Natural Gas vs. Coal

Is Burning Natural Gas to Generate Power a Better Alternative than Coal?

Dean Tucker
June 30th, 2024

The great enemy of truth is very often not the lie – deliberate, contrived and dishonest – but the myth – persistent, persuasive and unrealistic. Too often, we hold fast to the cliches of our forebears. We subject all facts to a prefabricated set of interpretations. We enjoy the comfort of opinion without the discomfort of thought.

John F Kennedy, Commencement Address at Yale University, June 11, 1962

Introduction

Is natural gas a better alternative to use as an energy source than coal? There are two diametrically opposed views when it comes to the issue of replacing coal with natural gas as a fuel source. The one that supports using gas points out that gas only produces half the CO_2 emissions of coal and is therefore a better fuel source from an environmental perspective. Thus, we in Canada should be producing as much natural gas as possible and converting it to LNG to ship to high coal burning countries such as China and India. The other view is that using gas to replace coal is just a smokescreen by the oil and gas industry to proliferate gas burning facilities and thus ensure a long-term market for gas. Proponents of this view generally believe it is not desirable to replace one fossil fuel with another, and in fact, gas is not any better than coal as an energy source when unintentionally released methane, or fugitive methane emissions, associated with gas production is taken into consideration. Both views are rather simplistic, and the answer to the question is, as with many issues in our world, much more complex.

This paper will first look at the technical and economic aspects of using natural gas instead of coal starting with an examination of the amount of fugitive methane emissions associated with full cycle gas production in British Columbia (BC) and Alberta. This will determine if fugitive emissions offset the environmental benefit of lower CO_2 emissions derived from using gas instead of coal as a fuel source. Then a comparison of the efficiencies of state-of-the-art gas and coal plants is made including the costs of each. This will provide insight into whether new coal plants are a viable option to gas fired plants from an efficiency perspective; and finally, the cost of capturing carbon for both alternatives is assessed.

Next global demand for natural gas is investigated to determine if switching coal for gas would just be a marketing ploy by gas industry interests to prop up gas demand. This is followed by a brief look at the role of liquefied natural gas (LNG) and Canada's potential to fill gas demand. The final section will summarize the findings and provide conclusions.

But first, a brief background to explain why the question of using natural gas over coal is even being asked.

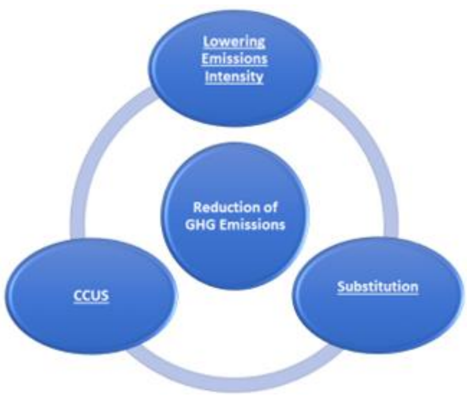
Background

Prior to the widescale use of hydrocarbons for energy, people and societies met their energy needs mostly through the use of water, wind and wood. At the beginning of the 1800's, coal powered the western world into the industrial revolution. Around a hundred years ago oil arrived, and by mid-century, natural gas, and accelerated development leading us into the modern era and a standard of living for people unsurpassed by anything in the history of humanity ~~was launched.~~ Of course, this is mostly true for more developed countries, which has led to other problems associated with energy poverty.

Nevertheless, oil and gas have been a cornerstone upon which the modern world has been built. It has enabled phenomenal advancement in technology, transportation, agriculture and industry that our predecessors would not have been able to imagine. It has also been the driver behind the "globalization" of the world's economy. This is all possible because of the "energy density" of oil and gas. Very simply, energy density is the amount of energy stored in a material per unit of volume. The "magic" of oil, and to some extent natural gas, is that the amount of energy packed into a given unit, is orders of magnitude higher than that of almost any other energy source[1] including wind, solar, hydro, wood, geothermal, etc. The abundance of this relatively cheap[2] high-density energy has enabled progression and wealth creation on an unprecedented scale.

However, the use of hydrocarbons generates GHG emissions which has detrimental effects on the environment in particularly through the effects it has on the world's climate. From 1900 to 2020 global CO_2 emissions have increased from approximately 3 billion tonnes (Gt) per year to over 35 Gt per year[3]. This is a massive problem that needs to be addressed. Yet if it is not practical nor possible to eliminate the use of petroleum and its associated products in the short-term[4], what can be done? One answer is to reduce, eliminate, and/or capture emissions as much as practically possible until other alternative sources of energy mature to replace hydrocarbon use.

Reduction of GHG emissions is a crucial goal in addressing climate change. There are three main approaches that can be taken in working toward this goal:



(i) Lowering Emissions Intensity - Improve Efficiency of Extraction, Transportation and Use
(ii) Use of Lower Emissions Energy Sources – Substitution: including substituting natural gas for coal as a fuel for power generation
(iii) Carbon Capture Utilization and Storage (CCUS)

This three-pronged approach would go a long way toward the reduction of GHG emissions and the achievement of various "net-zero" targets, however, it is the use of substitution, in particularly, the use of natural gas instead of coal as a fuel that is the area of focus for this paper.

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[1] With the exception of nuclear power

[2] Cheap is a relative term. When costs associated with environmental damage to the biosphere are added to the equation, the "price" for the use of hydrocarbons may not be quite so attractive.

[3] See Graph – Historical CO2 emissions and projected emissions from operating energy infrastructure as it was used historically, 1900-2100; IEA World Energy Outlook 2020

[4] How the World Really Works: Vaclav Smil, Viking, 2022 pp 42-43

The Technical and Economic Aspects of Using Natural Gas Instead of Coal

Does Burning Gas for Power Generation Result in less GHG Emissions than Coal?

It is true that natural gas only emits in general around half the CO_2 of coal when burned[5] (depending on the grade of the coal). However, just looking at the lower emissions of CO_2 from natural gas is not taking the whole picture into account. Natural gas is made up of about 70% CH_4, or methane, and the processed gas we use for fuel is approximately 95% methane[6]. During the production, processing, storage, transmission, and distribution of natural gas, some of this methane escapes to the atmosphere which is commonly referred to as fugitive methane emissions or just fugitive emissions. Although the amount of methane is relatively small compared to the large volumes of CO_2 in our atmosphere (just 16% of global emissions are methane), it is still a concern as methane is roughly 28 times more effective at trapping heat in our atmosphere over the long term[7]. This is important because if enough methane is lost through fugitive emissions, it may negate the advantage of lower CO_2 emissions of gas relative to coal.

