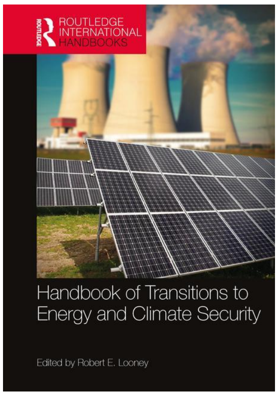


# Handbook of Transitions to Energy and Climate Security

Robert E. Looney

## Energy, climate and economic security, and Canada's road from oil exporter to deep decarbonization

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# Energy, climate and economic security, and Canada's road from oil exporter to deep decarbonization

*Chris Bataille*

## Introduction

As of late 2014, international political consensus was shifting to acceptance that deep emission reductions were necessary to avoid dangerous climate change, exemplified by a 2015 G7 communiqué where all members committed to limiting the anthropogenic increase in global mean surface temperature to less than 2 degrees Celsius (°C) by 2050 relative to 19th century global temperatures, and full decarbonization by 2100.[1] According to IPCC, to ensure a better than even chance of remaining below a 2°C average surface temperature rise global annual greenhouse gas (GHG) emissions will need to be reduced by 42–57% by 2050 relative to 2010, and 73–107% by 2100 in order to stay within a global carbon budget of 960–1,430 $GtCO_2e$.[2] Achieving this target requires steep declines to near zero carbon intensity in all sectors.

Being a signatory to the G7 communiqué was a major visible shift of public policy for the Canadian federal government. Since withdrawing from the Kyoto Protocol to the United Nations Framework Convention on Climate Change (UNFCCC) at Durban in December 2011, and with the rapid growth of the oil sands since 2000, Canada has gained alongside Australia a reputation as a "bad boy" in the climate policy world. As of writing, however, the Keystone XL pipeline has been rejected, Canada has a new Liberal majority government that has renamed the Ministry of Environment the Ministry of Environment and Climate Change, and there is much hope that Canada will "return to the climate fold."

Reality is, as always, a bit more complicated. Canada is a geographically large federation with distinct powers assigned to the federal and provincial levels of government. While energy policy is normally a provincial power, critical to climate policy, the federal government becomes involved when energy commodities cross provincial or international borders. The federal government is also responsible for signing international treaties, and has overriding powers of national interest based on "peace, order and good government."[3] The test for using this power is very strong; however, versions of it have only been used during civil insurrection and wartime, and it is unlikely to be used to enforce climate policy in the foreseeable future. Its existence, however, is an overarching influence on federal provincial relations.

In terms of climate policy, while the Canadian federal government has withdrawn from the Kyoto Protocol, the federal government has imposed restrictions on coal generation (no new generation can be more emitting than an average combined cycle natural gas turbine), personal vehicle efficiency and GHG intensity regulations are equivalent to US regulations and on the same trend as European regulations,[4] and Canada has joined the US in announcing heavy vehicle regulations. Also, in 2009, Canada signed the Copenhagen Accord to the UNFCCC, which, unlike the Kyoto Protocol, is a non-binding agreement; Canada agreed to reduce its GHG emissions by 17% from its 2005 levels by 2020, which translates to a reduction of 124 Mt. This target is highly unlikely to be met, but Canada is an active participant in the "Durban Process" by which all participants, not just Annex I, agree to participate and offer some level of emissions reduction for the 2025–2030 period, or Intended Nationally Determined Contributions (INDCs). At time of writing this new voluntary process is arriving at its first milestone, the Convention of the Parties (COP) 21 of the UNFCCC in Paris, where all the voluntary pledges being made during 2015 will be registered, and a process for their renewal will be discussed.

Canada announced its INDC in May 2015, pledging a 30% reduction from 2005 levels by 2030, which translates into 524 Mt in 2030 from a forecast of 798 Mt (including land-use GHGs). Canada's INDC is deep by any measure given current emissions trends, and is likely to be dependent on a suite of aggressive provincial policies and new federal policies. Canada's INDC is on one of several possible emissions reduction pathways consistent with a 2°C objective (Figure 9.1).[5] With the INDC 2030 target achieved, it would then be another policy and technology stretch to reduce emissions from a forecast level of 16 tonnes per capita in 2050 to the DDPP goal of 1.7 tonnes per capita in 2050.

Perhaps more importantly in terms of climate policy, however, several provinces, which have strong powers related to resources, energy and especially electricity generation and use, have some of the strongest climate policies in the world. Ontario's target is equivalent to 37% below 1990 levels by 2030, which it intends to achieve with a suite of policies, including an existing

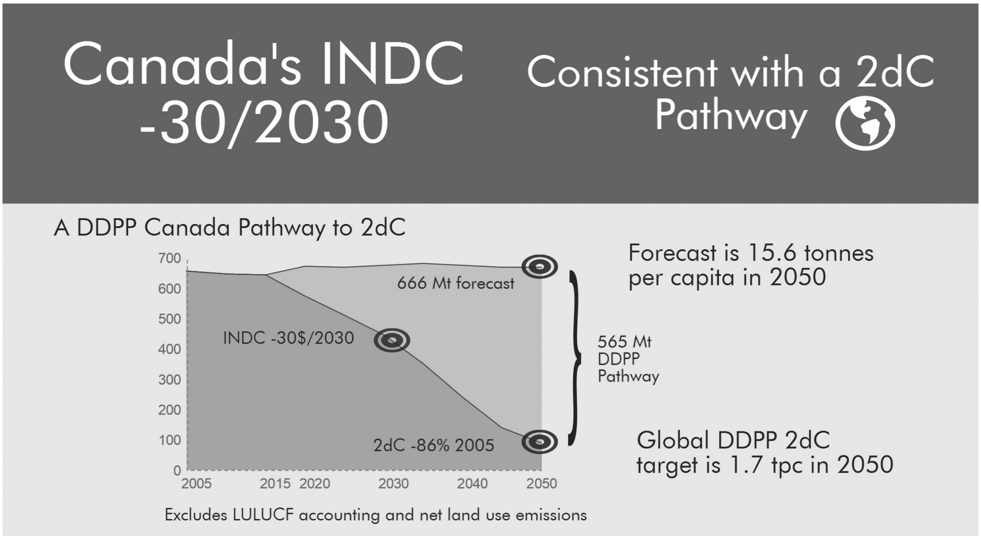


*Figure 9.1* Canada's INDC and the DDPC 2°C pathway
Source: Bataille, Sawyer, and Melton, *Pathways to Deep Decarbonization in Canada*; originally in Bataille, and Sawyer, "Canada's INDC and its Two (Thirteen?) Speed Climate Policy."

