The Energy Context

number 5 of a series of papers on energy and the offshore

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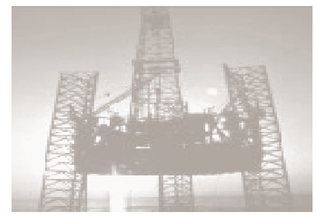
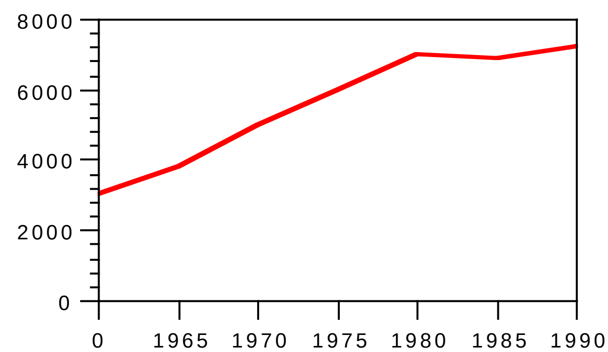
Energy and Society



Everything depends on energy; the physicist James Clerk Maxwell called it “the go of things”. Energy fosters our human activity; it cooks our food, fuels our travels, heats and cools our buildings, and powers our industries.

When our species first appeared on the earth many millions of years ago, we were like any other warm-blooded animal; the only energy we used was the calorie content of the food we ate. But somewhere around half a million years ago, we learned slowly how to use and control fire.

Canadian Demand for Energy (petajoules) 1960 - 1990



And as we first cut forests for wood and charcoal, then later mined for coal, drilled for oil, burned fossil fuels, and built nuclear reactors, the earth’s environment began to change, slowly at first, and then exponentially fast. It is our lust for the things energy provides, beginning with the warmth of those first Paleolithic hearths, that has reshaped the surface of the planet and dictated how our species has developed.

Most of our energy comes originally from three main sources: the warmth of the sun; the gravity-fed power of moving water; and the sudden burst released when the atoms of radioactive elements split apart.

Early humans only used as much energy as they ate. Times have changed.

Nova Scotia is one of the few places to use tidal power – its energy comes from the pull and push of the earth, sun and moon. Equally unusual are geothermal sources under the ground, like those of Springhill. Heat conducts to the planet’s surface, or is drawn up by volcanoes and hot springs.

We use energy sources directly, such as burning wood or oil to heat our homes; or indirectly, by changing them from one form to another, like using water power to spin a turbine to make electricity.

Energy from burning fuels supplies the vast majority of the world’s needs. Since the Industrial Revolution 150 years ago, we have become critically depend-ent on burning the fossil

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RENEWABLES AND NON-RENEWABLES

Energy sources are renewable, or non-renewable. A non-renewable source is one that we could use up – fossil fuels like hydrocarbons and coal, and nuclear ores.

Renewable sources do not rely on such limited fuels. Much of our renewable energy comes from the sun. Direct sunlight is used both as "active" solar – e.g., rooftop water heaters – and as "passive" solar – buildings designed to absorb and hold the sun's warmth.

Another way we use the sun's energy is by burning "biomass"; we use as fuels anything that grows and stores solar energy, such as wood and agricultural wastes, and, at one more remove, animal dung.

Other renewables are primarily sources for generating electricity – falling water (hydroelectricity); wind; and tidal power, like at Annapolis Royal, Nova Scotia. Geothermal energy is used in Springhill, Nova Scotia, and extensively in Iceland.

Hydrogen is a potentially unlimited new fuel which may appear in the next fifty years, if we can figure out how to produce it cheaply from the renewable sources of sun and water.

Energy and Society (from page 1)

fuels – in particular, coal, crude oil and its many derivatives, and natural gas. And, we use more and more every year, with potentially devastating consequences to our planet's climate.

And yet, we have built societies that are entirely dependent on cheap, abundant energy inputs – from cooking food to keeping us from freezing in the dark, to linking to the Internet, to making all our goods – everything depends on energy.

This paper reviews some key concepts in energy policy; its focus on fossil fuels, particularly hydrocarbons, reflects public interest in potential oil and gas development on Nova Scotia's offshore. A companion paper, **How We Use Energy,** reviews Canadian and Nova Scotian energy consumption patterns.

