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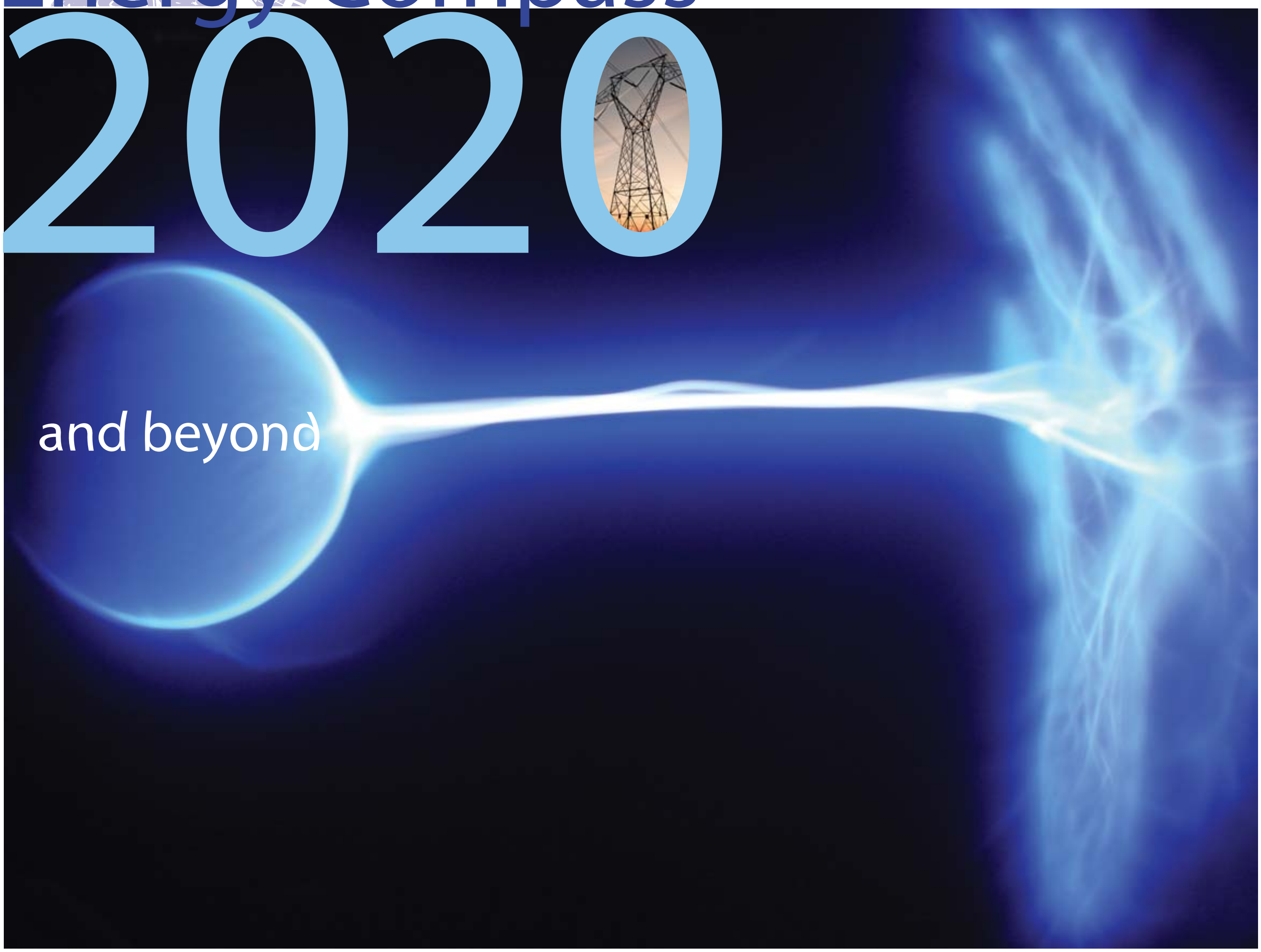

A Recommended Canadian Energy Decision Framework.

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A Recommended Canadian Energy Decision Framework

By the Canadian Society for Senior Engineers
October, 2010

Foreword

"If thou dear reader are bored with this wearisome calculation, take pity on me who has gone through this seventy times"
Johannes Kepler (1571-1630)

The Canadian Society for Senior Engineers (CSSE) is a Canada-wide charitable organization comprising senior (in age and experience), professional engineers, of all specializations, with diverse leadership experience in the public and private sectors.

Its members, all volunteers, strive to “give something back” to Canada for the benefits that they have received from Canada in their education and long engineering careers.

Two of the ways in which the CSSE “gives something back” are: (1) by helping, financially and otherwise, Canadian youth who aspire to a career in engineering or science; and (2) by advocating public policies that it feels will maximize the future well-being of all Canadians.

This, “A Recommended Energy Decision Framework for Canada”, is one such advocacy.

The members of CSSE have thousands of years of professional experience and considerable knowledge of all forms of energy. Therefore we of the CSSE feel that it would be remiss of us not to engage in the on-going energy debate. We do this bearing in mind our code of ethics which calls on us to work towards maximizing the future well-being of all Canadians.

Executive Summary

Herein, CSSE identifies Canada's currently-recognized 26 "energy alternatives", the general things that we Canadians can do, and are doing, regarding energy, and ranks those energy alternatives according to their relative importance (or "relevance") to maximizing the future well-being of Canadians.

Energy decisions affect nearly all aspects of our lives. Therefore a "relevance tree" (or "means-to-an-end construct") approach has been used to provide a systematic evaluation of each energy alternative. Each energy alternative is evaluated according to its relevance to the health, security, economic and education criteria affecting the future well-being of Canadians. Its ranking results from those evaluations.

The 26 energy alternatives comprise: (a) the use of the 10 primary forms of energy indigenous to Canada, (b) the 10 general energy-conservation measures, and (c) the exporting of 6 forms of energy surplus to Canada's energy needs.

