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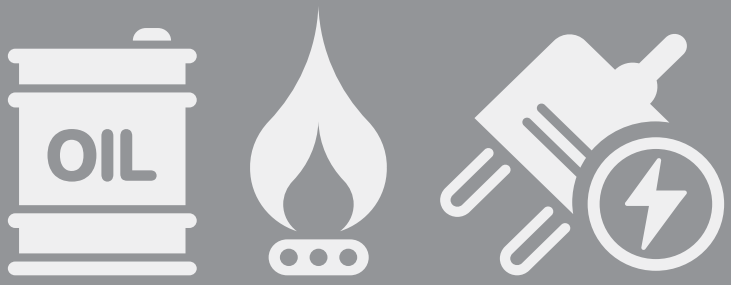
ENERGY SECURITY FOR ONTARIO

Robert Joshi



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APPLIED PUBLIC POLICY RESEARCH
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Energy Security for Ontario
By Robert Joshi
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Abstract

Ontario's energy security policy is comprised of three distinct policies covering oil, electricity and natural gas. Ontario's security policy is minimalist for oil, being left to markets and emergency planning; but more interventionist for electricity, with self-sufficiency favoured as an inherently worthwhile policy objective. The third area is Ontario's approach to natural gas security, which includes clearer governance and accountability structures and an explicit consideration of security of supply and how best to achieve it.

Three distinct approaches for the different energy sources may be the best approach when arrived at deliberately and with a common set of transparent assumptions. However, there is little justification or policy rationale for many provinces' commitment to self-sufficiency in electricity but not in other areas of energy. Policy-makers should consider all of the various energy options open to them and assess each in regards to the three key criteria that should be used when making energy policy decisions: security of supply, cost and environmental footprint.

Energy security means that everyone has access to the amount of energy they want, when they want it. Under Ontario's approach to energy security, the public and their policymakers do not know if the status quo is a good deal.

ENERGY SECURITY FOR ONTARIO

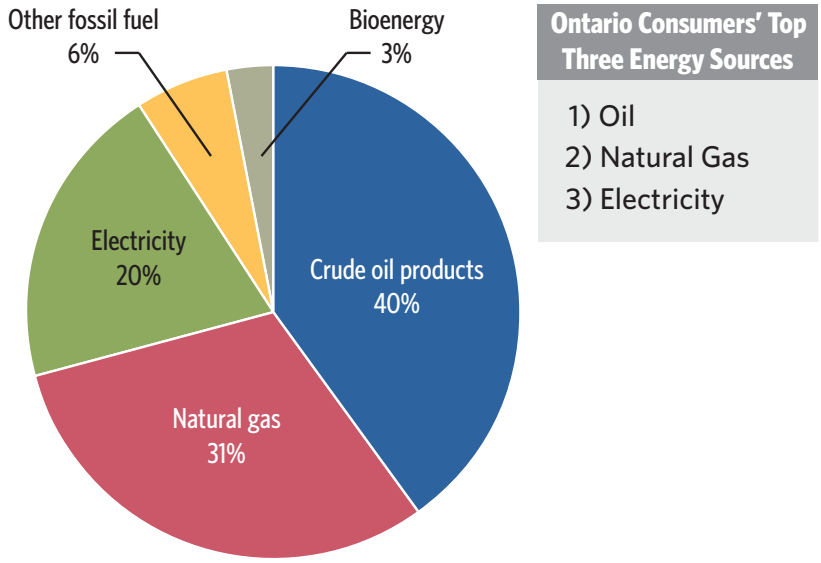
Robert Joshi

Ontario is faced with a changing energy environment: the phase out of coal, the review of the feed-in-tariff program, new sources of natural gas in great proximity and volatile oil prices. Within this changing environment, how much do Ontarians spend on energy security and what is received for those energy security dollars?

THE PATH WE ARE ON

Ontario's energy security policy is comprised of three distinct policies covering oil, electricity and natural gas. Ontario's security policy is minimalist for oil, being left to markets and emergency planning, but more interventionist for electricity, with self-sufficiency favoured as an inherently worthwhile policy objective without reference to the costs and benefits.

Figure 1 Ontario End-use Energy Sources, 2008



Source: Author's calculation using Natural Resources Canada Energy Use database.

The third area is Ontario's approach to natural gas security, which includes clearer governance and accountability structures and an explicit consideration of security of supply and how best to achieve it. In fact, the province's energy regulator is in the process of considering how new shale gas supplies could reverse the traditional flows of North America's natural gas markets, affect the security of supply and price, and implicate billions of dollars worth of pipelines in the process.

