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CGA By the Numbers:
Coal switching in Canada and the LNG potential abroad

In this issue of *By the Numbers*, we look the impact of fuel switching from coal to natural gas in the electricity generation sector. First, we begin by examining both the emission intensity and efficiency advantages of natural gas over coal. Then, we examine the progress that has been made thus far in Canada's, particularly in Ontario and Alberta's provincial grids. Finally, we extend our analysis to beyond Canada's borders, looking at how additional coal-to-gas switching can be applied abroad to achieve global emission targets and the role of LNG in helping to realize these targets.

KEY FINDINGS:

In Canada, historical switches from coal to gas for electricity generation has reduced emissions by 51%. As more conversions occur, the emission reductions are expected to be even greater since the switch to gas involves using more efficient technologies such as a combined-cycle turbine configuration.

Since 2005, the emissions intensity of Canada's electricity grid has steadily fallen by an average of 7.5 g CO_2e/kWh per year, caused primarily by the elimination of coal generation. More recently since 2017, significant growth in natural gas generation has allowed the country to maintain the same pace of emission reduction in the national grid, despite stagnated growth in non-emitting sources like wind, solar, hydro, and nuclear.

Canada can make significant contributions to lowering global emissions by supplying LNG to many countries in Asia who are looking to switch from coal to gas in their electricity sectors. The potential reductions are tremendous — switching just 20% of Asia's coal plants to gas is estimated to reduce global emissions by 680 million tonnes — equivalent to all of Canada's annual emissions.

We do not have to look beyond our borders to see the positive impacts of replacing coal generation with lower emitting sources, including natural gas.

To start, we will provide a brief background on the advantages of natural gas over coal in electricity generation from an emissions perspective. Firstly, it is already well established that natural gas is a much cleaner fuel when compared to coal. At combustion, natural gas emits about 52 g CO_2e/MJ when compared to the 95 g CO_2e/MJ emitted from coal. However, this is not the only reason why gas generation produces lower emissions.

The second advantage is improved energy efficiency. The technologies available with gas, particularly theCombined Cycle Gas Turbine (CCGT) and Combined Heat and Power units (CHP), have allowed gas generators to use less input energy to generate the same amount of energy output as that of a coal plant.

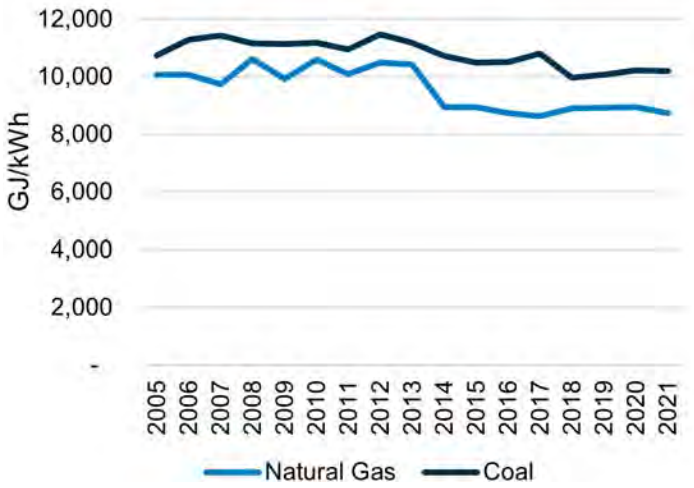
Figure 1 shows the average energy input needed for gas and coal plants in Canada. The trend reveals that gas generators have made steady improvements in energy efficiency compared to coal. As of 2021, the average coal plant in Canada required 10,201 MJ of input to generate 1 kWh of electricity while the average gas plant in Canada only required 8,745 MJ of energy input. In all, gas plants were about 14% more energy efficient. As more coal plants are converted to more efficient gas technologies in the coming years, this gap in energy efficiency is expected to widen.

When we consider these two factors, we can see how they both contribute to natural gas' lower emissions profile. Using Canada-specific data from the National Inventory Report (NIR), the average emission factor for a coal generating plant in 2021 was 981 g/kWh. The average emission factor for a gas generating plant in 2021 was 476 g/kWh, about 51% lower. However, we can further breakdown the marginal emissions from coal into the two factors that we have discussed. From figure 2, we can see that about 30% of the incremental emissions from coal is a result of poorer energy efficiency. The remaining 70% is a result of coal being more carbon-intensive during combustion.

