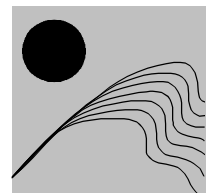


INQUIRIES For a Sustainable Future

*A Decision-making Approach
to the Study of Selected Canadian Issues*

ENERGY

Making Sustainable Choices



Learning for a
Sustainable Future

ENERGY

MAKING SUSTAINABLE CHOICES

In 1998 a five-day ice storm in Eastern Canada cut off the electrical supply to hundreds of thousands of Canadians. For days, sometimes weeks, people were without light and heat for the coldest part of the Canadian winter. Offices and factories were closed and everyday life brought virtually to a halt. It was a vivid reminder of how our ancestors lived only a century ago and a demonstration of how dependent our modern society is on our power supplies and the energy sources that fuel them.

In this century Canada has moved from an agricultural to a post industrial, urban society, thanks to an abundance of energy sources — coal, oil and gas, hydro and nuclear power — and efficient production and distribution infrastructures. The Canadian government's Energy Outlook predicts these energy sources and today's energy industry will continue to serve our needs well into the new century. But today other factors, more long range and profound in their effects than the 1998 ice storm, are causing us to rethink the ways we use energy and the sources that provide it. The first is that fossil fuels — coal, oil and gas — though at present abundant, are finite resources and will one day be depleted. The second is the realization that the use of fossil fuels can have a disturbing effect on the environment, contributing to air pollution, acid rain, and the greenhouse gases that may be affecting the global climate.

The challenge of potential climate change forces the global community to find strategies to reduce industrial emissions that may be contributing to global warming. Canada contributes about two per cent of greenhouse gas emissions. (Industrialized countries, as a whole, contribute about 58 per cent, and developing countries contribute about 42 per cent from the burning of fossil fuels and deforestation). At the international conference on climate change at Kyoto, Japan, in 1997, Canada undertook to make a six per cent reduction in emissions from the 1990 level. This amounts to a 20 to 25 per cent reduction in emissions by 2010 from a "business as usual" projection. Meeting the Kyoto goal will demand drastic changes in industrial practices, in transportation (which is the major contributor of emissions) and in public attitudes and life styles. The search for sustainable energy will focus attention on alternative energy sources, such as wind and solar power, on new technologies and processes (including new transportation fuels).

The complex relationship between energy sources and production, the natural environment and economic progress, is at the centre of questions about energy sustainability. Finding a response to possible global warming may set a new path towards a more sustainable energy strategy for the 21st Century.

REFLECTING ON ENERGY: THE SUSTAINABLE CHOICES

1. Describe what is meant by “an abundance of energy sources” in Canada. How has this abundance helped Canada to develop as a nation?
 2. Investigate and write a brief report on one of the following:
 - your main provincial power utility, its history and present service;
 - the growth of the oil and gas industry in Canada;
 - one of the mechanisms of energy distribution in Canada: hydropower lines, oil and gas pipelines;
 - the history and prospects of the coal industry.
 3. Summarize the main factors in Canada’s energy outlook to 2020 and assess the reasons for the predictions.
 4. Oil, gas and coal will continue to be the major sources of energy in Canada for the foreseeable future. To mitigate the effects on the environment and to conserve resources, new measures in energy efficiency and conservation will be needed. List some examples of each in these readings or from your experience in your own community and school.
 5. The government of Canada is investing heavily in renewable energy. Can a transition from carbon-based energy sources be made without affecting our present standard of living? Assess some of the renewable energy sources in terms of their advantages and disadvantages, and the changes each would make to Canadian lifestyles and landscapes. What government policies and public activities are needed to encourage the move to renewable energy?
 6. What challenges does Canada face in meeting its emissions reduction target set in Kyoto? What are the reasons for different targets for developed and developing countries? How can the Canadian public’s attitudes and behaviour, industrial activities and government policies help Canada to reach its emissions reduction target?
 7. Outline your vision of a sustainable energy future for the 21st Century with particular reference to the economic and social changes necessary.
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BACKGROUND TO THIS INQUIRY

Readings:

Energy: Making Sustainable Choices
The Two Energy Options
Non-renewable Energy Sources
Renewable Energy Sources
Canada's Energy Prospects to The Year 2020: The Canadian Government's Energy Outlook
Today's Energy Challenge: The Role of Fossil Fuels in Changing Climate
Climate Change: The Response of The Global Community
The Challenge For Canada In Meeting The Emissions Target
Meeting the Challenge Through Energy Efficiency: Canadian Government Policies
Energy Efficiency: Some Examples from the United States
Meeting the Challenge Through Community Energy Planning
Meeting the Challenge Through Renewable Energy
The Outlook for Renewable Energy in Canada
Canada's Growing Renewable Energy Industry
Solar Energy in Canada
Windpower: The World's Fastest Growing Energy Source
Wind Power: Becoming a Reality in Alberta
Canada's Fuel Cell Technology: The Dawn of the Hydrogen Age?
Paths to the Future?

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OUR DEPENDENCE ON ENERGY

Few peoples care about the source of our energy supply except when it is disrupted, but virtually all of us care about energy services, which range from the basic needs demanded by human beings everywhere — cooking, heating and lighting — to the hallmark of modern society, motors, appliances, wide-ranging mobility and various industrial processes. Because the world cannot function without regular supplies of energy, a significant section of the global economy is devoted to providing these services when and where required.

Lighting a room, for instance, is not achieved merely by flicking a switch; it is the last step in a long chain of conversion events. Energy resources — for example, the unrefined oil and natural gas recovered from wells driven deep into the Earth's crust and the coal that is sandwiched between terrestrial sediments — must first be extracted. The primary energy (crude oil, say) is then transported to a refinery to be processed into a wide range of products, and from there fuel oil is shipped to a power plant to be burned (and thus converted from chemical to thermal energy). The heat produced during combustion powers a turbine, which in turn drives an electric generator (converting thermal to mechanical to electric energy). Eventually, the electricity travels through wires until it reaches the end-use appliance — the incandescent lamp — where it is transformed into radiant energy.

The uneven distribution of the world's fossil fuels (oil, natural gas and coal) necessitates a flourishing worldwide trade in energy commodities; some 44 per cent of gas and 11 per cent of coal consumed are traded internationally... as a result of such global demand, fossil fuels are being depleted at a rate that is 100,000 times faster than they are being formed...