Table 1 Current Energy Security Policy

CRUDE OIL	NATURAL GAS	ELECTRICITY
Minimalist	**Explicit**	**Interventionist**
Unexamined alternatives Unknown implications	Balance costs, benefits and risks Update assumptions and plans	Self-sufficiency bias Missed opportunities

Three distinct approaches for the different energy sources may be the best approach when arrived at deliberately and with a common set of transparent assumptions. But that is not what we have.

There is little justification or policy rationale for many provinces' commitment to self-sufficiency in electricity but not in other areas of energy. Policy-makers should consider all of the various energy options open to them and assess each in regards to the three key criteria that should be used when making energy policy decisions: security of supply, cost and environmental footprint.

DEFINING SECURITY

The question of energy security gets a great deal more public attention in Europe and the United States. In Europe, vulnerability to interruptions of supply has made the question of energy security a high profile public policy issue. For example, disagreements between Russia and Ukraine highlighted EU vulnerability to interruptions of natural gas supply. In the US, a common theme in debates on energy policy is "energy security through self-sufficiency," which manifests itself in public debates around dependency on oil imports.

Energy security in these jurisdictions is situated within a context of geopolitical risk causing energy-access problems. While Ontario imports virtually all of its oil and natural gas, and is more dependent on imports than either the EU or US, imports are barely vulnerable to direct geopolitical risks. This does not mean Ontario faces no energy-access risks. Furthermore, Ontario's economy is vulnerable to how the geopolitics can suddenly increase prices, just like any other importer. Ontario should, therefore, understand its energy security position as distinct from how Canada as a whole may see it.

Consider the current state of EU and US energy security policy. The Lisbon Treaty establishes EU policy and includes energy security as one of the four foundational elements of energy policy.[1] From the European Commission website,

> With both energy consumption and dependency on oil and gas imports growing and supplies becoming scarcer, the risk of supply failure is rising. Securing European energy supplies is therefore high on the EU's agenda. Besides promoting energy efficiency, the EU promotes a broad mix of energy sources. Moreover, it aims for diversity in suppliers,

> transport routes and transport mechanisms. Several safeguard mechanisms shall secure energy supply for European citizens and industries: Building reliable partnerships with supplier, transit and consumer countries reduces the risks of Europe's energy dependency. [2]

The EU highlights the threats to security of supply and articulates a strategy that focuses on diversity of supply to address these risks.

The US, for its part, outlines a three-part strategy:

- Develop and Secure America's Energy Supplies,
- Provide Consumers With Choices to Reduce Costs and Save Energy, and
- Innovate our Way to a Clean Energy Future. [3]

The current US plan is to develop domestic resources, use less energy, use alternatives to oil, and to underpin both of these with technology development. Both the EU and US approaches give significant attention to oil and both approaches see energy efficiency and diversity of supply options as ways to mitigate security concerns.

The EU position differs from that of the US by paying greater attention to natural gas security, whereas the US sees an opportunity in using domestic natural gas resources to address oil security. Both approaches address electricity grids and renewable sources. While the EU gives more attention to integrating electricity grids across nations, the US, already having significant inter-state integration, devotes attention to connecting renewables to their grid.

Both examples show that there are different ways to approach energy security and its implications, based on the unique circumstances of each region. There is, however, a common starting point: The goal is to reduce the risk of losing access to energy.

Having a secure energy system means that everyone has access to the amount of energy they want, when they want it. Decisions to make the energy system more or less secure will impact energy prices, the economy and the environment. Ontario's current treatment of energy security is quite different for each of the province's top three energy sources: crude oil, natural gas and electricity.

CRUDE OIL AND REFINED PRODUCTS

For crude oil and refined products (gasoline, diesel etc.), Ontario's approach to security is about emergency planning. If there is a sudden disruption, there are plans in place for what to do. This is minimalist security in that, under international agreement[4] , because Canada as a whole is an oil exporter, no province needs to keep strategic stocks of oil and refined products. The stocks that Ontario has are for businesses to manage their supply chains.

A 2010 IEA report highlights the distinction as follows:

> At the same time, Canada is not immune to the risks of a supply disruption. Despite increases in nearby off-shore production, refiners in the country's eastern provinces

rely on imported crude oil, just as many refiners in other IEA countries do, and certain central provinces have experienced oil product disruptions, due to their relative geographic isolation from alternative sources of supply.