coal phase out and joining the Western Climate Initiative (WCI) cap-and-trade system. Québec's target is 20% below 1990 levels by 2020, again the centerpiece being the WCI cap-and-trade system among a suite of other policies. B.C.'s target is 33% below 2007 levels by 2020, via system-wide carbon tax (\$30/tonne $CO_2$e) and virtually 100% clean requirement for electricity. Alberta's target is 50 Mt below business as usual, via its own Specified Gas Emitters Regulation (SGER) intensity-based cap-and-trade system and CCS program (see the epilogue for an update on Alberta's climate policy).

Another key factor is that unlike many developed countries, Canada's population is growing quickly, and its economy with it (Table 9.1). Demand for energy services will increase, and how one perceives Canada's capacity to decarbonize depends on how one perceives the capacity to decarbonize all newly installed energy end uses.

The central theme of this book, of which this chapter on Canada is a part, is the policy trilemma currently facing governments, specifically the difficulty of simultaneously attaining *energy security*, sustainable climate (*climate security*), and economic competitiveness, or *economic security*. Canada's federal, provincial and municipal governments all face this challenge, but its nature is different because unlike most other developed countries Canada, and more specifically certain regions, are significant fossil fuel exporters. For example, by 2014, prior to the oil price collapse in 2015, annual crude oil and natural gas exports had risen to more than \$92 billion and \$16 billion respectively of total exports of \$529 billion (all in 2014 CA dollars),[6] the largest single component of exports, having edged out motor vehicles and parts, the longstanding previous largest component (\$75 billion). Almost all of these exports were originally sourced from British Columbia, Saskatchewan, Newfoundland and especially Alberta. Imports of energy products, about half crude oil and half refined petroleum products, were \$43.6 billion. Crude oil is only imported in bulk to Ontario, Québec and New Brunswick; we will return to this important regional differentiation later in the chapter.

In this chapter, I will take maintenance of the 2°C target as a "sustainable climate," and define climate security as having been met if the 2°C target is maintained. Redefining sustainable climate as climate security in this context is useful, because it allows us to compare the three security priorities using a similar definition, and allows meaningful comparison. When economic security, energy security and climate security point in the same direction, they are mutually reinforcing and climate policy is likely to advance. When one differs with the others, specifically climate security because it is a global issue with focused local mitigation costs, then decision makers prioritize, usually at the cost of significant climate policy.

In this essay, I will make a sequence of three arguments based on evidence from the Canadian federation and the Canadian Deep Decarbonization Pathways Project (DDPP) report:[7]

1 *Energy supply security is a prerequisite for economic security, but this does not require fossil fuels.* I will make the case that it is actually easier to decarbonize in Canada than other countries, due to its large hydropower and other potential renewables resources compared to its population, as well as a large geological potential for carbon capture and storage.

*Table 9.1* Development indicators and energy service demand drivers

| | *2010* | *2020* | *2030* | *2040* | *2050* |
|---|---|---|---|---|---|
| Population [millions] | 33.7 | 37.6 | 41.4 | 44.8 | 48.3 |
| GDP per capita [\$/capita, 2010] | 37,288 | 49,787 | 57,754 | 67,500 | 78,882 |

2 Economic security is fundamentally different for energy importers and exporters, and *climate security will typically enhance economic security for fossil fuel importers, but reduce it for exporters*. To exemplify this difference, I will contrast the cases of Alberta and Québec in the Canadian DDPP deep decarbonization scenario. To better articulate this argument, I will walk through three scenarios of oil prices (long run $40, $80 and $114 per barrel in 2015 USD) in the Canadian DDPP project, and show what different oil prices do to Canadian economic structure.

3 Climate security, to the extent damages are not immediate, will face ambivalence and resistance from fossil fuel exporters, who will produce as long as there is a business case for production. If one producer shuts down in face of political pressure, another less pressured one will take its place; the only sure way to cease fossil fuel emissions to the atmosphere is to ruin the business case for producing them. Based on this, I will argue *a necessary component of climate security is to encourage alternatives that reduce demand*. I will return to the oil price scenarios described earlier to exemplify the role of demand (in this case from the United States) in setting prices and therefore fossil fuel production.

Before proceeding, we need to clarify that the term "energy" is not sufficiently accurate for this conversation. Firms and consumers consume electricity, refined petroleum products (gasoline and diesel), natural gas, and coal. They are all forms of energy, but that is where the similarity ends. The supply chains and markets for these energy forms are all very different, in terms of location, cost and carbon intensity. Their substitutability depends on the end use, e.g. electricity, natural gas, heating oil, and coal can all be substituted for home heating, but not for lighting or running appliances. In transport, bioliquids can be used in place of petroleum products, and technology is slowly making electricity more substitutable for gasoline and diesel (i.e. in the form of hybrid and battery powered vehicles). In general, electricity is the most substitutable for most end uses, but it is also the most expensive per unit energy, and difficult to store in volume or for any length of time. As we proceed, we will describe how energy, economic and climate security are affected by the differing characteristics of these energy forms.

## Argument 1: Energy supply security is a prerequisite for economic security, but does not require fossil fuels.

There are two main approaches to considering energy security in relationship with economic and climate security. One mainstream approach, represented by a review of the literature on energy security in Winzer finds that while the term is used in many different ways depending on the time, context and place, the most durable and common vision defines energy security as "the continuity of energy supplies relative to demand."[8] Put more simply, a modern economy cannot run without an uninterrupted supply of electricity, heat and transport energy, and without them we would return to a late 1700s level of technology. The other stream, represented by Sovacool and Brown,[9] considers the environmental impacts of energy systems a "dimension" of energy security, and that the topics of energy security, sustainability, and economic efficiency are interlinked and overlapping. There are elements of truth in both approaches, and which is applied depends on the problem one wishes to study and the intellectual tools one wishes to bring to bear.