The major conclusions reached, in the context of maximizing the future well-being of Canadians, are:

(1) using our indigenous energy far outweighs using imported energy;

(2) conserving energy outweighs exporting our surplus energy;

(3) for provinces without extensive indigenous hydraulic energy ("hydro") potential the best energy alternative by far is to use our indigenous nuclear energy, followed by the use of our indigenous natural gas, oil, coal, biomass, geothermal, wind solar and tidal in that order. Where undeveloped hydro potential exists it may constitute a preferred first choice;

(4) improving the energy efficiency of our buildings and means of transportation and reducing wastage of energy rank highly;

(5) Canada needs a nation-wide electrical grid, mainly for security and economic reasons, particularly with the growing probability of cyber attacks on electrical plants and control systems;

(6) it is important that energy decisions, made at all levels of government and within the private sector, be made in collaboration with other jurisdictions likely to be affected;

(7) the energy debate is clouded by misinformation, alarmism and short-sightedness;

(8) energy decisions by our governments often are made without weighing adequately all of the costs and other life-cycle implications.

Of the several recommendations that are submitted herein, the major ones are that:

(1) the federal and provincial governments, acting in a sense of cooperative federalism, lead the development of an updated energy policy for Canada, considering the conclusions and recommendations of this paper, and others submitted by public-spirited persons;

(2) preference be given to using energy indigenous to Canada;

(3) energy conservation be vigorously pursued;

(4) the use of indigenous nuclear energy be the 1st choice in provinces in which hydraulic energy sources ("hydro") are either minimal or have been essentially fully-exploited, followed by use of our indigenous natural gas, oil, coal, biomass, geothermal, wind, solar and tidal ;

(5) the future of the federal government's ownership of the Canadian nuclear design organization and the risk-sharing between supplier and provincial customers be resolved quickly;

(6) the oil sands industry be supported, with appropriate regulation to ensure that environmental issues get resolved, so that Canadians will have an adequate, indigenous source of oil well into the future;

(7) a national electrical grid be developed; and

(8) clear and objective information on energy sources and use, widely available, be made available to our schools, and to public and private sector authorities to encourage and to enable rational decision-making.

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Introduction

Everything that people do needs energy of one form or another, so a sound energy policy is as essential as sound fiscal and monetary policies.

Canada is fortunate in having more available energy than we currently need, and it is available to us in all of its primary forms. Most of it is from sources indigenous to Canada, and that indigenous energy can be supplemented readily from foreign sources when doing so makes economic and business sense. The wealth of indigenous energy provides opportunities to export some of it that is surplus to Canada's current and foreseeable needs, for economic benefit.

Canada's energy resources and their application are managed and regulated by both the private and public sector, the regulating being done primarily by the federal and provincial governments. A sound energy policy for Canada is therefore dependent on the agreement of many parties. Hence this paper is being given wide distribution.

The paper, which is in 4 parts, delineates Canada's currently-recognized 26 "energy alternatives", the 26 general things that Canadians can do regarding energy. It then ranks those 26 energy alternatives according to how relatively-important each is, how relevant each is, to maximizing the future well-being of Canadians.

The set of 26 energy alternatives is divided into 3 subsets:
(1) the first subset regarding the 10 alternate forms of indigenous energy that we can use (Part 1 {"Using Our Indigenous Energy"});
(2) the second subset regarding the 10 general things that we can do to conserve energy (Part 2 {"Conserving Our Energy"}); and
(3) the third subset regarding the 6 alternative forms of surplus energy that we can export (Part 3 {"Exporting Our Surplus Energy"}).

Part 4 ("Ranking the Alternatives") ranks each of the 26 energy alternatives, and describes how those rankings are achieved.

The reader might note that the paper does not discuss the science of climate change, it being in the province of climate scientists to resolve. However, those aspects of the science that are generally accepted as scientific fact have been considered in ranking the energy alternatives (for example, known effects of emissions of the so-called "greenhouse gases", such as water vapour, carbon dioxide, methane and chlorofluorocarbons.).

The life-cycle environmental effects and relative costs of electricity generation technologies of the primary energy sources have been considered in evaluating the effects of the various energy options on the well-being of Canadians.

Sustainability has been an implicit consideration throughout.

The reader also might note in Part 1 that hydrogen is not included as one of the indigenous energy forms (“primary”, or “source”, energy forms). That is because hydrogen, like electricity, is man-made, and is therefore a “secondary form” of energy, or an “energy currency”, just as Canadian dollars are a money currency. It can be used efficiently in fuel-cells for powering land vehicles (including trains), waterborne vehicles and aircraft, among other applications.

Hydrogen can be stored safely, in liquid form or as a pressurized gas, and can be transported and used safely. Like electrical energy, hydrogen is relatively environmentally-benign, in that the combustion of it emits only water vapour.

Production of hydrogen, by electrolysis, is quite inefficient. However, from time to time we have surpluses of electricity, produced by using any of the 10 indigenous “primary” forms, providing opportunities for hydrogen to be produced in quantity.

The above facts regarding hydrogen have been borne in mind when establishing, discussing, evaluating and ranking the 26 energy alternatives.

Electricity, a common “secondary form” of energy, is discussed explicitly in Part 1. However, in the evaluation of the ten primary indigenous forms of energy, each of which can be used to generate electricity, the need for a national grid system, and how it would benefit a specific primary form of energy, kept recurring, affecting the evaluations and rankings in Part 4 variously. Mention of the benefits of a national grid system is made briefly in Parts 2 and 3.

Part 1. Using Our Indigenous Energy

1.0 Introduction

Discussed in turn below are our 10 indigenous-energy-use alternatives, namely, using indigenous Canadian: (1.1) biomass, (1.2) coal, (1.3) geothermal energy, (1.4) hydraulic energy, (1.5) natural gas, (1.6) nuclear fuel, (1.7) oil, (1.8) solar energy, (1.9) tidal energy, and (1.10) wind energy.

(1.1) Using Canadian Biomass

Canada's biomass includes an abundance of sustainable, renewable, combustible and/or consumable vegetation and waste material, available Canada-wide.

Whereas the majority of our biomass is converted, by metabolism, to human energy and the energy of our animals, biomass contributes nearly 6% of our other energy use.

Wood (directly and as pellets), a renewable source of energy, is used domestically and is exported. Forestry waste is used as a source of heat and for generating small amounts of electricity. Similarly, agricultural wastes are a source of fuel. Switchgrass, grown on marginal agricultural land, can be pelletized and used in the same energy-generating facilities as wood pellets.