Although the remaining amount of recoverable fossil fuel is thought to be equal to 10 trillion barrels of oil — enough to last another 170 years at present consumption rates — the supply will eventually run out and, in the interim, (if it is fully combusted) the prospect presents a possible threat to the environment.

How do we reconcile our burgeoning demand for energy with the need to maintain a viable global ecosystem?

Energy for the Planet Earth,
by Ged R. Davis
in Readings from Scientific American Magazine, 1991,

MOVING TO THE THIRD PHASE

Tracing the Relationship Between Technology, Economic Development and Energy Use

Solving energy problems, today as in the past, depends on the technologies that are available and the rate at which they evolve. Since the middle of the 19th Century, sources of power have shifted from wind, water and wood to coal and more recently to oil and natural gas. The interplay of energy and technology, as exemplified by three phases of the Industrial Revolution, accounts for the changes.

During the first phase, which emerged in the early 18th Century, the dominant technologies were coal mining, the smelting and casting of iron, and steam-driven rail and marine transport... adapted by James Watt to provide power for transport and the blast of iron smelters. The smelters, in turn proved materials for constructing the steam engine, locomotives, rails, ships and mining equipment. Through the creation of a transportation infrastructure and the machines to run factories, rapid industrialization was possible.

Toward the end of the 19th Century, the world was again transformed — this time by electric power, internal-combustion engines, automobiles, airplanes and the chemical and metallurgical industries. Petroleum emerges as a fuel and a food-stock for the petrochemicals industry. Now, toward the end of the 20th Century, society has embarked on a third phase of the Industrial Revolution, characterized by a shift to computers, advanced materials, optical electronics and biotechnology.

The third phase impact on global patterns of energy consumption is not yet certain, for application of technology depends on what society considers its objectives to be and especially on whether the public will embrace more of a sustainable world view or not...

In a sustainable world, the balance of new initiatives would shift from producer to consumer, from energy supply to energy services and from quantity to quality of energy...

As we learn more about the relation human beings have with their planet, we may find that rather than viewing energy as a commodity to be exploited **from** planet Earth, we will increasingly need to think and act in terms of energy **for** planet Earth. Our dependence on energy will persist, but it must do so in the context of an ecologically sound planet. This means human beings may well have to apply all their inventiveness to develop new energy technologies so as to guarantee the long-term quality of their habitat.

Energy for the Planet Earth,
by Ged R. Davis
in Readings from Scientific American Magazine, 1991,

NON-RENEWABLE SOURCES OF ENERGY

A Hydrocarbons, atoms consisting of hydrogen and carbon release energy in the form of heat when burned, include the following.

Oil (petroleum) and natural gas were formed by complex decay processes from microscopic life forms called phytoplankton (phyto = plant) which floated in the world's oceans millions of years ago. Just like today's phytoplankton, they harnessed the sun through photosynthesis to store energy. When these myriads of tiny floating plankton died, they sank to the sea floor and became mixed with mud from distant rivers, and were gradually buried. The oil and gas companies around the world know how to find these trapped reservoirs and release their contents by drilling holes into them. Much oil and gas production now comes from underneath the sea bed. As the technology for extraction continues to advance, production comes from deeper and deeper waters. This means that new oil and gas fields will continue to be found for some years yet, so the early forecasts of oil running dry have proved to be wrong. As everyone knows, crude oil and gas from these deposits form the basis for the world's largest energy industry: oil and gas. Oil and gas are also the base — called feedstock — for much of the chemical industry...

Every drop of oil we burn adds to the monumental environment problems we already have by pumping gases like carbon dioxide (CO₂) into the atmosphere. Many scientists fear that this continual release of greenhouse gases such as CO₂ is an important cause of climate change...

Natural gas consists mostly of the simplest hydrocarbon, methane (CH₄). It is the cleanest of the fossil fuels by far, yielding little more than CO₂ and water when it burns. Though it burns more cleanly than coal and petroleum, natural gas still produces the greenhouse gas carbon dioxide...

Coal is carbon; so is graphite (lead pencils) and diamond... Every living organism is made up of molecules based on carbon. Without carbon, there would be no life. Coal is the most plentiful fossil fuel and, unfortunately, the most polluting.

We use many types of coal from brown coal (lignite) to anthracite (the purest form). Much coal also contains other minerals which yield pollutants when the coal is burned. Sulphur is the worst of these and causes severe damage to buildings, forests and lakes due to acid rain.

One World's Guide to Energy,
Web site 1997

B Uranium generates nuclear power... Nuclear power is a mature, virtually non-greenhouse gas emitting technology that already supplies 17 per cent of the world's electricity and avoids the emission of more than 600 million tonnes of carbon (or 2,300 million tonnes of CO₂) annually ... it is the only readily and commercially available "no carbon" electricity generation option, other than hydropower, ...

IAEA Statement Highlights Environmental Benefit of Nuclear Power,
December, 1997

RENEWABLE SOURCES OF ENERGY

Solar Energy: An immense amount of energy from the sun strikes the surface of the earth every day. This energy may be captured and used in the form of heat in "solar thermal" applications, or it may be converted directly into electricity to power electrical devices using photovoltaic cells.

Solar thermal technologies use the heat in sunlight to produce hot water, heat for buildings, or electric power. Solar thermal applications range from simple residential hot water systems to multi-megawatt electricity generating stations.

The primary solar energy technologies include photovoltaics, solar thermal electric and solar heating and cooling systems.

Photovoltaics are one of the fastest growing solar energy technologies. Power is produced when sunlight strikes the semiconductor material in the solar cells and creates an electric current.

Solar thermal systems generate electricity with heat. Solar collectors use mirrors and lenses to concentrate and focus sunlight onto a receiver which converts sunlight into heat. The heat is then transported to a steam generator or engine where it is converted into electricity.

Flat-plate solar collectors are used for heating indoor air, water heating, air conditioning, salt production and water desalination. Inside the boxes, dark-colored metal plates absorb heat. Air or a liquid, such as water, flows through tubes and is warmed by heat stored in the plates.

Solar energy technologies offer a clean, renewable and domestic energy source. Developing countries, where half the population is currently without electricity and sunlight is usually abundant, represent the biggest and fastest growing market for power producing technologies. The largest potential domestic market for power production technologies is the utility sector.

