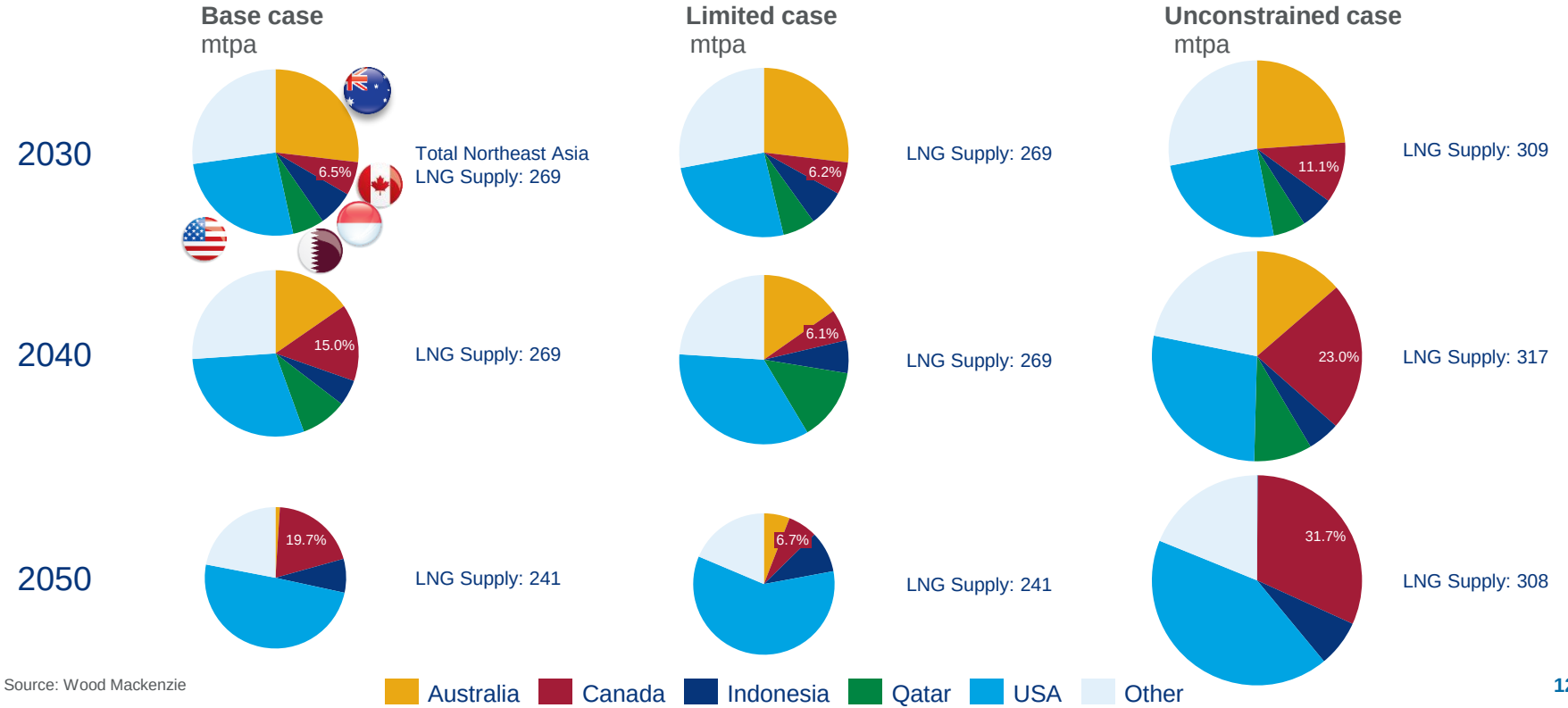
2022: **0** mtpa
2050: **105** mtpa[1]

1) Projects: LNG Canada Phase 1 & 2, Woodfibre LNG, Cedar LNG, Tilbury expansion, Ksi Lisims, Kitimat LNG, generic additional capacity up to 35 mtpa from 2035
Source: Wood Mackenzie

Up to 31% of Northeast Asian LNG market share available for Canadian LNG by 2050 in unconstrained case compared to 20% in base case, 7% in limited case

By 2050, only the US surpasses Canadian LNG exports to Northeast Asia in both the base and unconstrained cases