SCENARIOS AND FORECASTS

Scenarios are possible pathways into the future – they are anchored in present reality, and build internally consistent projections of likely events.

Effective scenarios reflect different ways of seeing the world, not just "high and low" forecasts. Such scenarios serve two purposes: anticipating and understanding risk, and finding new strategic options.

By presenting other ways of seeing the world, scenarios offer decision makers perspectives invisible within a single world view.

The scenarios that organizations such as the World Energy Council (WEC) use to make energy forecasts are based on assumptions about population growth, economic growth, and improvements in energy efficiency.

Small differences in these assumptions can make large differences in both regional and global projections. For example, the WEC's "high growth" scenario projects world energy demand to increase 98% from 1990 to 2020. Their "ecologically driven"

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HOW WE MEASURE ENERGY

Fuel is measured by volume (at particular temperatures and pressures) or weight. The energy *content* of a fuel is measured in joules in the metric system, and British Thermal Units (Btus) in the imperial system, still in use in the United States. The requirement for electricity is measured in kilowatts; the flow of electricity usage is measured in kilowatts/hour (kWh) and amperage.

A joule is defined as the work done by a force of one newton moving over a distance of one metre. One joule equals one watt-second, and 3600 joules = one watt-hour. Because the joule is tiny, it is normally used as a multiple. A kilojoule (kJ) is 10^3 joule; a megajoule (MJ) is 10^6 joules ; a gigajoule (GJ), 10^9; a terajoule (TJ) is 10^{12}, a petajoule (PJ), 10^{15}, and an exajoule (EJ), 10^{18}. One petajoule is approximately equal to .95 billion cubic feet of natural gas, or 26,190 cubic metres of oil, or .28 terawatt hours of electricity.

A Btu is the heat required to raise the temperature of 1 lb of water at 60ºF through 1ºF. One kilojoule equals .95 Btu.

Fuel	Metric unit	Imperial equivalent	Gross Energy Content (averaged, approximate)
oil	1 cubic metre	6.3 barrels	39 gigajoules
natural gas	1 cubic metre	35.3 cubic feet	39 megajoules
coal	1 tonne (1 cubic metre)	1.1 short tons	22 gigajoules

time to an increasing reliance on the service sector. What has this to do with energy demands?

It means that in the developed world, demand for cheap electricity has outstripped that for inexpensive bulk fuels, especially coal. Rust belts have replaced “King Coal” in many mill towns, and coal is now primarily in demand for producing electricity.

Today, energy inputs rarely affect competitiveness; for example, you can count the individual plants in Nova Scotia for which energy costs make a dramatic difference almost on the fingers of one hand, like cement or pulp and paper. Demand is driven now by consumers of electricity, rather than of bulk fuels.

HOW MUCH ENERGY DOES THE WORLD USE?

The world is using more and more energy every year, growing at an average annual rate of 2.5% since 1970. In 1970, the world's primary energy consumption totalled 190 exajoules annually; by 1993, it had almost doubled, to 378 EJ per year.

People living in the developed world use more than nine times more energy per capita than people in other nations.

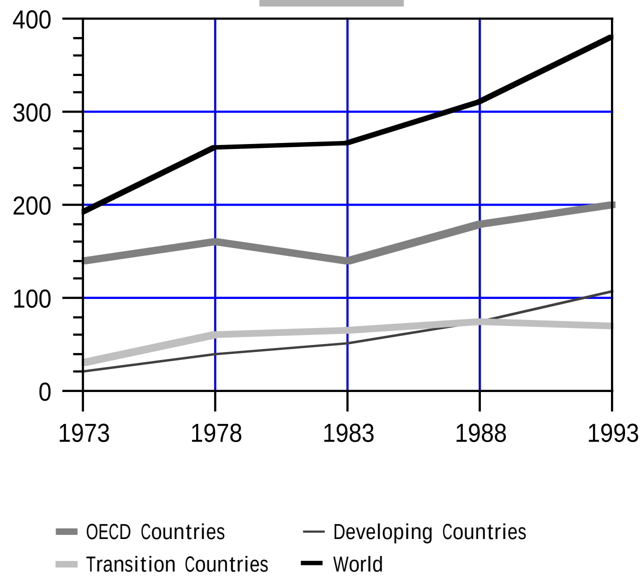
The world's energy use should continue to grow rapidly in the next 2 decades, according to forecasts from WEC and the International Institute for Applied Systems Analysis (IIASA).

