ERG2007/01

Review, reduce, and replace: The three 'R's of energy security

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18 February 2007

Abstract

Rising world energy costs, increasing demand for energy in newly emerging economies, and a decline in the number of oil and natural gas producing nations have all contributed to national and international concerns over energy security. If a jurisdiction's energy security is in jeopardy, the common reaction is to seek out other sources of energy from, ideally, more reliable suppliers with large reserves. Such an approach to energy security can be problematic in that it attempts to maintain the energy status quo, in part because of existing infrastructure investments.

This paper proposes a systematic approach to meeting a jurisdiction's energy security needs, consisting of the following three steps: review (an analysis of existing sources of energy, infrastructure, and types of demand), reduce (the development of wedges to reduce energy demand), and replace (the application of wedges that replace imported energy sources with indigenous ones). This approach, referred to as the three 'R's of energy security, allows policy makers to obtain an understanding of a jurisdiction's energy supplies, requirements, and alternatives, thereby permitting the development of appropriate energy security policies.

1. Introduction

Security, the freedom from risk or danger, is commonly used in reference to personal or national security. Our view of security has expanded in recent years to include "food security" when referring to a nation's ability to feed itself and "water security" when confronted with the issues of declining water quality. Over the past decade, increasing energy costs, coupled with rising demand and tight production, have resulted in a new type of security, often referred to as "energy security".

Broadly speaking, energy security is defined as the availability of a regular (i.e., uninterrupted) supply of energy at an affordable price (Costantini, 2005; IEA, 2001a). The World Bank has refined this definition to mean those activities that allow countries to produce and use energy sustainably at reasonable cost in order to (World Bank, 2005):

- Facilitate economic growth and, through this, poverty reduction; and
- Directly improve the quality of peoples' lives by broadening access to modern energy services.

Although intended for developing countries, this definition is applicable to developed countries as well, since maintaining economic growth, poverty reduction, and access to modern energy services still requires energy security.

How energy security is achieved varies between, and within countries, usually depending upon a jurisdiction's state of development and its sources of energy. For example, the priorities of industrialized, net-energy importing countries are (World Bank, 2005):

- Avoid disruption of energy supplies;
- Diversification of energy supply sources;
- Security concerns for energy infrastructure;
- Technological solutions to reduce dependence on imported supplies.

Ultimately, the success or failure of an energy security policy depends upon energy supply and the associated energy infrastructure. Ideally, a jurisdiction has adequate energy supplies with an infrastructure that allows the supplies to be distributed so that all energy demand is met. However, history has shown that the loss of supply, the loss of infrastructure, or the simple lack of infrastructure can result in the loss of energy security.

A jurisdiction's energy infrastructure can also limit its choice of energy supply sources, potentially leading to energy insecurity: a large natural gas network requires a supply of natural gas to protect both consumers and investors; in this situation, obtaining new suppliers may involve more costly infrastructure, such as LNG liquefaction and regasification facilities. Supporting existing infrastructure by building new infrastructure to carry energy supplies potentially over longer distances may produce short-term energy security solutions; however, the reliance on more infrastructure increases the likelihood of a failure somewhere in the supply chain.

As world supplies of crude oil and natural gas become increasingly politicized and problematic, politicians and energy planners are being forced to reexamine the energy security situation in their jurisdictions. To date, as shown in section 2, most jurisdictions focus on ways of maintaining the energy status quo, based in part on investments in existing infrastructure; this approach assumes that new supplies and suppliers are able to meet existing and projected demand. Seeking out new supplies and suppliers to satisfy existing energy demands may not be a viable, long-term approach to energy security; section 3 presents a methodology that fosters the development of energy security policies that focus on reducing energy demand and increasing reliance on indigenous energy supplies. In section 4, the methodology is applied to the Canadian province of Nova Scotia, showing what it could achieve in terms of energy security in the residential sector between 2007 and 2025. The paper concludes with a discussion of the methodology and suggestions on how it can be employed to improve energy security.

2. Approaches to energy security

Energy security is gaining prominence in many jurisdictions because of rising energy costs and supply issues. A growing number of energy-poor jurisdictions are becoming increasingly reliant on a dwindling number of energy-rich countries for their supplies; this section considers approaches to energy security in a number of them.

2.1. OECD Europe – natural gas

Imports accounted for more than one-third of OECD Europe's natural gas supplies in 2003, this is expected to grow to one-half by 2015 and two-thirds by 2030 (EIA, 2006); Russia presently supplies about two-thirds of Europe's natural gas imports (EIA, 2006). Europe's reliance on Russian natural gas was brought into sharp focus early in January 2006 when the Russian government and the Russian energy giant, Gazprom, cut supplies of natural gas to Ukraine, simultaneously reducing the flow to much of the European Union. (The requirement that energy security have both energy supply and infrastructure was illustrated in Ukraine, where the lack of supply rendered the infrastructure ineffective.)

Europe's reliance on foreign energy supplies has been growing, primarily because of declines in the production of oil and natural gas from the North Sea (Heinberg, 2006); the need for natural gas is due in part to existing investments in significant natural gas infrastructure. New supplies of natural gas from Norway to northern Europe and LNG to Spain and the U.K. are being touted as the means of helping the region improve its energy security (Brooks, 2006).