Wind is caused by the uneven heating of the earth. There is a great deal of power in wind. Where sufficient wind velocity exists, wind power can provide clean and cost-effective electricity. Wind turbines can capture the energy stored in wind and convert it into electricity or use the mechanical power directly. Wind power, already one of the most appealing sources of energy today, will continue to prosper as new turbine designs currently under development reduce the costs of wind power and make wind turbines economically viable in more places.

Wind energy is a domestic, renewable source of energy that generates no pollution and has little environmental impact. Up to 95 percent of land used for wind farms can also be used for other profitable activities including ranching, farming and forestry.

The obstacles include visual impact of the turbines; noise people living near the plant might hear; avian mortality in certain locations; and availability of suitable wind. To minimize impacts on people and wildlife habitat, wind farms are located away from population centers and sensitive wildlife areas.

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Hydro-electricity: Hydro-electric power stations capture the energy in flowing water to produce electricity. The quantity of electricity generated is determined by the volume of water flow and the amount of “head” (the height from turbines in the power plant to the water surface) created by the dam. The greater the flow and head, the more electricity produced. Hydro-electric generating systems provide clean, cheap electricity for local applications.

Small-scale hydro-electric systems capture the energy in flowing water and convert it to electricity. Where the resource exists, it can provide cheap, clean, reliable electricity. If they are well designed, small hydro-electric systems blend with their surroundings and have minimal negative environmental impacts.

Large dams change a self-regulating ecological system into one that must be managed. Placed on a river without thought to their upstream and downstream impacts, they can bring disaster. Because lakes cannot survive some of the abuses that rivers can, traditional farming and waste disposal practices must be changed. The dams themselves can be threatened by the silting of reservoirs cause by soil erosion, which may destroy a dam’s ability to store water and generate energy.

On-line Renewable Energy Education Module,
Centre for Renewable Energy and Sustainable Technology, 1994

Hydrogen is another way to store renewable energy, but it offers unique advantages in that it potentially can store and transport renewable energy. In other words, you can use renewable energy to make hydrogen, then send the hydrogen somewhere else and use it.

Hydrogen can be made simply by passing electricity through water, a process known as “electrolysis”. Hydrogen generated from renewable energy sources offers great environmental benefits. Generated from environmentally clean energy sources, hydrogen can then be cleanly converted back to electricity using “fuel cells”. Fuel cells work like electrolysis in reverse, combining hydrogen and oxygen to make water while producing electricity. The only exhaust from fuel cells, which are the main source of power on the space shuttle, is water vapor.

Hydrogen-powered cars, trucks, and buses would have essentially no emission. The vehicles would actually be propelled by electric motors, supplied with electricity from a fuel cell. Many auto makers, including BMW and Mazda, have already made prototype hydrogen cars, to hit the market around the year 2000 .

Hydrogen is a clean and efficient fuel but it can be dangerous at times. Hydrogen is both flammable and buoyant. It is more flammable than gasoline or natural gas, but it dissipates more rapidly than either of these two fuels in a spill. Like all gases, hydrogen should be used in a ventilated area.

Tidal Power

The use of ocean tides to power hydroelectric turbines is another promising technology. The province of Nova Scotia established a 20 megawatt power station — the first tidal power station

in North America — on the Bay of Fundy in 1984. The Bay has the highest tides in the world. This station has been operating successfully since then.

APEC Energy Week
Energy Fact Sheets — Renewable Energy in Canada
Natural Resources Canada
<http://www.nrcan.gc.ca>

Ocean Thermal Energy: The oceans can be considered the world's largest solar energy collector; nearly three-quarters of the Earth's surface is covered by oceans. Using even a minute fraction of the heat, or "thermal energy" trapped in oceans, could power the world. The sun's heating effect on the ocean causes the surface water to be much warmer than the cool deep ocean water. This temperature difference can be used to generate power in several ways. The only ocean thermal power plant to ever operate was a prototype open-cycle plant in Hawaii. Because ocean thermal energy systems rely on the difference in temperature between the surface and the deep ocean, the resource is greatest in areas where the surface is heated the most — in the tropics...

A Guide to the New World of Energy Choices, 1997

Biomass: In a process called "photosynthesis", plants capture sunlight and transform it into chemical energy. This energy may then be converted into electricity, heat, or liquid fuels using a number of different energy conversion processes. The organic resources that are used to produce energy using these processes are collectively called "biomass".

According to the World Bank, 50 to 60 percent of the energy in the developing countries of Asia, and 70 to 90 percent of the energy in the developing countries of Africa comes from wood or biomass, and half the world cooks with wood...

Fermentation and distillation of agricultural products (in Canada, mainly corn) is producing ethanol for blending with gasoline...

On-line Renewable Energy Education Module,
Centre for Renewable Energy and Sustainable Technology, 1994

CANADA'S ENERGY PROSPECTS TO THE YEAR 2020

The Canadian Government's Energy Outlook

Canada's crude oil production is derived from three principal sources: conventional deposits (light and heavy) from the Western Sedimentary Basin (mainly Alberta); the oil sands (synthetic crude oil (SCO) and bitumen) (in Alberta and Saskatchewan); and, the frontier deposits (mainly offshore Atlantic Canada). A substantial amount of Canada's crude oil production is exported. Canada also produces significant volumes of natural gas, about half of which is exported.

The Outlook projects increased Canadian oil production, mainly as a result of increased production from frontier areas and the oil sands. Supplies from these sources are expected to more than offset the decline projected for conventional oil production in Alberta. Natural gas production, which has increased significantly since the mid-1980s is expected to continue to grow, from 5.3 trillion cubic feet (Tcf) in 1995 to almost seven Tcf by 2020. Our analysis suggests that, for both crude oil and natural gas, Canada should have sufficient capacity to meet growing domestic and foreign demand for some time to come. Canada will remain a net exporter over the entire forecast period.

As a preferred fuel in Central and Western Canada for new power plants, natural gas is anticipated to be the fuel with the biggest growth rate, progressing from a share of three per cent in 1995 to ten per cent in 2020. In other words, gas-fired generation will be four times higher in 2020 than it was in 1995, and will be on the same level as nuclear generation. Electricity from coal is projected to decrease by 2000, reflecting concerns about coal emissions and increased generation from nuclear power plants in Ontario and New Brunswick and from natural gas in Alberta. Between 2000 and 2010 coal will experience a gradual comeback as excess capacity dwindles. During the 2010 decade, coal-fired generation will increase as a result of new capacity being built in the Maritimes, Ontario, and the Prairies. Oil-fired generation is expected to follow the same path as coal generation between 1995 and 2010. By 2020 it will mainly be used in the Atlantic region and in remote communities.

