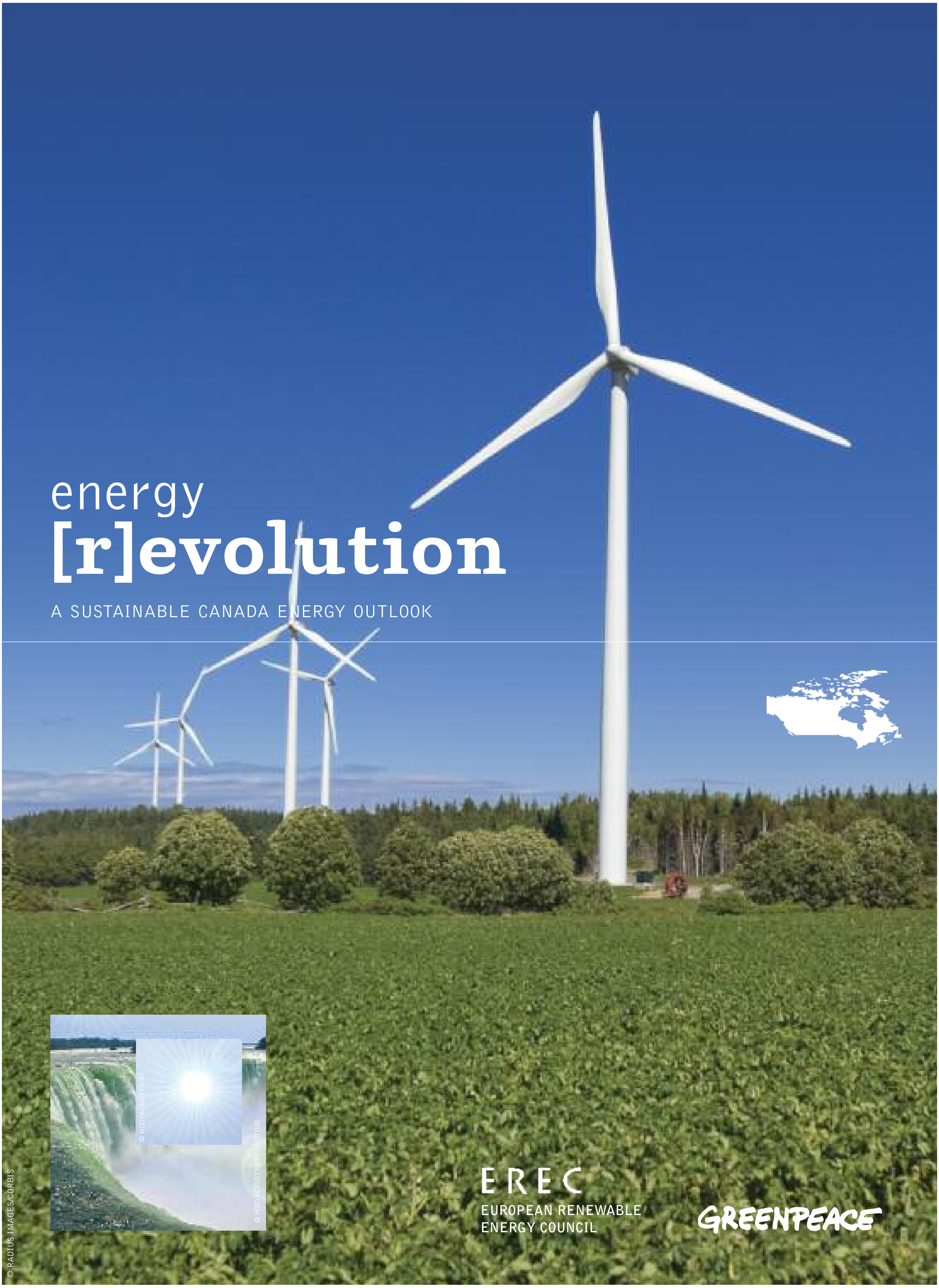

energy [r]evolution

A SUSTAINABLE CANADA ENERGY OUTLOOK

EREC
EUROPEAN RENEWABLE ENERGY COUNCIL

GREENPEACE

report national energy scenario

foreword

Of all the sectors of a modern economic system, the one that appears to be getting the maximum attention currently is the energy sector. While the recent fluctuations in oil prices certainly require some temporary measures to tide over the problem of increasing costs of oil consumption, particularly for oil-importing countries, there are several reasons why the focus must now shift towards longer-term solutions. First and foremost, of course, are the growing uncertainties related to oil imports, both in respect of quantities and prices, but there are several other factors that require a totally new approach to planning energy supply and consumption in the future. Perhaps, the most crucial of these considerations is the threat of global climate change which has been caused overwhelmingly in recent decades by human actions that have resulted in the buildup of greenhouse gases (GHGs) in the Earth's atmosphere.

"will we look into the eyes of our children and confess

that we had the **opportunity,**
but lacked the **courage?**
that we had the **technology,**
but lacked the **vision?"**

contents

image CHECKING THE SOLAR PANELS ON TOP OF THE GREENPEACE POSITIVE ENERGY TRUCK IN BRAZIL.
cover image WIND TURBINES, GASPE, QUEBEC, CANADA.

Impacts of climate change are diverse and serious, and unless the emissions of GHGs are effectively mitigated these would threaten to become far more serious over time. There is now, therefore, a renewed interest in renewable sources of energy, because by creating and using low-carbon substitutes to fossil fuels, we may be able to reduce emissions of GHGs significantly while at the same time ensuring economic growth and development and the enhancement of human welfare across the world. As it happens, there are major disparities in the levels of consumption of energy across the world, with some countries using large quantities per capita and others being deprived of any sources of modern energy forms. Solutions in the future would, therefore, also have to come to grips with the reality of lack of access to modern forms of energy for hundreds of millions of people. For instance, there are 1.6 billion people in the world who have no access to electricity. Households, in which these people reside, therefore, lack a single electric bulb for lighting purposes, and whatever substitutes they use provide inadequate lighting and environmental pollution, since these include inefficient lighting devices using various types of oil or the burning of candles.

Future policies can be guided by the consideration of different scenarios that can be linked to specific developments. This publication advocates the need for something in the nature of an energy revolution. This is a view that is now shared by several people across the world, and it is also expected that energy plans would be based on a clear assessment of specific scenarios related to clearly identified policy initiatives and technological developments. This report on the Canada Energy [R]evolution scenario provides a detailed analysis of the energy efficiency potential and choices in the transport sector. The material presented in this publication provides a useful basis for considering specific policies and developments that would be of value not only to the world but for different countries as they attempt to meet the global challenge confronting them. The work carried out in the following pages is comprehensive and rigorous, and even those who may not agree with the analysis presented would, perhaps, benefit from a deep study of the underlying assumptions that are linked with specific energy scenarios for the future.

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OCTOBER 2008

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Greenpeace International, European Renewable Energy Council (EREC)

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introduction

"NOW IS THE TIME TO COMMIT TO A TRULY SECURE AND SUSTAINABLE ENERGY FUTURE — A FUTURE BUILT ON CLEAN TECHNOLOGIES, ECONOMIC DEVELOPMENT AND THE CREATION OF MILLIONS OF NEW JOBS."

