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ENERGY PRODUCTION, CONSUMPTION AND TRADE: HOW CANADA AND B.C. STACK UP

HIGHLIGHTS

- If British Columbia or Canada ceased to exist tomorrow, the greenhouse gas emissions eliminated from energy production and consumption relative to the global total would be equivalent to a rounding error.
- Energy production and trade are hugely important to Canada's economy. In 2017, energy represented an 11% contribution to Canada's GDP, directly employed 276,000 people, and indirectly supported more than 600,000 additional jobs. Canadians are also energy innovators, a source of technology and process solutions.
- Energy is also important to British Columbia. In 2017, we derived $11 billion in value from energy related activities, with energy ranking second to forestry in the province's merchandise exports. Energy production and trade support tens of thousands of high-quality jobs and contribute significant tax revenues that help pay for valued services like health care and education.
- Renewables are an increasingly important part of the energy/electric system, globally, in Canada and in British Columbia. But they will not replace fossil fuels in the foreseeable future absent a dramatic technology disruption.
- In all medium-term energy production and consumption scenarios, fossil fuels remain significant, meeting between ~60% and 80% of global primary energy demand for many years to come.
- In 2017, electricity represented 16% of total global energy production. Of this, renewables (which include hydro) supplied almost 24% of total electricity, with solar/wind/geothermal/biomass together making up just over 8% of the total. This translates to 4% and just over 1%, respectively, of all energy produced worldwide.
- Action on climate change is necessary, both globally and in Canada. But in the short to medium term, it would be better to focus more attention on adaptation, making both human and natural habitats more resilient and better able to cope with impacts. At the same time, we should be using our ingenuity to find realistic and pragmatic solutions rather than hamstringing ourselves with increasingly costly, inward-looking policies and regulations.

THE VITAL IMPORTANCE OF ENERGY

It is no exaggeration, and worth reiterating: all human action is derived from the transformation of energy. We are dependent on energy, whether in the form of food or refined oil products for the global transportation system, to move goods and people, power our cities, run manufacturing plants, and heat our homes, factories, hospitals, schools and other buildings. Today's modern economies need vast quantities of reliable dense energy,[1] along with the physical delivery infrastructure and technology to find and convert the potential of various energy sources into useable flows. Energy sources and systems have evolved over time, as has trade in energy. A now interconnected and interdependent world exchanges all forms of energy in some way, based on a mix of comparative and competitive advantages. Sometimes this trade is global in scale, as is the case for coal and oil, and sometimes it is more local/regional, as is mainly the case with electricity.

The issue of climate change has put an intense spotlight on energy and environment issues. There are

[1] Energy density is the amount of energy that can be stored in a given mass of a substance or system. The higher the energy density of a system or material, the greater the amount of energy stored in its mass. (https://energyeducation.ca/encyclopedia/Energy_density)

multiple corroborating sources of data and science confirming trends in energy production, consumption, and the risks of continuing to increase greenhouse gas emissions from the combustion of fossil fuels. At the same time, history shows that energy transitions are slow and protracted, taking several generations to unfold, in part because of the need for different production, conversion and distribution systems. This was true for the shifts from wood to coal, from coal to oil, and from oil to natural gas. And it is likely to be true in the current journey to a lower carbon balance of global energy resources.