Recent European transportation proposals intended to reduce reliance on diesel fuel and reduce transportation-related greenhouse gas emissions has resulted in increased demand for biofuels (EU, 2005; EU, 2006). With Europe's limited biofuel potential, supplies of palm oil from Malaysia and Indonesia are being used to make biodiesel (Pearce, 2006). This is another example of investment in existing infrastructure (notably automobiles and the road network) driving energy security policy.

2.2. China – crude oil

China's rise to prominence in world energy markets can be traced back to 1993, when it moved from being a net exporter to a net importer of crude oil (BP, 2006). Since then, China's energy demand has grown by almost 130 percent, making it the world's second largest user of crude oil, surpassing Japan in 2003 (BP, 2006). China's approach to energy security has been to create companies such as CNOOC and Sinopec, which enter into exploration and extraction agreements with countries, some of which are boycotted by western governments for various political and human rights' reasons (for example, Sudan, Iran, and Burma).

For the most part, China's approach to acquiring energy assets or supplies has been "softly-softly", although tensions between major importing nations are becoming more apparent as demand puts extra pressure on supply. Two recent examples of energy-related tensions involving China include CNOOC's attempted purchase of the U.S. multinational Unocal in 2005 (blocked by the U.S. government (Washington Post, 2005a)) and the ongoing dispute with Japan over oil and natural gas in the East China Sea (Washington Post, 2005b). The driving force behind China's energy security policies is its push to modernize its economy and maintain future energy supplies.

2.3. United States – crude oil and natural gas

The United States is the world's largest importer and consumer of both crude oil and natural gas (BP, 2006). It is also experiencing a marked decline in its reserves and production of crude oil and natural gas (BP, 2006; Deffeyes, 2005). Not surprisingly, the U.S. government is actively pursuing policies that offset these declines in order to maintain (or increase) levels of supply; for example:

- Attempting to expand the exploration, development, and exploitation of unexplored areas of the United States. An example of this policy is the continued pressure to open ANWR (Arctic National Wildlife Reserve) to exploration (EIA, 2004). There is also growing pressure to lift the moratorium on offshore oil and natural gas exploration on the U.S. continental shelf (EIA, 2005).

- Encouraging the commercial exploitation of oil and natural gas resources in North America, most notably Alberta's tar sands and bitumen reserves (McKenna, 2005).
- Employing military force to keep sea-lanes and pipelines open, most notably in the Persian Gulf and Iraq. U.S. military presence in other parts of Central Asia is seen as a means of confronting the Russians and Chinese to protect crude oil supplies from these regions (Beehner, 2005).
- Developing grain-based ethanol production in farming states. The ethanol is mixed with gasoline to create fuels with between five (E5) and eighty-five (E85) percent ethanol. With legislation requiring ethanol to be added to gasoline in a number of states, some vehicle manufacturers are responding with "flex-fuel" vehicles that accept up to E85. Whether the ethanol program is energy policy or farm policy is unclear, as the EROEI (Energy Return Over Energy Invested) is close to one (Shapouri, 2004) and the principal beneficiaries are agribusinesses (Dircksen, 2006).

As with Europe, U.S. energy policy is intended to maintain existing infrastructure; for example, refined petroleum products and ethanol (the automobile and highway network) and natural gas (electrical generation and residential and commercial space heating).

2.4. Canada – energy "superpower"

Canadian Prime Minister Stephen Harper is calling Canada an "energy superpower", implying that energy security is not an issue in Canada (Globe and Mail, 2006). At first glance, this would seem to be a reasonable interpretation, given the seeming abundance of natural resources found in Canada: coal, oil, natural gas, uranium, and hydroelectricity. However, many of these resources are now in decline: conventional crude oil is rapidly being replaced by synthetic crude and bitumen production in Alberta, while natural gas production from existing wells continues to decline, as does the initial productivity from new wells (NEB, 2006).

Describing Canada as an "energy superpower" suggests that the country is homogeneous in its energy production; however, this is not the case. For example, hydroelectricity is produced primarily in British Columbia, Manitoba, Ontario, Quebec, and Labrador, while the major oil and natural gas producing provinces are Alberta, Newfoundland, and Saskatchewan.

Not only are the resources distributed unevenly across the country, the infrastructure available to access to these resources is also uneven. For example, all natural gas and oil pipelines from western Canada terminate in Ontario and Quebec – they do not extend into Atlantic Canada. Similarly, Atlantic Canada has limited access to Quebec's hydroelectricity. Despite these shortcomings, Canada is the only OECD country without a national strategic petroleum reserve (IEA, 2001b).

3. A systematic approach to energy security

Although approaches to energy security vary from country to country, most focus on the supply side, which is perhaps understandable given the reliance on and investments in existing infrastructure. In some cases, the demand side alternatives are also considered; for example, in the U.K. there is a push for residential-based "micro-generation", small-scale, natural gas fired cogeneration units, supplying heat and electricity to the residence and, in certain circumstances, sold to the local grid (Watson, 2004). Given the size and penetration of the U.K. natural gas distribution network, micro-generation appears to make more sense than, for example, installing district heating systems in parallel with the existing natural gas network.