It should be noted that the energy efficiency data presented in figure 2 represents an average of all gas plants within Canada. This population would include various types of gas plant configurations, including less efficient simple-cycle units. Considering that new CCGT units can reach efficiencies of up to 60%, compared to the typical 35% of a coal generator, the potential emission reductions could be even greater. One such example is the Cascade Power Plant in Alberta, which estimates the coal-to-gas conversion will emit 62% less emissions.[1]

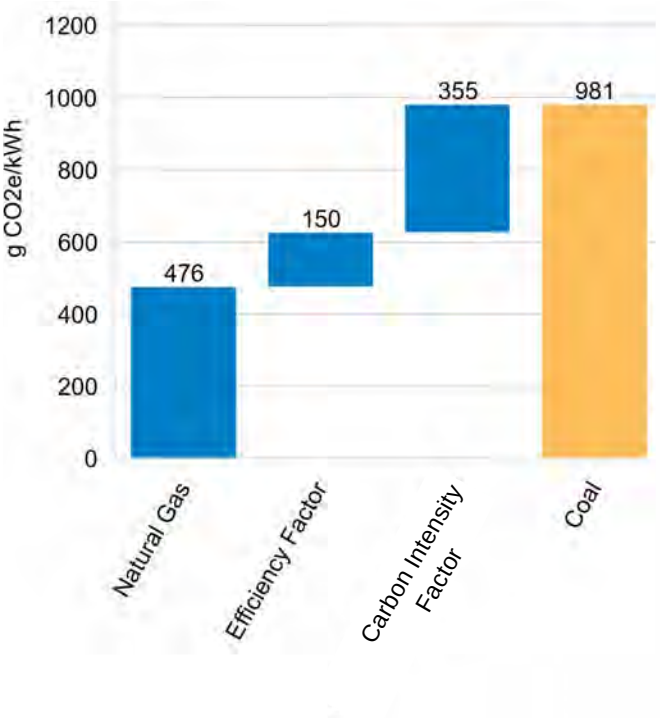
With this technical background, let's shift to examining the history of coal consumption in Canada to gain some insight into the emission reductions we've achieved to date at home. In Canada, there has been tremendous progress in reducing greenhouse gas emissions from the power generation sector. Much of that progress is directly related to the reduction of coal fired generation as shown in figure 3. Since 2005, the amount of electricity generated from coal has reduced by nearly two-thirds, resulting in a reduction of greenhouse gases by nearly 50%. Over that period, the emissions intensity of the electricity system fell from 225 g CO_2e/kWh to 105 g CO_2e/kWh, equivalent to an average reduction of 7.5 g CO_2e/kWh per year.