Both organizations expect consumption could reach at least 496 EJ to a high of 646 EJ by 2020, and from 596 to 1,042 EJ by 2050, depending on a host of other factors.

Changes in the world's commercial energy supply – energy produced for sale, as opposed to non-commercial, such as a family's burning wood gathered by household members, for example – are similar. Overall, forty per cent more commercial energy was produced in 1993 than in 1973.

The standard of living we in the industrialized world enjoy comes, by and large, from our access to energy. People living in the developed world use far more than in other nations, more than nine times more per capita.

Total Energy Consumption (exajoules)
1973 - 1993



In 1993, over half of the world's energy was used in countries belonging to the OECD (above, and right). In concrete per capita terms, someone from the United States uses seventy times as much energy as a Bangladeshi, and 300 times as much as someone from the African nation of Mali.

Canadians, per capita, use even more energy than Americans; in fact, Canadians consume about ***five*** times more energy per person than the global average, and more than any other G7 country (left). Canada's harsh climate, rapid population growth, vast geography and natural resource-based economy have made us more dependent on energy than most nations.

Despite their heavy per capita consumption of energy, most OECD countries are heavily dependent on imports of energy supplies to fuel their economies, as together they produce only slightly more

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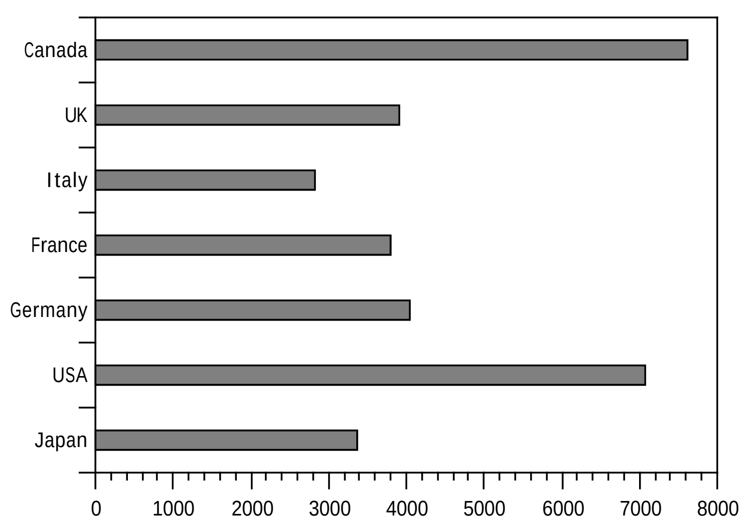
Primary Energy Consumption
(thousand metric tonnes of oil equivalent)



World Energy Consumption, 1993

than 1/3 of the world's supply.

Developing countries' energy use has grown quickly since 1970, but they started from a much smaller base, and are generally in hot climates without much need for space heating. Although their consumption almost tripled since 1970, they still accounted for less than a third of global energy use in 1993 – even though they contain the majority of the world's population.

Rapid population growth in the developing world, however, has kept per capita use very low compared to the developed world. By 2020, though, developing counties should use almost half of the world's energy, and almost two-thirds by 2050.

ENERGY AND ENVIRONMENT – A DIRTY BUSINESS

All forms of primary energy come with their own environmental effects and economic/engineering constraints, even the renewable sources, which are often perceived as environmentally benign.

All fossil fuels, when burned, emit pollutants and greenhouse gases. Of them, coal is a particularly "dirty" fuel, emitting pollutants like particulates and sulphur dioxide, as well as relatively large amounts of the greenhouse gas carbon dioxide for the amount of energy it produces. However, it is abundant and relatively cheap, and is still relied on today for steel-making and thermal electricity generation.

Producing energy from uranium is complex, costly, and carries potentially devastating impacts on human health and the environment.

Hydroelectricity has been perceived as clean and often cheap, but centralized sources can be vulnerable to disruption – like this past winter's ice storm. As well, building dams and generating stations drowns land and destroys river habitats, and can release mercury from sediments and methane, a greenhouse gas, from submerged plants.