Relying on natural gas fired micro-generation as is proposed in the U.K., is unlikely to improve energy security. First, since the U.K. is a net importer of natural gas, any supply disruption could affect the production of heat and electricity for residential consumers. Second, if there were insufficient natural gas to meet an individual consumer's micro-generation needs, the consumer would be unable to produce electricity for sale to the grid. In both of these cases, some form of backup energy system would be required to handle shortfalls in the supply of natural gas.

An energy security policy that is based upon increasing imported energy supplies simply to maintain an existing infrastructure is doing little to improve security, as the importer is at the mercy of the supplier. Similarly, implementing technology that relies on imported energy is liable to fall into the same trap.

Developing energy security policies that attempt to maintain the status quo are simply postponing the inevitable: eventually there will be another supply shortfall, requiring further action, either attempting to continue with the existing approach or searching for alternatives.

Simply put, maintaining the availability of an uninterrupted supply of energy at an affordable price cannot be assured if the energy system continues to rely on existing infrastructure that requires increasing volumes of energy from a limited or declining number of suppliers. This is as true for natural gas from Russia as it is for grain-based ethanol from American farmers.

If an energy security policy is meant to overcome the problems associated with maintaining the status quo, a seemingly obvious solution is to reduce demand. However, this may not be sufficient if the demand is still met by imported energy supplies, meaning that security also requires the replacement of imported energy with indigenous sources. In order to identify potential energy security problems and prioritize energy demand, it is necessary to start with a review of the jurisdiction's energy system. These three actions: review, reduce, and replace, are the three 'R's of energy security.

3.1. Review

In order to develop a meaningful, long-term energy security policy, it is necessary for the jurisdiction to consider all aspects of its energy system; this involves reviewing the following:

- Existing sources, suppliers, and supplies of energy. Ideally, all energy requirements are met from local sources; however, in most jurisdictions, one finds that some energy supply comes from non-indigenous sources. In either case, it is necessary to determine the lifetime of these sources and whether there are existing or potential supply problems caused by geopolitical issues or physical supply constraints.
- Existing demand. A review of the jurisdiction's existing energy demand, classified by

the type of energy (e.g., fuel oil, coal, natural gas, electricity) and how it is used rather than the total energy used in each sector. Such a review means that usage patterns can be identified, thereby allowing changes to energy consumption within or between sectors. For example, knowing that a residential sector consumes 100 petajoules per year is not as useful as knowing that 30 PJ of natural gas are used for residential space heating.

- Potential indigenous energy sources. Meeting demand from indigenous energy sources can reduce the reliance on imported energy; however, before this can be done, it is necessary to know what indigenous energy sources are available.

- Existing energy infrastructure. By reviewing the energy infrastructure presently in place, the strengths and weaknesses of the system can be identified. Knowing the supply and demand situation, this information allows for the judicious application of funds to infrastructure.

With this review in place, it is then possible to develop an energy security policy tailored to meet the jurisdiction's energy requirements.

3.2. Reduce

Improving a jurisdiction's energy security requires a reduction in energy consumption. Broadly speaking, this can be accomplished in two ways:

- Energy conservation. Energy conservation implies reducing consumption, leading to a reduction in the activity associated with the consumption. Examples of conservation include turning down a thermostat to reduce the energy needed to heat a space, driving an automobile at a slower speed, and turning off lights when no one is in a room.

- Energy efficiency. Energy efficiency means a reduction in consumption without a corresponding reduction in the activity associated with the consumption. Examples of energy efficiency include insulating a building to reduce heat loss thereby allowing the consumer to maintain the building's temperature while using less energy, abandoning one mode of transport for another, less energy intensive one, and replacing incandescent bulbs with lower wattage compact fluorescents or light emitting diodes.

Of these two approaches, energy efficiency can be problematic, as improving energy efficiency does not necessarily lead to actual energy reduction since there are no incentives to reduce consumption. If improving energy efficiency encourages the consumer to increase energy consumption, then the efficiency gains have done nothing to improve the jurisdiction's energy security.

As energy prices increase, energy reduction will occur naturally, as individuals and organizations looks for ways to reduce their energy costs. Reduction can be allowed to occur through market forces resulting in "demand destruction", or it can be addressed through policies that encourage reduction before rising energy prices make serious impacts on society.

3.3. Replace

Although reduction is an essential component in any energy security policy, its impact is limited by the fact that society requires a minimum level of energy to function. Therefore, in addition to reduction, achieving energy security will also require the replacement of imported energy supplies with indigenous ones. Replacement requires an analysis of the demand to ensure its appropriateness. This implies that there need not be a like-for-like match, in fact, in many cases, it could not be; consider, for example, finding a replacement for furnace oil, without local sources, other indigenous energy sources, such as solar thermal or biomass combustion, might be required.

To be effective, replacement policies must take into account the energy requirements of all sectors of the economy and then match them with the most appropriate energy source(s).

Depending upon the jurisdiction, replacement may also include the upgrading of existing infrastructure. The types of infrastructure in question range from the electrical transmission and distribution system to the transportation network (upgrading public transportation to allow modal shifts).