The amount of methane that escapes as fugitive emissions per unit of natural gas produced, or leakage rate, is referred to as the Fugitive Emission Rate (FER), or methane emissions intensity. Rates of leakage reported from some regulatory bodies using company reported numbers, or source-resolved inventory from individual site measurements, has been called into question by independent sources as being much less than what is actually being released. In an article co-published by Carlton University and Environmental Defense Fund, using two independent aerial surveys and satellite measurements, it was determined that methane emissions were 147% higher than official inventories[8]. It seems that there are indeed issues related to accurately measuring the amounts of methane escaping as fugitive emissions, and disagreements on methods and effectiveness abound.

The results in the above referenced paper, on average, found that the FER in Alberta was roughly 1.65% (upstream and downstream) and for BC was around 0.42%[9]. It could be argued that these are overstated, but the methods to derive these rates have merit and there does not seem to be any good reason to discount the findings. Other studies have also found issues with reporting systems for methane emissions and concluded they may be understated for similar reasons.[10]

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[5] MET Group: Natural Gas vs Coal – Environmental Impacts; November 20th, 2020

[6] Ask MIT Climate: How much does natural gas contribute to climate change through CO2 emissions when the fuel is burned, and how much through methane leaks? July 17th 2023

[7] United States Environmental Protection Agency: Importance of Methane; last updated November 1st, 2023

[8] communications earth & environment: A measurement-based upstream oil and gas methane inventory for Alberta, Canada reveals higher emissions and different sources than official estimates; November 15th 2023

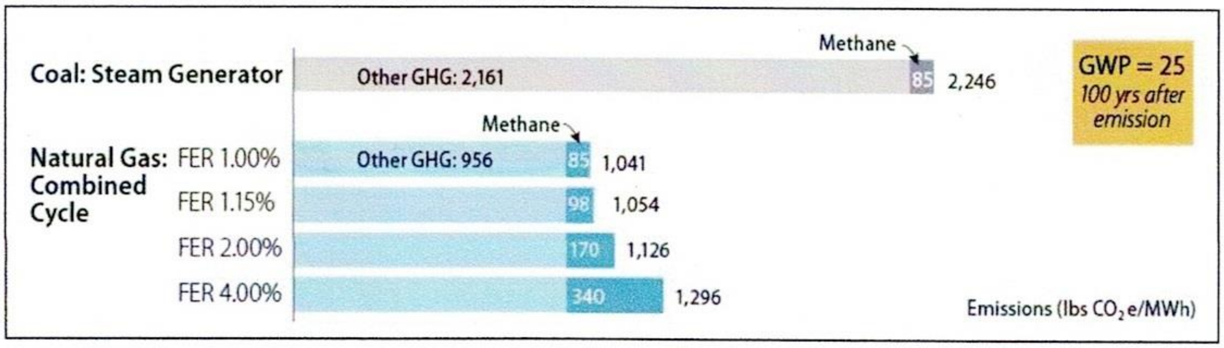
[9] It should be noted that BC production is almost all gas, whereas Alberta has a lot of oil production. The aerial surveys conducted did not differentiate between oil and gas facilities, and oil related facilities typically have greater rates of fugitive emissions than gas related ones. Because we are trying to ascertain whether gas is a better alternative than coal for power generation, the inclusion of oil related methane sources in the Alberta number tends to overstate the emissions related to only natural gas. However, it would be difficult to back out a gas related only emissions intensity for Alberta, so for simplicity, the 1.65% rate will be used.

[10] See Elementa: Science of Anthropocene; Sources and reliability of reported methane reductions from the oil and gas industry in Alberta, Canada; Scott P. Seymour, Donglai Xie, Hugh Z. Li, Katlyn MacKay November 1st 2022

So, does the amount of fugitive methane in Alberta and BC negate the advantage of natural gas generating less CO_2 than coal in power generation? In a paper by the Congressional Research Service, they looked at the life-cycle GHG emissions estimates with four selected FER's over a 100-year average and a 20-year average. Examining life-cycle GHG emissions for these two different averages is important because although methane is a much stronger heat trapping GHG, its effects dissipate much faster than CO_2. Therefore, in the shorter term, 20 years, the effects of methane are more impactful than over a longer time period of 100 years. In Figure 1 below, for a 100 year timeframe, it is estimated that a FER of 1.15% would produce approximately 47% of the life-cycle GHG emissions of a coal-fired steam generator. If the FER were in the range of 2-4%, natural gas could produce 50- 58% of the life-cycle GHG emissions of coal[11].

Figure 1: Life-Cycle GHG Emissions Estimates with Select FER, 100-Year Average

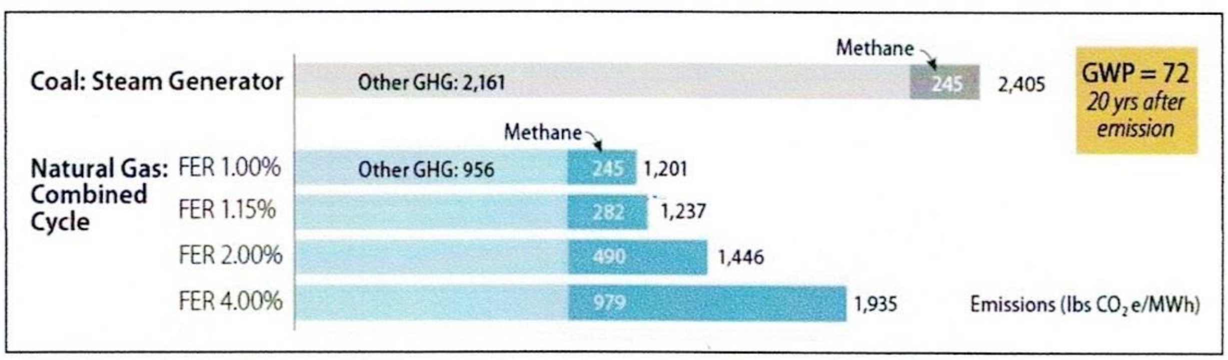
(Emissions in pounds of carbon dioxide equivalents per megawatt-hour of electricity generated)



In Figure 2, a 20-year average case, a FER of 1.15% would produce approximately 51% of the life-cycle GHG emissions of a coal-fired steam generator. If the FER were in the range of 2-4%, natural gas could produce 60- 80% of the life-cycle GHG emissions of coal.