The International Energy Agency (IEA)'s working definition of energy security as "the uninterrupted availability of energy sources at an affordable price" further distinguishes between short and long term security, specific to short term supply chain events, and longer term maintenance of supply infrastructure.[10] Kruyt, van Vuuren, de Vries, and Groenenberg,[11] in a widely referenced study, further define Winzer's narrower definition along four dimensions:

availability (i.e. physical availability somewhere), accessibility (i.e. availability for purchase), affordability (i.e. reasonable prices as a portion of income and revenue) and acceptability (i.e. based on social and environmental considerations).[12] Sustainability concerns, specifically those associated with climate change, impinge on all four of these criteria. Using solar photovoltaics (PV) as an example, given the efficiency of PV cells we can reasonably make, is there enough land, building surfaces and solar incidence that we could physically generate enough to meet our needs? Can we purchase the necessary equipment from a manufacturer? Are enough materials available? How much of our income will it consume? What other necessities might it crowd out? And finally, will people complain about seeing solar panels everywhere?

Mathy, Criqui, Hillebrandt, Fischedick, and Samadi,[13] while they are probably not the original source, used a broader definition than that typically seen in the energy security literature, that a secure energy system is one that is robust (i.e. suited to very different economic or technological environments, at the domestic and international level) and resilient (i.e. that swiftly recovers its balance in the event of crises, accidents or acute instability).

Jewell, Cherp, and Riahi come perhaps closest to a modern, usable definition of energy security with "low vulnerability of vital energy systems, delineated along geographic and sectoral boundaries."[14] Cherp and Jewell further link it to the broader security literature by arguing that any discussion of energy security should address the questions of "Security for whom, for which values, and from what threats?"[15] As was laid out in the beginning and will be discussed earlier, these are very salient questions because "security for whom" is very different for energy importers and exporters.

None of the above definitions of energy security require, however, that energy be derived solely or mostly from fossil fuels, to which Jewell, Cherp, and Riahi expressly address themselves.[16] Most energy end uses (e.g. heating, cooling) can be electrified, and electricity can be made carbon free from hydropower, wind, solar, biomass, nuclear, and fossil fuels where the emissions are captured and stored underground. There are some questions about intermittency of wind and solar, but wider spread and more transmission coupled with some storage can allow a very high share of intermittent generation (50%–100% if the excess electricity is used to produce syngas or hydrogen). Decarbonization of heavy industry, freight transport, and aviation is more difficult. Carbon capture and storage (for heavy industry), hydrogen or biofuels could address these end uses, but they need significant research, development, prototyping and commercialization. All these options are currently more expensive than fossil fuels, however, and should be accompanied by a strong push for across the board energy efficiency to reduce primary energy requirements. Please see our 2015 report, *Pathways to Deep Decarbonization in Canada*,[17] for details or go to www.deepdecarbonization.org.

How might this be achieved in Canada from a policy perspective? In the Canadian deep decarbonization pathways report, we offered the following policy package based on three key physical concepts: *efficiency*, *decarbonization of energy carriers* (e.g., electricity, biofuels and hydrogen), and *fuel switching* to these clean carriers. All suggested policies are technology agnostic and performance orientated, i.e. regulations are based on energy and GHG intensity, not adoption of specific technologies:

1 *Best-in-class regulations* require the use of zero or near-zero emission technologies in the buildings, transport and electricity sectors, applied to all new installations and retrofits. The requirements are as follows:

   - *Mandatory energy and GHG intensity regulations for buildings, vehicles and appliances.* These follow current federal and provincial regulations to the early mid-2020s, and then start dropping to a 90–99% reduction in GHG intensity by 2045.

- *Buildings*. Regulations would trend down to require net-zero-energy residential buildings after 2025, and commercial buildings after 2035. This would be enabled by highly efficient building shells, electric space and water heaters with heat pumps for continuous load devices, solar hot water heaters and eventually solar PV as costs fall. Community heating opportunities identified thorough energy mapping are also an option.
- *Personal and freight transport*. Personal vehicles and light freight regulations, because these sectors have several options including efficiency, electrification, bio fuels, hydrogen and mode shifting, would be on a rolling 5-year renewal and tightening schedule, with the announced long-run goal being for all new vehicles to decarbonize in the early 2030s. Heavy freight vehicles that have more limited options (including some rail-based mode shifting, efficiency, biofuels and hydrogen – batteries are not sufficiently power dense for freight) would be on a schedule to decarbonize by 2040.

2 *Mandatory 99% controls for all landfill and industrial methane sources (landfill, pipelines, etc.).* Any remaining emissions would be charged as per the following policy.
3 *A hybrid carbon-pricing policy, differentiated by heavy industry and the rest of the economy:*

- *A tradable GHG performance standard for "downstream" point source heavy industry* (including electricity), evolving from −25% from 2005 in 2020 to −90% before 2050, using output-based allocations to address competitiveness concerns. This system has the advantage that it produces an incentive for early "lumpy" emissions reduction projects, such as carbon capture and storage in electricity with consequent innovation effects, the excess permits of which can be sold to other emitters. If desired, an absolute cap and trade system could be implemented instead with mostly similar effects.
- *A flexible carbon price, either a carbon tax or an upstream cap and trade,*[18] *covering the rest of the economy*, rising to CDN $50 by 2020 and then in $10 annual increments to 2050.[19] The funds are recycled half to lower personal income taxes and half to lower corporate income taxes. The charge would be flexible based on progress – the above charge was required to meet the DDPP target, but technological advancement driven by carbon pricing and complementary innovation policy would likely dramatically reduce the necessary price, as happened with the US SOx cap-and-trade system.

*A land-use policy package that values the net carbon flows of large parcels of land*. The policy would provide standardized valuation and accounting for net carbon flows on agricultural, forested, brownfield and wild private lands. Government lands would be managed including net carbon flows in the mandate.