Manure from livestock is increasingly being used for heat and power on cattle farms. The use of manure as a fuel helps to reduce the risk of polluting sources of drinking water. Experience in Germany shows that this technology can be more widely used in Canada.

Using the methane in landfill gas to generate heat and electricity is an effective way of dealing with an obnoxious gas. The incineration of waste and sewage sludge can reduce disposal volumes and with new technology can reduce past concerns with contaminated effluent gas release.

In a relatively energy-inefficient process, Canada is growing crops to produce ethanol as a vehicle fuel to replace oil. Canada has been producing ethanol from corn in Ontario and grain in the western provinces. As well as a fuel for light vehicles, biomass is being used to produce biodiesel and aviation fuel.

Ethanol production has been cited as one of the reasons for the rise in food prices. Today, ethanol is an expensive way to replace gasoline. It requires mandated use as well as subsidies. New technologies using non-food-grain cellulosic feedstocks, new enzymes and algae might alleviate at least some of these issues.

There are many forms of biomass energy, raising the possibility of it being sustainable indefinitely. However, most biomass energy requires government subsidies in order to compete with traditional fuels. Many biomass energy projects are small local ventures.

Funding comes from many sources which makes it difficult to see the true economics and whether there is an actual environmental benefit.

While using biomass as a source of energy might have some environmental benefits, burning it does release a variety of gases and soot which can be harmful to humans, equipment and the environment.

Research to improve the availability, cost, and environmental impact of biomass fuel is ongoing in a number of countries, notably in the United States. Evidence indicates that biomass may become a more important energy source in the future.

(1.2) Using Canadian Coal

Canada has the world’s fifth largest coal reserves. We have an abundance of lignite, sub-bituminous, bituminous, and anthracite coal available, mined in five provinces, readily-stored, and transportable from coast to coast to coast.

The largest use of coal in Canada (~88%) is for electricity production, where it supplies between 15% and 20% of all electricity. Large and medium-sized coal-fired plants produce base, middle and peak load electrical energy for our electrical grids. Also, there are steel-making furnaces which are dependent on using anthracite coal and coking coal. Some coal is still used for home heating.

Canada’s coal reserves probably will last for several centuries using current mining methods, and even longer as new ways are found to extract coal from smaller seams.

In spite of its polluting track record, using our coal remains a relatively low cost and widely-available energy alternative.

Coal is the major source of electrical energy for our largest trading partner, the USA, as well as for the largest emerging economy, China. Any major change in coal use will have large social, environmental and economic effects. As a result there will be a strong effort to maintain its use, and reduce the negative environmental consequences. So far most of the ideas, such as gasification, for reducing the environmental effects, are expensive. However, prototype plants using innovative technology are in the early stages of building or operation.

Processes are being developed (notably in Germany and China) whereby coal can be converted into less-polluting forms of hydrocarbon.

Another benefit of coal is that uranium and thorium can now be recovered economically from the ashes of coal-fired power plants.

Many of the coal-fired power stations in Canada are nearing the end of their useful lives and it is timely to consider other sources of energy for generating electricity, particularly in Ontario where high sulphur coal is currently imported from USA.

(1.3) Using Canadian Geothermal Energy

Geothermal energy is most readily available around the edges of tectonic plates, and is being used in 22 countries, particularly in the USA and Iceland. There is very little geothermal electricity generation in Canada at present but there is a potential for generating a substantial amount. The high-temperature sources can be used for generating electricity and the cooler sources can be used for local heating. However, water injection into hot formations, intended for heat recovery in near-surface geothermal recovery processes, can initiate seismic disturbances.

Another source of heat is widely available from the **"**near-surface**"** of the Earth's crust where the temperature is fairly constant. The temperature at depths from a few meters to a hundred meters comes from a combination of conduction from Earth's core and solar heat absorbed on the surface – so it is labeled **"**ground heat**"**. Heat pumps can use the ground as a heat source in the winter and a heat sink for heat in the summer. Ground source heat pumps are increasing in popularity, both in Canada and elsewhere. They are capital intensive compared with other means of heating buildings, but are efficient in their use of electrical energy, which results in a reasonable capital pay-back time.

Successful installation of ground-source heat pumps requires technicians with a broad knowledge of ground conditions. Without a network of skilled technicians, and better performance guarantees, this form of energy is unlikely to grow as large as its theoretical potential.

Geothermal energy, including ground heat energy, will be available for as long as the earth is habitable.

(1.4) Using Canadian Hydraulic Energy

Hydroelectric power ("hydro") is the greatest source of power generation in Quebec, British Columbia, Manitoba and Newfoundland-Labrador. All four provinces have extensive potential hydro power resources aggregating some 30.000 MWe. In 2009, Ontario Power Generation's electricity supply-mix was 51% nuclear, 39% hydro power and 10% hydrocarbon (coal, oil and natural gas). Some potential hydro power resources exist in northern Ontario and one on the Slave River in Alberta.. Canadian-developed, high voltage direct current transmission may make these remote resources viable options.

Hydro power facilities are designed to generate electricity at very competitive costs for many decades. They also serve a vitally important role in system frequency control.

Hydro power generation is a renewable resource**.**

(1.5) Using Canadian Natural Gas

Natural gas (which includes methane, ethane, propane, butane and pentane) is relatively easily extracted, stored, transported and used in a multitude of applications, including electrical power generation, space heating and cooling, and vehicle propulsion. Increasingly, natural gas is seen as an attractive alternative to gasoline for trucks and automobiles.

The International Energy Agency (IEA) believes that enough recoverable natural gas resources exist to supply the world for 250 years at current production rates. USA and Canada now account for one third of the world's known reserves.

In the past decade, advances in horizontal drilling and production technology for natural gas held in low-porosity rock formations, such as shale and economically-inaccessible coal beds, have made producing such gas economical, opening vast new resources across North America and elsewhere.

A modern gas-fired combined cycle power plant produces electricity economically. Gas-fired electric power generation can be sized optimally for local applications next to consumers, and waste heat from co-generators can produce steam or hot liquid water, that can be circulated to heat nearby homes and businesses, providing low-emission electricity and zero-emissions heating. (However, urban communities may object to power plants being located close to schools and homes.)

Natural gas has the lowest emission "footprint" of the fossil fuels.