Although it is possible to have a policy based on reduction or replacement alone, policies based on both are most likely to succeed, especially in jurisdictions with limited indigenous energy sources:

- Reduction without replacement may reduce demand, but if much of the demand is still being met from non-indigenous sources, energy security can be compromised.
- Replacement without reduction may offset the use of non-indigenous supplies; however, the lack of reduction may mean that the indigenous supplies are not being used optimally. This may result in energy shortages that must be met from imported sources, once again, compromising energy security.

3.4. Wedges

Improving a jurisdiction's energy security cannot be achieved overnight, given the existing investments in energy supply and infrastructure. Reduction and replacement policies will require long-term goals or targets that are measurable and realistic with annual interim targets. Over time, the impact of each activity grows from nothing to some maximum, forming a wedge; collectively, these reduction or replacement wedges should reflect the decline in energy consumption and the increase in indigenous energy. Wedges or triangles have been proposed elsewhere for the stabilization of greenhouse gas emissions (Pacala, 2004).

4. Example: Nova Scotia's residential sector

Nova Scotia is Canada's second smallest province, located on the country's east coast. Many of its traditional industries (fishing, mining, forestry, and heavy industries) are in decline, some of which are being replaced by service jobs in call centers and a limited number of small and medium technology enterprises. It has a population of about 950,000, which has been relatively stable: an out-migration of young people seeking work elsewhere in Canada is being offset by older people returning to the province to retire.

Nova Scotia's primary energy demand in 2003 was 282 PJ, of which about 90 percent was met from energy sources outside the province, as shown in Table 1. In 2003, the province's final energy demand was 196 PJ (see Figure 1); the greatest usage was in transportation (71 PJ), followed by residential (43 PJ), industrial (40 PJ), and commercial-institutional (31 PJ). The overwhelming reliance on non-indigenous energy sources, coupled with the lack of major energy infrastructure links to the rest of Canada, means that Nova Scotia is particularly insecure in terms of its energy supply (Hughes, 2007).

The following demonstrates an application of the three ‘R’s to Nova Scotia’s residential sector, between 2007 and 2025.

4.1. Review

Nova Scotia’s residential sector consists of a variety of dwelling types, from single to multiple units of varying size and age. In 2003, the total number of dwellings was 369,240; with a population of 936,302, the number of people per dwelling was about 2.54 (NRCan, 2005). Although the population has remained relatively stable, the number of dwellings has increased over time and evidence suggests this trend will continue (NRCan, 2006). Figure 2 shows the actual (1990 to 2003) and projected (2004 to 2025) medium growth population for the province (Statistics Canada, 2006); the number of households is projected to grow by 0.6 percent per year between 2005 and 2020 (NRCan, 2006); this growth is assumed to continue to 2025. As a result, the number of people per dwelling is expected to fall to 2.23 by 2025.

Figure 3 shows the sources of energy used in the residential sector in 2003. With the exception of wood and some hydroelectricity, almost all sources are imported (natural gas, available from Nova Scotia’s offshore, is used by a few hundred residential customers). A rapid increase in the cost of any of these energy sources or the unexpected curtailment of supply could jeopardize the wellbeing of many Nova Scotians.

Nova Scotia’s residential energy demand is driven by its need for space heating during the heating season (October to May); space heating dominates all other forms of energy used in the residential sector (Figure 4). In fact, low-grade heat in the form of space and water heating are responsible for 84 percent of the sector’s energy demand; this percentage has shown very little change since 1990 (NRCan, 2005).

4.2. Reduce

If significant energy reductions are to be made in Nova Scotia’s residential sector, it will be necessary to target space and domestic hot water heating. There are two broad categories of buildings to consider, new (those constructed between 2007 and 2025) and existing (those constructed before 2007).

Methods of energy reduction in new buildings (that is, reduction relative to existing buildings) are well known; notably, reduction in house volumes, improvements in thermal envelop performance, and utilization of efficient heating and ventilation systems. For the purposes of this paper, it is assumed that all new residential buildings use 25 percent of the energy used in existing building construction.

Energy reduction in existing buildings requires building-upgrades including increasing envelop insulation, window and exterior door replacement, and heating and ventilation system improvements. As well, reductions can be achieved by the occupants improving conservation measures (Burby, 1980). In this example, a one percent per year reduction in residential energy consumption is assumed.

Figure 5 shows the potential energy reduction that could be achieved in the residential sector. Given projected growth in population and number of households, the unreduced residential space and water heating demand would be 39.7 PJ by 2025. Energy requirements for new buildings would produce a reduction wedge, bringing demand down by 2.5 PJ to 37.2 PJ in 2025.

The reduction wedge for existing buildings is 4.4 PJ in 2025. The existing energy reduction wedge is greater than that for new buildings simply because the number of new buildings is about ten percent of all residential buildings in 2025. The combined reduction wedges brings space and water heating demand down to 32.8 PJ, a total reduction of almost seven PJ.

4.3. Replace

For a jurisdiction to achieve any degree of energy security, it is necessary to replace existing imported energy sources with indigenous ones and have the infrastructure available to supply the energy to the consumers. In Nova Scotia's case, indigenous energy sources for residential space and water heating would have to supply about 33 PJ of heat. Table 2 contains a summary of potential energy sources that could be used for replacing Nova Scotia's residential space and water heating requirements; however, some of these sources are already being used and there could be competition for them as energy prices increase. Because of the overwhelming reliance on fuel oil for space heating, energy distribution infrastructure is limited to fuel oil trucks and the electrical grid; less than one percent of houses are connected to the natural gas network and district heating is limited to a few buildings sharing central heating plants.