Based on our modelling, Figure 9.2 provides an overview of the emissions trajectory and abatement drivers from the 2050 forecast to the 2050 DDPC target. Canada's +2°C budget works out to be about 75 Mt in 2050, or a 90% reduction below today's level. Per capita emissions transition from 20 tonnes per capita today to 1.7 tonnes by 2050 in the DDPC pathway. In terms of costs, deep decarbonization requires a significant restructuring of investment, but not a large overall increase. Overall investment per year increases only $13.2 billion (+8% over historical levels), but hides sectoral differences. Consumers spend $3.0 billion less each year on durable goods like refrigerators, cars, appliances and houses, while firms must

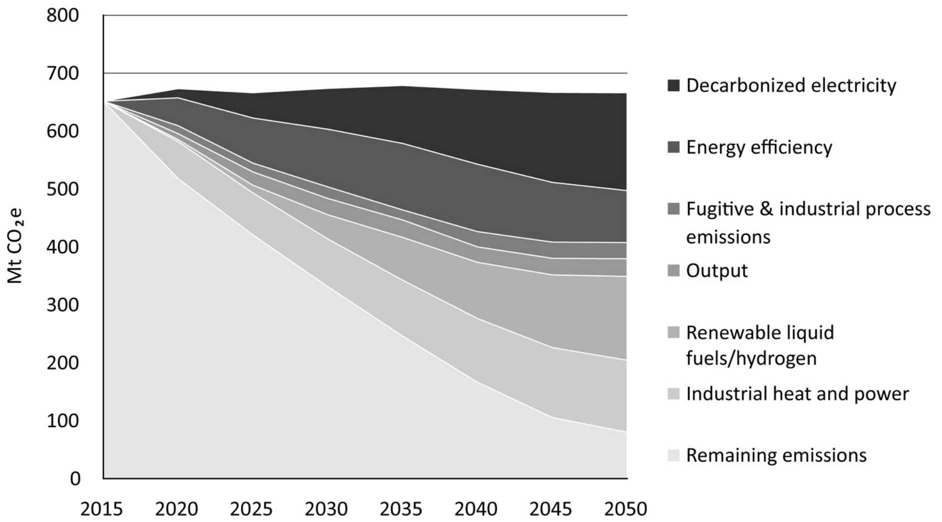


*Figure 9.2* Canada's emissions and abatement drivers under the DDPP policy package
Source: Bataille, Sawyer, and Melton, *Pathways to Deep Decarbonization in Canada.*

spend $16.2 billion more. $13.5 billion of this is in the electricity sector (+89% over historical levels), by far the most important shift, and $2.9 billion in the fossil fuel extraction sector (+6% over historical levels).

Beyond the "nuts and bolts" policy package above, a national and regional discussion is required on various pathways options to a deeply decarbonized future. The DDPP recipe for deep decarbonization, grounded on efficiency, decarbonization of energy carriers like electricity, and fuel switching from fossil fuels to these carriers, has many options within it, some more or less appropriate for a given region. Electrification was central to most country decarbonization plans in the DDPP, and was central in our Canadian pathways, but every region chose a different electricity generation mix, based on local resources, politics and social preferences. British Columbia, Québec, Manitoba, Newfoundland and the Maritime provinces largely adopted hydropower because of the available resources; Alberta and Saskatchewan went with a mix of fossil fuels and CCS with renewables with an emphasis on the former, while Ontario largely went with renewables with a smattering of everything else. Every region and country will choose a different generation mix based on local resources and politics, but they share decarbonization of electricity generation, and an increase in electricity use, typically around +40–50%.

In terms of dynamic pathway policy effectiveness and efficiency,[20] some actions and policies, such as efficiency, must be pursued early if they are to have substantial effect because of equipment stock turnover effects (i.e. replacement of high emission building, equipment and vehicles with low emission ones as they wear out), and in turn, efficiency provides insurance that less primary energy will be necessary if any one of the decarbonization energy carriers doesn't work out (e.g. if renewables, nuclear, or carbon capture and storage prove intractable).

Jewell, Cherp, and Riahi in their assessment of energy security under multiple decarbonization scenarios generated through the MESSAGE integrated assessment model, find that in most cases, because of the prominent place played by decarbonized electricity generation and fuel switching to electricity in most scenarios, decarbonization actually increases many measures of energy security, especially the proportion of primary energy sourced from outside a country, or the "net import dependence."[21]

Besides the energy and climate security benefits, there is some evidence that low-carbon technology options can contribute to enhanced economic security as a co-benefit via reduced exposure to fossil fuel market price volatility.[22] McCollum et al. also argue for increased well being from reduced air pollution induced by climate change mitigation, and show that costs for climate change mitigation could be substantially compensated for by the corresponding reductions in air pollution control and associated health costs.[23]

In sum, while the argument that energy supply security as defined by Winzer and other authors is necessary for economic security is fairly obvious, I argue that a secure energy supply need not be based on a system where fossil fuels are combusted in the open atmosphere, enhancing climate security for all.

## Argument 2: Climate security can enhance economic security for fossil fuel importers, but reduces it for exporters

For energy importing regions, energy imports require that a certain amount of income leaves the region to purchase energy. In the long run and all other things being equal, this requires exporting something else to acquire foreign currency, has negative effects on the purchasing power of the domestic currency relative to other currencies, and less income is available for consumption, savings and hence investment. Normally, for highly developed nations this is not a problem – Japan imports almost 80% of its energy, and easily covers the cost of this from its GDP (energy imports only represent 2.6% of GDP).[24] Yet energy security is still a concern for Japan, and there are official policies to diversify both types of energy source and supply sources within each type.

For fossil energy exporting regions the exact opposite is true. Exports increase potential consumption, savings and investment, have positive effects on the domestic currency, and make more foreign currency available for imports. Economic security is bound up with fossil fuel exports.

Where this becomes interesting is when a country contains regions that are fossil fuel importers and exporters. The Canadian regions of British Columbia, Alberta, Saskatchewan and Newfoundland are all exporters of oil; when the price of oil goes up they are positively affected because, despite some increase in gasoline and diesel prices, government, corporate and labor revenues rise. The regions of Ontario, Québec, New Brunswick, Prince Edward Island and Nova Scotia are all energy importers; they are negatively affected by an increase in the price of gasoline and diesel with no positive revenue effects.