The retail price of natural gas has fallen in recent years, and this trend, with some volatility, may continue, with the exploitation of the vast shale gas reserves in USA and Canada. While shale gas shows promise of increasing resources, it is still in the exploratory phase.

(1.6) Using Canadian Nuclear Fuel

Our abundance of natural uranium enables Canada to supply about 20% of the world's demand. Seventeen nuclear reactors are operating in Canada and three more are being refurbished. All of them are of the Canadian-designed CANDU type (natural uranium-fuelled and heavy water-moderated). More than 440 reactors are operating in 31 countries (most use enriched uranium), and another 56 reactors are under construction.

The operating experience with all CANDU plants, both in Canada and overseas has been good.

Nuclear power plants have high capital cost and very low fuel costs. Nuclear electricity costs are kept low by operating at high capacity factors over a long life. Countries with a high percentage of nuclear-produced electricity, like France, Japan, South Korea and Sweden have benefited significantly from their use of nuclear energy.

Uranium is mined, processed and used safely, with no significant effect on our environment.

Despite this performance there are persistent concerns which are briefly addressed below.

The safety of nuclear power is frequently questioned despite the fact that all reactors are independently monitored and licensed by each country's nuclear regulator. The operation of every power reactor in the world has now been subjected to international peer review.

Radiation is a public concern. Anti-nuclear activists use the argument that any dose of radiation will produce cancer deaths because each type of radiation damages our cells. However, every cell is damaged thousands of times per day by natural biological processes and natural radiation. Every living organism has a very effective damage-control biosystem that prevents, repairs or removes nearly all of the cell damage.

Recent studies reveal that exposure to low level radiation can be somewhat beneficial to humans.

Another concern is the handling of so-called 'nuclear waste' (i.e., partially used uranium fuel). This radioactive solid material is sealed in robust containers. In 2002, the Government of Canada established the Nuclear Waste Management Organization, following a scientific study which showed that radioactive material can be stored safely underground. This organization will implement a national project to safely manage partially-used fuel.

Today's reactors extract only about one percent of the energy available in uranium. Therefore, it is wise to store partially used fuel in a manner that will allow easy recovery and recycling by future generations. Future plants will be able to use nearly all the energy stored in this fuel. The technology already exists but is not being used because today's reactors can operate more cheaply using readily available uranium. With future reactors uranium (and thorium) will become a sustainable energy source, effectively an inexhaustible energy source.

Unfortunately, in Canada political decisions on nuclear energy appear to be stalemated while other governments worldwide are making commitments to new nuclear plants.

(1.7) Using Canadian Oil

We use refined oil products, such as gasoline and diesel fuels, to propel our land, water, and airborne vehicles, to generate electrical energy for our electrical grids, and for space heating and cooling.

Including the oil sands, our oil reserves are realistically-estimated to be the second greatest in the world, after Saudi Arabia, and there is potential for these resources to be significantly greater with innovative new extraction methods.

Crude oil, in its many forms, is owned mainly by provincial and federal governments, which receive significant royalties from its extraction.

We are becoming increasingly dependent on the oil sands. At present, about 54% of Canada’s oil extraction is from the oil sands, despite activist campaigns to stop oil sand development on the grounds that it harms the environment.

Oil sands bitumen is extracted by two methods. Bitumen containing sands near the surface are mined by removing the overburden, mining the oil-bearing sands and transporting the bituminous sands to a facility to extract the oil. Deeper deposits of bitumen are extracted by in-situ processes which pipe steam into the ground to reduce the bitumen viscosity so that it will flow to a wellbore to be pumped to the surface.

Open pit mining creates a temporary disturbance of the landscape which can be restored to be similar to the original landscape once the oil has been removed. Most of the future reserves (~80%) are deeper underground and will be extracted by in-situ processes. By 2016 it is estimated that in-situ extraction will overtake open pit mining. In-situ processes currently use natural gas for heating the injected steam.

New processes are being developed to be more energy efficient.

Studies have been conducted to explore the feasibility of using some indigenous nuclear fuel to supply the primary energy needed to extract oil from the massive deposits of oil sands in Alberta. This alternative may become practicable in the future.

Although, like natural gas, oil is not renewable, and therefore not “sustainable”, Canadian oil will be sufficient to meet Canada’s needs for the next several decades.

Canadian oil prices will continue to be volatile, due in large part, to: (a) successful development of less-polluting vehicles propelled efficiently by electricity, natural gas, hydrogen and/or other alternative fuels, (b) government subsidization of alternative fuels, (c) the world-wide growth in the number and size of vehicles and (d) international politics; all of which underline the importance of a clear and consistent Canadian oil policy.

(1.8) Using Canadian Solar Energy

By far the main uses of our current incoming solar energy is for the production of biomass, the heating and lighting of homes, the supply of energy to low-capacity electricity generators and, of course, the production of Vitamin D in our bodies.

Our experience with exploiting solar energy is in its infancy, but experimenting with such applications as roof-top solar panels for heating swimming pools, and solar power for generating electricity, is meeting with some success.

Ontario is forcing the development of solar power plant installations by granting huge subsidies to provide relatively-small, incremental, generating capacity to its grid. The current Government of Ontario has decided to offer returns-on-investment of from 18% to 24%, guaranteed for 20 years, to private individuals who invest in their own solar power electricity production. Since there are many locations on government buildings and on government land where solar power could be demonstrated, that would appear to make better economic sense.

The general public is beginning to question the value of solar power that has to be excessively subsidized through high guaranteed feed-in electric power purchase contracts, taxation and/or much-increased energy user rates.

Solar energy, like wind and geothermal energy, is geographically diversified, and given enough actual-generation experience to know how much energy we could count on, and a storage method, one might consider using solar energy to provide, for example, the power for local critical-communication hubs that could be counted upon in emergencies.

A major advantage of solar power is that it can be generated locally for residential or commercial use, without the need for long-distance energy transmission. Solar heating of homes can reduce the consumption of hydropower and fossil fuels.

A major disadvantage of solar power is that it becomes less effective in areas where cloud cover and fog is common. In the High Arctic, for example, there are prolonged periods of darkness during the winter months. Also, many areas are shaded by natural features or tall buildings.