© GREENPEACE/MARKEL REDONDO

image WORKERS EXAMINE PARABOLIC TROUGH COLLECTORS IN THE PS10 CONCENTRATING SOLAR TOWER PLANT IN SEVILLA, SPAIN. EACH PARABOLIC TROUGH HAS A LENGTH OF 150 METERS AND CONCENTRATES SOLAR RADIATION INTO A HEAT-ABSORBING PIPE INSIDE WHICH A HEAT-BEARING FLUID FLOWS. THE HEATED FLUID IS THEN USED TO HEAT STEAM IN A STANDARD TURBINE GENERATOR.

There is now an overwhelming consensus that global warming is an unequivocal, scientifically proven reality, caused in large part by the burning of fossil fuels.

In order to avoid disastrous climate change impacts, global greenhouse gas emissions must peak no later than 2015 and decrease rapidly after that. Renewable energy and efficiency technologies can provide much of the solution, but we will need to achieve an energy revolution. The obstacles to this revolution are political, not technological.

There is no time to waste. To achieve an emissions peak by 2015, we need to start rebuilding the energy sector now. The effects of climate change are already severe. In 2008, the melting of Arctic sea ice almost matched the record set in September 2007. The traditional lifestyle of northern indigenous peoples is disappearing along with the ice. Canada has also seen increased forest fires, numerous extreme weather events, dramatic loss of glaciers, and the melting of permafrost. Iconic wildlife species such as the polar bear are threatened.

countdown to copenhagen

In response to the global warming threat, the Kyoto Protocol committed its signatories to reduce their greenhouse gas emissions by 5.2% from their 1990 levels by 2008–2012. A global struggle is underway to put in place a second phase of the agreement for the period from 2013 to 2017. This agreement must be completed by the end of 2009 at the United Nations conference in Copenhagen. Industrialized countries will have to reduce their emissions domestically at least 25 to 40% by 2020 and 80% by 2050.

Canada's Kyoto commitment was a modest 6% below 1990 levels by 2012. However, instead of making reductions, successive Canadian governments since the Earth Summit in 1992 have allowed emissions to increase. Canada's greenhouse gas emissions were 721 million tonnes in 2006—about 22% above the 1990 level and 29% above the Kyoto target.

"renewable energy, combined with the smart use of energy, delivers half of the world's energy needs by 2050."

image ICEBERG MELTING ON GREENLAND'S COAST.


© GP/NICK COBBING

The Harper government has abandoned Canada's Kyoto commitment and instead has a 2020 reduction target of 20% from the country's 2006 level—less than 3% below 1990. By contrast, Greenpeace is calling on Canada to target a minimum 25% reduction from 1990 levels by 2020. Its Canada Energy [R]evolution scenario provides a practical blueprint on how to achieve this target, and even deeper reductions by 2050.

the energy [r]evolution scenarios

The European Renewable Energy Council (EREC) and Greenpeace have produced the Global and Canada Energy [R]evolution scenarios as practical blueprints for achieving significant greenhouse gas reductions while maintaining an affordable energy supply and steady economic growth. Both of these goals are possible at the same time.

These scenarios are not a prediction of the future—rather they identify a plausible and possible future, which is conditional on certain actions taking place. The scenarios identify practical and achievable future paths that can provide guidance for the adoption of energy and climate change policies today.

Commissioned by Greenpeace and EREC from the Department of Systems Analysis and Technology Assessment (Institute of Technical Thermodynamics) at the German Aerospace Centre (DLR), the scenarios identify sustainable energy pathways up to 2050. The future potential for renewable energy was assessed with input from all sectors of the industry. The energy supply scenarios were calculated using the MESAP/PlaNet simulation model. The demand-side projection by the Ecofys consultancy envisaged an ambitious development pathway for energy efficiency, focused on current best practice as well as anticipated future technologies.

The reference scenarios for both the global and Canada scenarios are based on the World Energy Outlook 2007, of the International Energy Agency (IEA). These projections generally reflect a "business as usual" approach that implies a continuation of current practice. These projections would almost double global greenhouse gas emissions by 2050 and result in an increase of the average global temperature much more than 2°C above the pre-industrial level—a level that would result in catastrophic climate change impacts.

Greenpeace first published its global energy scenario in *Energy [R]evolution: A Blueprint for Global Warming*, in January 2007, and this was followed in October 2008 by *Energy [R]evolution: A Sustainable Global Energy Outlook*.

This scenario was based only on proven and sustainable technologies, such as renewable energy sources and efficient, decentralized, combined heat and power (cogeneration). It reduced worldwide final energy demand by 38% in 2050, compared to the Reference Scenario. Under this scenario, renewable energy, combined with the smart use of energy, delivers half of the world's energy needs by 2050.

It excluded so-called "clean coal" power plants, which are not in fact carbon-free and would create another burden in trying to transport and store carbon dioxide underground (carbon capture and storage).

Nuclear power was also phased out in the Energy [R]evolution scenario. High cost has been the main objection to nuclear power, but it is far from the being the only problem. Nuclear power is a security nightmare. Terrorists don't need nuclear bombs if they can cause a meltdown at a nuclear power plant. Nor is nuclear power a "clean" technology—radioactive emissions and radioactive waste cause cancer and birth defects; there is always the risk of a catastrophic accident such as Chernobyl; and nuclear weapons proliferation is a constant danger. Nuclear power was rightly rejected as a solution to climate change at the 2001 United Nations climate change conference in Bonn. Nuclear power blocks investment in the real solutions to climate change—renewable energy and efficiency technologies are cheaper, cleaner, and safer.

A more radical scenario could even phase out coal by 2050. This is possible, but would require greater resources for research and development. Climate change and the scarcity of fossil fuels put the world at risk; we must start to think the unthinkable. The phaseout of fossil fuels and the acceleration of renewable energy development are the most pressing tasks for the world's next generation of engineers and scientists.

the cost of the [r]evolution

More and more countries are seeing the environmental and economic benefits provided by renewable energy. The Brent crude oil price was at $62* per barrel when the first Energy [R]evolution report was launched in January 2007. By July 2008 it had reached a peak of over $159 per barrel and subsequently fell again. Other fossil fuel prices have followed the volatile trajectory of oil, but there is no doubt that the inevitable price trend is upwards. By contrast, renewable technologies such as wind and solar don't need any fuel. Once installed, they deliver energy independently from the global energy markets and at predictable prices.

The global Energy [R]evolution scenario concluded that the restructuring of the global electricity sector required an investment of $16.7 trillion up to 2030. This compares with $12.8 trillion under the reference scenario based on International Energy Agency projections. While the average annual cost of the global Energy [R]evolution scenario would be just under 1% of global GDP, it would lower fuel costs by 25%—saving an annual amount in the range of $850 billion.

In fact, the additional costs for coal power generation alone from today up to 2030 under the reference scenario could be as high as $18.1 trillion: this would cover the entire investment needed in renewable and cogeneration capacity to implement the Energy [R]evolution scenario. These renewable sources will produce energy without any further fuel costs beyond 2030, while the costs for coal and gas will continue to be a burden on national and global economies.

***** ALL $ VALUES IN THIS REPORT ARE IN CANADIAN DOLLAR UNLESS IT IS MENTIONED OTHERWISE.

image THE PS10 CONCENTRATING SOLAR TOWER PLANT IN SEVILLA, SPAIN, USES 624 LARGE MOVABLE MIRRORS CALLED HELIOSTATS. THE MIRRORS CONCENTRATE THE SUN'S RAYS TO THE TOP OF A 115-METER-(377 FOOT)-HIGH TOWER WHERE A SOLAR RECEIVER AND A STEAM TURBINE ARE LOCATED. THE TURBINE DRIVES A GENERATOR, PRODUCING ELECTRICITY.

the potential for renewable energy

The good news is that the global market for renewables is booming. Decades of technical progress have seen renewable energy technologies such as wind turbines, solar photovoltaic panels, biomass power plants, solar thermal collectors and many others move steadily into the mainstream. The global market for renewable energy is growing dramatically; in 2007 its turnover was over $79 billion, almost twice as high as the previous year. The time window for making the shift from fossil fuels to renewable energy, however, is still relatively short. Within the next decade many of the existing power plants in the OECD countries will come to the end of their technical lifetime and will need to be replaced. But a decision taken to construct a coal or gas power plant today will result in the production of greenhouse gas emissions until 2050.