With these limitations, it is clear that replacing Nova Scotia's residential energy supplies with indigenous ones will be a challenge. The first and most obvious is to require all new houses to maximize their use of solar energy; for example, by orienting them on an east-west axis. Existing houses that could take advantage of the sun should also be encouraged to make the necessary changes to maximize their use of solar energy.

In addition to these reduction wedges, and recognizing the lack of infrastructure in the province, other reduction policies could be implemented depending upon location; for example:

Rural. Since many rural communities already rely on wood for heating, this wedge would be based on direct biomass combustion for heating.

Suburban. A wedge for suburban communities with low housing densities and good grid connections would be the use of wind-electric and thermal storage units for heating (Hughes, 2006).

Urban. Where densities warrant, a biomass-cogeneration, district heating wedge would be developed.

An example of potential replacement wedges for Nova Scotia's residential space and water heating requirements is shown in Figure 6. The projected space heating demand for 2025 is almost 40 PJ; the reduction methods described in the previous section take demand down to 32.8 PJ. If all new homes meet 75 percent of their heating demand from solar, the wedge drops demand slightly to 31.9 PJ; the size of this drop can be attributed to the small number of homes and their demand. A much greater impact is experienced with retrofitting existing homes with solar so that by 2025, 15 percent of all residential heating demand is met from solar energy, reducing demand to 27.0 PJ. The application of wind heating is assumed to make the biggest impact on residential space heating, reducing demand by 30 percent (almost 10 PJ) to 17.3 PJ; the availability of a provincial electrical grid means that no additional supply infrastructure, other than possible line upgrades, would be required. District heating is assumed to make less of an impact, given the cost of installing the infrastructure; in this example, it reduces demand by 1.6 PJ in 2025. Finally, the amount of woody biomass used for heating is assumed to double, from 10 to 20 percent by 2025, reducing residential heating demand to about nine PJ (the dogleg in the wood wedge takes into account the existing 10 percent heating).

4.4. Discussion

This section has shown an application of the three 'R's to space and water heating in Nova Scotia's residential sector. Reviewing the energy supply and demand and the associated infrastructure allows the jurisdiction to target areas that can maximize the benefits of changes to the energy system; in this example, space and water heating were chosen, as they are responsible for over 80 percent of the residential energy demand.

Reducing energy demand in this example focused on both new and existing buildings. Although demand reduction in new buildings offers more potential for reduction than do existing buildings, the size of the existing building market has meant that the greatest demand reduction would be achieved by improving existing buildings.

Replacing imported energy with indigenous supplies depends upon the available energy and the available infrastructure. With limited infrastructure, other than the electrical grid, replacement in this example focused on solar, biomass, and wind generated electricity for use in storage heaters.

An important issue that must be addressed in replacement is the potential conflict over the use of indigenous energy sources: if there are multiple uses for a single energy source the jurisdiction must decide how the commodity is used; for example, a biomass crop used for heating or food, or coal for cogeneration or liquefaction as a transportation fuel. This demonstrates the need for comprehensive reviews of indigenous energy supply and infrastructure in order to understand the energy security needs of a jurisdiction.

5. Concluding Remarks

Energy security relies on supply and infrastructure: the loss of either means that a jurisdiction will be unable to meet its energy needs. With rising world energy prices caused by production shortfalls, geopolitical issues, and increasing demand, energy security is becoming a priority in many energy-poor countries. When energy security becomes an issue, the typical response is to seek out other sources of supply to continue meeting demand. Not surprisingly, the type of energy usually remains unchanged, dictated by the type of infrastructure already in place.

As world energy supplies become more expensive and difficult to obtain, there will reach a point when a jurisdiction is unable to maintain its energy security using imported energy. If the jurisdiction is to avoid this situation, it must develop policies that break this dependence.

This paper has proposed a systematic approach to energy security that attempts to decrease energy demand and increase the use of indigenous energy sources through an approach referred to as the three 'R's of energy security:

- Review – an analysis of existing sources of energy, infrastructure, and types of demand;
- Reduce – the use of wedges to reduce the demand for all energy sources using the results of the review;
- Replace – the replacement of imported energy sources with indigenous ones, once again, using wedges and the results of the review.

The three 'R's offer a systematic way of understanding how a jurisdiction meets its energy demand, thereby allowing for the development of an energy security policy that can target consumption and encourage the growth of indigenous energy sources. The three 'R's can also be used in greenhouse gas reduction programs by ensuring that replacement focuses on low-carbon energy sources.

The ultimate test of any energy security policy is whether it is sustainable; policies based upon imported or declining energy sources cannot be sustained. Only by identifying how energy is used, then trying to reduce it, and finally replacing it with indigenous sources can a jurisdiction come close to achieving energy security.

Acknowledgements

The author would like to thank Alain Joseph, Mandeep Dhaliwal, Nikita Seth, and Tylor Wood of the Energy Research Group for their valuable contributions to this paper.