Ontario and Québec are particularly negatively affected because of their export orientated manufacturing base. When the price of oil rises, the demand for Canadian dollars to buy Canadian oil rises, and the Canadian dollar rises, making Ontario and Québec's manufactured products more expensive. In extreme cases this leads to what has been termed the "Dutch disease," first described in Ellman[25] in the case of Holland's natural gas boom of the 1960s, where dominance of exports in a given resource makes the currency too expensive, chilling exports of other products.

To provide an example of the relative effects of oil prices on Canadian regions, we ran three different long run oil price scenarios for the DDPP project:

- Deep decarbonization with a high oil price, based on the Canadian National Energy Board 2013 Reference scenario prices and output projections out to 2030. For 2031–2050, we carried out the 2030 price assumption while letting our models determine production based on the price. This scenario mirrors some of the International Energy Agency's 2°C scenarios that maintain high prices and relatively high demand. **HIDDPP** has oil prices rising to $114 in 2035 and then stabilizing to 2050; oil output rises 1.5 million barrels per day (mbpd) above our no-decarbonization reference case by 2050, topping out at 7.5 mbpd (Figure 9.3).

- Deep decarbonization with a medium oil price, based on the NEB 2013 low pathway where oil stabilizes at $80 per barrel in the long term, and the same methodology as HIDDPP past 2030. In **MIDDPP** output falls roughly 1.5 million barrels per day by 2050 compared to our no-decarbonization reference case.
- Deep decarbonization with a low oil price, based on conversations with global DDPP modellers (i.e. their view of possible oil prices in a deep decarbonized world) and using initial analysis from the 16 DDPP countries. The combined consensus view is that oil demand will likely fall about 50% in a deeply decarbonized world (Figure 9.4). Combined with existing resources producing based on variable costs without searching for new reserves, reduced demand coupled with ongoing supply stabilizes the long-term price at $40/barrel in today's USD in 2050. In **LODDPP** the price of oil evolves from 2015 in even steps down to average $40/barrel by 2050, with Canadian production falling to about 850,000 barrels per day. The remnant production largely represents the continuing operations of oil sands and shale facilities that have amortized their capital costs and operate until the resource is exhausted or the market price falls below variable unit production costs.

All three deep decarbonization scenarios include advanced low emissions oil sands technologies such as solvent extraction and direct contact steam generation, as well as large-scale implementation of CCS.

Source: Bataille, C., D. Sawyer, and N. Melton. (2015). Pathways to Deep Decarbonization in Canada.Table 9.2 provides a comparison of regional and national GDP under the scenarios. As can be seen, GDP at least doubles in all scenarios. Our major observation is that the uncontrolled combustion of fossil fuels is a high economic growth pathway, but is not necessary for continued rates of high GDP growth. The impact varies between provinces. Alberta's

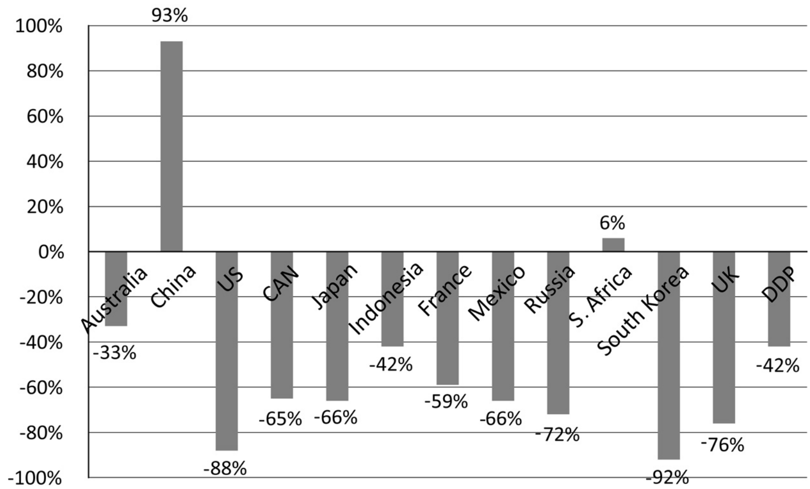


*Figure 9.3* Oil demand compared to today in a deeply decarbonized world
Source: Bataille, Sawyer, and Melton, *Pathways to Deep Decarbonization in Canada.*

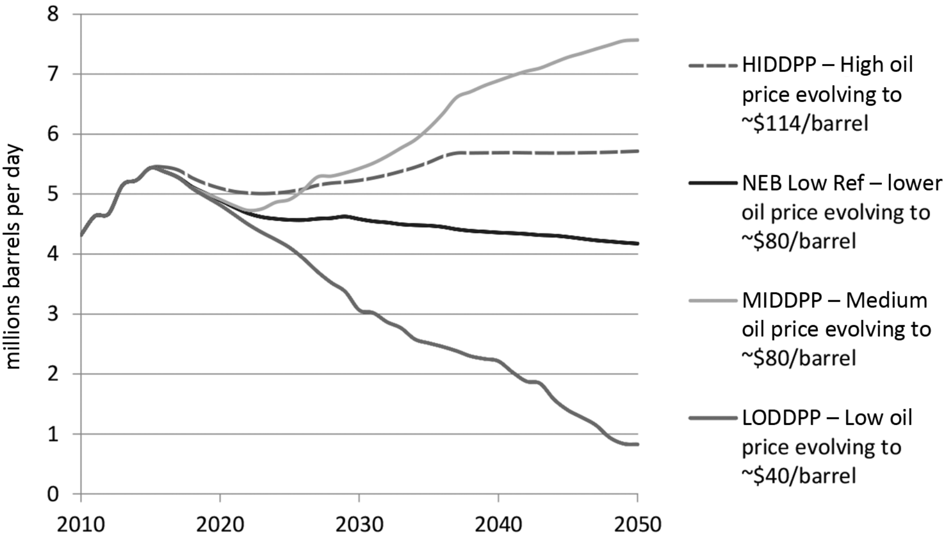


*Figure 9.4* Canadian oil output under varying oil price (USD 2014) assumptions

*Table 9.2* Changes from 2015 in regional GDP in 2050 (relative to 2015=1)