The power industry and utilities need to take more responsibility because today's investment decisions will define the energy supply of the next generation. We strongly believe that this should be the "solar generation." Politicians from the industrialized countries need to urgently rethink their energy strategy, while the developing world should learn from past mistakes and build economies on the strong foundation of a sustainable energy supply.

Renewable energy could more than double its share of the world's energy supply—reaching at least 30% by 2030. All that is lacking is the political will to promote its large-scale deployment in all sectors at a global level, coupled with far-reaching energy efficiency measures. By 2030 about half of global electricity could come from renewable energies.

The future of renewable energy development will strongly depend on political choices made by both individual governments and the international community. At the same time, strict technical standards will ensure that only the most efficient appliances, heating systems and vehicles will be on sale. Consumers have a right to buy products that do not increase their energy bills or destroy the climate.

implementing the energy [r]evolution

Sir Nicholas Stern, former chief economist of the World Bank, pointed out in his landmark 2006 report that the countries which invest in renewable energy and efficiency technologies today will be the economic winners of tomorrow.

As Stern emphasized, inaction will be much more expensive in the long run. We therefore call on the Canadian government to make this vision a reality. The world cannot afford to stick to the "business as usual" energy development path: relying on fossil fuels, nuclear energy and other outdated technologies. Renewable energy can and will play a leading role in our collective energy future. For the sake of a sound environment, political stability and thriving economies, now is the time to commit to a truly secure and sustainable energy future—a future built on safe, clean technologies, steady economic development, and the creation of millions of new jobs.

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FEBRUARY 2009

"by 2030 about half of global electricity could come from renewable energies."

executive summary

"GLOBAL WARMING IS A CLEAR AND PRESENT DANGER TO CANADA'S PUBLIC HEALTH, ECONOMY, AND ENVIRONMENT."

image CONSTRUCTION OF THE OFFSHORE WINDFARM AT MIDDELGRUNDEN, NEAR COPENHAGEN, DENMARK.

Energy [R]evolution: A Sustainable Canada Energy Outlook is a groundbreaking report which shows how Canada can cut greenhouse gas pollution to the levels needed to prevent the worst effects of global-warming, while allowing economic growth, and phasing out both coal and nuclear power.

Commissioned from the German Aerospace Center by Greenpeace and the European Renewable Energy Council (EREC—Europe's largest renewable trade association), the study shows how Canada can, with off-the-shelf technology, cut carbon dioxide emissions from the Canadian energy sector 40% below 1990 levels by 2020 and 82% by 2050.

This publication is part of a series of reports which examine energy needs and the potential for clean energy worldwide. Taken together, the reports are a global blueprint to prevent a climate catastrophe and create a stronger, more sustainable economy.

global warming: the challenge of our time

Global warming is a clear and present danger to Canada's public health, economy, and environment. Every region of the country is already feeling impacts. They include extreme weather and natural disasters such as flooding, storm surges, ice and wind storms, heat waves and drought. We are seeing loss of snow and ice cover, changes in plant and animal distribution, increases in forest fires, and coastal erosion. Impacts are more severe and happening faster in the Arctic and summer sea ice may disappear within the next five years.

If left unchecked, global warming will cause truly catastrophic damage. According to the Nobel Prize–winning Intergovernmental Panel on Climate Change (IPCC),[1] up to 30% of plant and animal species could face extinction by mid-century. Hundreds of millions of people worldwide, including millions here in North America, will face severe water shortages. The melting of the Greenland and West Antarctic ice sheets would trigger sea-level rise of 13–20 feet or more.

Former World Bank chief economist Sir Nicholas Stern estimated that global warming could reduce worldwide GDP by 20%.[2] The costs in terms of human lives and ecological destruction are incalculable.

Numerous studies[3,4] have concluded that to prevent catastrophic global warming worldwide average temperatures cannot rise by more than 2°C (3.6°F) above pre-industrial levels. Further research shows that to have

references

1 INTERGOVERNMENTAL PANEL ON CLIMATE CHANGE, 2007: SUMMARY FOR POLICYMAKERS. IN: *CLIMATE CHANGE 2007: IMPACTS, ADAPTATION AND VULNERABILITY. CONTRIBUTION OF WORKING GROUP II TO THE FOURTH ASSESSMENT REPORT OF THE INTERGOVERNMENTAL PANEL ON CLIMATE CHANGE*, M.L. PARRY, ET AL., CAMBRIDGE UNIVERSITY PRESS, CAMBRIDGE, UK, 7-22. HTTP://WWW.IPCC.CH/PDF/ASSESSMENT-REPORT/AR4/WG2/AR4-WG2-SPM.PDF.

2 STERN, N., STERN REVIEW ON THE ECONOMICS OF CLIMATE CHANGE, HM TREASURY (2006) AVAILABLE AT: HTTP://WWW.HM-TREASURY.GOV.UK/STERNREVIEW_INDEX.HTM.

3 *AVOIDING DANGEROUS CLIMATE CHANGE*, ED. H. J. SCHELLENHUBER, ET. AL., CAMBRIDGE UNIVERSITY PRESS, 2006. HTTP://WWW.DEFRA.GOV.UK/ENVIRONMENT/CLIMATECHANGE/RESEARCH/DANGEROUSCC/PDF/AVOID-DANGERCC.PDF.

4 EUROPEAN COMMISSION. *LIMITING GLOBAL CLIMATE CHANGE TO 2 DEGREES CELSIUS — THE WAY AHEAD FOR 2020 AND BEYOND*. JANUARY 10 2007. HTTP://EUR-LEX.EUROPA.EU/LEXURISERV/LEXURISERV.DO?URI=COM:2007:0002:FIN:EN:PDF.

an approximately 50% chance of keeping warming below 2°C (3.6°F), atmospheric greenhouse gas concentrations must stabilize below 450 parts per million (ppm). Greenhouse gas concentrations must stabilize below 400 ppm in order to ensure a "likely" probability of keeping the temperature increase below 2°C.[5]

With prudent assumptions about projected emissions in the developing world, IPCC[6] projected that to keep greenhouse gas concentrations below 450 ppm, developed countries as a whole would need to reduce emissions by 25–40% below 1990 levels by 2020 and by 80–95% by 2050.

Given this body of scientific evidence, the need for urgent action is unquestionable.

energy [r]evolution: the blueprint for a healthy climate

In the Energy [R]evolution scenario, Greenpeace and the European Renewable Energy Council posed a simple but daring series of questions.

First, is it possible, using currently available technologies, to cut carbon dioxide (CO_2) emissions to the levels needed to prevent the worst effects of global warming? Second, can we do it while maintaining strong economic growth? Third, since nuclear power presents a number of intractable problems,[7] can we also phase out all nuclear power by 2050? And, finally, can we do it here in Canada?

The answer, from some of the world's top energy experts at the German Aerospace Center, is a resounding yes on all counts.