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Table 1: Nova Scotian energy sources and suppliers for 2003

Fuel source	Supply (PJ)	Percent of supply	Suppliers
Refined petroleum products	178.3	63.1%	North Sea, Venezuela, Middle East, Hibernia, U.S.
Coal (imported)	69.1	24.5%	Columbia, Venezuela, U.S.
Renewables (used in non-electrical utility applications)	16.6	5.9%	Nova Scotia
Coal (local)	10.3	3.7%	Nova Scotia
Natural gas liquids	3.1	1.1%	Imported, Nova Scotia
Primary electricity	2.7	1.0%	Nova Scotia
Natural gas	2.3	0.8%	Nova Scotia
Total	282.4	100.0%	

Table 2: Indigenous resources in Nova Scotia

Source	Resource	Comments
Coal	220 Mt	High-sulphur coal, located both on-shore and under the ocean. Most mines are abandoned. Resource would meet 75 years of existing demand for coal-fired electricity.
Forest biomass	6.9 million m^3 (2004 cut)	Most of this resource is used in forest products industries (pulp and lumber). The total annual cut from many private woodlots is unknown.
Agricultural biomass	407,000 ha (all farms, including dairy and beef)	Most potential energy crops are used for silage or human consumption.
Natural gas	1-2 tcf	About 90 percent of the annual production is shipped to the United States; production peaked in 2001. Offshore exploration has stopped.
Wind	Unknown	Some good coastal sites; however, there is no comprehensive wind atlas for the province.
Solar	320 $kWh/m^2/mo$ (heating season)	Resource is reasonable, although some areas are hampered by fog.
Nuclear		Although not strictly indigenous, the Canadian government is promoting the use of nuclear technology, notably CANDU reactors, as a source of electricity.

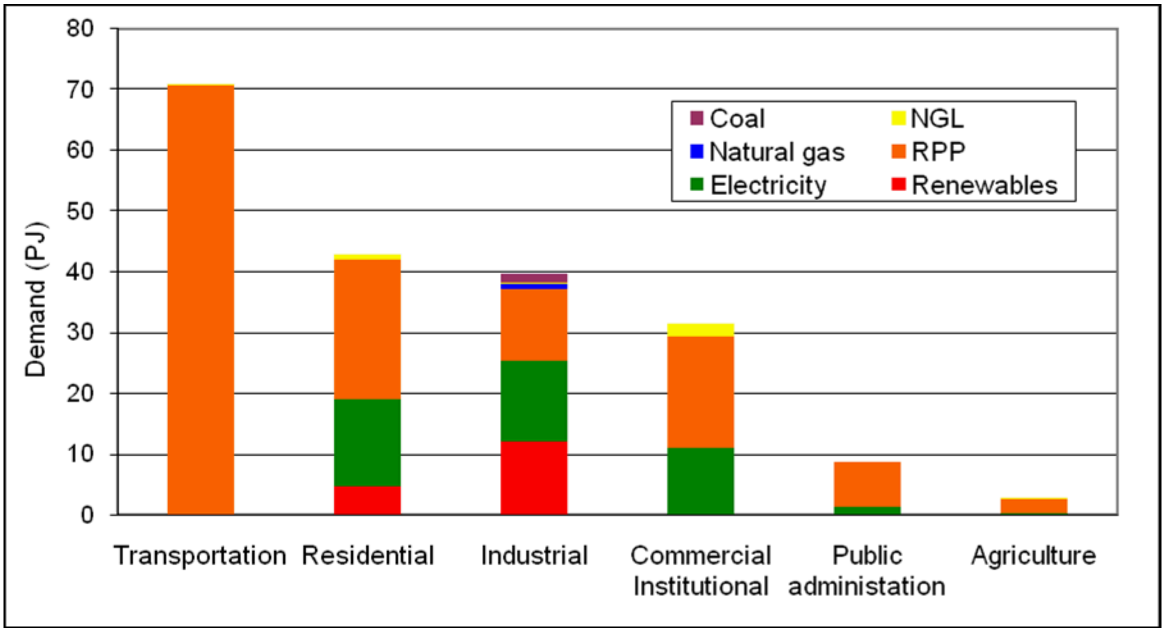

Figure 1: Nova Scotia's secondary energy demand (NRCan, 2005)