FIGURE 1: ENERGY INPUT FOR ELECTRICITY GENERATION



Source : Statistics Canada

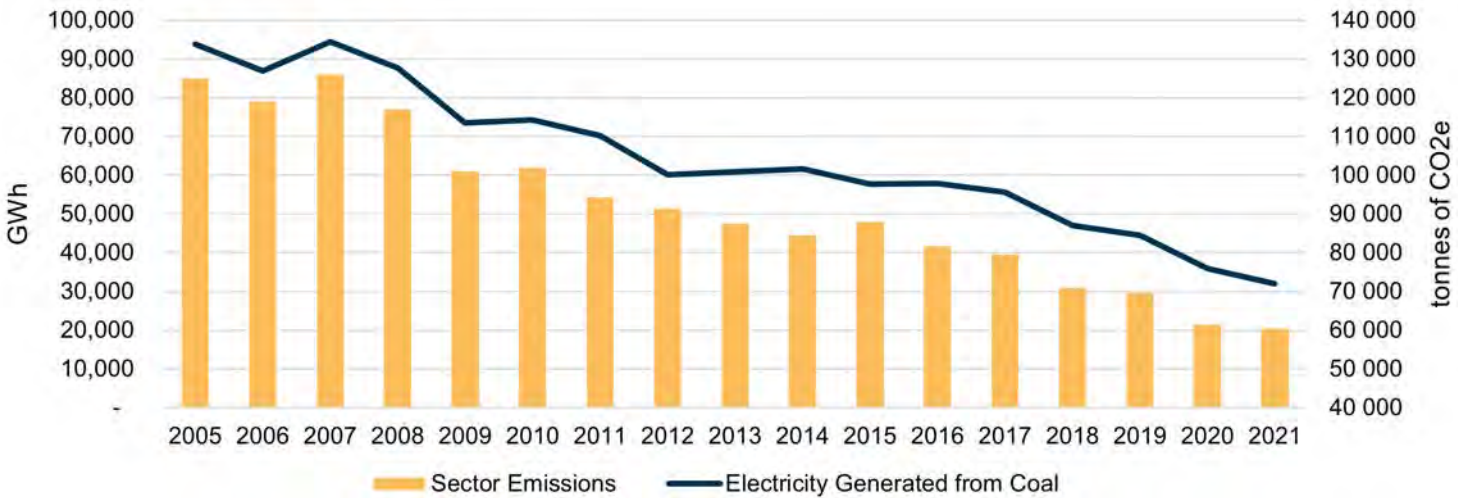
FIGURE 2: NATURAL GAS VS COAL GENERATION EMISSION FACTOR



Source: NIR

[1] "Cascade Combined-Cycle Gas Turbine (CCGT) Power Plant, Alberta" (5 March 2020), online: *Power Technology* <www.power-technology.com/projects/cascade-combined-cycle-gas-turbine-ccgt-power-plant-alberta>.

FIGURE 3: POWER GENERATION FROM COAL

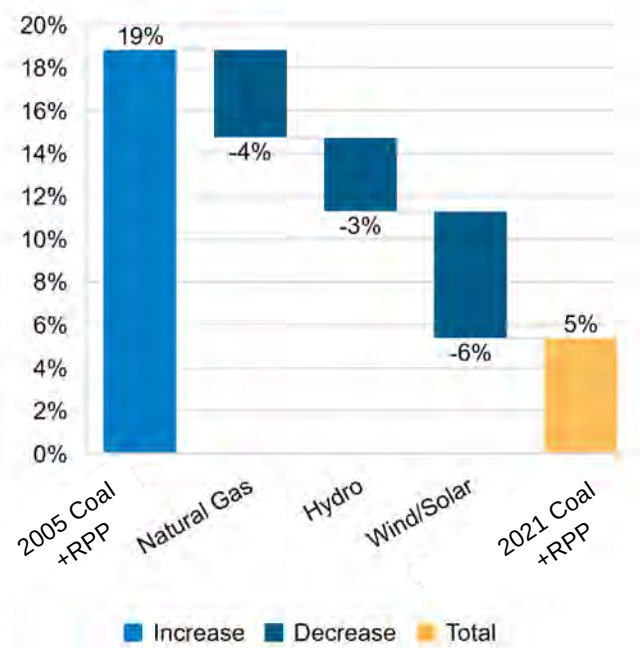


Source: ECCC

Historically, we can attribute the coal reduction trend to two distinct periods: from 2007–2014 and then from 2016–present. The first period is attributed to Ontario when it enacted the Cessation of Coal Use Regulation in 2007. By 2014, it had shut down its last coal plant.[2] The second period is attributed to Alberta, when it announced plans to phase out coal in November 2015. The last of Alberta's coal plants are expected to be converted to natural gas by the end of 2023.[3]

Since 2005, the mix of electricity generation in Canada has changed significantly, with higher emitting sources like coal and refined petroleum products (RPPs) being replaced with lower emitting sources. Figure 4 shows how the percentage of electricity generated from coal and RPPs in Canada has changed between 2005 and 2021 and which energy sources have taken their place.

FIGURE 4: CHANGE IN POWER GENERATION MIX 2005-2021



Source: NIR

[2] "The End of Coal" (last updated 25 January 2023), online: *Government of Ontario* <www.ontario.ca/page/end-coal>.

[3] Blake Shaffer, "Alberta steps closer to ending coal power, faster than many expected. But then comes the hard part" *CBC* (last updated 4 February 2022), online: <www.cbc.ca/news/canada/calgary/opinion-alberta-end-coal-power-natural-gas-solar-wind-nuclear-1.6300606>.

We can see that power generation from coal and RPPs sources reduced from 19% to only 5% between 2005–2021. Furthermore, the energy sources that have replaced coal and RPPs are quite diverse: 4% was replaced with natural gas, 3% with hydro, and 6% with non-hydro renewables like solar and wind.