Nuclear power ... production is anticipated to remain constant until 2010, then start to decline gradually as 4.4 GW of old nuclear power plants built during the 1970s in Ontario are decommissioned. By 2020, generation from nuclear energy will represent only ten per cent of the total. This is the only fuel to see a decrease both in importance and in energy production, a consequence of the replacement of old nuclear capacity in Ontario with new natural gas and coal capacity during the 2010s.

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Hydroelectricity is and will remain the dominant source of electricity. Over the study period, its generation is still growing, although its relative share is expected to diminish slightly from 62 per cent in 1995 to 57 per cent by 2020.

Electricity from renewable energy, such as biomass, waste, wind, geothermal, small hydro is anticipated to witness a very high growth, jumping from a relative share of one per cent in 1995 to three per cent by 2020. The bulk of the increase is in generation from biomass and waste fuels.

Canada's Energy Outlook, 1996-2020,
Natural Resources Canada, 1997

TODAY'S ENERGY CHALLENGE

The Role of Fossil Fuels in Changing Climate

Human activities are releasing greenhouse gases into the atmosphere. Rising levels of greenhouse gases are expected to cause global warming and, hence, climate change. By absorbing infrared radiation, these gases control the flow of natural energy through the climate system. The climate must somehow adjust to the “thickening blanket” of greenhouse gases in order to maintain the balance between energy arriving from the sun and energy escaping back into space.

What are the greenhouse gases?

Some occur naturally and some are made by humans.

- Water vapour is the most common greenhouse gas but Carbon dioxide or CO₂ is the most important of the greenhouse gases released by humans. It can be natural or made by humans and it is the major contributor to climate change — especially through the burning of fossil fuels when we drive, heat homes and other buildings or run our industries. Global deforestation — the clearing of forested areas — also adds to CO₂ levels because plants absorb carbon dioxide, and when there are fewer trees, there is less carbon dioxide absorbed. CO₂ build-up has increased if forests are cleared by burning, as in the case of the Brazilian rainforest. Scientists believe that if we keep going the way we are, we could double the amount of carbon dioxide in the air before 2050.
- Methane is produced naturally when vegetation is ... digested or rotted without the presence of oxygen. Today, large amounts of methane are released by garbage dumps, rice paddies, fossil fuels, and the digestive processes of grazing cattle.
- CFC's (chlorofluorocarbons) are industrial chemicals made by humans and used in air conditioning, foam, and cleaning solvents. CFCs primarily damage the ozone layer.
- Nitrous oxide also occurs naturally in the environment, however in recent years quantities have increased because of human activities. It is released when chemical fertilizer is used and when fossil fuels, such as coal for generating electricity or gas used in vehicles are burned.

A Change in Our Climate: What's Going on in Our Greenhouse,
Environment Canada, October 1997

CLIMATE CHANGE: THE RESPONSE OF THE GLOBAL COMMUNITY

The international community is tackling this challenge through the Climate Change Convention. Adopted in 1992, the Convention seeks to stabilize atmospheric concentrations of greenhouse gases at safe levels. The Kyoto meeting held in December, 1997, was the third session of the Conference of the Parties (COP), made up of 165 countries. The established protocol aims to lower by 5.2 per cent overall emissions from a group of six greenhouse gases by 2008 - 2010. Cuts in the three most important gases — carbon dioxide (CO₂), methane (CH₄), and nitrous oxide (N₂O) — will be measured against a base year of 1990. Cuts in three long-lived industrial gases — hydrofluorocarbons (HFCs), perfluorocarbons (PFCs), and sulphur hexafluoride (SF₆) — will be measured against either a 1990 or 1995 base year.

The Protocol encourages governments to pursue emissions reductions by improving energy efficiency, reforming the energy and transportation sectors, protecting forests and other carbon "sinks", promoting renewable forms of energy, phasing out inappropriate fiscal measures and market imperfections, and limiting methane emissions from waste management and energy systems.

Press release
Climate Change Convention Secretariat, December 11, 1997

Developed countries that cannot meet their own emissions targets can strike deals with other developed countries that do better than required, to buy the excess "quota" — a concept known as emissions trading. This may encourage reductions to be made where most cost-effective...

The European Union agreed to reduce their emissions by 8 percent below 1990 levels; the United States signed on to a 7 per cent reduction; and Japan agreed to a six per cent reduction. Some countries, including Russia and Ukraine, are not bound to make any reductions while countries with smaller economies such as Iceland, Norway and New Zealand are allowed to actually increase their emissions. Australia was also allowed to increase greenhouse gas emissions. Countries undergoing the process of transition to a market economy but that are also classified along with the EU, Japan and the United States as Annex I parties to the Convention — including the Czech Republic, Hungary and Poland, among others — face smaller reductions.

Developing countries — including China and India — have no formal binding targets, but have the option to set voluntary reduction targets.

Disagreements continue over the obligations among developing countries in an emissions trading regime as well as the details of emissions trading between developed and developing countries.

The Day After in Kyoto: Agreements and Next Steps,
by Matt Pitcher, Feature
www.weathervane.rff.org/features

THE CHALLENGE FOR CANADA IN MEETING THE EMISSIONS TARGET

Canada is very unlikely to achieve the 2010 stabilization target in the absence of additional policy measures.

The above conclusion appears to hold even if more optimistic assumptions from an emission perspective — lower economic growth, high oil prices — are employed...

Of particular note is the transportation sector, a major and growing source of emissions. There may be considerable potential [for emissions reduction] in this sector, but it is very difficult to access by policy means. A somewhat similar conclusion applies to the industrial sector. Electricity generation may provide considerable opportunities but they are not achievable in the short term, and alone cannot get Canada to its Kyoto target.

... The combined effects of population and economic growth, coupled with low energy prices, produce an inexorable growth in emissions. Without significant and widely adopted technological breakthroughs, even achievement of long-term emissions stabilization will require major structural and life-style changes.

Canada's Energy Outlook, 1996-2020,
Natural Resources Canada, 1997

MEETING THE CHALLENGE THROUGH ENERGY EFFICIENCY

Canadian Government Policies

Canada has world-class capabilities in energy S&T (science and technology) focusing on energy efficiency and alternative energy technologies. Nevertheless, Canada needs to renew, strengthen and expand its commitment to use energy resources wisely and sustainably. Canadians must understand how much they have accomplished in improving their use of energy, but they also need to know that much more can be achieved without detriment to the services they receive or the country's economic development.