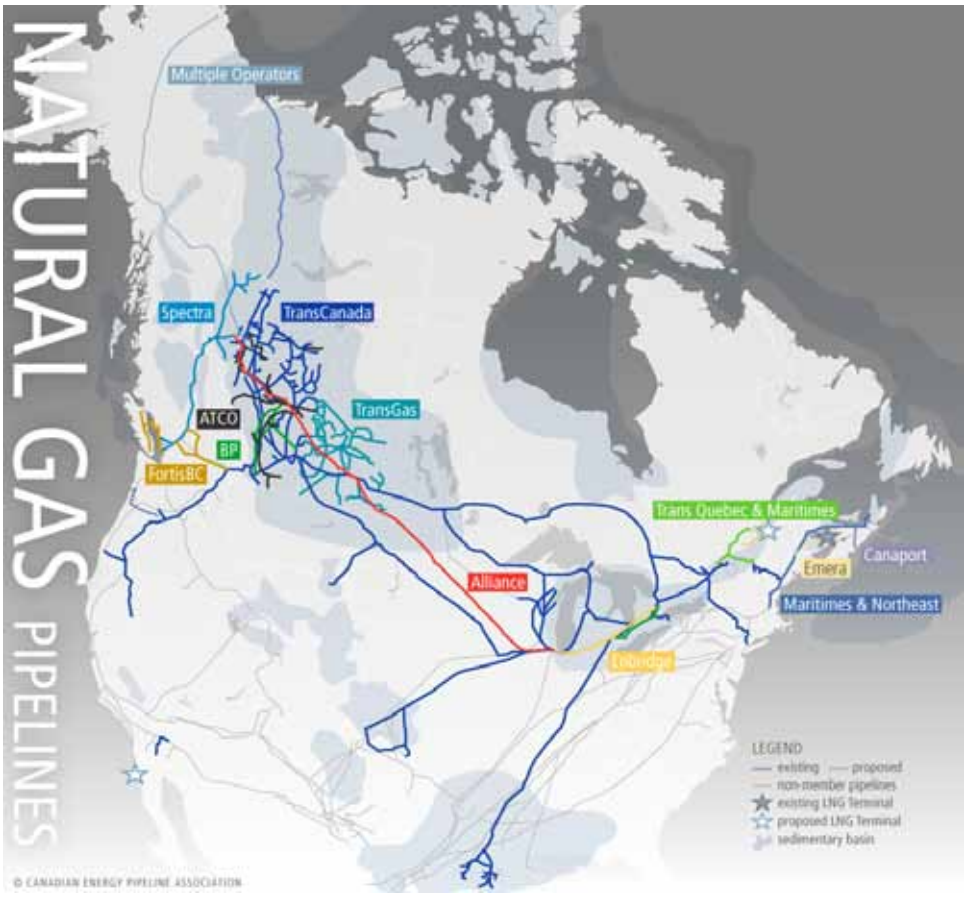
All stocks held in Canada are commercially- or military-owned (although military stocks are not counted in IEA methodology). As oil companies are not required to hold emergency stocks in normal times, they maintain stocks for operational and logistical purposes only.[5]

A key question for Ontario is whether its stocks are sufficient given known risks to supply and international standards accepted by importer nations.

NATURAL GAS

Natural gas security is an explicit consideration in Ontario regulatory decisions and the topic is rapidly gaining importance with growing shale gas supplies, even though the new gas supplies are, it seems, from everywhere but Ontario.

Figure 2 Natural Gas Pipelines



Source: Canadian Energy Pipeline Association.

The development of shale gas in eastern North America could significantly change the North American gas market, including the market in Ontario. It could make imports by Ontario of Western Canadian natural gas less economic as closer supply comes on line. If this were to occur, it implicates the usefulness of billions of dollars worth of assets in the form of the TransCanada Mainline and new pipelines for the nearby shale gas.

Western Canadian exports to international markets could reinforce such a trend. North American natural gas prices are relatively low and stable, and can be competitive in the international market. As a result, there are already proposals to export natural gas from B.C. to Pacific Rim countries.

The combination of substantial shale gas production in the east and potential overseas exports of western gas brings into question the need for so much west-to-east pipeline capacity across the continent. In addition to the National Energy Board evaluating the tolls for TransCanada's Mainline, the Ontario Energy Board (OEB) is considering the implications of uncertain North American natural gas flows with Ontario's interests in mind as it continues to incorporate security into its natural gas decision-making.[6]

There are also lessons for broader energy security policy in Ontario's evolving approach to natural gas security. In a 2005 report, the OEB determined that access to energy resources enhances security, but that long-term contracting for energy resources is not necessarily worth the cost risk:

> The Board is mindful of the importance of security of supply. However, it is not convinced that long-term utility supply contracts are essential for security of supply. The Board is of the view that access to a liquid hub provides the best assurance of secure access to competitively priced supply. In contrast, the Board is concerned that the potential risks to ratepayers from long-term supply contracts could be significant. [7]