Rightfully so, much of the emission reductions that have been realized are credited to the growth in renewables like hydro, solar, and wind power in Canada's electrical grid. About 81% of the emissions reduction achieved to-date can be attributed to the replacement of coal by renewables. Having said that, it is important not to discredit the role natural gas has played in achieving that remaining 19%.

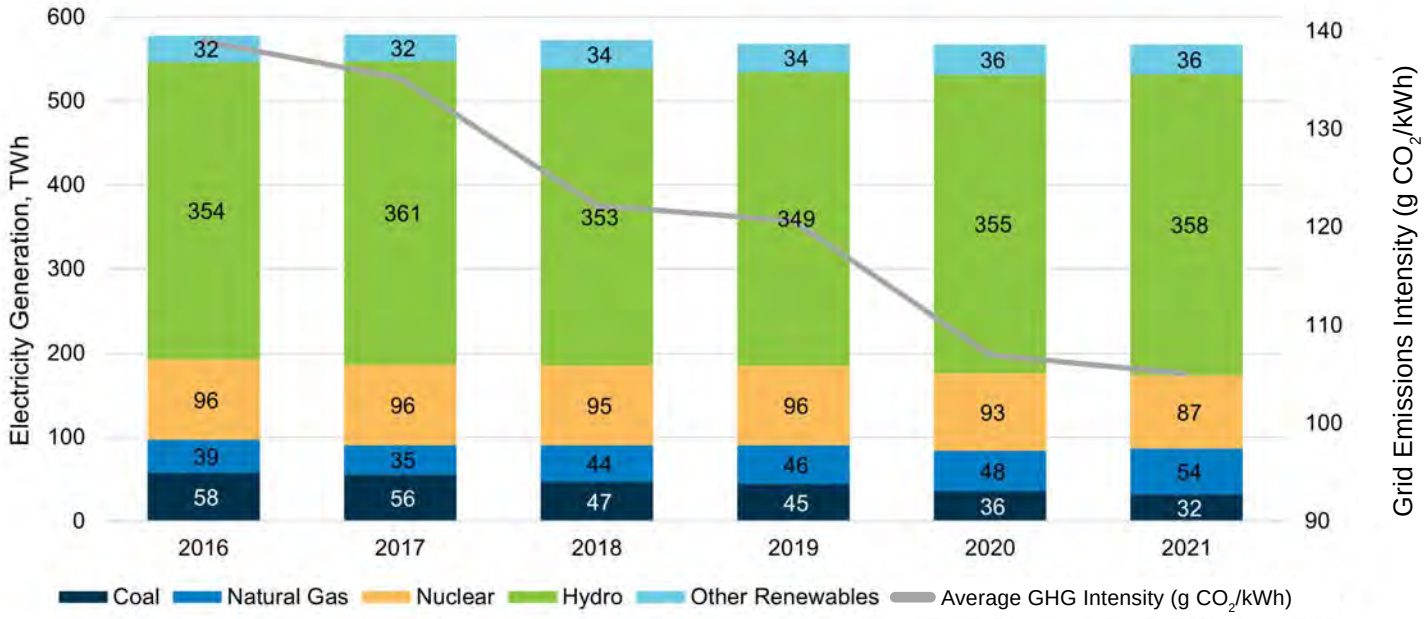
To illustrate this, we can take a closer look at the power generation mix between 2017–2021, amid Alberta's coal-phase out period, illustrated in figure 5. Over this time frame, coal generation in the country decreased by 26 TWh or 44%. But when we look at what types of energy sources have replaced coal, we can see that power generation from renewable sources has mostly stagnated. While wind and solar grew by 13%, this was mostly negated by nuclear generation decreasing by 9%.

Conversely, natural gas generation had the most significant amount of growth during this period, increasing by 15 TWh or about 38%. All the while, the average emissions intensity of Canada's grid continued to decrease to by 30 g CO_2e/kWh. Furthermore, if we calculate the average rate of reduction, we get an annual reduction of 7.5 g CO_2e/kWh, which is on pace with the average rate of reduction we previously calculated between 2005–2021.

Ultimately, what the analysis figure 5 shows is that we cannot dismiss or minimize the role of natural gas in making significant emissions reductions, especially in the short-to-medium term future. Driven mainly by Alberta, gas-to-coal substitutions have enabled Canada to maintain its pace of emission reductions in the electricity sector over the last five years, despite the low growth in renewables.