Figure 2: Life-Cycle GHG Emissions Estimates with Select FER, 20-Year Average

(Emissions in pounds of carbon dioxide equivalents per megawatt-hour of electricity generated)



If the higher emissions intensities of 1.65% for Alberta and 0.42% for BC are accepted, and the more impactful 20-year life cycle GHG is used, gas that is sourced from both Alberta and BC still generates less

[11] Congressional Research Service: Life-Cycle Greenhouse Gas Assessment of Coal and Natural Gas in the Power Sector Updated June 26, 2015

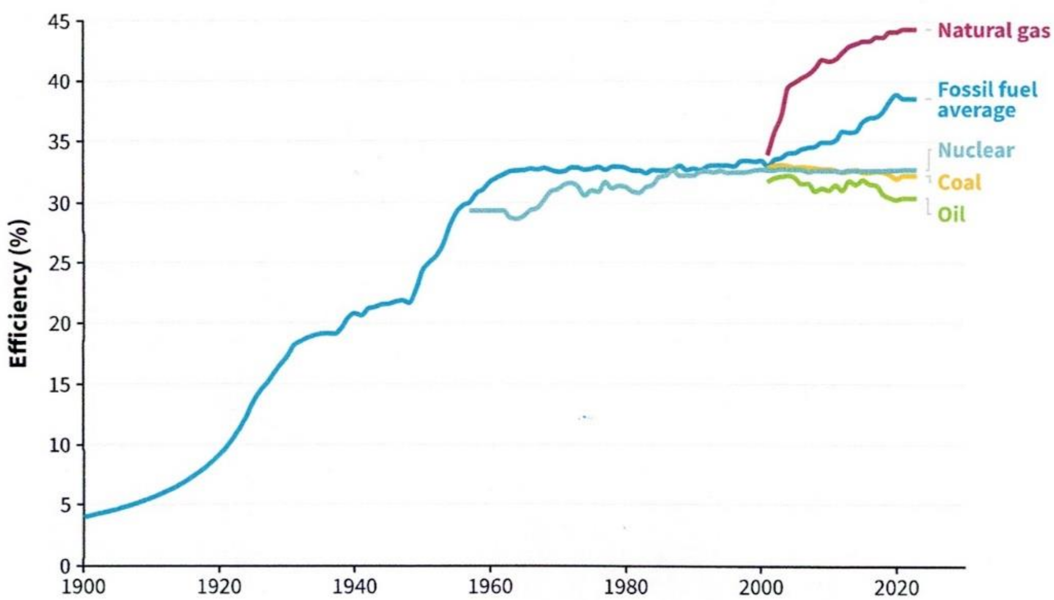
than half the equivalent CO_2 per megawatt hour than coal power generation, even when including the effects of fugitive methane emissions.

In addition to emitting less CO_2 per unit of energy, burning natural gas also emits 40% less nitrogen oxide and 44% less sulphur dioxide than coal[12] and the thermal efficiency of natural gas generated power is greater than coal (i.e. combustion of gas liberates more of its potential energy than coal, on a unit basis). Thus, you have to burn more coal than natural gas on a unit basis to generate the same amount of power. In fact, natural gas is approximately 38% more thermally efficient than coal[13] and, in general, natural gas fired power plants have shorter construction times, lower investment and lower operating costs[14].

Efficiencies and Costs of State-of-the-Art Gas and Coal Plants

In general, as described above, thermal efficiencies of coal fired power plants are around 32% whereas natural gas fired are closer to 44%. See Figure 3 below[15]. However, ultra super-critical (USC) coal plants can reach efficiencies closer to 50%[16] making coal a viable option to gas fired plants on an efficiency basis. In spite of this higher efficiency of USC, the costs for USC coal plants are in the range of $3.6 to $4.5 million per MW[17], whereas gas plants with comparable efficiencies are in the range of $0.7 to $2.1 million per MW[18]. Thus, you are paying more than double, on average, for a USC plant as opposed to a natural gas fired plant for the same efficiency; and these are just the capital costs.

Figure 3: Thermal Power Plant Efficiencies in the United States



[12] Wood MacKensie: Reducing the emissions from natural gas; Ed Crooks; May 13th, 2024

[13] U.S. Energy Information Administration, Form EIA-923, "Power Plant Operations Report," May 15th, 2024

[14] Institute for Advanced Materials: Greenhouse Gas Emissions from Fossil Fuel Fired Power Generation Systems; M. Steen

[15] Source: US Energy Information Administration: Boston U Institute for Global Sustainability; Visualizing Energy, cc by 4.0

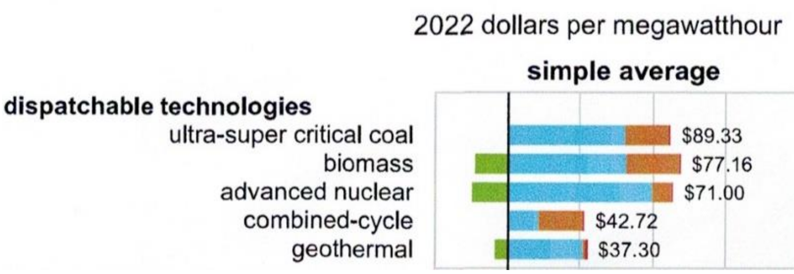
[16] Energy Education U of C: Supercritical coal plant; J.M.K.C. Donev et al, 2024

[17] ESFC Investment Group: Coal-fired power plant construction costs, 2024

[18] Market Realist: Natural gas-fired power plants are cheaper to build, Mayur Sontakke, January 16th, 2015

Other costs, including fixed and variable operating costs, transmission costs, etc. need to be taken into account in order to provide a full cost analysis. Figure 4 shows the full cost breakdown for various power sources taking into account all costs associated with delivering power[19].

Figure 4: Levelized Costs of Electricity*

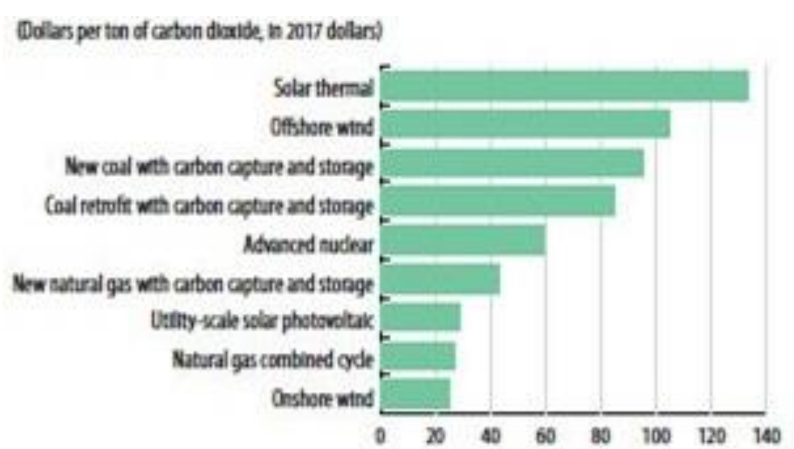


Thus, for a full cost analysis, a USC coal plant is still more than twice as expensive as a natural gas fired power plant (combined-cycle) on a dollars per megawatt/hour basis.