| | *2050 REF ($80/barrel)* | *MIDDPP ($80/barrel)* | *HIDDPP ($114/barrel)* | *LODDPP ($40/barrel)* |
|---|---|---|---|---|
| AB | 1.71 | 1.34 | 1.71 | 1.20 |
| BC | 2.42 | 2.14 | 2.10 | 2.17 |
| SK | 2.67 | 2.23 | 2.20 | 2.16 |
| MB | 2.71 | 2.50 | 2.47 | 2.51 |
| ON | 2.09 | 1.89 | 1.87 | 1.90 |
| QC | 2.29 | 2.47 | 2.40 | 2.57 |
| AT | 2.18 | 1.97 | 1.95 | 2.01 |
| Canada | 2.15 | 1.98 | 2.01 | 1.99 |

Source: C. Bataille, D. Sawyer, and N. Melton. (2015), *Pathways to Deep Decarbonization in Canada.*

economy is substantially smaller with decarbonization because of obvious effects on the fossil fuel industry, but still increases between 20 and 70% by 2050 in all cases relative to 2015. Québec's economy actually grows with decarbonization compared to our reference case because of its plentiful low-cost hydroelectricity, and benefits yet again from lower transport costs associated with lower oil prices in LODDPP.

Figure 9.5 shows the impact of the high (HIDDPP) and low (LODDPP) price scenarios relative to the DDPC reference case (MIDDPP). Alberta and Québec are again the most highly affected, with large gains to Alberta in the high oil pathway (HIDDPP) accompanied by some losses to Québec and Ontario, while the low oil price negatively affects Alberta and benefits Ontario and Québec.

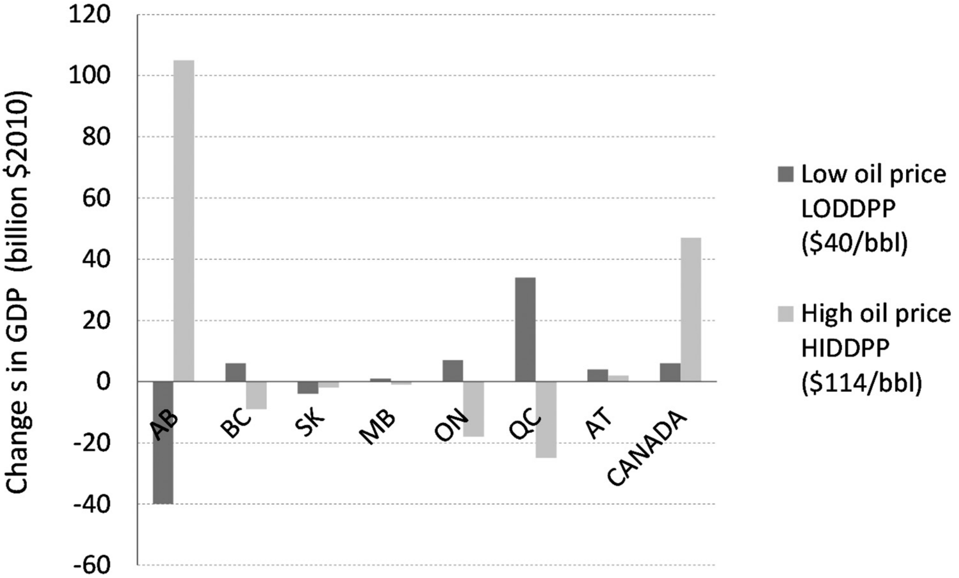


*Figure 9.5* Impact of changes in oil price on GDP in decarbonization scenario in 2050 (relative to the MIDDPP scenario)
Source: Bataille, C., D. Sawyer, and N. Melton. (2015). *Pathways to Deep Decarbonization in Canada.*

*Table 9.3* Changes from 2015 in sectoral GDP in 2050 (2015=1)

| | *2050 REF ($80/barrel)* | *MIDDPP ($80/barrel)* | *HIDDPP ($114/barrel)* | *LODDPP ($40/barrel)* |
|---|---|---|---|---|
| Conv. oil | 0.2 | 0.2 | 0.2 | 0.1 |
| Oil sands | 1.7 | 1.1 | 3.2 | 0.1 |
| Refining | 1.4 | 1.1 | 0.7 | 1.0 |
| Natural gas | 0.9 | 0.7 | 0.8 | 0.7 |
| Electricity | 1.2 | 5.9 | 5.9 | 6.0 |
| Cement-lime | 2.5 | 2.7 | 2.4 | 2.4 |
| Pulp & paper | 3.2 | 2.7 | 2.4 | 3.0 |
| Iron & steel | 1.7 | 1.3 | 1.2 | 1.3 |
| Aluminum | 2.7 | 2.8 | 2.6 | 2.8 |
| Coal mining | 2.0 | 2.9 | 2.7 | 3.0 |
| Other industry | 2.7 | 2.5 | 2.2 | 2.8 |
| Services | 2.3 | 1.9 | 1.9 | 2.0 |
| Manufacturing | 1.9 | 1.6 | 1.4 | 1.6 |
| Trade | 2.4 | 2.0 | 2.0 | 2.0 |
| Transport | 2.2 | 2.1 | 2.1 | 2.2 |
| Government | 2.5 | 2.2 | 2.2 | 2.2 |
| *Total* | *2.2* | *2.0* | *2.0* | *2.0* |

Now we look at the effect of the oil price pathways on economic structure, as defined by the output of firms. Table 9.3 gives detailed GDP by sector and scenario, showing changes due to the oil price.

Figure 9.6 shows the biggest sector impacts of decarbonization are on the electricity and services industries, as well as on resource rents collected by government. Electricity GDP grows strongly because output and prices increase, while services decrease (while still more than doubling from 2002) due to the overall drag associated with the decarbonization policies. Industry, manufacturing and transport have an inverse relationship with oil prices due to transport costs (low prices raises industry GDP and vice versa).