All Canadians need to make changes in the way they generate and use energy, how they move people and goods, how they heat their homes, and how they produce goods. With this in mind, climate change efforts of the federal Department of Natural Resource's (NRCan) are aimed at moving the market toward improved energy efficiency, developing alternative energy markets and focusing research and development resources on providing technology solutions to this global challenge.

NRCan encourages and facilitates energy efficiency and the use of alternative energy sources in all sectors of the economy and all regions of the country. Toward this end, since 1991 the Department has delivered a comprehensive Efficiency and Alternative Energy (EAE) Program that encompasses more than 40 initiatives aimed at all end-use sectors (residential, commercial, industrial and transportation). These initiatives are producing meaningful results that will benefit our economy, environment and society for years to come.

Under the federal Energy Efficiency Act, NRCan now prescribes minimum energy performance standards for 22 products, including appliances. Thirteen industrial task forces have committed to energy-efficient improvement targets. In addition, organizations that account for more than 50 per cent of all GHG emissions in Canada have now registered with the Climate Change Voluntary Challenge and Registry (VCR Inc.). NRCan is partnered with over 100 Canadian companies to develop technologies that provide climate change solutions and respond to marketplace needs. NRCan has a package of incentives for commercial buildings, homes and renewable fuels, and has established the Office of Energy Efficiency (OEE) as a readily accessible clearinghouse for information on energy efficiency.

NRCan's energy efficiency strategies include:

- leadership, to increase energy efficiency and the use of alternative energy in federal operations;
- information programs, to advise energy users about energy efficiency opportunities and how to benefit from them;

continued overleaf

- voluntary programs, through which major energy users commit to set energy efficiency targets, as well as action plans to realize them; and
- regulations, to eliminate the less energy-efficient products from the marketplace;
- fiscal incentives for energy efficiency in commercial buildings and for heating and cooling from renewable energy sources;
- new energy performance labelling programs for houses and motor vehicles; and
- the creation of the Office of Energy Efficiency (OEE).

The OEE is a centre of excellence, coordination and facilitation for energy efficiency in Canada. Bringing NRCan's market transformation energy efficiency initiatives under the umbrella of the OEE will raise the profile of energy efficiency in Canada, increase program recognition and garner wider industry participation.

Under the direction of the Minister of Natural Resources, the OEE identifies opportunities for new and expanded energy efficiency measures and informs key decision-makers in government, industry and the environmental and international communities about Canada's energy efficiency efforts and successes. Steady improvements in the Department's ability to collect and analyze energy use statistics will give the OEE a solid foundation of data and information.

The OEE also makes NRCan's extensive knowledge about energy efficiency widely available to Canadians and others through its Home Page on the World Wide Web. This recently launched web site (<http://oe.e.nrcan.gc.ca>) is a storehouse of reliable, practical and up-to-date energy efficiency information, tips and data for all end-use sectors... The site is divided into four categories:

- energy efficiency for you and your family;
- energy efficiency for businesses, institutions and government;
- energy efficiency regulations; and
- statistics.

ENERGY EFFICIENCY

Some Examples from the United States

In a 1976 article in *Foreign Affairs*, the physicist, Amory Lovins, said that conservation would reduce energy needs so spectacularly that not only would oil not run out, but energy prices *would decline*... Today, Lovins' forecast seems, if anything, timid. Conservation has happened faster than he predicted: total United States energy use per constant dollar of GNP has declined 28 per cent since 1976. The energy-intensity of American heavy industry has declined 50 per cent since 1978... In 1994 gasoline was selling for less in real-dollar terms than in 1940. When Lovins wrote his article, 3.2 per cent of the typical household budget went to energy. By 1993, the figure was down to 2.6 per cent and still falling. In 1972 the average car consumed 785 gallons (3 569 litres) of gasoline per year. By 1988, the average consumption was down to 507 gallons (2305 litres), ...

Today, Lovins predicts new energy savings in some ways more out-landish than those he foresaw in 1976, because the energy efficiency trends that began with gasoline are now catching up with electricity. Growth in demand for electricity, running at three to four per cent annually in the 1970s, has slowed to two per cent or less, with declines experienced in some parts of the country. Lovins thinks the United States could support its industrial base and lifestyle using just 30 per cent of its current electric-generating capacity, with the conservation investment required available at a long-term cost of one cent a kilowatt-hour, far less than the typical price of six cents for new generating capacity...

Lovins proposes not sacrifice but technical advances and market efficiency... consider this example from Duke Power, a North Carolina utility. In 1974, the typical Duke residential customer had a 1 000-square-foot [92-square-metre] dwelling with no air conditioner, no color television, and no frost-free refrigerator. By 1992, the typical Duke Power customer had 1 250 square-feet [115-square-metre] of air-conditioned space, two color televisions, and a frost-free fridge — yet was using slightly less electricity than in 1974...

The Electric Power Research Institute (EPRI), the think tank of the utility industry ... projects the American lifestyles and production could be supported with about 70 per cent of current power use. At EPRI's conservation level, something like half of all coal-fired power stations could be closed down. Much of the savings would be realized by a new utility philosophy with the cumbersome name, "demand side management".

A Moment on the Earth, The Coming of Age of Environmental Optimism,
by Gregg Easterbrook,
Viking Press, 1995

MEETING THE CHALLENGE THROUGH COMMUNITY ENERGY PLANNING

NRCan's (Natural Resources Canada) Community Energy Systems Program helps Canadian communities become more energy-efficient by exploring an integrated approach to community-based energy planning. Technology options include district heating and cooling, the combined production of heat and power, industrial waste heat recovery and thermal storage. NRCan works with Canadian industry, energy utilities, researchers, engineers and other levels of government to develop and transfer technologies and to stimulate interest in their implementation. It also evaluates opportunities for community energy systems and provides financial and technical support for their implementation.

Today, in addition to more than 100 institutional systems, there are at least ten community district energy systems operating successfully across Canada, including one of North America's largest, in downtown Toronto. Many of these community systems were developed with support and advice from NRCan.