Northeast Asian LNG supply market share by source country

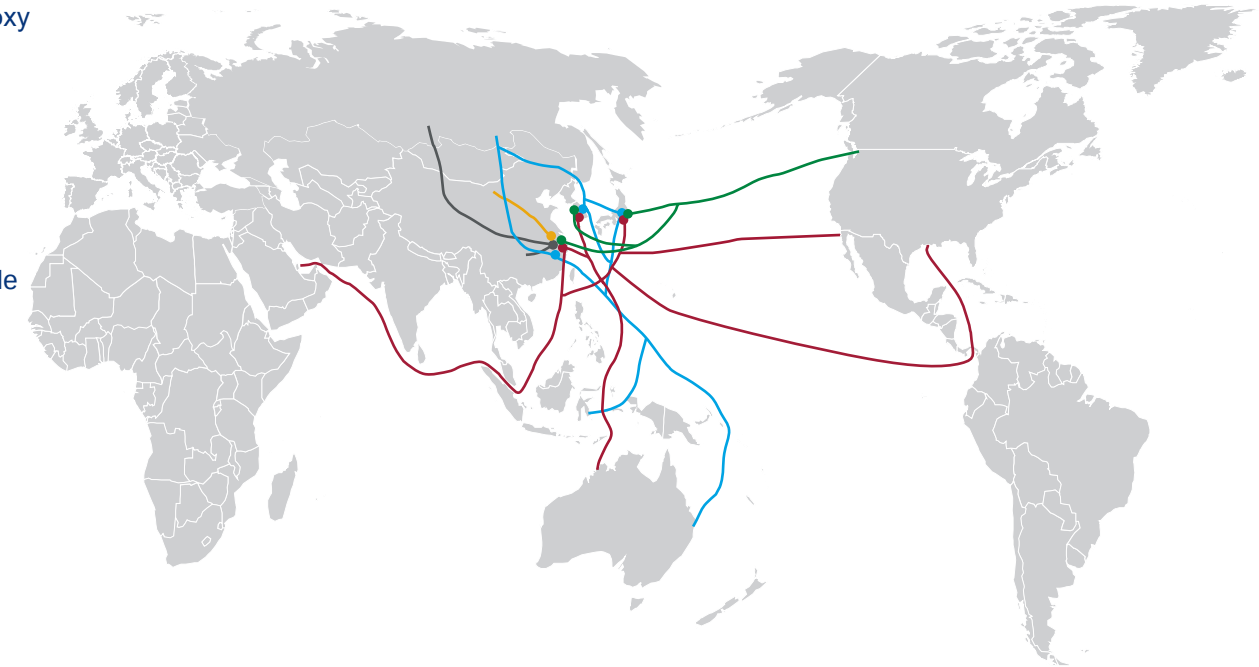


Source: Wood Mackenzie

The emissions analysis compares LNG, Gas, Coal and other fuel sources and their scope 3 emissions to serve key Northeast Asia markets

The analysis focuses on four regions, and we've selected a city as delivered point proxy

1. China – Shanghai
2. Japan – Tokyo
3. South Korea – Seoul



Each region will have several fuels available to serve demand under our sensitivities:

For all markets:

- Canadian LNG Gas imports
- Non-Canadian LNG Gas imports
- Coal imports

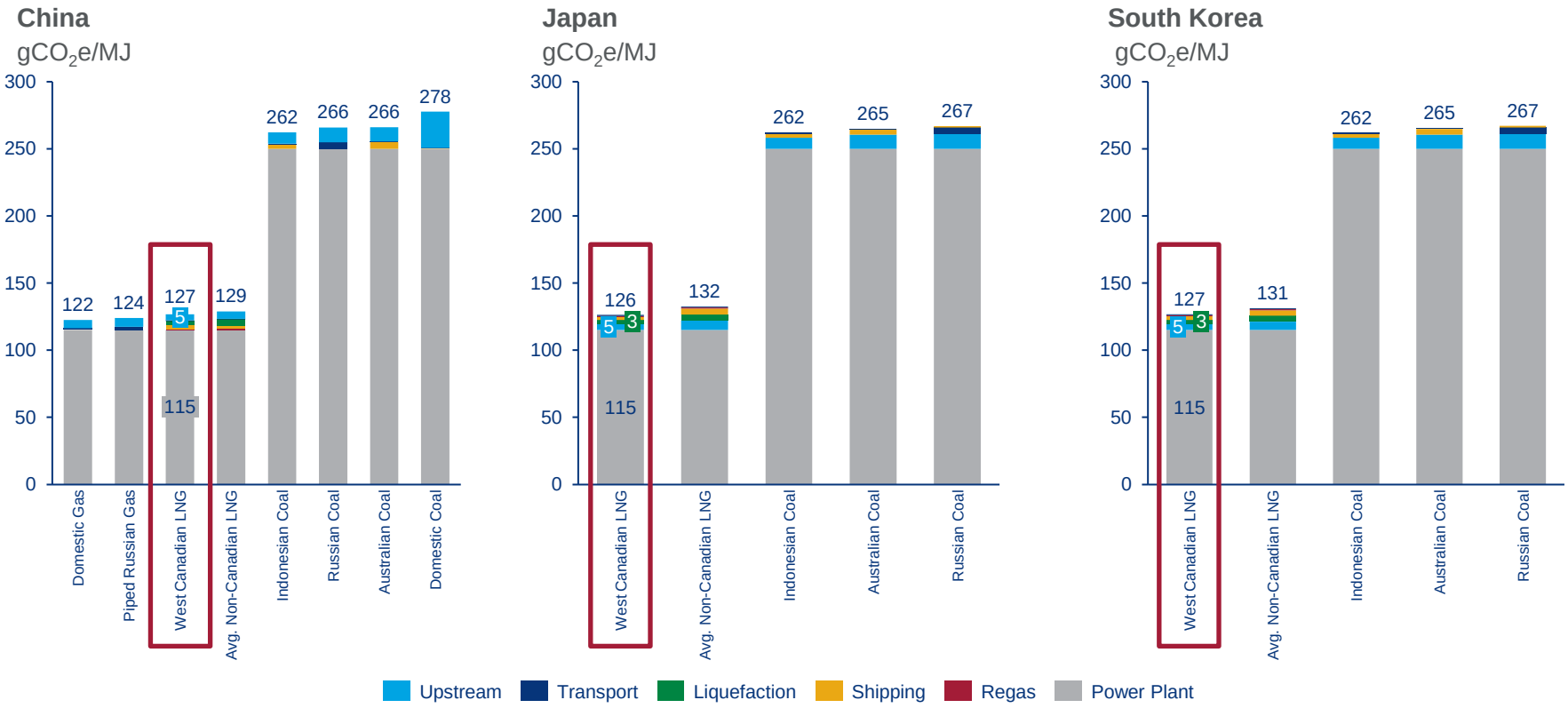
In addition, mainland China has:

- Russian & domestic piped Gas
- Domestic Coal

Source: Wood Mackenzie

Canadian LNG is among the lowest emitting sources of energy to Northeast Asia

Canadian LNG has fewer upstream and liquefaction emissions compared to the average NE Asia LNG supplier



Source: Wood Mackenzie

To assess the impact of Canadian LNG on Northeast Asia, Wood Mackenzie estimated the emissions results for NE Asia under two sensitivities:

Sensitivity A (Base Case vs. Limited Case)

Northeast Asian emissions if **Canada has less LNG liquefaction capacity than expected** (Base Case vs. Limited case)

With less Canadian LNG supply, total Northeast Asian emissions would increase **121 $MtCO_2e$** from 2022 to 2050, an average of **4 $MtCO_2e$** per year (2022-2050)

+121 $MtCO_2e$
Between 2022-50
Direct increase in Asia by limiting **Canadian LNG**

+4 $MtCO_2e$
Average per year 2022-50
Direct increase in Asia by limiting **Canadian LNG**

Sensitivity B (Base Case vs. Unconstrained Case)

Northeast Asian emissions if **Canadian LNG helps replace coal for power generation** (Base Case vs. Unconstrained Case)

If Canada increases LNG capacity to help Northeast Asia reduce its reliance on coal-fired power generation, net emissions decline **-5,459 $MtCO_2e$** from 2022 to 2050, an average of **-188 $MtCO_2e$** per year (2022-2050)[1]

-5,459 $MtCO_2e$
Between 2022-50
Net reduction in NE Asia from coal displacement with **Canadian LNG**