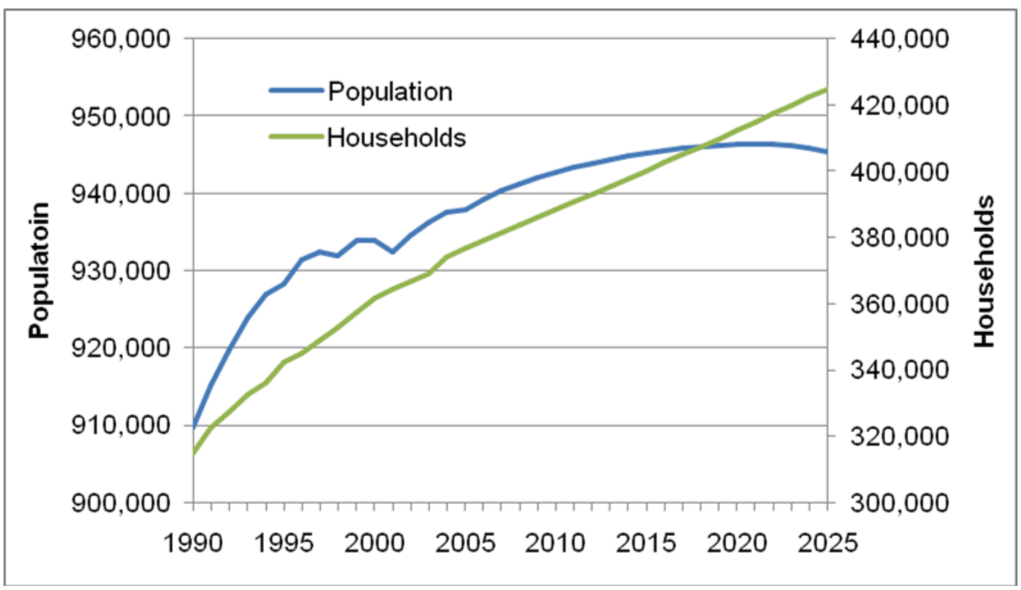

Figure 2: Population and households (2004-2025 projections)

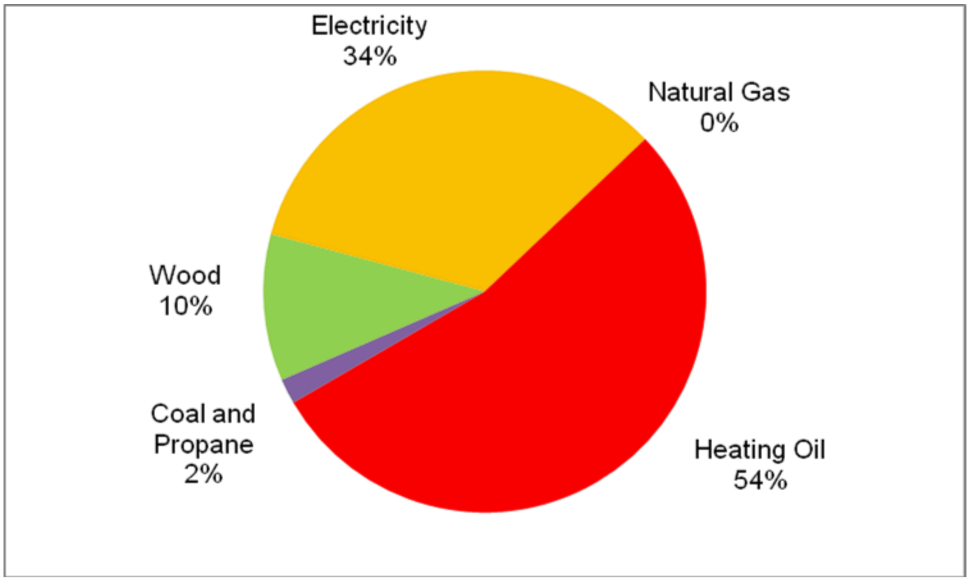

Figure 3: Energy sources for residential sector in 2003 (NRCan, 2005)

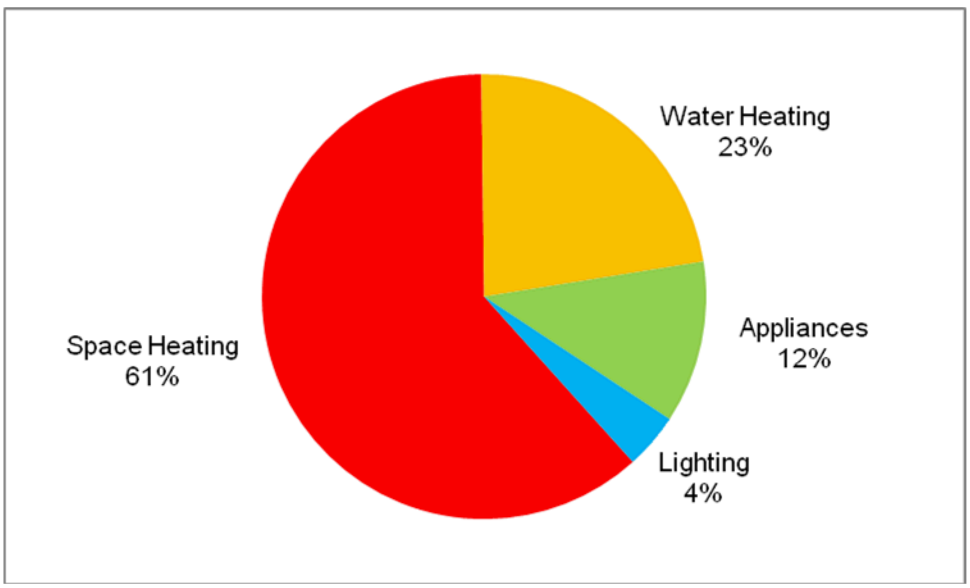

Figure 4: Nova Scotia's residential energy demand for 2003 (NRCan, 2005)