Biomass sources are in limited supply, but can be cheap and reduce landfill burdens, and are neutral in terms of carbon dioxide impacts; they only emit as much CO_2 when burned as they had recently absorbed from the air, and assuming other plants are grown to replace them, the net effect is zero.

The full cycle costs of seemingly benign wind and solar power must include their manufacture and construction impacts. Wind installations do not emit gases, but can kill migratory birds in large numbers, are often unsightly, and may interfere with local habitat use by other species.

Solar systems also have ecological costs – large scale solar arrays can damage terrestrial habitats, and the plastics and chemicals which go into high tech solar power generators and storage facilities have their own environmental burdens.

Finding out about energy

Energy production and consumption data are available in extravagant detail. Why? Energy is crucial to our society, the fossil fuel trade is economically important, and small changes in energy pricing have large financial impacts.

Two of the most reliable annual international publications are the *Energy Statistics Yearbook*, published by the United Nations Statistical Office (UNSO); and the *BP Statistical Review of World Energy*, by British Petroleum.

The World Energy Council's triennial *Survey of World Energy Resources* contains far more information on reserves, detailed production (e.g., by type of coal), and alternative energy sources than the Energy Statistics Yearbook.

The Energy Information Administration of the U.S. Department of Energy publishes the *International Energy Annual*; this contains only "English standard" measurement units and covers only the most important energy-producing and consuming countries.

UNSO and the International Energy Administration (IEA) also publish analyses of country energy balance sheets that describe consumption of energy by sectors.

The World Resources Institute, with the United Nations, publishes the annual *World Resources* surveying all planetary resource issues, not just energy.

In Canada, Natural Resources Canada and the National Energy Board publish reports and forecasts on both supply and consumption.

Industry-supported associations like the Petroleum Communication Foundation and the Canadian Electricity Association publish regular updates. Non-profit organizations like Energy Probe, Citizens for Renewable Energy and the Canadian Renewable Energy and Sustainable Energy Web Site are also useful sources.

In Nova Scotia, information is available from the Nova Scotia Department of Natural Resources, local affiliates of national organizations, Solar Nova Scotia, and Ecology Action Centre.

The easiest and cheapest way to contact any of these is via the Internet; URLs are listed at the end of this article. Regional Nova Scotian libraries provide public Internet access to their web sites. The main publications are available at least at one of the university libraries in Nova Scotia, or through inter-library loan.

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HOW LONG ARE THE WORLD'S RESERVES OF OIL, GAS AND COAL LIKELY TO LAST?

Official estimates of world energy reserves have grown over the past 20 years, despite how much more we use. For example, "proved" recoverable reserves of petroleum rose 60% between 1973 and 1993; natural gas rose more than 140%. The supply of natural gas should last at least 60 years, and that of coal for well over 200.

Conventional estimates assume 1,020 billion barrels of oil (Gbo) in proved reserves at the start of 1998. As we now produce some 23.6 GBo a year, the official estimates suggest that crude oil could remain cheap, and plentiful, for at least 43 more years. However, debate is currently raging over the amount of oil left to the world.

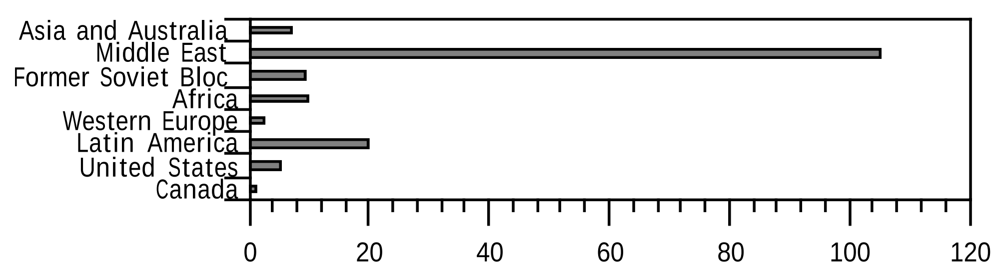
A recent (March, 1998) article in Scientific American has challenged the conventional wisdom. Its authors argue that estimates of reserves are distorted, that the underlying assumption that production will remain constant is false, and that, most importantly, the rate at which any of today's wells produces oil will inevitably fall over time, to a trickle – the last bucket cannot be pumped from the ground as quickly as it gushes today. They predict that production will peak between 2000 and 2010, while demand steadily grows. Radical increases in oil prices in the next ten or twelve years would result.