Every step of the way, we made conservative assumptions to ensure that the Energy [R]evolution scenario would not just add up on paper but also work in the real world. We used numbers from the International Energy Agency (IEA) to project economic and population growth.[8] The Energy [R]evolution scenario assumes that only currently available, off-the-shelf technology will be utilized between now and 2050. Unproven technologies like "carbon-free coal" were omitted. We assumed that no current energy infrastructure—from power plants to home appliances—will be retired prematurely. Even with these conservative assumptions, the Energy [R]evolution scenario demonstrates how Canada can convert to a clean-energy economy and help stop global warming.

By following the Energy [R]evolution blueprint, Canada can cut carbon dioxide emissions from the energy sector roughly 80% by 2050.

We can solve global warming, but we must start now.

global warming and security of supply

Spurred by recent volatility in the price of oil, the issue of security of supply is now at the top of the energy policy agenda. While the price of oil may go up and down, the long-term trend is clear. Prices will inevitably increase, because supplies of all fossil fuels—oil, gas and coal—are becoming scarcer and more expensive to produce.

The days of cheap oil and gas are coming to an end. Uranium, the fuel for nuclear power, is also a finite resource. By contrast, global reserves of renewable energy are large enough to provide about six times more power than the world currently consumes—forever. Renewable energy technologies vary widely in their technical and economic maturity, but there is a range of increasingly attractive sources. These include wind, biomass, photovoltaic, solar thermal, geothermal, ocean and hydroelectric power. Their common feature is that they produce little or no greenhouse gases, and rely on virtually inexhaustible natural sources for their "fuel." Some of these technologies are already competitive. Their economics will further improve as they develop technically, as the price of fossil fuels continues to rise and as their saving of carbon dioxide emissions is given a monetary value.

At the same time there is enormous potential for reducing our consumption of energy, while providing the same level of energy services. This study details a series of energy efficiency measures which together can substantially reduce demand in industry, homes, business and services. Under the Energy [R]evolution scenario, primary energy demand decreases 50% between 2005 and 2050.

the energy [r]evolution: a sustainable energy future for canada

The Canada Energy [R]evolution scenario reduces carbon dioxide emissions from the Canadian energy sector by 40% below 1990 levels by 2020 and roughly 80% by 2050. This, in concert with additional greenhouse gas savings in other sectors, is necessary to keep the increase in global average temperature from the pre-industrial level as far below 2°C as possible.

To achieve these reduction targets, the scenario is characterized by significant efforts to fully exploit the large potential for energy efficiency. At the same time, all cost-effective renewable energy sources are accessed for both heat and electricity generation, as well as the production of sustainable biofuels.

In 2005, renewable energy accounted for 15% of Canada's primary energy demand. Hydro power for electricity production and biomass, mainly used for heating, are the main renewable energy sources. The share of renewable energies for electricity generation is 59.6%. The contribution of renewables to primary energy demand for heat supply is around 12%. About 75% of the Canadian primary energy supply currently comes from fossil fuels.

The Canada Energy [R]evolution scenario describes a development pathway which turns the present situation into a sustainable energy supply for Canada:

- Energy efficiency will reduce primary energy demand by 50% by 2050. This dramatic reduction in primary energy demand is a crucial prerequisite for increasing the share of renewable energy in the overall energy supply system, to compensate for the phase-out of nuclear energy, and for reducing the consumption of fossil fuels.
- The increased use of combined heat and power generation (CHP) improves the overall efficiency of the supply system. District heating networks are a key precondition for achieving a high share of decentralized CHP. Fossil fuels for CHP are increasingly being replaced

references

5 MEINSHAUSEN M. 2005. *ON THE RISK OF OVERSHOOTING 2°C*. SWISS FEDERAL INSTITUTE OF TECHNOLOGY (ETH ZURICH), ENVIRONMENTAL PHYSICS, DEPARTMENT OF ENVIRONMENTAL SCIENCES. HTTP://WWW.STABILISATION2005.COM/14_MALTE_MEINSHAUSEN.PDF.
6 INTERGOVERNMENTAL PANEL ON CLIMATE CHANGE, "POLICIES, INSTRUMENTS AND CO-OPERATIVE ARRANGEMENTS," IN: *CLIMATE CHANGE 2007: MITIGATION*, BOX 13.7, 2007. AVAILABLE AT: HTTP://WWW.IPCC.CH/PDF/ASSESSMENT-REPORT/AR4/WG3/AR4-WG3-CHAPTER13.PDF.
7 PROBLEMS ASSOCIATED WITH NUCLEAR POWER INCLUDE ITS HIGH COST, ROUTINE AND ACCIDENTAL RADIOACTIVE EMISSIONS, THE UNSOLVED PROBLEM OF RADIOACTIVE WASTE MANAGEMENT, THE POSSIBILITY OF CATASTROPHIC ACCIDENT, AND THE RISK OF NUCLEAR WEAPONS PROLIFERATION.
8 INTERNATIONAL ENERGY AGENCY, WORLD ENERGY OUTLOOK 2007 (2007).

image IN 2005 THE WORST DROUGHT IN MORE THAN 40 YEARS DAMAGED THE WORLD'S LARGEST RAIN FOREST IN THE BRAZILIAN AMAZON, WITH WILDFIRES BREAKING OUT, POLLUTED DRINKING WATER AND THE DEATH OF MILLIONS OF FISH AS STREAMS DRY UP.

image A WOMAN CLEANS SOLAR PANELS AT THE BAREFOOT COLLEGE IN TILONIA, RAJASTHAN, INDIA.

image NORTH HOYLE WIND FARM, UK'S FIRST WIND FARM IN THE IRISH SEA, WHICH WILL SUPPLY 50,000 HOMES WITH POWER.

by biomass and geothermal energy. District heating networks are a key precondition for achieving a high share of decentralized CHP. Improved conservation measures and the production of heat directly from renewable sources will cap the expansion of CHP in the long term.

- The electricity sector takes the lead in renewable energy utilization. By 2020, over 80% of electricity will be produced from renewable energy sources, and over 90% by 2050.
- The share of renewables in energy generation will continue to grow, reaching 22% by 2020 and more than 64% in 2050. In particular, biomass, solar collectors and geothermal energy will replace conventional systems for direct heating and cooling.
- Before sustainable biofuels are introduced in the transport sector, efficiency will have to be greatly increased. As biomass is mainly limited to stationary applications, the production of biofuels is limited by the availability of biomass. Electric vehicles will play an increasingly important role from 2020 onwards.
- By 2020 about 25% of primary energy demand will be supplied by renewable energy and that will rise to about 58% by 2050.

To achieve an economically attractive growth of renewable energy sources, a balanced and timely mobilization of all renewable energy technologies is of great importance. The balanced growth of all renewable energy technologies will require policy support in the form of feed-in tariff programs, which pay premium prices for renewable energy, reflecting its environmental benefits.

carbon emission reductions under the energy [r]evolution scenario

Under the reference scenario, energy-related greenhouse gas emissions in Canada will increase about 5% by 2015 and decrease to the 1990 level by 2020. They remain with almost no further reduction until 2050. By contrast, under the Canada Energy [R]evolution scenario, emissions will decrease 43% by 2020 and 83% by 2050 (from 509 million tonnes in 2005 to 291 million tonnes in 2020, and 86 million tonnes in 2050. Annual per capita emissions will drop from 15.8 tonnes in 2005 to 8 tonnes in 2020 and to 2 tonnes in 2050.