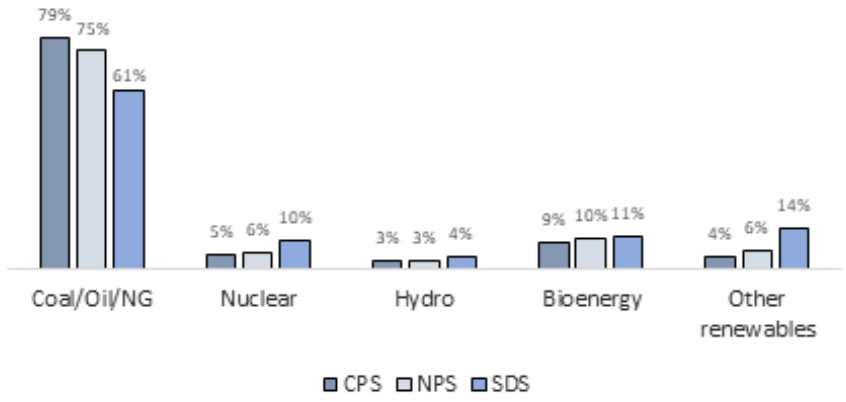
WORLD VIEWPOINT

In 2016, total global energy demand of 576 exajoules[2] (EJ) was met 80% by fossil fuels. By 2025 and 2040, this forecast for total energy demand could rise to ~650 EJ and ~800 EJ, respectively. These two numbers are based on the International Energy Agency's Current Policies Scenario (CPS), where fossil fuels continue to meet over three-quarters of world energy demand through 2040.

This paper uses the CPS as the main reference point rather than the IEA's often-cited New Policies Scenario (NPS), because the difference between the two is relatively small. For example, the gap between the two fossil fuel demand profiles in 2025 is only 2%. By 2040, the gap doubles to 4%, but in the scheme of world demand and greenhouse gas emissions, such a change is insignificant and could be undone by either an increase in economic growth or some other factor affecting global energy demand. Even under the IEA's more aggressive (and in our view unrealistic) *Sustainable Development Scenario* (SDS), the share of fossil fuels in the world energy mix is only slightly less than in either of the other two scenarios in 2025. A bigger difference shows up in 2040, where, if all countries implemented all the policy tools described in the SDS, fossil fuels would drop to ~61% of total world energy demand.

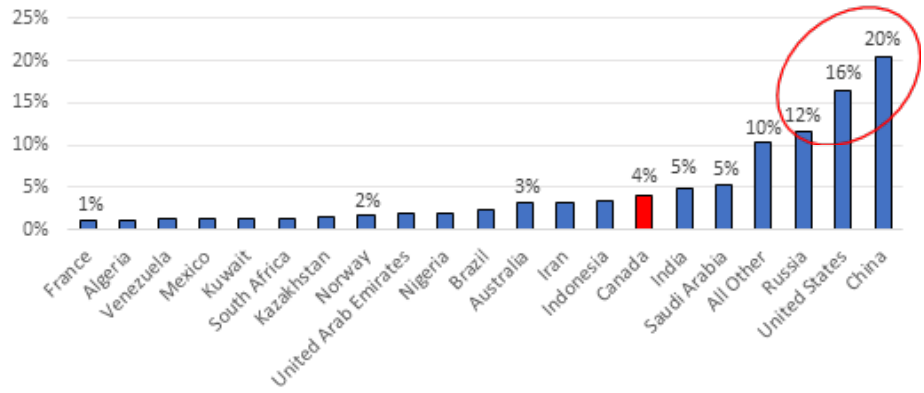
But absent the discovery and very fast deployment of disruptive technologies, the CPS is a more likely outcome — especially given the resurgence of "nationalist" impulses in many countries and the weakening of international institutions and rules-based international regimes. In short, under any realistic view of the future to 2040, fossil fuels will remain foundational to the global energy mix.

FIGURE 1: **IEA 2040 TOTAL GLOBAL ENERGY DEMAND SCENARIOS**



Source: International Energy Agency.

FIGURE 2: **TOTAL GLOBAL ENERGY PRODUCTION 2017**

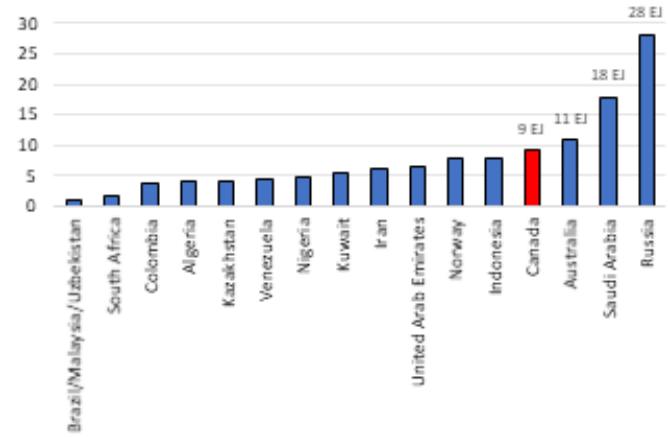


Note: countries with less than 1% of production are included in All Other.