Solar energy advocates claim that it has virtually no discernible effect on our environment. However, they fail to mention the environmental effects resulting from the mining, processing and manufacturing of solar panels and associated equipment.

Further, the use of solar panels for community and regional power supplies requires the use of extensive land areas. Not much grows under a solar panel. Increasingly, arable land is in short supply, world-wide.

Although Canada’s northern latitudes don’t lend themselves to reliable and economically-viable solar power, it is quite likely that, in the distant future, we will make more use of solar energy to meet some of our energy needs.

(1.9) Using Canadian Tidal Energy

Canada’s long coastlines are exposed to the vagaries of varying, and periodic, ocean tides caused by our moon’s gravitational pull. Ocean tides reaching heights of up to 15 meters and more (e.g. in Leaf Basin in Ungava Bay and Minas Basin in The Bay of Fundy), provide a significant, but relatively costly, periodic, potential source of energy.

In addition to the 18 MWe tidal-power plant at Annapolis Royale, Nova Scotia Power is testing water turbines that could produce about 300 megawatts of electrical power in The Bay of Fundy by 2012-2013. An experimental unit also is being tested at Race Rocks, a high tide-race water current area near Victoria, British Columbia.

Tidal energy is sustainable.

Tidal barriers on rivers can have major environment consequences, including changes to geomorphology and sediment deposition, disruptions of salinity and freshwater gradients, and barriers to fish passage.

The damming of small water basins and rivers can be done so as to avoid significant harm to bottom soils and wildlife.

(1.10) Using Canadian Wind Energy

An immense amount of wind energy can be harnessed each year across our nation, and across our adjacent ocean waters (albeit at a very high cost). Despite the high growth rate in the number of wind turbines, wind still supplies only a few percent of national electricity.

In Canada, wind turbines can be installed on the land or along large bodies of inland waters, and in our adjacent ocean waters. We also can harness wind-generated wave energy with buoyancy systems, for limited applications, on the surface of large bodies of inland waters and in our adjacent ocean waters, where the winds can generate waves of sufficient height.

Because the wind speeds and directions vary from hour to hour and from day to day, the use of wind energy is restricted to generating and supplying incremental capacity to electrical grids; and to such local applications as driving water pumps on farms. (Unfortunately, winds generally abate at sunset, when energy demand peaks for cooking dinner and illumination.)

Wind power might be appropriate for remote communities, especially when coupled with other energy sources and means of storage (e.g., elevated reservoirs of water).

Denmark is often cited as the prime example of the successful use of wind power. Its success, however, derives in large measure from its unique situation, wherein high-capacity electrical power grid interconnections with Scandinavian water storage hydro and coal- fired power in Germany and Eastern Europe permits Denmark to account for the majority of the time that wind power is not feeding electricity into the grid. Denmark has the highest electricity prices in Europe, although partially due to its taxation policy. While Denmark gets about 20% of its electricity generation from wind, in recent years it has added only around 5% per year to its wind capacity, while other countries are adding up to 30 % per year.

Wind energy available at a site is a function of the cube of the wind speed (as well as the reliability of the equipment). So predicting the long term wind speeds (and the reliability of the equipment) accurately at a site is essential to the economics.

Wind energy, although variable, is sustainable and relatively “clean”. But it is costly for the foreseeable future, given the large towers and power lines that must be built and maintained, and the land values and tourism that will be lost in many cases.

Recent environmental concerns have been raised about the aesthetics of wind farms near communities and scenic areas, the effect of inaudible "infra-sound" vibrations on the health of nearby residents, and the effects on migratory birds. Some governments perceive that there has been some public support for wind energy, but this is now being challenged worldwide by people living near proposed and existing wind farms.

In addition, the general public is beginning to question the value of wind power that has to be subsidized through taxation and/or increased energy user rates.

Although wind energy technology has been advancing, and the size of installations growing to around 5MWe per unit, many of the existing wind farms are now working with outdated technology. Increased wind turbine size is a major factor in improving the economics of wind power but it is also a major deterrent due, to the negative impact on persons and wildlife living in the environs of the wind farms.

In some parts of Canada there has been a rush to embrace ‘green’ wind energy technology as a creed, without taking into account fully the factors that apply in Denmark but not Canada.

Modern wind farms are generally safe, but the highly-stressed gearboxes and other parts of the facility, and the susceptibility to lightning strikes, have led to catastrophic failures world-wide. Long-term maintenance might get costly.

An American Society for Mechanical Engineers (ASME) study suggests that wind power on an annual basis only delivers 10-15% of its nameplate rated capacity into the electric power grid.

Part 2. Conserving Our Energy

2.0 Introduction

“Energy conservation” and “energy efficiency” are sometimes used interchangeably, although they represent different concepts. Paradoxically, improved energy efficiency can often lead to <u>more</u> energy use because the improvements lead to a larger market.

Several studies have suggested that energy-conservation measures resulting in energy savings of 20% to 40% are possible in the next couple of decades, and will generally be cost effective, paying for themselves. These gains, if realized, would have an important effect on the economy, and therefore deserve a clearly-articulated policy, together with plans, from all levels of government. Such a policy would highlight the reduction of energy wastage and the improvement of energy efficiency, discussed in (2.1) and (2.2) respectively below.

As discussed below, Canada can conserve its indigenous energy by importing energy:
(2.3) by importing electrical energy via the North American Electrical Power System;
(2.4) by importing hydrogen;
(2.5) by importing biomass;
(2.6) by importing natural gas;
(2.7) by importing oil;
(2.8) by importing coal; and
(2.9) by importing nuclear fuel.

Finally, energy is conserved, temporarily at least, by storing it; as discussed in (2.10) below.

(2.1) Reducing Wastage of Energy

Public demands for the reduction of waste have existed for decades. Nevertheless, in the public arena it has not been easy to get more than a modest commitment to the reduction of wasted energy. The attitude is: “If I can afford it and enjoy using it, then why should I not use more energy?”

Due, in large part, to this attitude, from 1990 to 2004 energy demand in Canada increased 23%, as the GDP and population grew. Had it not been for the increase in energy efficiency of 14%, over the same period, energy use would have grown 36%, costing Canadians an estimated additional $14 billion dollars annually.

To encourage Canadians to not be wasteful, governments will need a range of tools, including pricing, regulation, and incentives, as well as information and exhortation, to change public opinion and behaviour.