Cost of Capturing Carbon and Other Flue Gases for Both Natural Gas and Coal Fired Plants

Regardless of plant efficiencies, CO_2 and other flue gases from coal fired plants are greater than those from natural gas fired plants, but does the technology exist to effectively capture these gases? The answer is yes. Using various types of scrubbers, absorbers and other forms of flue gas treatment technologies, over 90%, of harmful flue gases can be captured for both coal and natural gas fired plants[20]. If a decision is made to capture and store a high percentage of CO_2 and other toxic gases from coal plants, or capture carbon from a natural gas fired plant, there are costs associated with this operation. Figure 5 compares the total costs required to for a new build coal plant with carbon capture and storage (CCS) to a natural gas plant with CCS.

Figure 5: Comparing Costs[21]



[19] EIA: Levelized Costs of New Generation Resources; Annual Energy Outlook, April 2023

[20] Water Technology: Wastewater; Smokestack scrubbers: How they work and why they are used, Oct 22nd, 2018

[21] International Monetary Fund: F&D Finance and Development Magazine, Carbon Calculus, Kenneth Gillingham, Dec 2019

*Dispatchable technologies refers to electricity sources that can be adjusted to market needs

In this case, the gas plant is still only roughly half the cost as a coal plant with the same efficiency and capture of carbon. Even a coal plant retrofit is still double the cost of a new build gas plant.

It should be noted that in all the above discussion we are only referring to the use of natural gas versus coal for power generation, and not for uses such as the generation of industrial heat. A study in 2015 Carnegie Mellon University found that in using gas for the generation of industrial heat its advantages over coal were greatly reduced[22], if not negated.

In this section the technical and economic aspects of using natural gas instead of coal have been examined to determine if using gas instead of coal as a fuel source is a better option. Next global demand for natural gas is investigated, to determine if switching coal for natural gas is just a marketing ploy by gas industry interests to prop up gas demand or not.

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[22] E&E NEWS by Politico: CLIMATEWIRE Is LNG dirtier than coal? Its complicated; Benjemin Storrow, Feb 5th, 2024

Global Gas Demand: Now and into the Future

The intent of this document is to look at just one small part of the energy and emissions equation and try to bring some clarity to the complexities surrounding the decision of whether replacing coal fired power stations with gas fired ones makes sense. The preceding section focused primarily on the technical and economic aspects of this question, however, in order to understand the full scope of this issue and arrive at an optimal solution, asking a broader question is required; does future demand exist for natural gas or even fossil fuels at all, as the role of renewables and other alternative energy sources continues to expand. Indeed, this is the basis of the second view described in the Introduction, that using natural gas to replace coal is just a ruse by the gas industry to create a market for their product.

Scenarios for Projections of Future Energy Demand

There are a plethora of reports, articles, information and opinion on energy demand in general, and fossil fuel demand specifically, for the next twenty-five to thirty years. Unfortunately, many of these documents, from both sides of the debate, message data to fit with pre-existing ideas regarding energy demand. Perhaps one of the more balanced or unbiased sources of information is the IEA World Energy Outlook**. The World Energy Outlook 2023 provides three possible scenarios for how energy demand will unfold over the next three decades. They are[23]:

1. STEPS: Stated Policies Scenario where policies committed to reducing CO_2 emissions have been legislated into law. Projected to result in a 2.4^o temperature change by end of the century
2. APS: Announced Pledge Scenario where commitments have been made but not legislated into law. Projected to result in a 1.7^o temperature change by end of the century
3. NZE: Net Zero Emissions scenario where it is assumed actions will be taken to ensure global temperature rise will be 1.5^o by end of the century.

Current commitments, or pledges, (APS) by 2030, are expected to result in an increase in emissions of 10.6% above 2010 levels, which is an improvement over last year's projection. Yet, in order to hold global temperature rise to 1.5^o by the end of the century: "*The UN's Intergovernmental Panel on Climate Change's 2018 report indicated that CO_2 emissions needed to be **cut 45%** by 2030, compared to 2010 levels*".[24] Current policies in place (STEPS) will result in a temperature increase of 2.4^o by the end of the century, and current pledges in place (APS) will only decrease this rise a small amount by 2100[25]. It would seem that globally, action on GHG emissions is falling short of the more aggressive scenarios of APS and NZE. A report by the UN Climate Action in 2021 states that although pledges and commitments are growing, follow through to implement these promises is falling well short[26]. Even today, the UN Climate Acton website reports that "*commitments made by governments to date fall far short of what is required*" to hit net-zero by 2050[27].

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[23] World Energy Outlook 2022, pp 91-92
[24] UN Climate Change: Climate Plans Remain Insufficient: More Ambitious Action Required Now, Oct 26. 2022
[25] UN environment programme: Emissions Gap Report 2022, October 27, 2022
[26] UN Climate Action: Net-Zero pledges grow; ambition falls short, April 1st, 2021
[27] UN Climate Action Website/Solutions/Net Zero/Are we on track to reach net zero by 2050?
** Determined in conversation with multiple people in the energy world and academia

Given the current trajectory of emissions curtailment it would seem prudent to use the less aggressive scenario of STEPS when discussing future global energy demand.

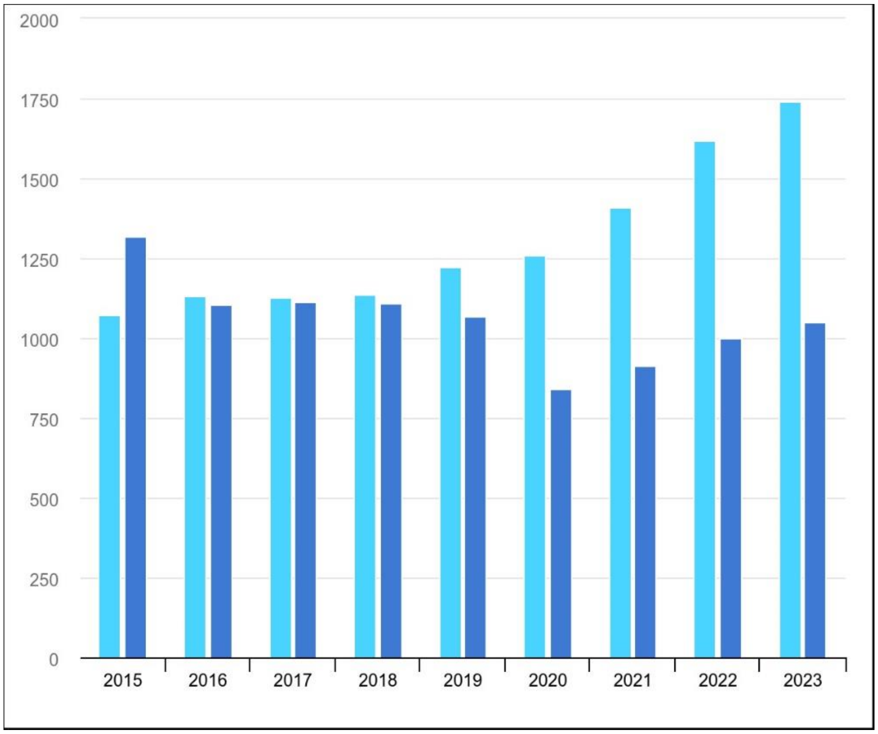
Global Economy and Energy Demand Projections