Source: IEA Statistics; BP Energy Outlook Statistics; Enerdata.

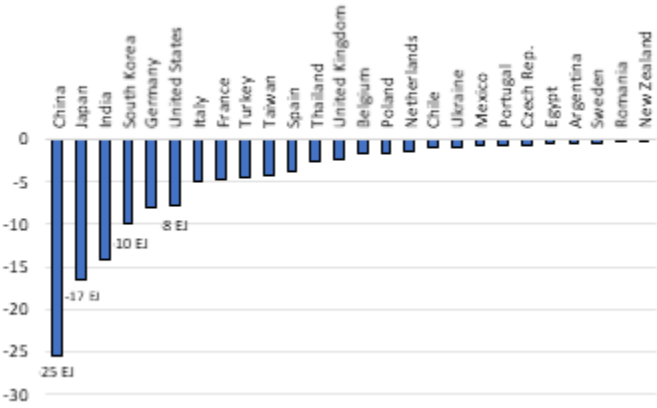
[2] Joule defined: is a derived unit of energy in the International System of Units equal to the energy transferred to (or work done on) an object when a force of one newton acts on that object in the direction of its motion over one metre.

FIGURE 3: **COUNTRIES WHERE TOTAL ENERGY PRODUCTION > CONSUMPTION 2017 (EJ)**



Source: IEA Statistics; BP Energy Outlook Statistics; Enerdata.

FIGURE 4: **COUNTRIES WHERE TOTAL ENERGY CONSUMPTION > PRODUCTION 2017 (EJ)**



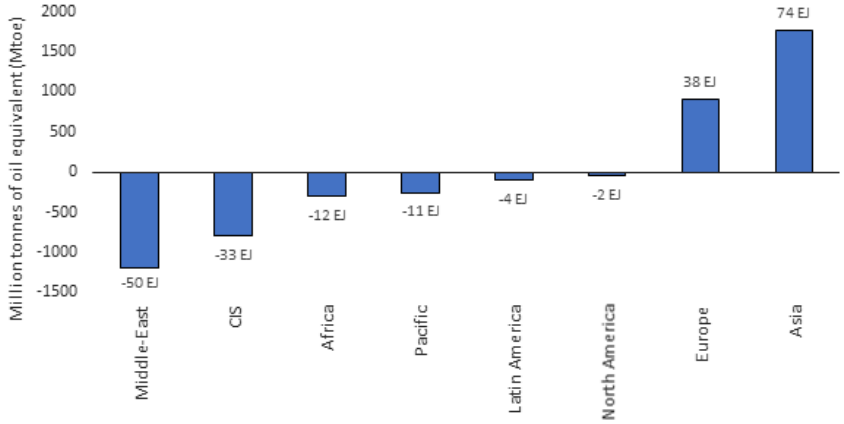
Source: IEA Statistics; BP Energy Outlook Statistics; Enerdata.

THE ENERGY PICTURE IN CANADA AND B.C.

As shown in Figure 2, in 2017 about 48% of the world's total energy production (all forms) came from three countries: Russia, United States, and China, in that order. Canada's share was 4%.

Of course, Canada is a net energy exporting nation, consuming less than it produces. Of the ~21 EJ that Canada produces, we contribute about ~9 EJ to help meet others' energy needs. Canada trades in all energy sources — coal, oil, natural gas, uranium, and electricity. Energy is also a significant source of revenues, from both domestic sales and exports, for British Columbia. In fact, "[t]he value of B.C.'s international merchandise exports grew 12.7% in 2017 … The improvement in export activity [over 2016] was primarily driven by an increase in energy exports … US-bound [energy] exports [were] led by a 40.8% increase in natural gas exports and a more than six-fold increase in [metallurgical] coal exports."[3] Indeed, energy makes up about one-quarter of the province's merchandise exports.[4] The value of British Columbia's energy output (GDP) was a non-trifling $11 billion in 2017.[5]

FIGURE 5: **ENERGY TRADE AMONG GEOGRAPHIC REGIONS (2017) (MTOE AND EJ)**



- excess production + consumptions gaps

Source: IEA Statistics; BP Energy Outlook Statistics; Enerdata.