While Canada has made tremendous strides in its coal phase out over the last two decades, the same cannot be said about the rest of the world. According to the BP Statistical Review of World Energy, coal is still the largest source of electricity generation in the

FIGURE 5: ELECTRICITY GENERATION IN CANADA BY TYPE 2016-2021



Source: NIR

world. As of 2021, it accounted for 36% of all globally generated power.

Currently, most of the global coal demand current comes from Asia. Of the top 15 coal power generators in the world, nine reside on the continent. Even after excluding China and India, the rest of Asia generates nearly 40% of all the coal powered electricity in the world.

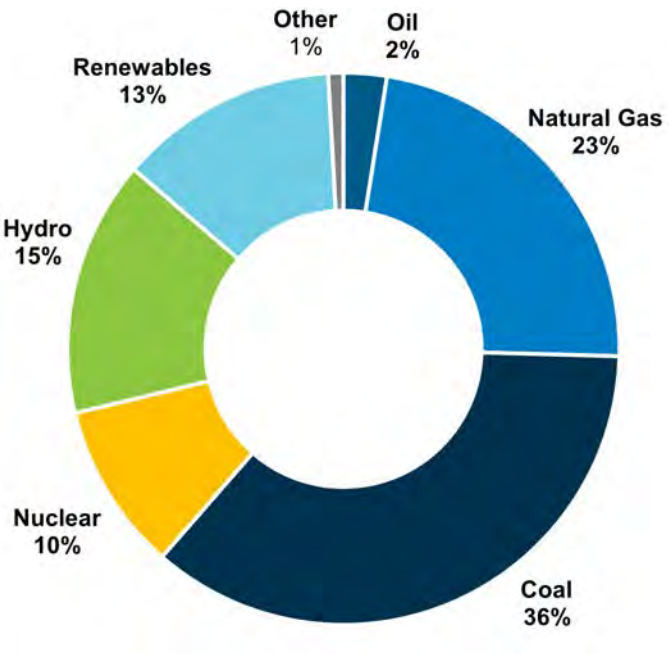
It should be noted that the continent has been making efforts to reduce its reliance on coal. Of note, highly coal-dependent nations like Vietnam, Indonesia, and South Korea have all pledged to phase out unabated coal power.[4] However, they will need alternative energy sources to replace coal, and many are looking to coal-to-gas conversions as the most economical and timely option.

After all, the potential emission reductions available for coal-to-gas conversions are extremely enticing. It is estimated that switching just 20% of Asia's coal generation to gas can reduce global emissions by 680 million tonnes.[5] To put that into context, that is equivalent to the same emissions output as Canada.

However, the problem that arises is supply. Despite accounting for nearly 23% of global gas consumption, Asia only has about 16% of the world's share of indigenous gas production. The remaining supply is primarily provided in the form of LNG imports to the region. Asia is already the largest importer of LNG, being responsible for 72% of all LNG imports in 2021.

With this known potential in mind, how can Canada help lower global emissions? Or should we simply pat ourselves on the back and marvel at what we've accomplished with our own coal phase out so far?

FIGURE 6: GLOBAL ELECTRICITY GENERATION BY SOURCE



Source: BP Statistical Review of World Energy

Should we rest on our laurels as the rest of the world looks to lowering their emissions?

The obvious answer is that Canada can directly contribute to reducing global emissions through the development of LNG projects. While Canada has been not been a significant player in the LNG markets, that is expected to change soon. The table below summarizes some of the country's approved and proposed LNG projects. In context, the total global LNG trade in 2021 was equal to 516 billion cubic metres. Assuming these projects start up as anticipated, the projects listed below would

[4] Sanjeev Gupta, Eric Jost, Gilles Pascual, "How LNG can address Asia-Pacific power needs and decarbonization targets" (13 September 2022), online: *EY* <www.ey.com/en_vn/energy-resources/how-lng-can-address-asia-pacific-power-needs-and-decarbonization-targets>.