The global economy is projected to grow at a rate of 2.6% per year up until 2050[28], and the population is forecasted to increase from 8.0 billion in 2022 to 9.7 billion by 2050[29] with 1 billion of this increase occurring in Africa. Energy poverty is already a pressing problem in sub-Sahara Africa where around 80% of people do not have access to electricity[30], this population growth will only exacerbate an already dismal situation. Can renewables and other alternative sources of energy meet the growth demand over the next ~30 years, and the increasing energy poverty in Africa, India and South East Asia? According to the IEA Would Energy Outlook 2023, the answer is a qualified yes.

The share of total primary energy consumption related to renewables reached 14.6% in 2023, an increase of 0.4% over the previous year[31]. Together with nuclear, they represented over 18% of total primary energy consumption. Figure 6 shows the huge increase in investment in clean energy over the last 8 years, while investment in fossil fuels has dropped off slightly. In fact, more renewable energy will be added over the next 5 years than there has been in total over the last 100 years[32]. Thus, with the investments being made, it is plausible that clean energy may indeed keep up with increasing global energy demand.

[28] World Energy Outlook 2022, p 79
[29] World Energy Outlook 2022, p 94
[30] World Energy Outlook 2022, p 183
[31] Energy Institute: Statistical Review of World Energy 2024, 73rd Edition p 4
[32] IEA Renewables: Latest Findings – The Global power mix will be transformed by 2028, July 11, 2023

Figure 6: Global Energy Investment in Clean Energy and in Fossil Fuels, 2015-2023[33]



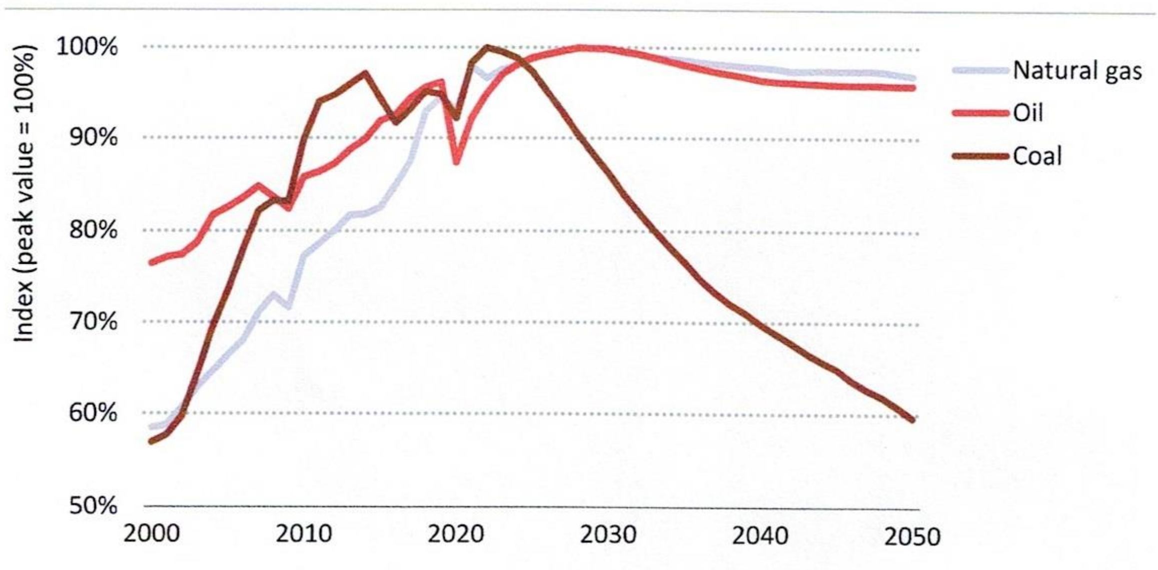
Clean Energy investment indicated in light blue; fossil fuel investment dark blue; in billions of USD

Yet despite massive investment, supportive legislation, and huge resources dedicated to the increasing use of renewables, fossil fuels as a source of primary energy are still 81.5%[34]; and although all fossil fuel use peaks before 2030, as the share of renewables and other alternative energy continues to climb, use of natural gas and oil stays very close to its current demand level as far out as 2050 (see Figure 7). Even coal use is still at 60% of current demand in 2050, but it could be lower if more gas fired power plants were used to replace coal plant demand.

[33] IEA World Energy Investment 2023: Overview and Key Findings

[34] Energy Institute: Statistical Review of World Energy 2024, 73rd Edition p 4

Figure 7: Fossil Fuel Consumption by Fuel in the STEPS Scenario, 2000 - 2050[35]



<u>Sensitivities to Global Economic Growth and Energy Demand</u>

Based on the preceding section there is good news that renewables will be able to keep up with the projected energy demand growth over the next three decades, but how firm is this projected demand? If demand turned out to be greater than projected, how would this affect the global energy transformation? There are several key variables that have great impact on the global economy and energy demand, and this section will take a closer look at each of them. They are as follows:

1. The growth of China's economy
2. Geopolitics: its effect on supply chains and resulting economic consequences
3. Oil & Gas industries' ability to maintain supply or increase if required