NRCan is working with Aboriginal communities, municipalities, utilities, urban planners and others to explore the potential from community energy planning. For example:

a study of district energy opportunities in Ottawa has shown that the potential exists for district heating and cooling in several sectors of the city. NRCan is currently discussing implementation strategies with city officials;

NRCan completed a feasibility study that has led to a district energy project in Windsor, Ontario. Phase 1 of the project involves locating a combined heating and cooling plant at Windsor's new casino. The system will serve the casino and nearby buildings and, when fully installed, will reduce CO₂ emissions by an estimated 40 000 tonnes per year.

NRCan will continue to explore ways to reduce community energy consumption that maximize the use of waste heat and renewable energy resources. As well, it will take steps to address one of the main barriers to district energy in Canada — a lack of information. Although district energy has been used extensively in Europe for several years, it is still a relatively new approach in Canada. NRCan will work to remedy this situation through a number of activities, including seminars and the coordination of technology missions to other countries.

MEETING THE CHALLENGE THROUGH RENEWABLE ENERGY

By the middle of the next century, renewable energy sources could meet half the world's energy needs.

All signs indicate that renewable energy sources are destined to be developed in the future. First, there is the imperative need to reduce greenhouse gases, and second, there is probably also a new industry to nurture. For these reasons, numerous initiatives have been undertaken by the industry and some governments.

For example, in the United States, a proposed energy bill will require that 5.5% of the energy produced by all local energy distributors must come from renewable sources. Renewable energy sources include wind, solar, biomass, and geothermal energy. Hydroelectricity is not considered a renewable energy source (because of the limited number of rivers) and is not on the list.

This measure will probably be introduced in the form of exchangeable permits: a distributor with more the 5.5% renewable energy sources in his portfolio could sell the extra to a distributor who has less. "This means that the US will have to double its use of renewable energy between now and 2010,": says Philippe Dunsky, director of the Centre Hélios, an energy advisory board.

In the summer of 1997, the American government also announced that it was considering converting 500 000 federal buildings to solar energy by 2010.

England has also announced its intention to reduce its dependence on petroleum and coal by replacing these kinds of fuel with "green" energy sources. The Non-Fossil Fuel Obligation program is planning the construction of seven thermal centres fed by biomass.

Another significant initiative is that of Shell International which created a subsidiary in the fall of 1997 to develop renewable energy sources (specifically biomass and solar energy). Shell International Renewable (SIR) will have a start-up budget of \$500 million. Shell firmly believes in the future of these energy sources which, it says, could meet half of the world's energy requirements by the middle of the next century...

THE OUTLOOK FOR RENEWABLE ENERGY IN CANADA

Renewable resources have long been an important source of energy in Canada. Wood has been used for centuries for space heating and cooking, and water and wind have been harnessed to general mechanical power. Currently, renewable energy sources account for 18 per cent of Canada's primary energy supply, an impressive share compared with other nations.

Large-scale hydroelectricity constitutes the bulk of the renewable energy supply. Canada is blessed with abundant water resources that have provided many opportunities to produce low-cost electricity. Thanks to a number of large projects developed over the past few decades, Canada now obtains more than 60 per cent of its electricity from hydroelectric sources. Due in part to these developments, Canada's electric power industry generally depends less on fossil fuels, and therefore produces fewer greenhouse gas emissions, than the electricity sectors in most other industrialized nations...

Renewable energy can also be produced from the ocean, by capturing water during high tide and releasing it through hydroelectric turbines as the tide recedes. Canada is home to one of the only a few tidal power demonstration plants in the world.

In total, hydroelectric sources make up about 11 per cent of Canada's primary energy supply. Most of the remaining renewable energy supply comes from bio-energy, which is produced by burning biomass (mostly plant materials and waste) or converting it into gaseous or liquid fuels. There is still excellent potential for increasing the use of bio-energy because of Canada's enormous forest resources and large agricultural sector. Currently, the forest products and pulp and paper industries produce most of Canada's bio-energy. Through combustion of their waste materials, these industries produce steam and electricity to meet their own energy needs or to sell to others. To a lesser extent, bio-energy is produced from wood burned for residential heating. More than six per cent of Canadian single family homes use wood for primary heating and another 13 per cent use wood to complement their heating systems.

CANADA'S GROWING RENEWABLE ENERGY INDUSTRY

Canada's alternative and renewable energy industry comprises about 200 companies and employs up to 4 000 people. The industry produces one billion dollars worth of goods and services annually, of which \$200 million worth is exported.

NRCan is committed to promoting a strong and viable renewable energy industry in Canada. Toward this end, the department's *Renewable Energy Strategy — Creating New Momentum* provides for steps to develop alternative, environmentally friendly technologies and to create a new momentum in the marketplace to welcome these technologies. It aims to improve the environmental performance of the energy sector and to enhance the sustainability of Canada's energy mix while bringing energy security and economic benefits to Canadians...

The enhancement of renewable energy technologies has been the backbone of NRCan's renewable energy efforts since the mid-1970s. Although significant technology advancements have been achieved, Canada's renewable energy resources continue to offer significant untapped energy potential.

Through the Renewable Energy Technologies Program, NRCan works in partnership with industry to develop technologies in such areas as bio-energy, small-scale hydroelectricity, active solar, photovoltaics (solar electric) and wind energy. Activities are directed at improving the reliability and lowering the costs of renewable energy technologies, testing new technologies and equipment, showcasing technologies before their commercialization, supporting feasibility studies, disseminating technical information, and developing national performance and safety standards. Most of NRCan's research and development (R&D) resources are used to fund activities performed by the private sector on a cost-shared basis. As well, NRCan performs R&D in its own laboratories when the required facilities or technical expertise are not readily available elsewhere.

One area of particular focus for NRCan is the energy challenge facing remote communities, many of which rely on high-cost diesel fuel to generate electricity. These diesel systems could be supplemented or replace with wind energy, small-scale hydro, photovoltaic (PV) or biomass-fired cogeneration systems at an equal or lower cost. As part of NRCan's PV for the North Program, a new state-of-the-art hybrid power-generating system, comprising PV, wind and diesel power, was completed at the Aurora Research Institute in Inuvik, NorthWest Territories. The installation will serve as a demonstration and training system and will assist the Canadian PV industry in becoming leaders in cold climate applications. Other benefits include increasing the market penetration of PV technologies and reducing the consumption of fossil fuels in the NWT.