ELECTRICITY

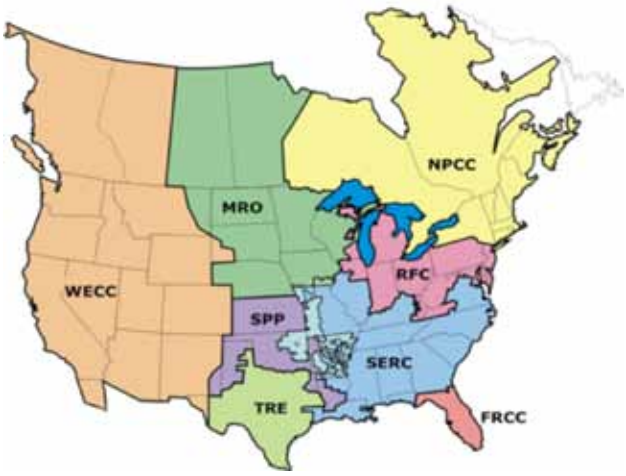
On a day-to-day basis, the operation of Ontario's electricity system is intimately linked with that of its neighbours. The implicit policy preference for self-sufficiency, despite the reality of electricity system operations, can be costly.

The fact that electricity cannot be directly stored[8] like crude oil and natural gas creates the need to constantly match supply to demand. To coordinate this, Ontario' and other North American jurisdictions employ system operators working under a North

> "Unlike for other forms of energy, electricity cannot be stored. Ontario's electricity system must be able to move enough electricity to meet the changing demand for it instantaneously - all day and all night, every day and every night."
>
> - Ministry of Energy's Long-Term Energy Plan, 2010

American reliability framework.[9] The 2003 blackout triggered much greater efforts by these system operators to improve how they coordinate their efforts, evaluate their performance, and direct investments into the electricity system to improve reliability.[10] The coordinated approach includes electricity constantly flowing across borders for short-term trade and security.

Figure 3 NERC Regions



Source: National Energy Research Council.

Ontario's approach to electricity security is not unusual among provinces. Most plan their electricity systems to be able to meet their own needs – they tend not to be net importers over the course of a year, even though they may be importing or exporting in any given hour.

For long-term electricity security, Ontario plans include a number of sources, such as nuclear, wind, hydro, and natural gas. Self-sufficiency is preferred. Like the approach to natural gas, this approach recognizes the value of supply diversity. The electricity approach differs from natural gas in that, for gas, long-term contracts are seen to be of questionable net value, whereas for electricity the dominant approach is long-term contracting to secure Ontario-based supply.

This can be costly. On self sufficiency, also called energy independence, Cohen et. al note that,

> Policymakers often equate the attainment of energy security with 'energy independence'. Rising imports as a share of total consumption is thus taken to imply lower energy security, without an analysis of a country's vulnerability to supply disruptions or energy price increases. Equating security with independence also leads policymakers to focus primarily on promoting expanding domestic supplies – for example through subsidies or quotas on domestic production – rather than on efficient methods to manage risk by diversifying suppliers or enhancing substitution among fuel types. [11]

In practice, the implications can be seen in recent news from B.C. B.C. pursues electricity self-sufficiency with well-defined targets and timelines.[12] A recent review, initiated

to find ways to slow down consumer price increases, found the following:

> The BC Hydro system has significant flexibility to import power at times of the day or year when market prices are low, as a result, BC requires additional flexibility in its energy policy.
>
> The panel recognizes that the economic and energy situations have changed, and that the existing self sufficiency definition may be overly conservative and place an undue burden on ratepayers. The panel recommends that BC Hydro and the province evaluate alternative definitions and timelines for self-sufficiency that meet the needs of the province and ratepayers in a way that is sustainable for the long term. [13]

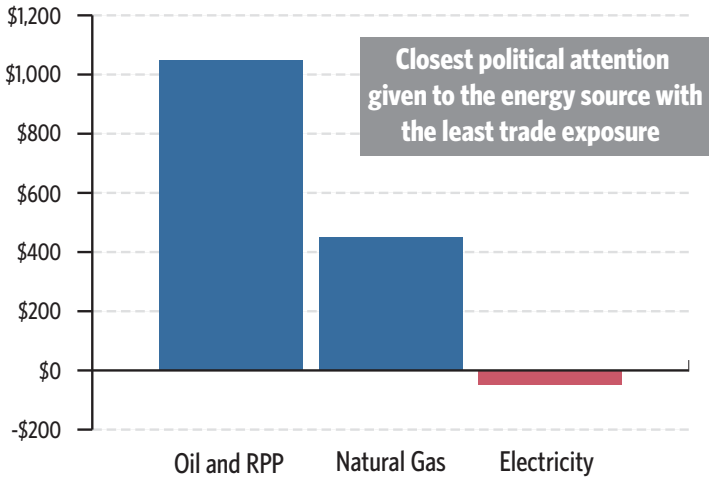
Provinces are questioning the value of self-sufficiency and, at a minimum, they need to have a clear understanding of the costs and benefits of this policy choice.