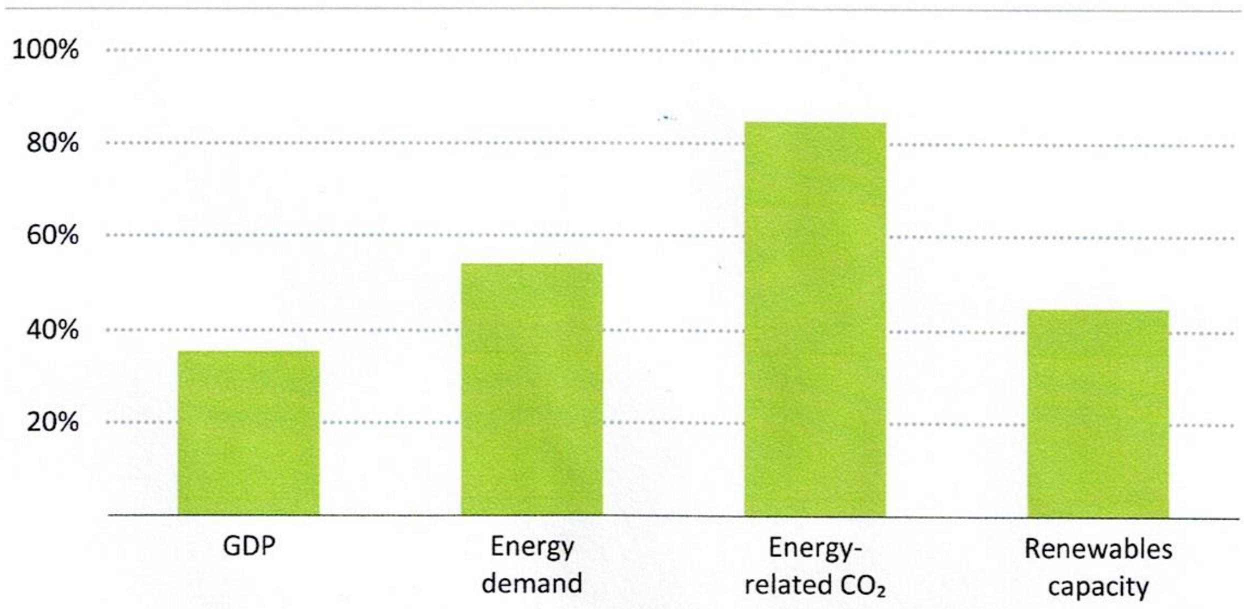
China's Economic Growth Projections:

Although China's economy is slowing from the breakneck pace of the last few decades, all projections for global economic growth are still very dependent on China's economy[36]. The IEA projection for growth in China's economy to 2030 was revised downward in 2023 to 4.0% from 4.5% in 2022[37]. This resulted in a 5% contraction of China's economy to 2030, so even small changes to economic growth projections can result in larger changes to their overall economy. This is significant because variations in China's economy still have huge impact on the global economy and energy sector. Figure 8 illustrates that over 50% of global energy demand is affected by changes within the Chinese economy. Ergo, if downward

[35] World Energy Outlook 2022, p 26
[36] World Energy Outlook 2022, p 31
[37] World Energy Outlook 2022, p 32

projections for Chinese economic growth are off by even a small amount it can have huge impacts on global energy demand.

Figure 8: China's share in the change of global economic and energy sector indicators, 2012-2022[38]



Geopolitical Concerns:

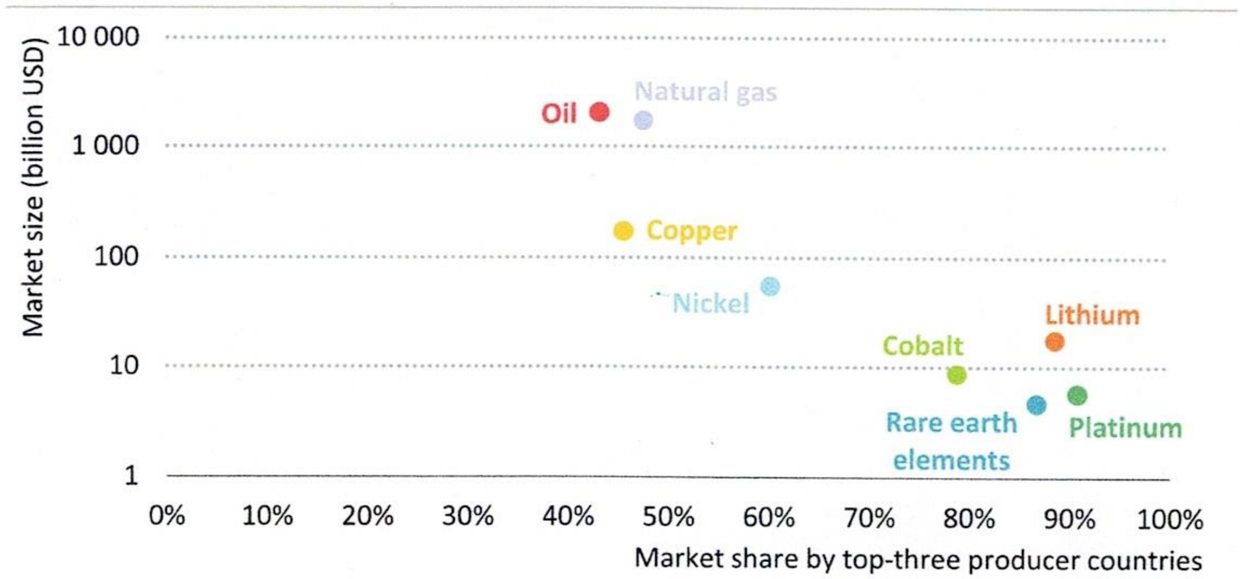
Geopolitics has always influenced the supply of oil and gas and vice versa, and there is no reason to assume that energy geopolitics will not continue to be volatile[39]. When looking at how to reduce emissions from fossil fuels, consideration has to be given to energy security and the price people pay for energy. If a country can't secure energy supply for its citizens or industries, or people can't afford to fill their car with gasoline or heat their home, no one is particularly concerned with the environment, which is obviously counterproductive. In order to have an orderly energy transformation, all three variables need to be taken into consideration. Disruptions of supply, or increases in demand, resulting in price spikes set back the transformation, thus, it would seem to make sense to not ride the supply/demand line too tightly and instead have some extra oil and gas reserves available to help smooth out energy demand and supply spikes. Of course, if all countries had access to their own supply of fossil fuels, supply and price disruptions would not occur as often nor be as severe, but unfortunately, only a limited number of countries have abundant supplies of hydrocarbons that can be transported to other energy poor states.

Opportunities to produce low-cost clean energy are distributed more evenly around the world than oil and gas. For example, any country can build wind and solar farms to generate electricity. Thus, it would be natural to assume domestic economies that utilize renewables would be far less effected by supply upheaval caused by unpredictable geopolitics than countries reliant on oil and gas imports[40].