In spite of phasing out nuclear power, and a slightly increased electricity demand, greenhouse gas emissions will decrease in the electricity sector enormously. Efficiency gains, the increased use of renewable electricity for vehicles, and some sustainable biofuels will reduce greenhouse gas emissions in the transport sector by over 75%. However, the transport sector will nevertheless become one of the largest sources of greenhouse gas emissions in Canada, with 38% of total emissions in 2050.

According to some of the latest scientific research, even deeper reductions of greenhouse gas emissions will be necessary to avoid dangerous climate change impacts. This would require the development of renewable energy technologies that are not currently utilized, such as ocean energy, and even greater efficiency measures.

This is possible, but it will require more funding for research and development, as well as bold political leadership. At the same time, lifestyle and behavior changes could become increasingly important.

To complement these reductions of greenhouse gas emissions in the energy sector, other measures will have to be taken, including the phase-out of fluorinated gases, halting deforestation, and increasing natural carbon sequestration by forests and soils, for example by the regeneration of forests and by sustainable farming practices.

costs

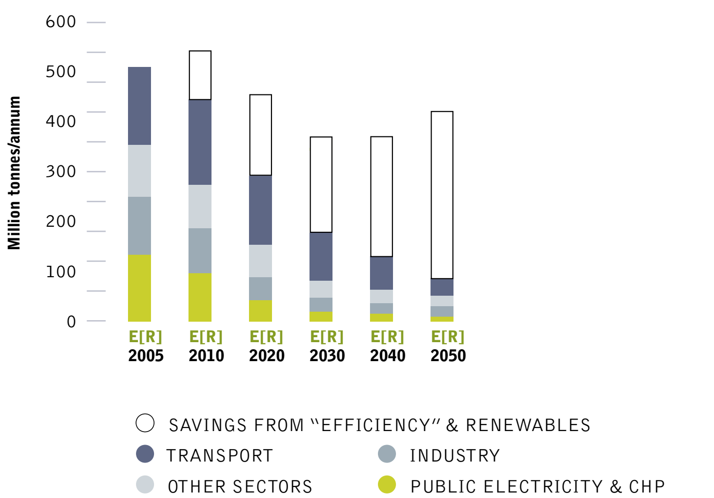
The slightly higher specific electricity generation costs under the Canada Energy [R]evolution scenario are to a large extent compensated for by the reduced electricity demand. Assuming average costs of 1.7 cents/kWh for implementing energy efficiency measures, the Energy [R]evolution scenario will save $5.9 billion on Canada's electricity bill in 2020. If costs for CO_2 emission were added to Canada's reference scenario, the saving would be even higher. However, the specific generation costs under the Canada Energy [R]evolution scenario are only about 0.6 cents/kWh lower than under the reference scenario. The main reason for these savings is lower demand and more-efficient energy use.

to implement the canada energy [r]evolution scenario, the following policy changes are recommended:

1. Phase out all subsidies for fossil fuels and nuclear energy.
2. Account for the social and environmental costs of energy production through "cap and trade" emissions trading and/or carbon taxation.
3. Mandate strict efficiency standards for all energy-consuming appliances, buildings and vehicles.
4. Establish legally binding targets for renewable energy and combined heat and power generation.
5. Reform the electricity markets by guaranteeing priority access to the grid for renewable power generators.
6. Provide defined and stable returns for investors, for example by feed-in tariff programs.
7. Implement better labelling and disclosure mechanisms to provide more environmental product information.
8. Increase research and development budgets for renewable energy and energy efficiency.

canada: development of CO_2 emissions, by sector, under the energy [r]evolution scenario

("EFFICIENCY" = REDUCTION COMPARED TO THE REFERENCE SCENARIO)



climate protection

1

"never before has humanity been forced to grapple with such an immense environmental crisis."

GREENPEACE INTERNATIONAL
CLIMATE CAMPAIGN

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international energy policy

At present, renewable energy generators have to compete with old nuclear and fossil fuel power stations which produce electricity at lower cost because of historic subsidies; because consumers and taxpayers may have already paid the interest and depreciation on the original investments; and because many jurisdictions with restructured electricity sectors have effectively provided bailouts through stranded-cost arrangements. Political action is needed to overcome these distortions and create a level playing field for renewable energy and efficiency technologies to compete.

At a time when governments around the world are in the process of liberalizing their electricity markets, the increasing competitiveness of renewable energy should lead to higher demand. Without political support, however, renewable energy remains at a disadvantage, marginalized by distortions in the world's electricity markets created by decades of massive financial, political and structural support to conventional technologies. Increasing renewable energy will therefore require strong political and economic efforts, especially through laws that guarantee stable tariffs over a period of up to 20 years. Renewable energy will also contribute to sustainable economic growth, high-quality jobs, technology development, global competitiveness and industrial and research leadership.

renewable energy targets

In recent years, in order to reduce greenhouse emissions as well as increase energy security, a growing number of countries have established targets for renewable energy. These are either expressed in terms of installed capacity or as a percentage of energy consumption. These targets have served as important catalysts for increasing the share of renewable energy throughout the world.

A time period of just a few years is not long enough in the electricity sector, however, where the investment horizon can be up to 40 years. Renewable energy targets therefore need to have short-, medium- and long-term steps and must be legally binding in order to be effective. They should also be supported by mechanisms such as feed-in tariffs for renewable electricity generation. In order for the proportion of renewable energy to increase significantly, targets must be set in accordance with the local potential for each technology (wind, solar, biomass, etc.) and be complemented by policies that develop the skills and manufacturing bases to deliver the agreed-upon quantity of renewable energy.

In recent years the wind and solar power industries have shown that it is possible to maintain a growth rate of 30 to 35%. In conjunction with the European Photovoltaic Industry Association,[9] the European Solar Thermal Power Industry Association[10] and the Global Wind Energy Council,[11] the European Renewable Energy Council and Greenpeace have documented the development of those industries from 1990 onwards and outlined a prognosis for growth up to 2020 and 2040.

demands for the energy sector

greenpeace and the renewable energy industry have identified the main policy changes needed for an energy [r]evolution:

1. Phase out all subsidies for fossil fuels and nuclear power.
2. Introduce a pricing mechanism for greenhouse gas emissions (for example, through "cap and trade" emissions trading, and/or a carbon tax).
3. Set stringent and ever-improving efficiency and emissions standards for appliances, buildings, vehicles, and power plants.
4. Establish legally binding targets for renewable energy and combined heat and power generation.
5. Reform electricity markets by guaranteeing priority access to the grid for renewable energy producers.
6. Provide stable return for investors through fixed-price mechanisms for renewable energy (for example, by feed-in tariff programs).
7. Implement labeling and disclosure mechanisms to provide better product information on energy use and environmental impacts.
8. Increase research and development budgets for renewable energy and efficiency.

Conventional energy sources receive an estimated US$250–300 billion[12] in subsidies per year worldwide, resulting in heavily distorted markets. Subsidies artificially reduce the price of power, keep renewable energy out of the market place and prop up non-competitive technologies and fuels. Eliminating direct and indirect subsidies to fossil fuels and nuclear power would help move us towards a level playing field across the energy sector. Renewable energy would not need special provisions if markets factored in the cost of climate damage from greenhouse gas pollution. Subsidies to polluting technologies are perverse in that they are economically as well as environmentally detrimental. Removing subsidies from conventional electricity would not only save taxpayers' money. It would also dramatically reduce the need for renewable energy support.

references
9 EPIA, "SOLAR GENERATION V," SEPTEMBER 2007.
10 ESTIA, "CONCENTRATED SOLAR POWER –NOW!", ESTIA/GPI, NOVEMBER 2005.
11 GWEC, "GLOBAL WIND ENERGY OUTLOOK," GWEC/GPI, OCTOBER 2008.
12 "WORLD ENERGY ASSESSMENT: ENERGY AND THE CHALLENGE OF SUSTAINABILITY," UNITED NATIONS DEVELOPMENT PROGRAMME, 2000

image OFFSHORE WINDFARM, MIDDELGRUNDEN, COPENHAGEN, DENMARK.

canadian climate change policy

Under Liberal former prime minister Jean Chrétien, Canada supported the Kyoto Protocol in 1997, and ratified it in December 2002, binding Canada to reduce its greenhouse gas (GHG) emissions 6% below 1990 levels during the period 2008–2012. However, very little action was taken, and emissions continued to rise.