THE PATHS NOT TAKEN

Just because Ontario can pursue self-sufficiency in electricity does not mean it should. And just because it cannot on oil, does not mean that it should not consider security of supply more deliberately. Both areas may require a re-think, and the deliberate and adaptive approach to natural gas security is instructive.

Ontario's approach to energy security can be considered across a spectrum of distant to close political attention. At one end of the spectrum, political attention is distant for oil security, which is largely left to markets and emergency planning. In the middle, natural gas security is overseen by the province's energy utility regulator. At the other end of the spectrum, electricity security policy favours self-sufficiency and includes close political attention in the form of a high-profile ministerial plan.

Figure 4 Net Import Spending Per Person



Source: Author's calculation.

Along this spectrum, the closeness of political attention is inversely related to the exposure of Ontario's economy to outside energy markets. Based on 2009 data, Ontario spends over $1000 per person on crude oil and refined product net imports, representing high economic exposure, versus exporting, on net, about $25 per person worth of electricity. [14]

Similarly, looking at environmental footprint, the closest attention is given to electricity despite refined petroleum products being responsible for approximately double the greenhouse gas emissions. [15]

There is clearly a mismatch between energy security policy attention and economic and environmental exposure when comparing electricity and oil. Given that policies related to natural gas security are in the process of adapting to rapidly evolving market flows, are there lessons to learn for long-term crude oil and electricity security?

CRUDE OIL AND REFINED PRODUCTS

While Canada is an oil exporter, Ontario is not – Ontario is more dependent on oil imports than the EU or US. Two policy levers to address this dependence are: 1) Ontario can voluntarily follow the agreement of oil importing nations in regards to strategic and emergency stocks; 2) Ontario can more aggressively pursue efficiency and conservation.[16]

The Agreement on an International Energy Program establishes that emergency crude oil and refined product stocks should be equivalent to 90 days of net imports. While not an issue for Canada as a whole, this is significantly higher than the 40 days observed in Ontario in 2009.[17]

The incremental cost of meeting a 90 day requirement would be about $2.60 per barrel per year for storage and $2.6 billion for the initial purchase of oil and refined products. The annualized cost, at 5% interest, would be about $230 million, or 0.9 cents per litre, if levied as an ongoing fee on the fuels.[18]

Another lever would be for Ontario to pursue more aggressive energy efficiency and conservation policies to target oil consumption. These could include tighter vehicle efficiency regulations, fuel taxes and vehicle taxes, road tolls, and switching homes off heating oil, among other options. Ontario has policies in these areas, but efforts could be more comprehensive and more aggressive. Each option has its own cost-benefit balance, including reducing the exposure of Ontario's economy to oil price shocks, net economic benefits for some options, and environmental benefits for most, if not all, options.

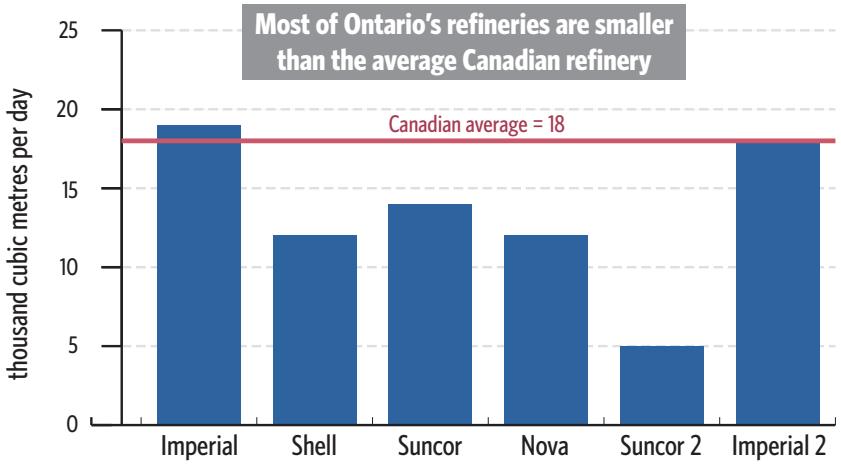
For energy security, the direct impact of efficiency and conservation policies is unclear. If oil stocks are largely market-driven, as they are today, then stocks may proportionally decrease with demand – the less gasoline Ontarians use, the less that industry needs to keep on hand to manage supply – keeping the number of days in reserve constant. In that case, Ontario would still have the same security margin, measured in days, during which to resolve a supply disruption.