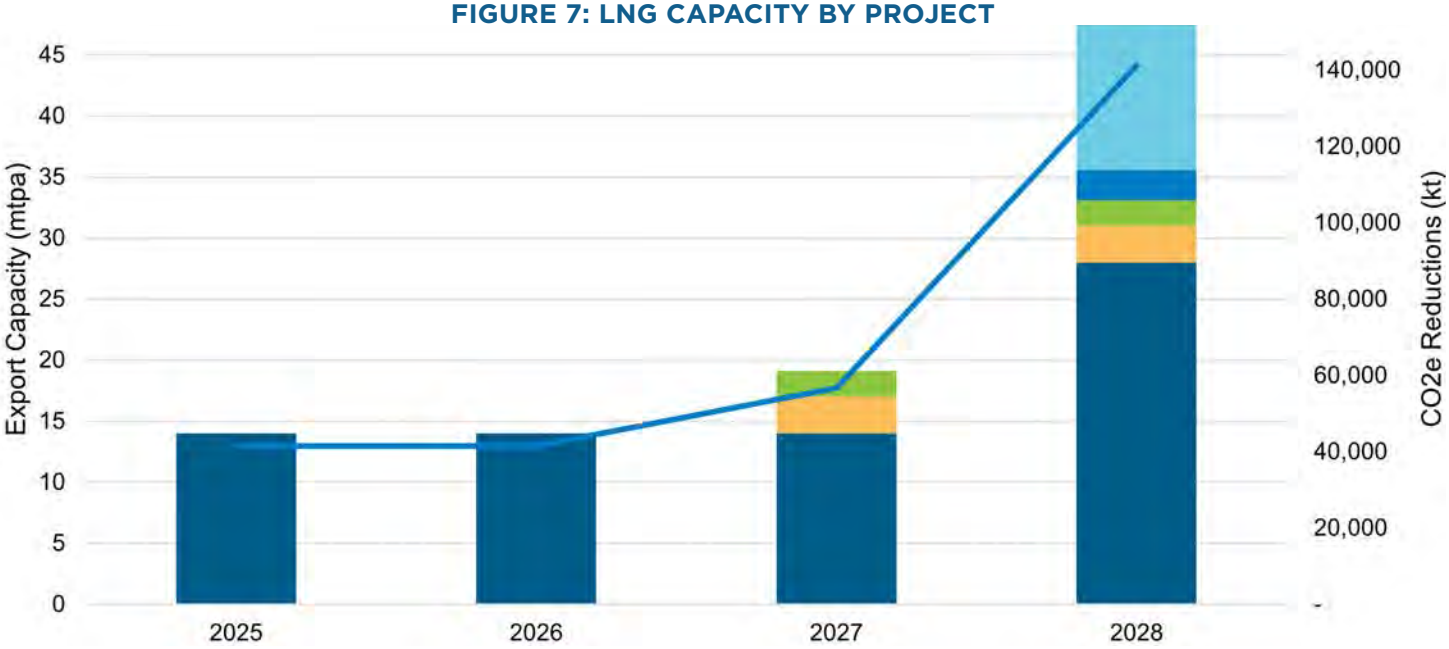
[5] "Shell LNG Outlook 2023", online: *Shell Global* <www.shell.com/energy-and-innovation/natural-gas/liquefied-natural-gas-lng/lng-outlook-2023.html>.

Project	Anticipated Start-Up	Capacity (mtpa)	Capacity (bcf/d)
LNG Canada – Phase 1	2025	14	1.9
Cedar LNG	2027	3	0.4
Woodfibre LNG	2027	2.1	0.3
LNG Canada – Phase 2	2028	14	1.9
Tilbury LNG	2028	2.5	0.3
Ksi Lisms LNG	2028	12	1.6

grow Canada's export capacity to 65 billion cubic metres per year by 2028. This would represent a 13% increase in global LNG supply and would also rank Canada as a top three LNG exporter behind only the United States and Australia. Furthermore, through coal-to-gas conversions, the estimated emissions reduction enabled by these LNG projects is 140 million tonnes of CO_2e, roughly 20% of Canada's total emissions. Put in another way, this is equivalent to offsetting all the emissions from Canada's electricity and building sectors combined. By 2028, we'd be able to offset the equivalent emissions as the amounts set out by both the Clean Electricity Regulation and the Green Building Strategy.

In this issue of *By the Numbers*, we examined how the phase out of coal has transformed Canada's electricity sector and made a significant contribution to lowering our domestic emissions. And while Canada's coal phase out story has been successful thus far, there is further action that we can take to help the rest of the world. Through the development of LNG projects, Canada can make direct contributions to global emission reductions by enabling other nations to begin their own coal phase-out journeys.

FIGURE 7: LNG CAPACITY BY PROJECT



Source: Power Perspective 2023