(2.2) Improving Energy-efficiency

To-day we have refrigerators that use one-fifth of the energy that similar-sized refrigerators did 35 years ago. There are countless other examples of contrivances whose energy efficiencies have been significantly improved, and there’s good reason to expect that such improvements will continue to be developed.

The heating of buildings and transportation consume about two-thirds of all energy use.

The internationally-recognized program “LEED” (Leadership in Energy and Environmental Design) is followed in Canadian building-design, and there are a growing number of the installations of (replacement) high-efficiency gas furnaces for home heating, saving consumption of natural gas and money.

Improvement opportunities in the energy-efficiency of buildings are primarily:
1) improved envelope thermal resistance (more insulation, decreased use of windows and increased use of low-emissivity double glazing);
2) increased average residence occupancy density of conditioned space by making basements high-quality living spaces rather than simply storage space (by solving water, mould, radon and thermal comfort problems); and
3) decreased requirements for ventilation with outdoor air (by using more efficient ventilation technologies, removing indoor pollutants at source, and increasing the use of air purification, cleaning and filtering devices, thereby reducing infectious-disease transmission and "sick-building" syndrome health effects that are currently associated with low outdoor-indoor ventilation rates).

Opportunity 1 is primarily driven by energy-versus-renovation costs, while Opportunities 2 and 3 are primarily driven by indoor air quality problem-solving successes. Since heating ventilation air is more expensive in Canada than in USA, Europe and Asia, due to our cold climate, this is a natural area for Canada to lead in the development of new technologies for domestic and international use.

Fuel economy in cars and trucks has been improving steadily for several decades, and needs encouragement to continue this trend. Where available, rail transportation offers significant economic benefits

(2.3) Importing Electrical Energy via the North American Electrical Power System

Surplus electrical energy on the electrical grids of USA can be purchased from time to time at relatively low prices to feed Canadian electrical grids, thereby conserving some of our own energy resources.

Significant amounts of surplus electrical energy generated by utilities in Canada and USA are exchanged hourly to the mutual benefit of the participating utilities; the object being to optimize the management of their systems, thereby minimizing their costs of operation. Within Canada, cross-provincial-border electrical energy transfer, particularly among Ontario, Quebec and New Brunswick, and between Alberta and British Columbia, is a significant component of generation / load management.

A national grid system certainly would be beneficial in this regard.

(2.4) Importing Hydrogen

Importing hydrogen will be an issue when there is more extensive use of this "clean" energy currency.

Foreign countries with a surplus of otherwise unusable energy can use some of that surplus to produce hydrogen relatively cheaply.

Importing hydrogen from those countries would conserve our own hydrogen and fuels.

(2.5) Importing Biomass

Biomass is generally bulky and has high transportation costs. At present, even locally produced biomass has to be subsidized to be competitive. Despite this, corn is being trucked into Ontario from the USA for both feeding livestock and producing ethanol. This seems to be an irrational consequence of a combination of regulation and subsidies.

If ethanol use is still mandated, there could be importation of bio-fuel from Brazil and other tropical countries.

Probably bio-aviation fuel will be imported in some quantities from the USA as Canadian airlines test the use of this replacement for traditional fuel.

(2.6) Importing Natural Gas

Like importing other fuels, importing natural gas would result in a little less pollution in Canada by not having to extract and process it.

The new development of extracting natural gas from shale might change the structure of natural gas sales in North America and make it appropriate to import US shale gas in Eastern Canada (while still exporting natural gas from Western Canada).

(2.7) Importing Oil

To date, it is estimated that approximately half of the world's published oil reserves have been consumed. The remaining half will be more expensive to extract and the overall process may possibly be more polluting.

Despite all government pressures in North America there is still a persistent growth in the use of oil. This will only change if there are major shifts in energy conservation, disruption of supply from unsettled regions of the world, and/or displacement of oil by other fuels. Predicting the balance between these pressures is not easy and any plans will have to be flexible to ensure that there is no panic caused by short term disruptions.

It remains, that importing oil conserves Canada's oil reserves and other forms of energy.

For logistic/economic reasons, Eastern and Central Canada use imported oil.

(2.8) Importing Coal

There is an abundance of foreign coal available to Canada, often at a lower cost. Not having to mine and process it means less pollution in Canada and less risk to Canadian lives.

For economic reasons mainly, coal is imported into Eastern and Central Canada for power station use. Canada is a net importer of coal for electricity production.

Another reason for considering imported coal is the prospect of importing "cleaner-burning coal" from such countries as Germany and China, where scrubbing and slurry-making processes are being developed, perhaps faster than they are in Canada.

By importing coal, we conserve our own energy.

(2.9) Importing Nuclear Fuel

Canada is unlikely to import nuclear fuel directly as we have abundant sources of high-grade ores and hence low-cost uranium. If Canada buys either the Advanced CANDU Reactor or Light Water Reactors, then enriched fuel will be needed. Canada does not have enrichment facilities at this time and might be forced to import enriched uranium to fabricate its nuclear fuel.

(2.10) Storing Fuel

Canada is generally self-sufficient in all forms of energy, unlike the USA which is dependent on imported oil. As a result, the USA has strategic stores of oil to cover about two months use. Canada can store fuel simply by leaving it in the ground.

In Canada, the storage of fuel is purely to meet any likely disruptions in the fuel supply chain: for example, oil storage to allow for problems in refineries, and seasonal storage of corn and wheat for producing ethanol.

While there appears little need for storing fuel in Canada it is always worth having a periodic assessment to ensure that there is no lurking risk of shortage.

Part 3. Exporting Our Surplus Energy

3.0 Introduction

For various reasons we can, and do, export some of our surplus indigenous energy in the forms of (3.1) biomass, (3.2) coal, (3.3) hydraulic energy (cross border), (3.4) natural gas, (3.5) nuclear material and (3.6) oil.

Our future well-being depends, to some degree, on how much of which forms of energy that we export.

In the following paragraphs the CSSE gives its perspective on exporting each form of energy.

3.1 Exporting Surplus Canadian Biomass

Canada has been one of the world's leading exporters of biomass for over 100 years, exporting much of its surplus agricultural products, particularly grains. We have also been a leading exporter of surplus forest products.