There is, however, a difference between crude oil security and security in the refined products that consumers actually use (gasoline, diesel, heating oil and jet fuel). From the Canadian Petroleum Products Institute (CPPI):

> Over the past 35 years, the number of Canadian refineries has decreased significantly, as smaller inefficient facilities were closed and replaced with more efficient, cleaner and expanded facilities. These 18 refineries have a combined capacity that is double the capacity of the 44 refineries in operation in Canada in the early 1970s.[19]

Of the six Ontario refineries identified by the CPPI, two are at or slightly larger than the national average and the other four are significantly smaller than the average refinery.[20] Are one or more of Ontario's refineries "smaller inefficient facilities" relative to current North American norms?

Figure 5 Ontario Refinery Capacities



Source: Canadian Petroleum Products Institute data.

If historical trends continue, particularly given that new vehicle standards may lead to declining demand, then an Ontario refinery may close in the near future.[21] Additional made-in-Ontario policies to reduce oil demand may increase the chance of this happening sooner rather than later.

That said, such an outcome would not be unusual — most North American states and provinces do not have the local refining capacity to meet their demand, and Ontario's capacity is already below total demand.[22] This situation can work because oil security is really about having access to the refined products we use. One way to have access is by having oil stocks and extra refining capacity to turn that oil into gasoline, diesel and jet fuel. Another way is to have secure access to the refined products themselves. Neither way is inherently superior.

Increased oil security could have some benefits, such as moderating the kind of isolated gas shortages Ontario experienced in Summer 2011,[23] but is it worth the cost? Ontario's capacity to access refined oil products should be evaluated to see how well it could handle more reliance on imports. The evaluation could include pipeline access,

border issues related to trucking supplies into Ontario, aligning fuel quality standards with neighbouring jurisdictions, and whether or not to hold strategic stocks of refined products.

ELECTRICITY

Self-sufficiency may have been the cleanest and cheapest power option when Niagara Falls could power the province and, later, when optimistically planning for cheap and plentiful nuclear power, but now it looks like an expensive choice. Even if self-sufficiency is only an implicit goal, the consequence is that Ontario may be missing opportunities to reduce electricity costs for consumers or the environmental footprint of electricity use, while delivering equal or improved electricity security. One alternative for electricity security is to apply the natural gas approach. The electricity grid is also regulated by the OEB and, similar to natural gas, electricity security benefits from access to a diverse supply selection,[24] but the net benefit of contracting for or owning the supply is less clear.

As already discussed, North American regions coordinate their grids for improved reliability and trading opportunities. Ontario is prepared to import on an hourly basis but does not wish to be a net importer over the course of a year. Should this policy preference change?

Being a net importer is not a new concept. In the UK's electricity grid, for example, England is dependent on Scotland, Wales and even continental Europe for electricity imports to meet its electricity needs. Similarly, in Australia, New South Wales historically imports electricity while Victoria and Queensland export.[25] Closer to home, Quebec and Manitoba are long-standing electricity exporters to neighbouring states and provinces.

If increased imports are combined with more capacity (ie. 'tie lines' to neighbouring jurisdictions), then electricity security – reliable access to electricity – could even be increased while potentially saving money and achieving similar environmental outcomes relative to the self-sufficiency approach. Ontario buys electricity primarily through long-term contracts and could look to its neighbours for long-term supply. As an example of securing trade benefits, Hydro Quebec recently signed long-term electricity supply agreements with Vermont utilities, and Manitoba Hydro with Wisconsin and Minnesota utilities.

The Hydro Quebec agreement with Vermont utilities is projected to start at $60 per megawatt hour in November 2012 and to be comprised of 90% or more renewable power. This compares to $135 and $443 for Ontario-based wind and solar power, respectively, under Ontario's feed in tariff.[26] There is potentially a savings of 50% or more, although the Hydro Quebec-Vermont agreement provides less cost certainty than Ontario's feed in tariff.

Unlike Ontario-based variable power options, such as wind and solar, the Hydro Quebec-Vermont agreement is for electricity during the 16 peak hours of a day and is "firm," meaning that the electricity is not subject to variable wind or sunshine conditions.[27]

If Ontario was able to sign the same deal with Hydro Quebec as the Vermont utilities, Ontario could save $96 million per year, relative to $135 per megawatt hour wind power.[28] This is an example of having the same or better electricity security while reducing costs to Ontarian electricity consumers.