In sum, oil prices, and not national decarbonization policy, are the key determinant of Canadian oil production and therefore, to a certain extent, Canada's regional economic structure. Overall GDP is relatively unaffected, but with strong regional effects. Domestic deep decarbonization is feasible in all cases.

In terms of energy security, the analysis indicates high oil prices, and their high oil production and lower climate security, are directly related to higher economic security for fossil fuel exporting regions of Canada (e.g. Alberta), but not for Canada as a whole, and are directly detrimental to economic security for fossil fuel importing regions (e.g. Ontario and Québec).

## Argument 3: A necessary component of climate security is the undoing of the business case for producing fossil fuels by providing alternatives that reduce demand.

We now arrive at the third part of this essay, a discussion of the necessary conditions for climate security from the perspective of a fossil fuel energy exporter. As discussed at the beginning, when climate security adds to energy or economic security, it is not likely to face any more

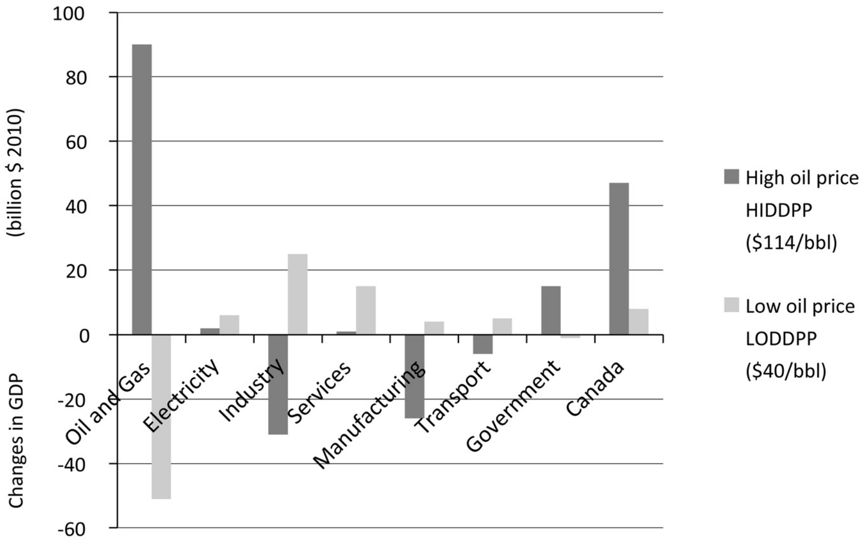


*Figure 9.6* Impact of changes in oil price on sector GDP with DDPC policies in 2050 (relative to reference case)

Source: C. Bataille, D. Sawyer, and N. Melton. (2015). *Pathways to Deep Decarbonization in Canada.*

than usual political headwind or intransigence. When it works against economic security, as it does for current fossil fuel exporters, strong, even policy-fatal headwinds can be expected.

As we have already seen, basic economics would suggest that energy exporting regions like Alberta will continue to produce fossil fuel commodities as long as the expected market price is higher than the cost of production, including the cost of border penalties, carbon pricing or other regulations, for the life of the producing investment. On the other hand, if the market price for fossil fuel commodities falls below the all-inclusive cost of production, producers will gradually reduce and eventually cease production of their own accord, as per the full life-cycle capital amortization and variable operating costs of their individual production stock. This is explicitly seen in the LODDPP scenario, where the equilibrium price of oil falls to $40/barrel in today's dollars.

So, to enhance climate security, how does one go about bringing down fossil fuel demand, or the market price received by producers?

(A) *Direct supply side constriction regulations*. These raise the market costs, inducing demand reductions, but they also have a weakness. If they are not imposed globally, some other supplier will take the place of the constrained supplier (e.g. fracked oil replacing oil sands crude oil).

(B) *Demand side technology specific regulations*. These enforce a specific technology. While achieving a specific GHG intensity objective, they lock out cheaper or more appropriate options that may be available, and do not encourage technology or process innovation.

(C) *Demand side technology performance regulations*. Performance regulations, while they may be based on a given technology, do not dictate a specific technology but instead a performance level, like grams of $CO_2$ per kilometer driven. They allow the market place to find the cheapest way of meeting the target, but do not push technology innovation beyond the current regulation unless they explicitly get tighter through time.

(D) *Carbon pricing through carbon tax or cap and trade*. These operate by adding to the effective costs for consumers of fossil fuels, thereby directly reducing demand, and also by increasing the cost base for fossil fuel producers, effectively reducing their profit per unit of production. These are the standard first choice instruments of climate policy, and directly incentivize technology innovation in a carbon reducing way on both the demand and supply sides of the market. If, however, consumers of fossil fuels have no perceived or real alternatives in the near term, political resistance will build quickly, eventually to policy fatal levels. As seen in Bataille, Sawyer, and Melton[26] and many other sources (e.g. see the literature review in Pye and Bataille[27]), by itself, the carbon price necessary for 2°C compliance will be very high, on the order of several hundred dollars per tonne, and may not survive the political process by itself.

(E) *Encourage replacement substitutes for fossil fuel end use consumption*, e.g. subsidize and support development of more efficient, biofuel, syngas or electric cars in place of standard gasoline cars; encourage electrification of all building heating and cooling end uses; and encourage electrification or the use of hydrogen in heavy industry. While not economically efficient in the short term, subsidies and development support for low carbon end use alternatives provide implicit policy support for technology performance or pricing regulations. They show firms and consumers that options are available, or soon will become available. Once these low carbon alternatives are successful in capturing market share, their costs will fall with economies of scale, they will gradually lower fossil fuel demand, and eventually fossil fuel prices will fall according to supply and demand dynamics. There will be some "rebound" back to fossil fuels, but eventually the long run price for fossil fuels will fall below its subsistence level, and the business case for fossil fuel production will expire. One key weakness of direct subsidies, however, is that the scale required to transform overall global fossil fuel consumption is simply unaffordable. They can, however, be used to help incentivize and start technology innovation and market transformation.