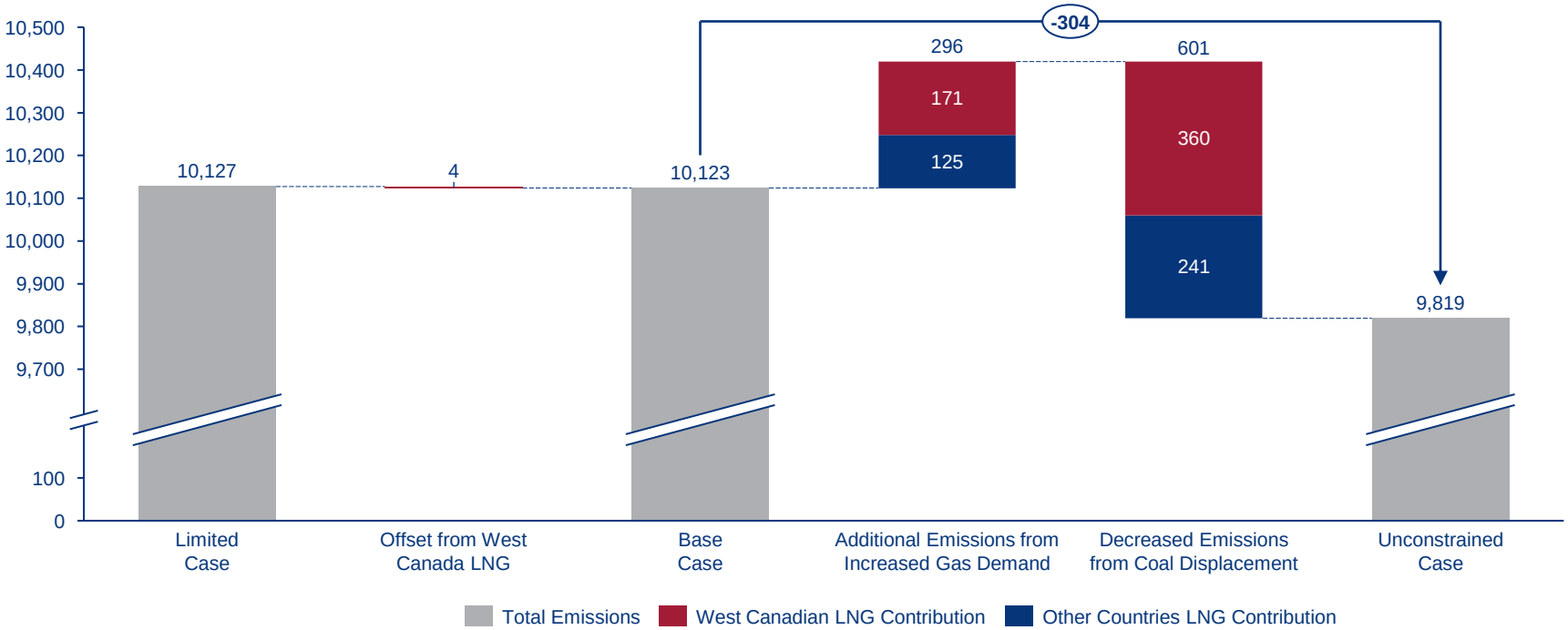
-188 $MtCO_2e$
Average per year 2022-50
Net reduction in NE Asia from coal displacement with **Canadian LNG**

1) Total emissions displaced from Sensitivity B (Unconstrained Case) are -8,824 or -304 per year (2022-2050), with 62% being from Canadian LNG (-5,459 or -188 per year for 2022-2050)
Source: Wood Mackenzie

Under Sensitivity B (Base vs Unconstrained), Canadian LNG contributes 62% of the emissions reduction (-188 $MtCO_2$ on average per year)

Northeast Asia Total Energy Related Emissions (2022-2050 Yearly Average)

$MtCO_2$-e



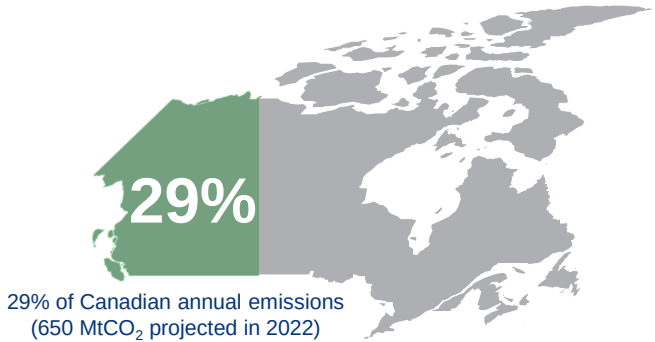
Source: Wood Mackenzie

The reduction of 188 $MtCO_2$ emissions on average per year from Canadian LNG sent to NE Asia under Sensitivity B represents 29% of Canadian yearly emissions

Emissions Reduction from Unconstrained Case in Context

-188 $MtCO_2$

in average per year, is equivalent to:



29% of Canadian annual emissions
(650 $MtCO_2$ projected in 2022)

All Canadian Cars Removed from the Road

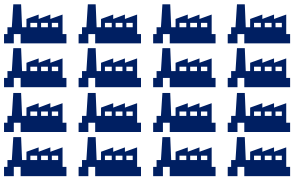
41 million cars removed from the road (4.6 tons per car per year. Canada had 36 million vehicles registered in 2019)

or

188 M Passengers

188 million passengers flying from London to Vancouver (~1 ton per passenger per round trip)

or



174 Carbon Capture and Storage Projects

The Quest Project in Alberta is designed to capture up to 1.08 million tons of CO_2 per year, with an over $700 million investment

Source: Wood Mackenzie, Government of Canada, Government of Alberta, EPA, Statistics Canada, The Economist

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