Biomass combustion is another area of R&D focus for NRCan. Improved combustion systems have the potential to double the use of biomass as a sustainable energy source. Technologies being developed include using artificial intelligence to control large-scale biomass boilers in the pulp and paper industry, modeling and optimizing biomass furnaces, developing novel condensing

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systems to improve industrial biomass efficiencies by more than 20 per cent, determining effective uses for biomass ash and developing an advanced combustion integrated wood fireplace.

In support of active solar technology, NRCan provided assistance to Conseval Engineering Inc. to develop and commercialize the Solarwall™, a solar-powered system for preheating ventilation air that has demonstrated an average solar energy collection efficiency of more than 70 per cent. Funding from the Department helped the company obtain orders for new installations in Canada, the United States, Germany, Italy and southeast Asia. The world's largest Solarwall™ installation has been completed at Bombardier's Canadair plant in St-Laurent, Québec.

For more than 20 years, NRCan has supported R&D for technology to produce ethanol from cellulose (vegetable fibres). Togen Corporation, a long time NRCan R&D partner, announced in August 1997 that it will build Canada's first cellulose-to-ethanol plant in Ottawa. The demonstration represents a major development in the commercialization of the technology, which converts feedstocks such as wood chips, straw and grass to ethanol for use as a gasoline fuel additive. Enough wood waste is generated in the Prince George, BC, areas alone to produce an estimate 100 million litres of ethanol per year — nearly five times Canada's current ethanol production from grain.

An Agenda to Address Climate Change,
Natural Resources Canada, 1998

SOLAR ENERGY IN CANADA

The solar panel market could reach \$2.5 billion of business in ten years in the United States alone. It is currently at \$100 million. In Canada, the market is estimated at \$25 million, and is growing at a rate of 15% per year.

The sun's potential is also explosive in other parts of the world. In Third World countries, solar energy could be used for heating water and to efficiently replace wood, coal and kerosene for cooking food. Researchers at the Brace Institute at McGill University have already come up with the solar oven with this in mind. They are now working on a portable solar water heater that can be transported in a car. This product will be targeted at campers and owners of remote summer cottages.

In the industrialized world, solar energy is mostly used to reduce the heating costs of houses. But a plethora of other uses appear, such as heating water at fish farms, drying hay, fueling remote telecommunications stations, etc..

In Canada the main user of solar panels is the Coast Guard. Some seven thousand buoys, beacons, and lights are fed by solar power. But the development of solar energy in Canada is still in its infancy; power generated is only three Megawatts (MW). In comparison, the total power generated in Québec is around 38 000 MW). Québec uses only a small part of the three MW of solar power. "One of the reasons for that is the refusal of Hydro-Québec to absorb the surplus energy produce by its solar panels into its network," maintains Benôit Perron, president of Énergie solaire Québec...

For now, the greatest potential for solar power in Canada seems to be in the communities of the far North (for example, in the NorthWest Territories). In the NWT, three fifths of the electricity comes from diesel generators. It is very expensive ... and the cost of transporting the fuel is also very high. In this context, solar energy represents an interesting economical and environmental alternative. It would decrease the emission of greenhouse gases in a fragile region, and reduce the pollution created by disposing of fuel barrels...

In agriculture, the electricity produced by solar cells can be used, among other things, for drying hay and pumping water. In Saskatchewan, Sask Power subsidizes the purchase of solar panels for pumping water on farms. In Alberta, successful experiments have been conducted using solar panels to dry hay. The system is efficient and reduces the costs of drying 3 000 tonnes of more each year by 40% compared to a natural gas drying system.

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Similar results were recorded at a fish farms in British Columbia. The cost of heating the water was reduced by one quarter.

Faced with all this success, the Canadian government has decided to become more involved in the promotion of solar energy. For example, as of April 1, 1998, Natural Resources Canada's REDI (Renewable Energy Deployment Initiative) program will subsidize the installation of solar energy (solar water- and house-heating systems) and biomass systems...

Solar Energy Applies to Everyone,
by Stéphane Gagné
Le Devoir, May 2-3, 1998

WINDPOWER

The World's Fastest Growing Energy Source

Latest reports indicate that wind energy is currently experiencing an annual growth rate of 25%.

The field of wind energy, which experienced a tremendous expansion during the 1980s, appears to be on the verge of its Big Bang, ...

Québec ... could generate 35 000 Megawatts (MW), according to the Canadian Wind Energy Association; that is, between 50% and 80% of the most profitable wind-energy potential in Canada...

In 1971, according to research by the Centre Hélios for the (Québec) Parliamentary Commission on the Economy and Employment (1997), wind use for energy production totaled 19 MW in the world, while 6 000 MW of wind-energy was produced last year. The prediction is for 20 000 MW by 2005, which is when the real boom will be.

When we speak of wind turbines, we are no longer referring to little windmills placed on top of metal pylons. We are now talking about elegant closed towers, more than 50 metres tall, with blades that now reach 55 metres in diameter, attached to 750 kV machines.

The past few years have been marked by spectacular progress: the weight of the blades has dropped from three kilogram per square metre to one kilogram with the use of synthetic fibres developed by the military... The reliability of the current has increased from 20% in the early '80s to 99.8% in 1997.

Turning Toward Wind Energy,
by Louis-Gilles Francoeur,
Le Devoir, May 2-3, 1998

WIND POWER

Becoming a Reality in Alberta

The powerful chinook winds of Pincher Creek [Alberta] will bow in a national first for Calgary: the choice to flick on a light switch with “green power”. Those opting for windmill or biomass-generated power will face an approximate \$5 a month — or three cents a kilowatt — increase in their electricity tab.

The first customer in this novel, market-driven plan to give consumer’s cleaner energy choices is the federal government. [In 1998] Environment Minister Christine Stewart announced her Department’s building would pay a premium price to buy wind generated power from the city’s new energy utility, Enmax. Other departments have similar “green power” deals in the works...

Enmax’s lead to provide green power has clearly cheered environmentalists. Notes Rob Macintosh, policy director of the Pembina Institute, Alberta’s energy watchdog, “it is the beginning of an extremely important shift in how government and corporations encourage communities to use clean energy technology”...

The premium attached to green power buys consumers an additional and potentially tradable commodity known as an “emissions reductions credit”, a kind of certificate for offsetting worrisome CO₂ emissions. Various governments around the world will soon limit this greenhouse gas in one form or another. One clean kilowatt of wind power, for example, cancels out one kilogram of CO₂. But it takes an open market to do this. Until Alberta deregulated its electrical market in 1996, green power from wind producers or biomass plants (the burning of wood chips to generate power) couldn’t compete freely with coal-fired electrons in the power grid...