In recent decades we have been increasing our efforts to re-grow our forests, and assuming that those efforts are sufficient to assure sustainability, we can continue to export our surplus forest products profitably.

We are exporting some of our biomass waste to such places as Michigan and China.

3.2 Exporting Surplus Canadian Coal

Exporting our surplus coal to some countries, besides being profitable, can foster international trade, and promote good relations, especially when the coal is relatively "clean" and/or the receiving country has facilities for converting coal into less-polluting forms of hydrocarbon.

Our coal exports are roughly 50% greater than our coal imports.

Nearly all Canadian coal exports are metallurgical coal for steel making.

3.3 Exporting Surplus Hydraulic Energy (Cross-border)

Surplus electrical energy on the electrical grids of Canada is sold from time to time to feed U.S.A. electrical grids, thereby contributing to North American energy self-sufficiency.

As mentioned in 2.3 above, the hourly exchange of electrical energy enables optimal load management and minimum operating costs for both countries.

Ties between two (or more) systems can be advantageous, for example, when peak demand requirements occur at different periods of time during the year. This is the case at the present time for the systems of Eastern and Western Canada and those of the Northeastern and Northwestern USA. This prevents having to build the otherwise required spare capacity to maintain reliable service.

Also as mentioned in 2.3 above, a national grid system certainly would be beneficial for analogous reasons.

3.4 Exporting Surplus Canadian Natural Gas

The low-cost, ready availability and relatively clean-burning characteristics of natural gas will make it a strong candidate to fuel the medium and long term future of world-wide building and residential heating, new electrical power production, industrial processes, and transportation.

With such growing markets, Canada is in a good position to export and profit from its surplus natural gas resources via its pipelines to the US and new coastal LNG terminals to Europe and elsewhere.

3.5 Exporting Surplus Canadian Nuclear Material

Uranium and thorium are available in abundance. Historically, Canada has exported more nuclear materials than any other nation.

The lost opportunity inherent in these past exports is our failure to reap the benefits of enriching uranium (currently ultra–centrifuge technology is the most competitive) before export. In this way, Canada has foregone billions of dollars in foreign exchange.

Ultra-centrifuge enrichment technology is well within the capability of Canadian industry. This is one of the greatest chances for improving Canada's balance of trade; a true "low-hanging fruit".

3.6 Exporting Surplus Canadian Oil

Canada can become a major net exporter of oil, and benefit economically from being so, particularly if we exploit fields like the Bakken field in Southern Saskatchewan.

Western oil production is exported primarily to the USA, mainly by pipeline.

Recent pipeline leaks have raised public concern and more stringent regulations, regarding inspection and maintenance standards, are expected, rendering the incidence of a future spill less likely, and demanding that pipeline companies have emergency procedures available to limit any problem.

Generally of concern is the possibility that NAFTA and other treaty obligations might stem this potentially-lucrative source of revenue

Part 4. Ranking the Alternatives

The 26 energy alternatives discussed in Parts 1, 2 and 3 above are ranked according to how relevant each is estimated to be in maximizing the future well-being of Canadians.

The future well-being of Canadians depends on the relative amounts of effort that Canadians expend on the 8 health-enhancement measures, the 7 security-enhancement measures, the 8 wealth-enhancement measures and the 3 education-systems-enhancement measures.

The health-enhancement measures are:
(1) reducing the incidence of contaminated food products;

(2) improving our water quality;
(3) improving our air quality;
(4) improving the cleanliness of our soil and our neighbourhoods;
(5) improving our health-enhancement knowledge;
(6) improving our lifestyles;
(7) improving our medical diagnosing; and
(8) improving our medical treatment.

The security-enhancement measures are:
(1) improving our security-enhancement knowledge;
(2) increasing our household security;
(3) increasing our workplace security;
(4) increasing our neighbourhood security;
(5) increasing our national security;
(6) increasing North American security; and
(7) promoting world peace.

The wealth-enhancement measures are:
(1) improving our wealth-enhancement knowledge,
(2) increasing personal net worth;
(3) increasing the economic well-being of our municipalities;
(4) increasing the economic well-being of our provinces and territories;
(5) increasing the economic well-being of Canada;
(6) increasing the economic well-being of North America;
(7) increasing the economic well-being of the world; and
(8) improving our natural environment.

The education-systems-enhancement measures are.
(1) improving our family and community life;
(2) improving our formal education systems; and
(3) increasing the diversification of our work experience.

The energy alternatives are ranked by:

(1) estimating the percentage of our total effort, toward maximizing our future well-being, should be spent on each of those health-enhancement, security-enhancement, wealth-enhancement and education-systems enhancement measures; and
(2) estimating the relative importance, or relevance, of each of the 26 energy alternatives to each of the 26 enhancement measures; then
(3) weighting each relevance estimated in (2) by the percentages estimated in (1).

To arrive at the 26 percentages of (1), the estimates of CSSE members from coast of coast to coast were averaged to give 26 CSSE consensuses.

To arrive at the 26 x 26, or 676, CSSE consensuses of (2), those same CSSE members were each asked to give his/her 26 x 26, or 676, estimates (over a 6-month time span). Then the members’ estimates were averaged to arrive at 676 CSSE consensuses.

In the evaluation of the ten primary indigenous forms of energy, each of which can be used to generate electricity, the need for a national grid system, and how it would benefit a specific primary form of energy, kept recurring, affecting the evaluations and rankings variously. The national grid concept also affected positively the evaluations of importing and exporting (cross-border) electricity.

Also, in evaluating energy conservation alternatives (2.2) (improving energy efficiency) and (2.1) (reducing wastage of energy), in particular in regard to our homes and other buildings, the value of "smart grid" systems became apparent.

The resulting rankings are shown in the table below. (Note. It should be remembered that these rankings are *national* rankings, intended to serve as a guide to developing an energy policy for *Canada*. Each province has unique conditions. However, depending on what those conditions are, the rankings below can serve as a guide for choosing the best energy alternatives available to any given province.)