Three climate plans were formulated under the Liberals: Action Plan 2000, the 2002 Climate Change Plan for Canada, and finally the 2005 Climate Change Plan (April 2005). These plans were ineffective because they relied primarily on voluntary measures, instead of mandatory regulation, large-scale incentive programs, and meaningful market-based mechanisms. Canadian GHG emissions rose from 592 million tonnes in 1990 to 721 million tonnes in 2006—an increase of 129 million tonnes, or about 21.7% above the 1990 level and 29.1% above Canada's Kyoto target.[13]

This was the situation as Canada held a federal election in January 2006, which saw the defeat of the Liberals under former prime minister Paul Martin, and the election of a minority Conservative government under current Prime Minister Stephen Harper.

The Harper government's so-called "Clean Air Act" (Bill C-30) was introduced in October 2006. The Act proposed to make no greenhouse gas reductions before 2020, and only set a distant and inadequate target for reductions of "between 45 and 65% from 2003 levels by 2050."[14]

Faced with rising public concern about global warming in 2006, the Harper government revised its climate policy in the spring of 2007. The Regulatory Framework for Air Emissions (the Framework) introduced new targets—a 20% reduction from 2006 levels by 2020, and a 60 to 70% reduction from 2006 levels by 2050.[15] To frame this according to the internationally used 1990 base year, the Framework target is less than 3% below 1990 level for 2020, and about 51 to 63% below 1990 levels for 2050.

To put this in perspective, the Intergovernmental Panel on Climate Change (IPCC) has stated that in order to have a reasonable chance of avoiding catastrophic climate change impacts, industrial countries will have to reduce their emissions 25–40% from 1990 levels by 2020, and 80–95% by 2050. Recent research suggests that even greater reductions will likely be necessary.

The main elements of the Framework include:

- **Regulation of Industrial Emitters.** Industrial facilities will be regulated in the following sectors: electricity; oil and gas; forest products; smelting and refining; iron and steel; some mining; and cement, lime and chemicals. Regulated emissions include the six GHGs in the Kyoto Protocol, and exclude "fixed-process emissions," i.e. emissions for which there is no known technique to avoid emission releases (for example, the calcination of limestone for cement production).
- **Intensity-based Targets.** The Framework targets are based on intensity—a measure of GHGs emitted per unit of economic activity. Facilities operating in 2003 or earlier would have to reduce emissions intensity an average 18% from 2007 to 2010, based on 2006 levels, and a further 2% per year until 2020.[16] Baseline emissions intensity will vary by sector, and will be calculated either by facility, sector, or company.
- **New Facilities.** Facilities that began operation in 2004 or later, or existing facilities that had a major expansion or transformation will be given an exemption for three years, after which they would have to meet an intensity target based on so-called "cleaner fuel standard," such as natural gas combined-cycle generation technology. Further exemptions would be made for facilities built to accommodate carbon capture and storage (CCS) technology at a later date ("CCS-ready").[17]

Instead of reducing their own emissions, corporations will be able meet their targets through a variety of compliance mechanisms, including:

- **Technology Fund.** Until 2018, regulated corporations can obtain credit towards their targets at a rate of $15 per tonne of GHG from 2010 to 2012, and $20 per tonne in 2013, escalating at the rate of nominal GDP thereafter.[18] Corporations could contribute 70% of their total regulatory obligation to the Technology Fund in 2010, 65% in 2012, 55% in 2013, 50% in 2014, 40% in 2015, 10% in 2016 and 10% in 2017, and contributions end in 2018.
- **Inter-firm Emissions Trading.** Credits would be issued to corporations below their intensity-based target, which could be banked or sold to other regulated emitters, or on a market to be established by the private sector.
- **Domestic Offsets.** Emissions trading would also include offsets, which are reductions taking place outside of regulated activities. The government would approve eligible activities, and emission reductions must be measured under a quantification protocol.[19]
- **Clean Development Mechanism (CDM) & Other International Systems.** The government would allow certain types of CDM credits up to a maximum of 10% of each corporation's total target. The government also noted that it will "explore opportunities" for connecting with emissions-trading systems in the U.S. and Europe.[20]
- **Credit for Early Action.** The Framework allows a one-time allocation of credits to corporations that reduced GHG emissions between 1992 and 2006. A maximum of 15 megatonnes (Mt) would be allocated, with no more than 5 Mt to be used in any one year.[21] However, it is likely that early reductions greatly exceed the 15-million-tonne limit. The government says that if "oversubscribed," the distribution would be allocated on a pro rata basis. This effectively punishes corporations that have taken early action (forest product, chemical industry and metal production sectors), and rewards corporations that delayed action (the oil and gas and electricity sectors).

references

13 ENVIRONMENT CANADA, *NATIONAL INVENTORY REPORT: GREENHOUSE GAS SOURCES AND SINKS IN CANADA 1990-2006*, APRIL 2008, P. 5. EMISSIONS DECLINED SLIGHTLY BETWEEN 2003 AND 2006, HOWEVER, THIS CAN BE ATTRIBUTED LARGELY TO WARMER WINTERS, AND OTHER EXTRANEOUS FACTORS RATHER THAN DELIBERATE CLIMATE CHANGE POLICY MEASURES.
14 *NOTICE OF INTENT TO DEVELOP AND IMPLEMENT REGULATIONS AND OTHER MEASURES TO REDUCE AIR EMISSIONS*, OCTOBER 19, 2006, SECTION 9.3.
15 GOVERNMENT OF CANADA, *REGULATORY FRAMEWORK FOR AIR EMISSIONS*, APRIL 26, 2007, P. 5.
16 GOVERNMENT OF CANADA, *REGULATORY FRAMEWORK FOR AIR EMISSIONS*, APRIL 26, 2007, PP. 10-11.
17 GOVERNMENT OF CANADA, *REGULATORY FRAMEWORK FOR AIR EMISSIONS*, APRIL 26, 2007, P. 1.
18 GOVERNMENT OF CANADA, *REGULATORY FRAMEWORK FOR AIR EMISSIONS*, APRIL 26, 2007, P. 13.
19 SEE: ENVIRONMENT CANADA, *CANADA'S OFFSET SYSTEM: GUIDE FOR PROTOCOL DEVELOPERS*, AUGUST 9, 2008.
20 GOVERNMENT OF CANADA, *REGULATORY FRAMEWORK FOR AIR EMISSIONS*, APRIL 26 2007, P. 15.
21 GOVERNMENT OF CANADA, *REGULATORY FRAMEWORK FOR AIR EMISSIONS*, APRIL 26, 2007, P. 16.

other federal legislation

Canada has had two minority Conservative governments under Stephen Harper following elections in January 2006 and October 2008. This has allowed opposition parties to pass legislation on climate change issues, without the support of the government.