More than 40 countries have national policies to harness the wind, including tiny Denmark which supplies seven per cent of its energy needs from windmills. Even coal-rich Australia has given customers the option to buy green power.

Federal Government First in Line for Calgary’s Wind Power,
by Andrew Nikiforuk,
The Calgary Herald, 1998

CANADA'S FUEL CELL TECHNOLOGY:

The Dawn of the Hydrogen Age?

Cars that go 5,000 miles between fill-ups, electric power plants you buy like appliances, and a better standard of living... Automobile and power companies are spending billions to make it real.

I'm at the headquarters of Ballard Power Systems in Burnaby, a suburb of Vancouver, and my big fuel cell moment is about to occur. Following the example of the premier of British Columbia, the mayor of Chicago, and the chair of the Los Angeles Metropolitan Transit Authority, I am going to drink the exhaust from Ballard's prototype fuel cell municipal bus. This is less foolhardy than it sounds, since the only emission from the fuel cell engine is water. For this reason, many people think that fuel cells can change the world.

At Ballard, the exhaust-drinking routine has grown so tiresome that when I ask for a sip, Paul Lancaster, Ballard's treasurer, doesn't even offer me a glass: he suggests I cup my hands under the bus's exhaust pipe. The pipe points straight down, presumably because its effluence is not a noxious gas that must be spewed into the atmosphere in hopes that it will dissipate. I bend over, and, within a few seconds, I collect several teaspoons of warm, clear liquid. As I begin to drink, I try to imagine a mountain stream, but the water is disappointingly bland. "Like distilled water," Lancaster explains, and I realize that what I'm drinking is, in a sense, exactly that - the pure product of the union of hydrogen, the element that powers fuel cells, and oxygen in the engine.

... After decades of unfulfilled promise, fuel cell momentum is now so great that its emergence as a predominant technology appears just short of inevitable. During the early 1990s, nearly every major car manufacturer in the world launched a program to build a fuel cell automobile. Then, in April, a stunning announcement by Daimler-Benz AG suddenly gave the fuel cell age a timetable. Mercedes-Benz's parent company said it was investing US\$145 million to buy a one-quarter interest in Ballard, the world's leader in fuel cell technology, and \$150 million toward a joint venture with Ballard to create a new vehicle fuel cell engine company. Daimler-Benz also announced that beginning in 2005, the new company would produce 100,000 fuel cell engines annually. This is a remarkable figure, considering that the company, the world's 15th-largest auto manufacturer, makes only 700,000 cars a year now...

Though Daimler's fuel cell car will be powered by methanol, a hydrogen-rich derivative of natural gas, it is widely assumed that the use of fossil fuels to power fuel cells will be transitional, leading to an era in which hydrogen is extracted from sustainable energy sources. It is hard to overstate the implications of such a development: A drastic decline in air pollution, oil spills, acid rain, and greenhouse-gas emissions. An epochal geopolitical shift as global reliance on Middle East oil comes to an end and international trade balances are realigned. The emergence of quiet, decentralized electric plants sized according to need - small enough to power your car (and perhaps, at night, your house); big enough to power a town of 15,000 people, or, in tandem, a city. The disappearance of the electric grid is a possibility; a make-over of the electric-utility

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industry is nearly certain. It is likely to take 50 to 100 years to achieve a mature "hydrogen economy," but the impact of fuel cells should be felt long before that. Over the next decade, products are likely to emerge on the market that are both more efficient and more environmentally benign than their predecessors.

The century-long reign of internal-combustion engines will almost certainly be challenged by fuel cell-powered cars and buses that are quiet and clean, and use energy far more efficiently than today's vehicles. Naval forces in several countries are looking into fuel cells to run submarines and provide auxiliary power on oceangoing vessels; the US Army is building a backpack-sized fuel cell generator that can power a soldier's electronics gear, from night-vision goggles to infrared heat detectors. Fuel cell-driven desalination plants may offer clean water cheaply, defusing a potentially critical 21st-century resource shortage. Within a few years, fuel cells will probably power professional video cameras and many other products that now use batteries. Your laptop may eventually run on a fuel cell whose range is measured in days, not hours.

Dawn of the Hydrogen Age,

By Jacques Leslie¹

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Post Scriptum:

Dr. Geoffrey Ballard, founder of Burnaby-based Ballard Power Systems, and the man behind the world's first fuel-cell-powered bus, is one of five people names "Heroes for the Planet" in the February 22 [1999] edition of Time magazine. Ballard says although his work showed the way to energy self-sufficiency, the fuel-cell car is just the beginning of what needs to be done to help the environment.

Vancouver Sun, February 13, 1999

¹ Jacques Leslie is the author of *The Mark: A War Correspondent's Memoir of Vietnam and Cambodia*. This is his eighth piece for Wired.

PATHS TO THE FUTURE?

The road ahead will not be without obstacles and detours. The investments required for achieving a sustainable energy system are sizable, the economic forces to be overcome well organized, and the challenges to human ingenuity enormous. Still, when economic historians look back on the mid-nineties, they may well decide that the world had already embarked on a major energy transition by then — just as, with hindsight, we can say the same about the 1890s. Today, as then, economic, environmental, and social pressures have made the old system unsustainable and obsolete, and the process of change is quietly gaining momentum.

Slowly, people and governments are rising to one of the most fundamental challenges humanity has ever faced: passing on to our children a natural environment that has not been substantially degraded...

A new generation of private entrepreneurs, grassroots activists, and policy innovators is already laying the groundwork for an energy transition. Just who will emerge as the Thomas Edison or Henry Ford of the coming energy revolution is unclear, but they are almost certainly out there today — inventing new electric vehicles, assisting villagers to install solar lighting systems, and fighting before regulatory commissions to reform the utility industry.

After two decades of mainly uphill battles, the forces of change may finally be gaining ground in the effort to forge a more sustainable energy system. If a persuasive vision of that energy system comes into focus soon, the transition is likely to accelerate — solving energy problems that have plagued humanity for decades, and creating a host of new economic opportunities.

Power Surge: The Guide to the Coming Energy Revolution,
by Christopher Flavin and Nicholas Lenssen,
The Worldwatch Environmental Alert Series,
W.W. Norton, 1996