Also notable, particularly with Ontario's rapidly expanding supply of electricity from wind, is how Ontario's electricity system would mix with Manitoba's and Quebec's. First, Manitoba and Quebec demand the most electricity in winter, with their widespread use of electric heating, while Ontario's demand peaks in the summer, for air conditioning. Second, wind electricity generation is generally higher in the winter.[29] Ontario's demand and growing wind supply may be a good balance with Manitoba's and Quebec's systems.

To illustrate the potential benefits, when comparing peak demand to average demand over the last 10 years, Ontario, Manitoba and Quebec required a combined 12,100 megawatts of extra capacity to meet peak demand.[30] However, when viewing the systems as integrated, only 10,300 megawatts of extra capacity, or 15% less, would be required.[31] The 1,800 megawatt capacity difference would save about $1.2 billion, based on building natural gas-fired power plants to meet peak demand.[32] These options — becoming a net importer or increasing integrated resource capacity planning with adjoining grids — should be evaluated using a deliberate approach to energy security that does not implicitly favour self-sufficiency.

There are options to the south as well that are consistent with Ontario's policy to phase out coal-fired power generation. First, electricity from natural gas plants and other non-coal sources is available from US markets for less than the cost of many Ontario options.[33]

Second, a number of nuclear plants have been proposed in nearby states, including Ohio, Michigan, New Jersey and Pennsylvania.[34] Ontario is committed to obtaining about half of its electricity needs from nuclear but, based on past experiences, there are concerns about cost overruns. US proposals offer the opportunity of ensuring that, if Ontario is going to contract for long-term nuclear power, the best price and sharing of risks is obtained, as opposed to being limited to considering only one technology[35] to be used at only a small number of Ontario locations.

Whether US or Canadian-sourced, it is unnecessary to view net imports in the long-term supply mix as necessarily harmful to electricity security – access to more imports and out-of-province generating capacity can even increase security. On the other hand, there may be geopolitical risks with imports that are avoided when using local supply. For example, local supply is less vulnerable to political decisions taken elsewhere. Emerging cyber-security issues must also be carefully considered. Is cyber-security risk higher, lower or unrelated to diversity of supply and grid connections? These questions should be addressed explicitly within an electricity security framework.

An implicit preference for self-sufficiency removes some options from the table for Ontario's electricity planning. A deliberate and adaptive approach is needed in Ontario that considers all options through the lens of security, cost and environmental footprint.

GETTING FROM HERE TO THERE

Outside of the OEB's work on natural gas security, there is little understanding of the costs and benefits of Ontario's selection of energy security policies, much less a consistent and transparent set of assumptions to underpin the analysis. This lack of an explicit understanding of the costs and benefits of the current approach is all the more surprising given that Ontario is more dependent on oil and gas imports than either the EU or US, both of which maintain explicit and evolving energy security policies.

Table 2 Future Energy Security Policy

CRUDE OIL	NATURAL GAS	ELECTRICITY
Explicit		
Deliberate: Balance costs, benefits and risks Adaptive: Update assumptions and plans		

More specifically, Ontario could explore using the 'natural gas approach' to evaluate oil and electricity security, which would include more careful assessment of the costs and benefits of actions as diverse as importing nuclear power, importing shale gas, or aligning fuel quality standards with neighbouring states and provinces. Such an approach would better inform policy-makers about their options. It would also make explicit when our energy policies are being informed by criteria other than security, cost or environmental footprint, and at what cost. Given the amount of money being spent on current policy choices, it may be that investments in fuel efficiency standards, building codes or conservation efforts may all provide improved energy security or smaller environmental impact.

For electricity, the OEB is well positioned to handle an independent evaluation of multiple options, including those that do not favour self-sufficiency, and to update the evaluation as needed.[36] It is unclear which organization, if any, is well-positioned to evaluate crude oil and refined products, although such an evaluation should take place. These evaluations should be done so Ontarians know the answer to the questions, "How much do Ontarians spend on energy security and what is received for those energy security dollars?"