BY THE NUMBERS — PRODUCTION AND CONSUMPTION OF ENERGY

Oil

Oil and refined petroleum products are the fuel of choice for the global transportation system and represent about one-third of total global energy production. There are few

[3] 2018 British Columbia Financial and Economic Review 78th Edition (August 2018). https://www2.gov.bc.ca/assets/gov/british-columbians-our-governments/government-finances/financial-economic-review/financial-economic-review-2018.pdf.
[4] Trade Data, International Commodity Trade, Annual data. https://www.bcstats.gov.bc.ca/Files/55a99dc9-5947-4254-bd2e-77696fdfcc1a/ExportsAnnualData.xls.
[5] Ibid.

substitutes for oil in transportation, with the near-ubiquitous use of the internal combustion engine (ICE) in everything from planes and trains to automobiles. Electric vehicles (EV) remain a very small sliver of the global vehicle fleet and, although growing quickly in number, have yet to reach critical mass. There are significant issues with the move from ICE to EV vehicles. In trucking, for example, the commercial and widely available technology does not presently exist. For individuals, cost is an issue, along with battery range concerns and availability of supporting charging infrastructure. These barriers to EV adoption are being addressed in some jurisdictions, but oil will continue to provide the vast majority of the energy required to run transportation for decades to come.

Canada is the fourth largest producer of oil, behind Russia, Saudi Arabia and the United States, in that order. The latter three countries together produce approximately 46% of global oil (about 15% each). Canada is the 6th largest global oil exporter, with our exports making up 8% of the crude oil traded in the international marketplace (and 3% of refined products traded).

From a balance of trade perspective, 98% of Canada's oil exports go to the United States, along with 84% of our exports of refined products. Canada also imports oil and refined products — from the US, the Middle East, and Latin America. Again, with imports the dominant trading relationship is also with the United States. This singular trade relationship and constrained pipeline capacity means we sell our oil at a sizable discount[6], costing the country tens of billions of dollars in lost income/revenue every year. This is not a healthy situation for Canada.

Coal

Of the 40 countries that produce coal (primarily for use in electricity generation), 29 produce less than 1% of the world's total each; Canada is among this group. India, Australia, the United States, and China account for 71% of global coal production. China is the largest producer by a significant margin, accounting for 46% of the global total. It consumes all of the coal it produces. Australia is the world's biggest exporter of coal, with 83% of its coal production sold to other markets. Together, China and India consume 62% of global coal, while China, India and the United States consume 71%. Canada's share of world coal production is 0.82%, a miniscule amount by any measure. We consume about two thirds of our production in domestic coal-fired electricity generation facilities in Alberta, Saskatchewan, Nova Scotia, and New Brunswick. British Columbia's coal production is mostly metallurgical coal used in steel-making and exported to Asia. None of it is used to generate power in the province.

Trade in and use of coal will continue. In 2017, global production increased by 3.5%[7] and on average by 1.5% between 2006 and 2016. An alarming and emerging issue is China's development of coal-to-oil (i.e., diesel) conversion facilities.[8] These plants will not only use large amounts of water, but they also will emit significantly more GHGs[9] than simple production and use of coal in electricity generation. At the same time, Canadian environmental activists are trying to block the development and expansion of Canadian oil (and LNG). This is nonsensical if the objective is to reduce global (rather than domestic) GHG emissions.