[38] World Energy Outlook 2022, p 31
[39] Energy Geopolitics: The changing world of energy and the geopolitical challenges 1. Understanding energy developments, Samule Furfari, 2017, printed by CreateSpace, p 17
[40] World Energy Outlook 2022, p 69

However, although the option to build renewable capacity exists for many countries, the same cannot be said for the clean energy supply chains. In fact, *"the three largest producer countries account for at least 70% of manufacturing capacity for key mass-manufactured* technologies; *wind, batteries, electrolysers, solar panels and heat pumps*[41]*"*. In addition, current production capacity for critical minerals is far more concentrated than traditional hydrocarbon sources as illustrated in Figure 9.

Figure 9: Average market size and level of geographical concentration for extraction of selected commodities, 2020-2022



Thus, many more countries may be held captive by fewer suppliers than currently exists with traditional oil and gas supply, and there is no reason to believe that supply chains for critical minerals will be any less susceptible to geopolitics than hydrocarbons. Indeed, with less suppliers, the effects could be greatly amplified.

Other Considerations:

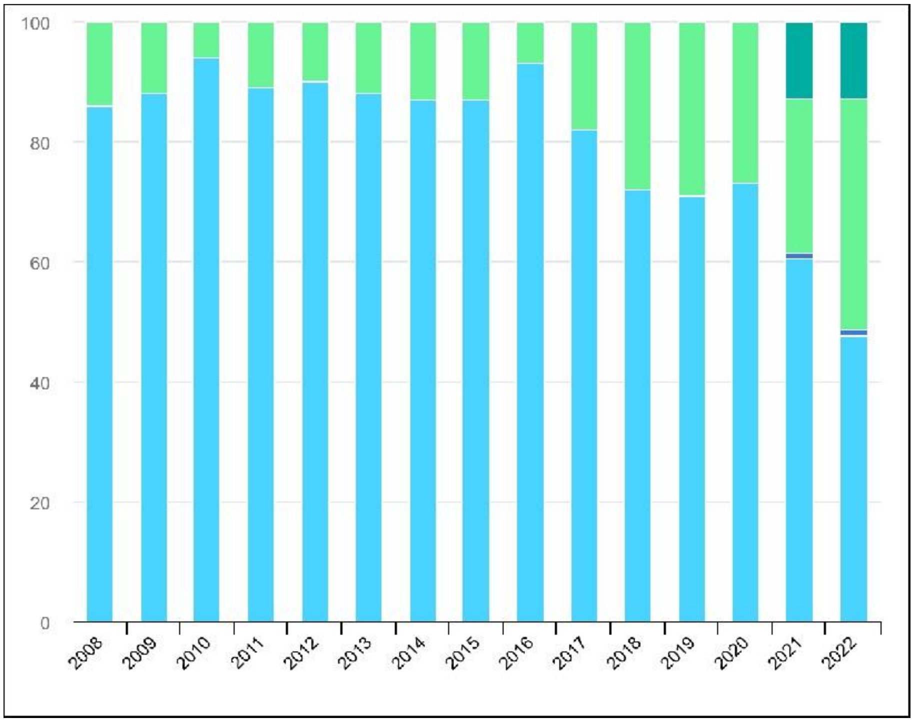
There has been a lot of focus on the demand side of the energy equation with respect to oil and gas. However, a decrease in supply has the same effect as an increase in demand, and although there is an abundance of oil and gas reserves available to develop, the investment needed to extract future reserves has been declining at an enormous rate. (see Figure 10 next page)

Prior to 2018, capital expenditures by oil and gas companies on developing new oil and gas reserves averaged around 88% of total cash available. Starting in 2018 spending began to decrease and in 2022 it was less than 50%, replaced by share buybacks, dividends and debt repayment. Large capital projects, such as those to bring new oil and gas on stream, take years, if not decades, to execute. If demand for hydrocarbons were to substantially increase for a prolonged period of time, for any number of reasons, there would be very little excess product available to meet demand. This lack of investment in traditional

[41] World Energy Outlook 2022, p 70

supplies, due to worry regarding demand erosion, would result in catastrophic price spikes which would derail an orderly energy transformation.

Figure 10: Distribution of cash spending (%) by the oil and gas industry, 2008-2022[42]



Light Blue: Oil and gas capital expenditure

Dark Blue: Low-carbon capital expenditure

Light Green: Dividends plus buybacks minus issuances

Dark Green: Net debt repaid

This section has provided a detailed look into the current and future global energy demand, and gas demand specifically. The next section will look at the role of LNG in global gas demand and what part if any, Canada can play.

Liquefied Natural Gas (LNG) and Canada's Potential[43]

Global Trends:

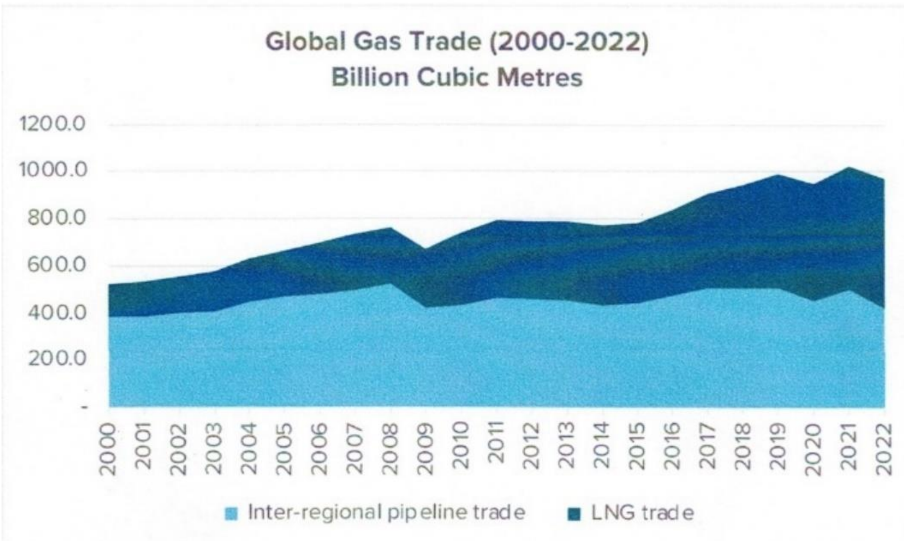
As discussed in the previous sections, if gas is to be a viable alternative to coal for power generation, how would countries without any, or even limited domestic gas production, obtain the natural gas they need to replace coal? The answer is through the growing global liquefied natural gas (LNG) market.

As illustrated in Figure 11, global gas demand has almost doubled in the last 20 years with LNG leading the way.