Thus, the opposition passed the *Kyoto Protocol Implementation Act*,[22] which came into force on June 22, 2007. This Act requires the government to meet its commitments under the Kyoto Protocol, including the preparation and reporting on plans to achieve a 6% reduction of emissions from 1990 levels during the period 2008–2012.

In response, the government released climate plans through Environment Canada on August 21, 2007,[23] and May 31, 2008,[24] but essentially flouted the law by claiming that meeting Canada's Kyoto commitment would have adverse economic implications,[25] and that purchase of international credits would not result in verifiable emission reductions.[26]

Similarly, the opposition passed the *Climate Change Accountability Act*,[27] in June 2008. However, the bill had not been passed by the Senate prior to the election of October 14, 2008, and thus it died on the order paper. The Act required Canada to reduce its GHG emissions 25% below 1990 levels by 2020 and 80% by 2050. The bill was re-introduced (as Bill C-311) by the opposition in March 2009.

emissions trading

During the campaign for the Canadian election of October 14, 2008, the Conservative Party announced that it supported a cap-and-trade system for greenhouse gas emissions. Their election platform stated:

We will work with the provinces and territories and our NAFTA [North American Free Trade Agreement] trading partners in the United States and Mexico, at both the national and state levels, to develop and implement a North America–wide cap and trade system for greenhouse gases and air pollution, with implementation to occur between 2012 and 2015.[28]

However, on November 5, 2008, prior to the U.S. election, Prime Minister Harper called publicly for a North American cap-and-trade system that would exclude the tar sands.[29] The Prime Minister must have recognized that an intensity-based emissions approach would not be acceptable in a joint North American emissions trading system, but nevertheless wished to defend the greenhouse gas–intensive tar sands.

It is unlikely that the tar sands could just be written out of a North American emissions-trading deal. Equal treatment for all participants is a basic principle of any emissions trading system.

President Barack Obama has already released a budget blueprint for a GHG cap-and-trade system that is expected to raise $646 billion (USD) through permit auctioning by 2020, beginning in 2012.[30] This plan is made more likely to succeed by the fact that two regional trading systems are already well advanced in the U.S.. The Western Climate Initiative (WCI) is a regional cap-and-trade initiative based in the western U.S.. The Canadian provinces of British Columbia, Manitoba, Ontario and Quebec have already joined the WCI, and the province of Saskatchewan is an observer. WCI partners now include: Arizona, British Columbia, California, Manitoba, Montana, New Mexico, Ontario, Oregon, Quebec, Utah, and Washington. WCI Observers include the U.S. states of Alaska, Colorado, Idaho, Kansas, Nevada and Wyoming; the Canadian province of Saskatchewan; and the Mexican states of Baja California, Chihuahua, Coahuila, Nuevo León, Sonora, and Tamaulipas.

The design recommendations for the WCI were released in September 2008. Each WCI partner will be allocated emissions allowances, and the regional cap would be in place for 2012–2020, with three-year compliance periods, aiming at emissions reductions of 15% below 2005 levels by 2020.[31]

The other emissions trading initiative is the Regional Greenhouse Gas Initiative (RGGI), a cooperative effort by 10 northeast and mid-Atlantic states in the U.S.[32] to limit greenhouse gas emissions from the electricity sector. RGGI has already begun auctioning of permits. It has no Canadian participation.

intensity targets

The Notice of Intent for the Clean Air Act stated in 2006 that "the government intends to adopt a target-setting approach based on emissions intensity..."[33] The Regulatory Framework for Air Emissions made it clear that the government will use intensity-based targets for purposes of industrial regulation:

For existing facilities, the emission-intensity reduction target for each sector is based on an improvement of 6% each year from 2007 to 2010. This yields an initial enforceable reduction of 18% from 2006 emission-intensity levels in 2010. Every year thereafter, a 2% continuous emission-intensity improvement will be required, resulting in an industrial emission-intensity reduction of 26% by 2015. Targets for new facilities will be established based on cleaner fuel standards.[34]

Emission intensity is a measure of greenhouse gases emitted per unit of economic activity. For example, Canada's greenhouse gas intensity, measured in megatonnes per billion dollars of gross domestic product decreased 21.1% between 1990 and 2006, from 0.84 to 0.661 million tonnes per $billion of gross domestic product (Mt/$B GDP).[35] However, this apparent improvement occurred at the same time that the absolute level of GHG emissions increased 21.7%. Simply put, GHG emissions increased, even while the intensity level decreased. Thus, intensity-based targets can be used to disguise a worsening emissions trend.

references

22 THIS WAS A PRIVATE MEMBER'S BILL, SPONSORED BY LIBERAL MEMBER OF PARLIAMENT PABLO RODRIGUEZ.
23 ENVIRONMENT CANADA, *A CLIMATE CHANGE PLAN FOR THE PURPOSES OF THE KYOTO PROTOCOL IMPLEMENTATION ACT* – 2007, AUGUST 21, 2007.
24 ENVIRONMENT CANADA, *A CLIMATE CHANGE PLAN FOR THE PURPOSES OF THE KYOTO PROTOCOL IMPLEMENTATION ACT*, MAY 2008.
25 SEE FOR EXAMPLE: GOVERNMENT OF CANADA, *THE COST OF BILL C-288 TO CANADIAN FAMILIES AND BUSINESS*, 2007. HTTP://WWW.EC.GC.CA/DOC/MEDIA/M_123/TOC_ENG.HTML.
26 ENVIRONMENT CANADA, *A CLIMATE CHANGE PLAN FOR THE PURPOSES OF THE KYOTO PROTOCOL IMPLEMENTATION ACT* – 2007, AUGUST 21, 2007, P. 8.
27 ANOTHER PRIVATE MEMBER'S BILL, SPONSORED BY THE LEADER OF THE NEW DEMOCRATIC PARTY, JACK LAYTON.
28 *THE TRUE NORTH STRONG AND FREE: STEPHEN HARPER'S PLAN FOR CANADIANS*, CONSERVATIVE PARTY OF CANADA, OCTOBER 2008, P. 32.
29 SHAWN MCCARTHY & CAMPBELL CLARK, "OTTAWA SWOOPS IN WITH CLIMATE-CHANGE OFFER," *GLOBE AND MAIL*, NOVEMBER 6, 2008, PP. 1 & 8.
30 U.S. OFFICE OF MANAGEMENT AND BUDGET, *A NEW ERA OF RESPONSIBILITY: RENEWING AMERICA'S PROMISE*, FEBRUARY 26, 2009. HTTP://WWW.WHITEHOUSE.GOV/OMB/ASSETS/FY2010_NEW_ERA/A_NEW_ERA_OF_RESPONSIBILITY2.PDF.
31 WESTERN CLIMATE INITIATIVE, *DESIGN RECOMMENDATIONS FOR THE WCI REGIONAL CAP-AND-TRADE PROGRAM*, SEPTEMBER 23, 2008. HTTP://WWW.WESTERNCLIMATEINITIATIVE.ORG/EWEBEDITPRO/ITEMS/O104F19865.PDF.
32 THE STATES OF CONNECTICUT, DELAWARE, MAINE, MARYLAND, MASSACHUSETTS, NEW HAMPSHIRE, NEW JERSEY, NEW YORK, RHODE ISLAND, AND VERMONT ARE SIGNATORY STATES TO THE RGGI AGREEMENT.
33 *NOTICE OF INTENT TO DEVELOP AND IMPLEMENT REGULATIONS AND OTHER MEASURES TO REDUCE AIR EMISSIONS*, OCTOBER 19, 2006, SECTION 9.3.
34 GOVERNMENT OF CANADA, *REGULATORY FRAMEWORK FOR AIR EMISSIONS*, APRIL 26, 2007, P. IV.
35 ENVIRONMENT CANADA, *NATIONAL INVENTORY REPORT: GREENHOUSE GAS SOURCES AND SINKS IN CANADA 1990–2006*, APRIL 2008, P. 5.

image PHOTOVOLTAICS FACILITY AT "WISSENSCHAFTS UND TECHNOLOGIEZENTRUM ADLERSHOF" NEAR BERLIN, GERMANY. SHEEP BETWEEN THE "MOVERS" KEEPING THE GRASS SHORT.