Rank	(Reference) (to) (Section)	Energy Alternative	Estimated Relevance To Our Future Well-being (%) (Rounded)
1	(1.6)	Using indigenous Canadian nuclear fuel	14.9
2	(1.4)	Using indigenous Canadian hydraulic energy ("hydro")	8.5
3	(1.5)	Using indigenous Canadian natural gas	8.5
4	(2.2)	Improving energy-efficiency	7.8
5	(2.1)	Reducing wastage of energy	7.0
6	(1.7)	Using indigenous Canadian oil	6.7
7	(1.2)	Using indigenous Canadian coal	5.9
8	(1.1)	Using indigenous Canadian biomass	3.4
9	(1.3)	Using indigenous Canadian geothermal energy	3.3
10	(1.10)	Using indigenous Canadian wind energy	3.2
11	(1.8)	Using indigenous Canadian solar energy	2.9
12	(3.5)	Exporting nuclear fuel	2.9
13	(1.9)	Using indigenous Canadian tidal energy	2.6
14	(3.3)	Exporting hydraulic energy (hydro) (cross-border)	2.5
15	(2.10)	Storing energy	2.3
16	(3.4)	Exporting natural gas	2.1
17	(3.2)	Exporting coal	2.1
18	(3.6)	Exporting oil	2.1
19	(2.3)	Importing electrical energy (cross-border)	2.0
20	(2.9)	Importing nuclear fuel	1.7
21	(3.1)	Exporting biomass	1.5
22	(2.7)	Importing oil	1.4
23	(2.6)	Importing natural gas	1.3
24	(2.8)	Importing coal	1.1
25	(2.4)	Importing hydrogen	1.1
26	(2.5)	Importing biomass	1.0

Conclusions

From the foregoing table in Part 4 above, the following conclusions are reached.

(1) Using our indigenous energy far outweighs using imported energy.

(2) Conserving energy outweighs exporting our surplus energy.

(3) For provinces without extensive indigenous hydraulic power (hydro) potential the best energy alternative by far is the use of indigenous nuclear energy, followed by indigenous natural gas, oil, coal, biomass, geothermal, wind, solar and tidal in that order. Those provinces with extensive hydro power .potential are expected to pursue their development;

(4) Regarding the 10 energy-conservation alternatives, improving the energy-efficiency of our buildings and means of transportation, putting more effort into reducing wastage of energy and storing energy are the three prime energy-conservation measures.

(5) Whereas the importing of all importable forms of energy has a total relevance of 9.6%, a major portion of that relevance derives from economic and political, as opposed to energy conservation, considerations.

(6) If, for economic or political reasons, we must import some of our energy, the best form of energy to import is (cross-border) electrical energy, followed closely by the other forms of importable fuels.

(7) If, for economic or political reasons, we export some form of our surplus energy, our surplus nuclear material and surplus electrical energy (cross-border) are the best choices, followed closely by the other forms of exportable fuels.

(8) In the months of CSSE's deliberations, it has become clear that Canada needs a nation-wide electrical grid, mainly for economic and security reasons, particularly with the growing probability of cyber attacks and blackouts.

(9) It is important that energy decisions, made at all levels of government and within the private sector, (a) be made with the knowledge that energy is a global issue (decisions made in one jurisdiction potentially affecting many others), and therefore (b) be made in collaboration with other jurisdictions likely to be affected.

(10) It is vital to keep up-to-date with worldwide changes in energy reserves and use, to ensure that decisions are made in the best interests of Canada.

(11) In Canada, energy decisions are taken at all political levels and within the private sector, often with insufficient coordination.

(12) The energy debate is clouded by misinformation, alarmism and short-sightedness.

(13) Energy decisions by our governments often are made without weighing adequately all of the costs and other implications. For example, the purchase of expensive wind turbines and solar plants from abroad, leaving Canadians with few jobs except in site construction and fewer less in automated operating jobs, ostensibly in support of "green" technology, end up being ill-advised political decisions. Such political subsidies only increase the cost of electric power to individual consumers and lower the international competitiveness (and therefore employment) in the jurisdictions in which such decisions are made.

Recommendations

It is recommended that:

(1) the federal and provincial governments, acting in a sense of cooperative federalism, lead the development of an updated energy policy for Canada, considering the conclusions and recommendations of this paper, and others submitted by public-spirited persons;

(2) preference be given to using energy indigenous to Canada;

(3) energy conservation be vigorously pursued;

(4) the use of indigenous nuclear energy be the 1st choice, in provinces in which hydraulic energy sources (hydro power) are either minimal or have been essentially fully-exploited, followed by indigenous natural gas, oil, coal, biomass, geothermal, wind, solar and tidal in that order;

(5) the future of the federal government's ownership of the Canadian nuclear design organization and the risk-sharing between supplier and customers be resolved quickly;

(6) the potential of the new source of natural gas in shale be better understood and evaluated;

(7) the oil sands industry be supported, with appropriate regulation to ensure that environmental issues get resolved, so that Canadians will have an indigenous source of oil well into the future;

(8) coal be recognized as a large and low cost but environmentally-questionable source of energy, requiring continuing innovation to minimize its environmental effects;

(9) the full cost and implications of all forms of renewable energy be assessed so that there is a clear understanding of all of the costs and environmental benefits and shortfalls before committing more capacity;

(10) continuing pressure be exerted to improve the efficiency of energy use in transport and buildings;

(11) the electricity generating and distribution system be upgraded, toward a national grid system, with more interconnects with USA grids, jointly introducing the benefits of a 'smart' grid system, and ensuring reliable supply in a changing environment;

(12) if it is economically or politically necessary that we export some form of our surplus energy, our surplus nuclear material and surplus electrical energy (cross-border) be best choices, followed closely by the other forms of exportable fuels;

(13) if it is economically or politically necessary that we import some form of energy, electrical energy (cross-border) be the first choice, followed closely by the other forms of importable fuels;

(14) the development of applications of the use of hydrogen (as a "clean energy currency", like electricity), and the economical production and/or importation of hydrogen be facilitated;

(15) clear and objective information on energy sources and use, widely available, be made available to educational institutions, and to public and private sector authorities to encourage and to enable rational decision- making; and

(16) Canada's energy policy, once formulated, be updated periodically, as the world energy situation changes.

To the reader, if you have any questions, it is recommended that you contact the lead author of this paper, Arnold Eyre, who will endeavour to answer them to your satisfaction. Arnold can be reached by emailing arnoldeyre@hotmail.com.