[42] IEA World Energy Investment: Overview and Key Findings

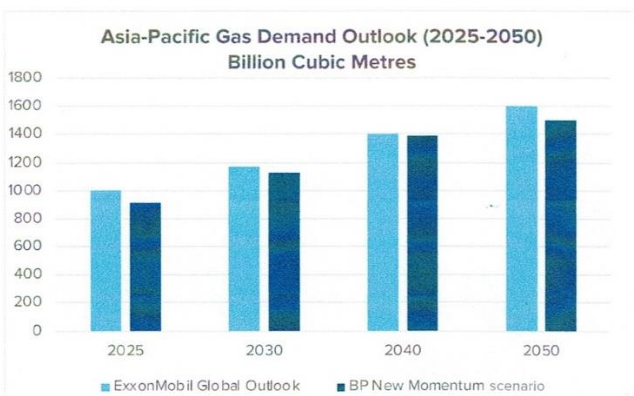
[43] Most information in this section is obtained from: Evaluate Energy LNG Briefing Note: Fall 2023, Linking North American LNG Supply to Asia-Pacific Markets, Tom Young

Figure 11:



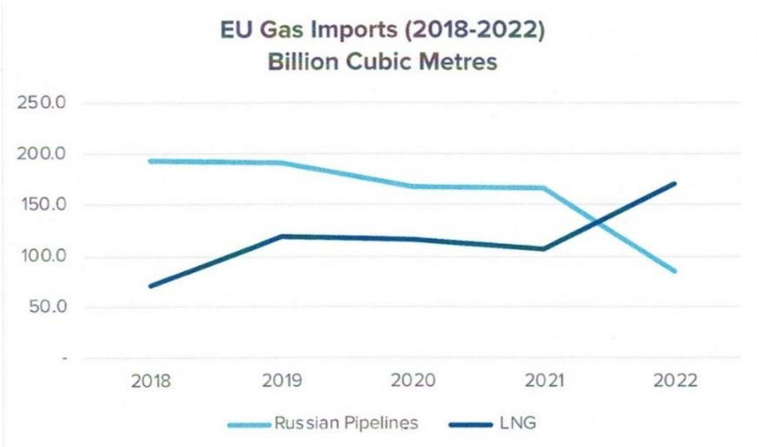
Both the BP New Momentum scenario and the ExxonMobil 2023 Global Outlook both project strong demand growth in Asia-Pacific markets out to 2050. (see Figure 12)

Figure 12:



In fact, during the aftermath of the Russian invasion of Ukraine, imports of LNG in Europe increased significantly to offset the loss of Russian gas as shown in Figure 13 During this time, Asian markets turned away from LNG imports due to the high price and turned to coal instead, so LHG imports to emerging economies is very important to help offset emissions.

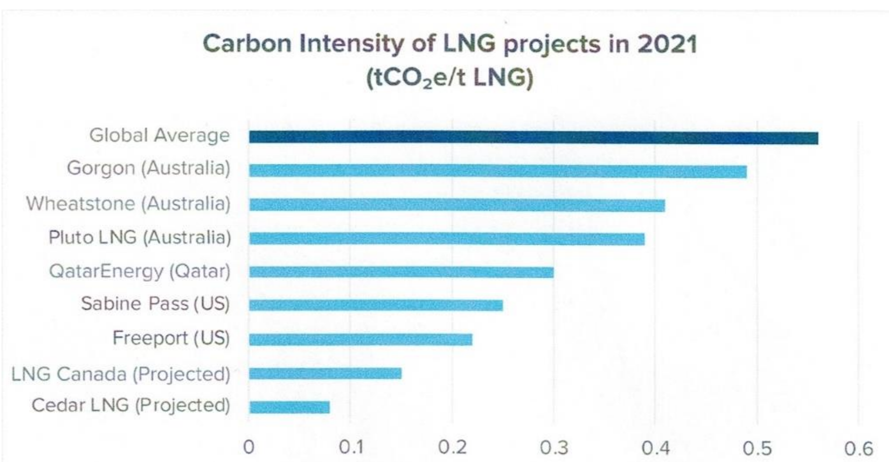
Figure 13:



Where does Canada fit in the Global LNG Market:

The majority of global LNG exports come from the US, Qatar and Australia, as shown in Figure 14, with Canada yet to join the market. However, Canada is well positioned to be a major player in this market with its close geographical location to Asian markets and reasonable pricing. But perhaps the greatest advantage Canadian LNG will have is low emissions. The first two projects to come on stream in Canada have projected emission way below other major exporters and the global average.

Figure 14:



Thus, despite comments to the contrary, by some politicians, there is a strong business case for Canadian LNG. In fact, it could be argued that if Canada is indeed serious about reducing global GHG emissions, it would be remiss to not supply as much Canadian LNG as possible to the global market.

Summary & Conclusions

The Technical and Economic Aspects of Using Natural Gas Instead of Coal

Summary: Even when taking into account the full cycle fugitive methane emissions with natural gas in BC and Alberta, natural gas is still a far better alternative than coal from a total GHG emissions perspective. Although coal fired power plants can match the efficiency of natural gas fired ones as well as capture most GHG emissions, the price premium for coal plants to match the performance of natural gas plants is, in all cases, more than double, all things being equal.

Conclusion: From a total GHG emissions and economics perspective, natural gas fired power plants are a better alternative than coal fired plants utilizing natural gas produced in BC or Alberta.

Global Gas Demand: Now and into the Future

Summary: Trying to understand the global demand for energy is problematic but the IEA STEPS scenario is arguably the most reliable source available. Global energy demand is growing and it would seem that renewables may be able to keep up with this demand growth. However, even with demand for natural gas peaking in 2030, the demand for natural gas remains essentially at its current level out to 2050. Furthermore, assumptions used in demand forecasting are sensitive to several factors, any one of could drive this demand higher.

Conclusion: Gas demand is strong for the foreseeable future and gas interests do not need to create an artificial market by pushing to use natural gas for coal in power generation.

Liquefied Natural Gas (LNG) and Canada's Potential

Summary: LNG is a viable option for countries without natural gas reserves to access for supply for the purpose of moving away from coal fired plants to gas fired plants. LNG demand how grown significantly in the last 20 years and is projected to continue to grow significantly out to 2050, especially in Asia. Without LNG supply, resource constrained countries will most likely turn to coal. Canada has yet to enter the market but has geographic, cost, and emissions advantages over its competition.

Conclusion: LNG is a viable option to provide gas to resource constrained countries and Canada can be a major player in this space.

It is hoped that this paper has provided some credible answers to the question of using natural gas instead of coal for power generation. If nothing else, perhaps it has at least provided greater insight into the complexity of the questions such as switching coal for natural gas, and the interdependency of so many variables in making such determinations.

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