Emissions Reductions in the United States

The United States owes its remarkable reduction in greenhouse gas emissions over the past decade mainly to the transition in the electricity sector from coal-fired to natural gas-fired generators. In this regard, the United States has benefitted from a North American continental natural gas infrastructure and trade, and a well-developed regional electric system. Much of the transition from coal to natural gas is a logical one based on replacing an aging coal generation fleet with more efficient, more flexible, and less costly natural gas facilities. This transition was organic and logical in the context of market and technology decisions made by owners of those plants rather than driven by policy action of governments.

Natural gas

Natural gas, whether shipped by pipeline or in its liquefied state, is a critically important resource in the transition to a lower carbon global energy system. Like coal, its dominant use is in electricity generation. It emits 50 to 60% less carbon dioxide than coal when combusted in a new, efficient natural gas power plant, compared with emissions from most of today's coal plants.

Canada is the third biggest trader of natural gas on a volume basis,

[6] Relative to global pricing benchmarks for both light and heavy oils.
[7] International Energy Agency Statistics, https://www.iea.org/statistics; Statistical Review of World Energy. https://www.bp.com/en/global/corporate/energy-economics/statistical-review-of-world-energy.html.
[8] http://www.chinadaily.com.cn/a/201806/14/WS5b224a41a31001b82572235c.html.
[9] Adam R. Brandt & Alexander E. Farrell. *Scraping the bottom of the barrel: greenhouse gas emission consequences of a transition to low-quality and synthetic petroleum resources.* Climatic Change (2007) 84:241–263.

behind Russia and Norway,[10] and our exports represent 12% of natural gas flows in the world (not including LNG, yet). British Columbia, and Canada as a whole, also has significant marketable natural gas resources, estimated at about 16 trillion cubic meters (2015), primarily located in the Horn River and Liard Basins in northeastern B.C.[11] Our only export market remains the United States. But with increased use of horizontal drilling and major finds in North Dakota, Texas and elsewhere, the tables are turning as the US moves inexorably toward self-sufficiency in natural gas. In short, we must find other markets.

Why is this important? Given China's coal use — both in electricity and its plans to convert coal to synthetic oil — the world should be looking to find ways of enabling, at a minimum, an interim transition to natural gas in China's electricity system. But like electricity, natural gas markets are largely national/continental, shipped primarily through pipelines. British Columbia's natural gas can only reach end-use markets outside North America if it is liquefied.

Yet in this province, some are seeking to block natural gas development based on the narrative that producing LNG will make it impossible to meet B.C.'s GHG reduction targets. To that we offer the following response. First, B.C.'s targets are arbitrary and ignore the fact that climate change is a global issue; therefore, they are essentially irrelevant in a world context. If B.C. or Canada ceased to exist tomorrow, the resulting GHG emissions reductions would be about 0.2% and 1.7%, respectively, of the global total — less than a rounding error in terms of the impact of energy use from world population growth alone. Viewed differently, Canada's 1.7% share of global GHG emissions is roughly the difference between the International Energy Agency's CPS and NPS fossil fuels energy demand scenarios (see above).

Second, if British Columbia were to supply at least some of its natural gas in the form of LNG to China to offset the development of new coal-fired generation facilities there — which will be built, whether we want them to or not — we could have a positive impact, globally. Not developing our natural gas resources makes zero sense when viewed in the global context. From both a Canadian economic and a world environmental perspective, we should be making sure that Canadian fossil fuels are in the global energy mix.

Electricity

Before we dive into the data on electricity, it is important to note that North America DOES NOT have one power grid, neither does Canada. To this point, North America has 7 electric grids, commonly referred to as reliability regions, some more strongly connected to one another than others.[12] But they DO NOT operate in an integrated way, and in fact are mostly isolated to avoid catastrophic outages cascading. Furthermore, Canada is connected north-south through these reliability regions, not east-west. Electricity is NOT traded globally, only regionally, given its unique characteristics, the most important of which is that it is an instantaneous resource. Supply must match demand, always. It cannot be stored and shipped in containers.