Current production capacity of petroleum is ample, and so oil prices are relatively low. No matter whose time projection is right, however, oil resources are finite, and production will inevitably begin to decline. The real size of reserves is unknown, partly because higher oil prices can stimulate further exploration and make it financially feasible to use currently marginal deposits, like tar sands. The higher the cost of energy, the more **economic** reserves exist.

As well, most of the world's hydrocarbon resources are heavily concentrated in a few countries, many of which are in politically unstable areas – severe shortages could result from events beyond our control.

No matter whose time projection is right, oil resources are finite, and production will inevitably begin to decline

World Oil: Proved reserves, end 1992 (in billion cubic metres)



HOW MUCH OF THE WORLD'S OIL AND GAS DOES CANADA SUPPLY?

Canada ranks 3rd in world natural gas production, accounting for about 7% of the total planetary supply, and is 11th in crude oil, supplying slightly over 2.5% of world production.

Alberta leads the other provinces, supplying about 82% of all Canadian hydrocarbons; Saskatchewan and British Columbia together produce another 16%. The rest is split between Nova Scotia (Cohasset-Panuke), Newfoundland and Labrador (Hibernia), Ontario, and the Northwest Territories.

In total, Canada produces 1.6 million barrels a day of conventional crude oil, pentanes, and condensate; Cohasset-Panuke averages about 20,000 barrels of light crude a day. Hibernia currently averages about 85,000 per day, which is expected to rise to 135,000 at full production.

Together, Cohasset-Panuke and Hibernia currently supply about .125% of world oil production – about the same relative amount as the film of water left in a glass after you drink it!

Finding out about energy
(cont'd from pg. 6)

BP Statistical Review of World Energy
http://www.bpamoco.com/worldenergy/

World Energy Council
http://www.wec.co.uk/collabor.htm

International Energy Agency
http://www.iea.org

Energy Information Administration
http://www.eia.doe.gov/

Natural Resources Canada: Energy Sector
http://www.nrcan.gc.ca/es/

National Energy Board
http://www.neb.gc.ca

Canadian Electricity Association
http://www.canelect.ca

Petroleum Communication Foundation
http://www.pcf.ab.ca/

Citizens for Renewable Energy
http://www.web.ca/~cfre/

Canadian Renewable Energy & Sustainable Energy Web Site
http://www.newenergy.org/

Energy Probe
http://www.nextcity.com/EnergyProbe

NS Department of Natural Resources
http://www.gov.ns.ca/natr/

Solar Nova Scotia
http://chebucto.ns.ca/Technology/SolarNS/

Ecology Action Centre
http://www.chebucto.ns.ca/Environment/EAC/

Scenarios and forecasts
(cont'd from pg. 6)

scenario also projects an increase in demand, but only of 30%. The truth probably lies somewhere in the middle.

It is beyond the scope of this handout to examine all the possible scenarios and their conclusions; where demand or supply projections are used to illustrate a point, "middle of the road" ones have been chosen, that do not forecast dramatic technological or policy changes. A companion paper on **Global Environmental Implications of New Hydrocarbon Developments** reviews several scenarios and their implications.

The Energy Context

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GLOSSARY

Economic reserve: fuel that is financially feasible to extract and use.

End use: any specific activity that requires energy, e.g., refrigeration, home heating, manufacturing, feedstocks.

Energy intensity: amount of energy used per unit of activity.

Fossil fuel: any naturally occurring fuel from decayed organic matter, e.g. peat, oil, coal, natural gas

Geological reserve: fuel known to exist under the ground, but which may or may not be an *economic* reserve.

Hydrocarbon: fossil fuels composed primarily of hydrogen and carbon – includes crude oil, condensate, and natural gas.

Joule: the work done by a force of one newton moving over a distance of one metre.

Primary energy use: total requirements of all uses of energy.

Secondary energy use: energy used by final consumers in homes, agriculture, commerce, industry and transportation.