I argue that some combination of C, D and E, *technology performance regulations*, *carbon pricing and encouragement of replacement substitutes*, is necessary to secure climate security. Given that subsidies are expensive, especially for a large scale transformation, and carbon pricing of any form is politically difficult, I argue that effective climate security will come from a combination of technology performance regulation and carbon pricing sticks, and development assistance and direct subsidization of end use alternative carrots. This game of sticks and carrots takes time, however, sufficient time for research, development, prototyping and commercialization of alternatives. This gives current fossil fuel exporters time to plan for falling production, and the associated economic structural adjustment.

Except for Norway and Statoil, no major fossil fuel producer has explicitly acknowledged that the time of uncontrolled release of fossil fuel combustion will come to an end. We still live firmly in the era of fossil fuel combustion; the world is not yet in a position to stop emitting GHGs and still meet human needs, especially for basic energy services in the developing world. The mortal danger to major oil, gas and coal producers is not from policy today or even targets in 2030; it is from inappropriate, unamortized production capital in the future. Adjustment to deep decarbonization for fossil fuel producers is a matter of investing according to something like the following algorithm:

- Maximize efficiency and minimize carbon intensity of existing facilities. Be especially careful with methane emissions from wells, pipelines and facilities.
- Consider the lifetimes of new production equipment and facilities. Is production of a given commodity (coal, oil, or natural gas) likely to be required over that period if climate targets are mandated?
- Consider stepping down the carbon intensity ladder for production and internal consumption: coal to oil, oil to gas, gas to syngas, and so on down to electricity, hydrogen, or biofuels.
- Consider reallocating new capital to lower and zero carbon sources.

If deep decarbonization comes to pass, economic security for fossil fuel producing regions like Alberta, will require a re-visioning and logistical planning process. What will be the working and non-working population to plan for? What associated socioeconomic infrastructure will be needed (roads, hospitals, schools, etc.)? What will be the potential tax base? Will the population need structural adjustment help, or will the transition be paced to new investment, and will all new workers and investment find their way to lower GHG intensity employment? If deep decarbonization occurs it will take a generation or more, but reorganizing and shaping the economies of fossil fuel exporters in the least painful way possible will also take as long.

## Conclusion

In this chapter I have made three arguments based on the Canadian federation and the Canadian chapter of the Deep Decarbonization Pathways Project. I have argued that energy security is essential to economic security but does not necessarily require fossil fuels, that climate security normally improves energy and economic security for energy importers, but reduces economic security for exporters and therefore their likelihood of compliance, and finally, that climate security will require a combination of demand and supply side sticks and carrots.

There is a common conception that direct pressure on fossil fuel suppliers like the Canadian oil sands will increase climate security (e.g. by blocking expansion of pipelines like Keystone XL). While important politically, climate security cannot be achieved solely by convincing fossil fuel exporting regions to stop producing. If pressure on one supplier is successful, as it seems to have been for the oil sands, there is a long list of potential suppliers waiting to take up the slack, starting with North American tight oil through fracking. The key to real climate security is to create real and perceived alternatives to fossil fuel consumption, and apply the necessary carrots (subsidies, development support) and sticks (technology performance regulations, carbon pricing) to encourage the great majority of firms and consumers to transition to low carbon options. This will shrink the demand side of the market, and undo the business case for production by bringing the fossil fuel market price below where it is economic to produce for any producer.

## Epilogue

Two major relevant events occurred after this chapter was written. The first was COP 21 in Paris in December 2015,[28] resulting in what has come to be known as "The Paris Agreement." Based on the voluntary INDC process established at Durban, the Paris Agreement is generally recognized as being a breakthrough success in international climate policy negotiations, in that all major emitters have committed to emissions reductions for the first time, with the commitments reflecting domestic circumstances. It is also generally recognized, however, that the sum of the committed INDCs commits the world to a temperature increase of somewhere between 2.7 and 3.5°C, depending on estimates. This is well over the 2°C increase agreed to at Durban and upon which the DDPP analysis was based, much less the aspirational 1.5°C target mentioned in the Paris Agreement. The agreement is also purposefully non-binding, specifically so that United States Senate approval is not required, where the agreement would almost certainly be rejected. The US administration negotiated from the point of view that the US 2025–30 INDC could be achieved through natural developments in the US electricity industry (i.e. switching from coal to natural gas) combined with administrative command and control regulation imposed by the executive branch through the US Department of Energy on the electricity and transportation sectors. While the Paris Agreement is a big step forward, a great increase in domestic and global policy ambition is required if the 2°C limit is not to be breached.

The second major event from the perspective of this article occurred in Alberta, home of Canada's oil sands. In the spring of 2015 a newly elected provincial government ordered a review of the province's climate policies. The review was set up as a three month stakeholder engagement process, based on written submissions, internet engagement, and community open houses. 25,000 online responses and 535 formal submissions were received, including the Canadian DDPP report, submitted by Carbon Management Canada. At the same time, the Keystone XL pipeline, a key conduit for new oil sands production, was cancelled due to US perception of the oil sands in relation to its climate policy goals and domestic energy agenda; this increased pressure on the Alberta domestic discussion to increase ambition.

On November 20, 2015, the outcome of the Alberta review was announced.[29] The report and announced policies recognize the importance of the fossil fuel industry to Alberta's current economic well-being while preparing the province for an eventual global low carbon economy, with a focus on economic diversification, decoupling energy use from economic growth and reducing the carbon intensity of energy. As recommended in the Canadian DDPP report, from which the recommended policy package was quoted prominently in the panel report, Alberta will be implementing a general carbon tax rising to $30 in 2018, a cap-and-trade system for large emitters like the oil sands using output based allocations, electricity decarbonization regulations, an aggressive methane control program, and energy efficiency policies for buildings and communities. The policy package is designed for coordination with trading partners and eventual increased ambition. It puts in place most of the main tools to eventually decarbonize the Alberta economy, and is a model of its kind for an energy exporter. Even more significant is the broad political consensus behind the policies, from households, environmental NGOs to oil sands firms, established using a first class stakeholder engagement process.

In sum, in late 2015 there was a significant public and political shift in favor of some level of global climate policy to ensure climate security, but it cannot be said that this shift is as yet strong enough to ensure climate security defined as staying below an average 2°C temperature rise.

## Notes

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