ENDNOTES

1. Treaty of Lisbon, signed December 13, 2007, Article 176 A.
2. Security of Supply (August 15th, 2011)
3. Based on the White House's "Blueprint for a Secure Energy Future", March 30, 2011.
4. Agreement on an International Energy Program, amended September 25, 2008.
5. "Oil and Gas Security: Emergency Response of IEA Countries, Canada." 2010.
6. See their 2010 Natural Gas Market Review (EB-2010-0199).
7. "Natural Gas Regulation in Ontario: Renewed Policy Framework." March 30, 2005.
8. "While many forms of energy storage have been installed, pumped hydro systems are by far the most widely used, with more than 127,000 megawatts (MW) installed worldwide. Compressed air energy storage (CAES) installations are the next largest, followed by sodium-sulfur batteries. All remaining energy storage resources worldwide total less than 85 MW combined, and consist mostly of a few one-off installations." Electric Power Research Institute, "Electricity Energy Storage Technology Options." Technical Update, December 2010.
9. See: North American Electricity Reliability Council (NERC), nerc.com. Ontario is represented by the Independent Electricity System Operator, ieso.ca.
10. The current state of reliability assessments and indicators, and performance evaluations can be found at nerc.com.
11. Cohen, Gail, Frederick Joutz, and Prakash Loungani, "Measuring energy security: Trends in the diversification of oil and natural gas supplies." Energy Policy 39 (2011), 4860-4869.
12. See the discussion beginning on page 30 in the B.C. Utility Commission's Decision, July 27, 2009.
13. "Review of B.C. Hydro." B.C. Government, 2011.
14. Mowat Centre estimates. For example, an oil estimate based on 445,000 barrels per day of consumption at the 2009 currency-converted West Texas Intermediate price results in $882 per capita, however Ontario is a net importer of significant volumes of crude oil and the more valuable refined products.
15. Before phasing out coal-fired generation. After phase out, the ratio could be over 5:1.
16. The US oil security approach of switching to alternative fuels is less applicable given that Ontario also imports almost all of its natural gas. There may, however, be biofuel (ethanol and biodiesel) opportunities to explore.
17. Statistics Canada 45-004-X, Table 5.1, 2009. Includes the average of opening and closing crude oil and refined product inventories compared to end use for energy from 57-003-X, Table 3-8, 2009.
18. EIA estimates $1.50 to $2.00 per barrel per year, if owning the facilities, in the early 1990s. The estimate is adjusted for inflation from 1995. The cost of oil and refined products is the average of $100 per barrel oil and recent wholesale prices for gasoline and diesel of about 80 cents per litre.
19. Website accessed on August 17, 2011.
20. This metric does not account for specialization, such as a smaller refinery that produces lubricants and other chemical products, instead of producing the major energy commodities. For example, Ontario's Nova refinery and the 'Suncor 2' refinery in the chart produce primarily for the petrochemical and lubricants markets, respectively.
21. In 2005, Ontario's Petro Canada refinery in Oakville closed.
22. Many states have no refining capacity, based on atmospheric crude oil distillation operable capacity, from the US EIA.
23. For example: Casey, Liam "Fuel chaos could become the norm, experts warn." Toronto Star, August 11, 2011.

24. For an example of an attempt to value the benefits of electricity interconnection see, "Review of Assistance Reliability Benefits." Northeast Power Coordinating Council Inc., NPCC CP-8 Working Group, June 1, 2011.
25. "State of the Energy Market 2010." Australian Energy Regulator, chart on page 27.
26. Ontario Power Authority website, accessed August 18, 2011. "FIT Price Schedule", onshore wind and under 10 megawatt ground mounted solar. Large-scale solar is likely closer to $300 per megawatt hour.
27. Agreement information is from a submission to the State of Vermont Public Service Board, August 17, 2010.
28. 220 megawatts x 16 hours per day x 365 days per year x $75 per megawatt hour price gap. The regulatory documents indicate that the agreement is for 218 to 225 megawatts.
29. This occurs because cold air is more dense and Ontario winters tend to be windier than the summers.
30. This estimate does not include additional reserves that are required to insure against rare weather events or the sudden shutdown of a major generation plant. Reserves are typically 15% to 20% of forecast demand.
31. NERC capacity and demand data from their Electricity Supply and Demand data set, 2010, supplemented with information from IESO.
32. Energy Information Administration (US), "Updated Capital Costs for Electricity Generation Plants." November, 2010. Overnight capital cost of the advanced natural gas combustion turbine, the lowest cost option.
33. US electricity markets include options to buy renewable energy credits, to meet environmental goals, and "capacity" markets are developing to purchase access to generation capacity, as needed, instead of buying electricity that may or may not end up being needed. These markets are, however, near-term markets of a few years; relying on them for long-term security would require shifting Ontario's supply policy away from long-term contracting.
34. Subset of a list from the World Nuclear Association.
35. Candu reactor, developed by Atomic Energy of Canada.
36. For example, the Ministry of Energy directive to the OEB on smart grids already includes cybersecurity and physical security as a policy objective. Order in Council 1515/2010, November 23, 2010.

ABOUT THE AUTHOR

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