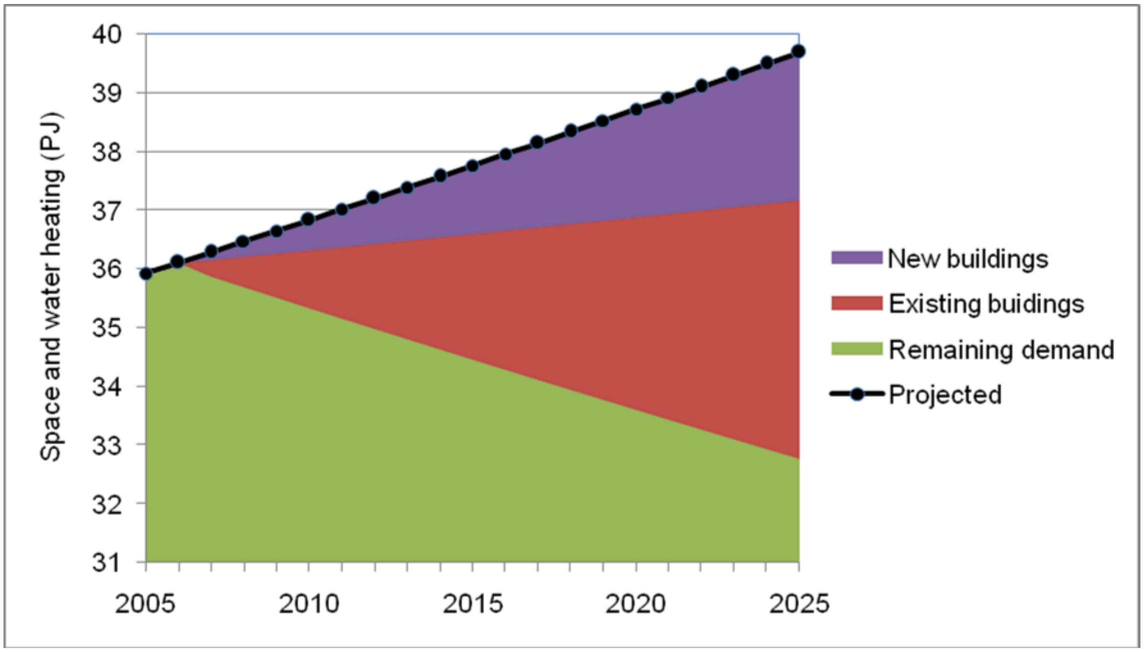

Figure 5: Space and water heating demand: actual, projected, and reduced

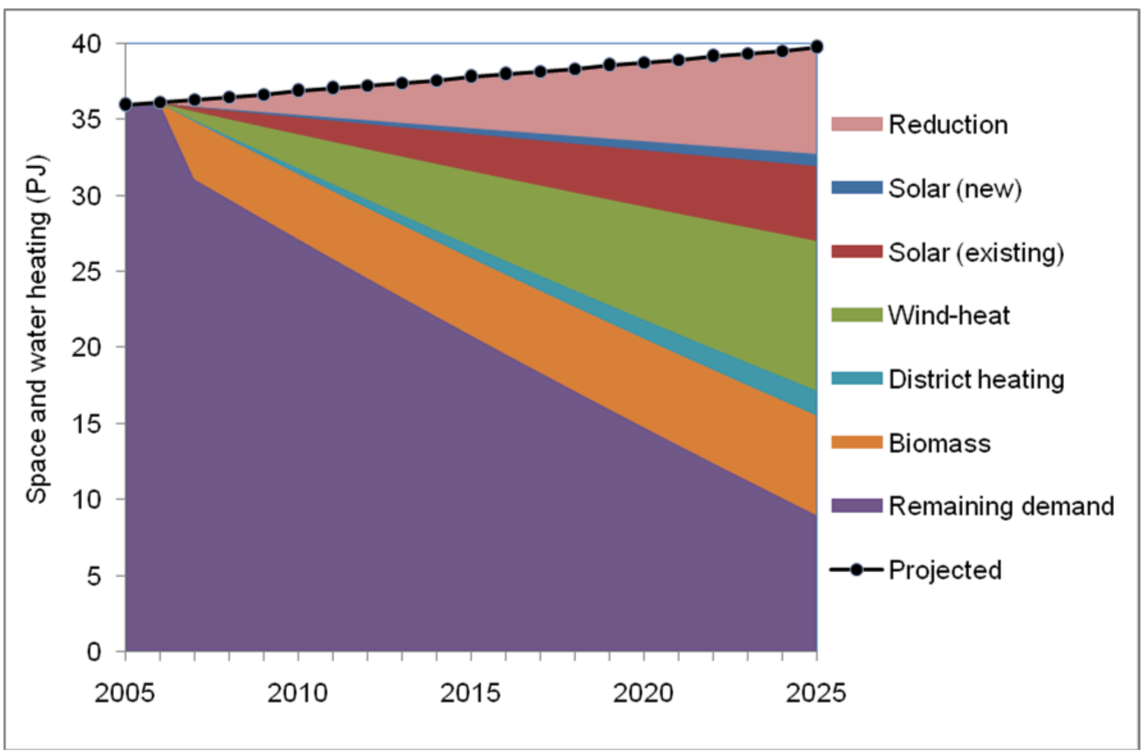

Figure 6: Example space and water heating replacement wedges