Electricity represents about 16% of global primary energy production. Of this, two-thirds comes from the combustion of fossil fuels. Renewables – hydroelectric, solar, wind, geothermal, and biomass — account for 24% of total electricity generation, and for 4% of total global energy production. Including nuclear power raises the percentage of clean energy in the power sector to about 6% overall. Renewables other than hydro electricity presently supply less than 2% of total global electricity generation — a figure that's sure to grow, but from a very small base. Canada is the world's sixth largest electricity generator. British Columbia stands out as a clean electron provider. We trade power with western US states that are members of the Western Electricity Coordinating Council (often referred to as the Western Interconnection —one of the 7 regions noted), and with Alberta. B.C. plays a critical role in the operations and reliability of the Western Interconnection; most of the electricity we produce is used at home.

Table 1 shows the global distribution of power generation by fuel type. The key points about electricity are the ones already mentioned – continental/regional development and trade, and supply that must always match demand. Thus, electrons are not traded in a global market. Furthermore, as has been discussed extensively in

[10] International Energy Agency Statistics, https://www.iea.org/statistics; BP Statistical Review of World Energy. https://www.bp.com/en/global/corporate/energy-economics/statistical-review-of-world-energy.html.
[11] https://www.neb-one.gc.ca/nrg/ntgrtd/mrkt/nrgsstmprfls/bc-eng.html#s3.
[12] https://www.nerc.com/AboutNERC/keyplayers/Pages/default.aspx.

TABLE 1: **GLOBAL ELECTRICITY GENERATION BY FUEL TYPE**

Total percent of global energy production	16%			
Oil		4%	65%	
Natural Gas		23%		
Coal		38%		
Nuclear energy		10%	% non-emitting electricity sources (nuclear, hydro, renewables)	36%
Total Renewable percent of global production	~4%			
Hydroelectric		18%	% renewables including hydro and other	26%
Non-hydro renewables percent of global production	~1.4%			
Renewables		8%		
Solar			% of renewables	21%
Wind				52%
Geothermal, biomass, other				27%
Other (includes sources not specified elsewhere - e.g., pumped hydro, non-renewable waste and statistical discrepancies)		0.7%		

three books *Power Density, A Key to Understanding Energy Sources and Uses Power Densities*; *Energy Transitions, History, Requirements, Prospects*; and *Energy and Civilization, A History*,[13] the spatial requirements for renewables are enormous. For example, the replacement of the world's 12 TW of fossil fuel infrastructure, its estimated size in 2010, would require 12,500,000 km^2 of land — equal to the combined area of the United States and India,[14] clearly an impossible proposition. This does not mean we do not need to find ways to increase the penetration of renewables in the electricity sector — indeed, further progress here will be essential to addressing climate change — but at the same time we should not overlook the limitations and costs.

CONCLUSION

The reality is that we have spent the past 150 years building a heavily interrelated, integrated, and fossil fuel-heavy global energy system. All of the corroborating data shows that global energy demand between now and 2040 is not likely to change dramatically, absent a technological revolution that includes very fast deployment of new energy technologies/sources. As a pragmatist, it is best not to rely on wishing things could be different, either for energy production and consumption or in relation to managing greenhouse gases. Canada's and B.C.'s climate targets suffer from being completely inward focused and their full realization, if even possible, will result in heavy self-inflicted costs, while making almost no difference to the trajectory of global GHG emissions. If we truly want to contribute to getting China off coal, preventing its conversion of coal to synthetic oil is a good start, along with helping it reduce electricity generation from coal. For B.C. this means ensuring our vast natural gas resources are developed, responsibly, and are available to support the transition of China's GHG intensive electricity sector to cleaner options. For Canada and B.C., it also means actively marketing our extensive experience, expertise, and innovation in the development of energy resources (i.e., electricity, oil, and gas), as well as in operating complex multi-jurisdiction electricity systems that can and do meet multiple economic, social, and environmental objectives.

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[13] Vaclav Smil, Distinguished Professor Emeritus at the University of Manitoba.
[14] Smil, Vaclav. Energy Transitions, History, Requirements, Prospects, 2010 and http://vaclavsmil.com/wp-content/uploads/docs/smil-article-power-density-primer.pdf.