The problem of intensity-based targets can be seen in the case of the Canadian oil and gas sector, which saw a 66% increase in production from 1990 to 2006.[36] About 1.2 million barrels per day (mbd) were produced from Alberta's tar sands in 2006, and this is expected to increase to 2 mbd by 2011, and 3.8 mbd by 2020.[37] In other words, it is estimated that tar sands production will increase more than 150% by 2011, and more than 300% by 2020. This rapid expansion will overwhelm the government's proposed improvements in energy intensity.

This is particularly problematic given the energy and GHG intensity of the tar sands. GHG emissions from tar sands extraction and upgrading are about five times higher than conventional oil production.[38] Thus, GHG emissions from the tar sands will be an increasingly significant part of Canada's contribution to the global warming crisis.

table 1.1: federal, provincial & territorial greenhouse gas reduction targets

JURISDICTION	TARGET (DATE ADOPTED)	KYOTO COMMITMENT*	2020 TARGET (1990 RELATIVE)
Canada	20% reduction from 2006 levels by 2020 (April 2007)	no	approx. 3% reduction
Alberta	50% reduction from business-as-usual levels by 2050, or 14% from 2005 levels (January 2008)	no	approx. 31% increase**
British Columbia	33% from 2007 levels by 2020 (February 2007)	no	10% reduction ***
Manitoba	6% from 1990 levels by 2012 (October 2002)	yes	no target
New Brunswick	10% from 1990 levels by 2020 (June 2007)	no	10% reduction
Newfoundland & Labrador	10% from 1990 levels by 2020 (June 2007)	no	10% reduction
Nova Scotia	10% from 1990 levels by 2020 (March 2007)	no	10% reduction
Nunavut	no target	no target	no target
Northwest Territories	no target	no target	no target
Ontario	15% from 1990 levels by 2020 (June 2007)	no	15% reduction
Prince Edward Island	reduce to 1990 levels by 2010 and 10% from 1990 levels by 2020 (August 2001)	no	10% reduction
Quebec	6% from 1990 levels by 2012 (June 2006)	yes	no target
Saskatchewan	32% from 2004 levels by 2020 (June 2007)	no	approx. 12% increase****
Yukon	no target	no target	no target

* CANADA'S COMMITMENT UNDER THE KYOTO PROTOCOL WAS A 6% REDUCTION FROM 1990 LEVELS DURING THE PERIOD 2008–2012.
** ASSUMES A 2020 TARGET OF 250 MT. ALBERTA EMISSIONS IN 1990 WERE 171.5 MT.
*** THE STATED B.C. TARGET FOR 2020 IS "10 PER CENT UNDER 1990 LEVELS." HOWEVER, B.C. EMISSIONS IN 1990 WERE 48.9 MT, AND IF THEIR EMISSIONS IN 2007 REMAIN AT THE 2006 LEVEL OF 62.3 MT, A 33% REDUCTION WOULD BE A REDUCTION OF OVER 14% FROM THE 1990 LEVEL.
**** SASKATCHEWAN EMISSIONS IN 2004 WERE 72.3 MT, AND 1990 EMISSIONS WERE 44 MT.
source of emissions data ENVIRONMENT CANADA, NATIONAL INVENTORY REPORT 1990–2006, APRIL 2008.

uncertainty of the regulatory framework

It is not clear when the government intends to actually put the regulations under the Framework into force. However, even assuming that the regulations become law, there can be no ultimate certainty that they will be effective.

First, as noted above, intensity-based targets offer no guarantee of absolute emission reductions if production levels increase. Second, the various compliance mechanisms tend to be rather complex and represent uncertain emission reductions occurring an unspecified time in the future. Finally, the full text of the regulations, including the specific targets, has not yet been made public.

provincial climate change policy

A number of initiatives for GHG emission reduction have been taken by Canadian provinces and territories. Our table gives an overview of their positions on Canada's Kyoto target, and their medium targets for 2020. Some highlights include:

- Only two provinces, Manitoba and Quebec, have agreed to meet their share of Canada's Kyoto Protocol commitment of 6% below 1990 levels by 2012.
- Six provinces (British Columbia, New Brunswick, Newfoundland & Labrador, Nova Scotia, Ontario, and Prince Edward Island) have 2020 GHG reduction targets significantly better than the federal government's.
- Two provinces are targeting increases of GHG emissions for 2020—31% for Alberta, and 12% for Saskatchewan.
- No province or territory has adopted a science-based target of at least a 25% reduction from 1990 levels by 2020.
- Nunavut, Northwest Territories and Yukon have not adopted any GHG targets.

Below, we have provided some highlights from the climate policies of several provinces.

british columbia

With a population of 4.3 million people, British Columbia (B.C.) had about 13% of Canada's population, but was responsible for only 8.7% of GHG emissions (14.4 tonnes) in 2006.[39]

In February 2007, B.C. announced in a Throne Speech that it was setting a target to reduce GHG emissions by 33% below 2007 levels by 2020,[40] placing emissions 10% below the 1990 level.[41] In addition to this target, the Throne Speech included several other significant commitments:

references
36 ENVIRONMENT CANADA, *NATIONAL INVENTORY REPORT: GREENHOUSE GAS SOURCES AND SINKS IN CANADA 1990-2005*, APRIL 2007, P. 11.
37 GOVERNMENT OF ALBERTA, *INVESTING IN OUR FUTURE: RESPONDING TO THE RAPID GROWTH OF OIL SANDS DEVELOPMENT*, DECEMBER 29, 2006, P. 39.
38 JOHN NYBOER & JIAN JUN TU, *GHG EMISSIONS TREND ANALYSIS IN THE FOSSIL FUEL PRODUCTION INDUSTRIES 2008 UPDATE*, PREPARED FOR ENVIRONMENT CANADA BY THE CANADIAN INDUSTRIAL END-USE ENERGY DATA AND ANALYSIS CENTRE (CIEEDAC), SIMON FRASER UNIVERSITY, CANADA, FEBRUARY 2008, FIG. 15, P. 30.
39 ENVIRONMENT CANADA, *NATIONAL INVENTORY REPORT: GREENHOUSE GAS SOURCES AND SINKS IN CANADA 1990–2006*, APRIL 2008, P. 547.
40 GOVERNMENT OF BRITISH COLUMBIA, "THRONE SPEECH LAUNCHES B.C. INTO PACIFIC CENTURY", NEWS RELEASE, FEBRUARY 13, 2007.
41 THE STATED B.C. TARGET FOR 2020 IS "10 PER CENT UNDER 1990 LEVELS." HOWEVER, B.C. EMISSIONS IN 1990 WERE 48.9 MT, AND IF THEIR EMISSIONS IN 2007 REMAIN AT THE 2006 LEVEL OF 62.3 MT, A 33% REDUCTION WOULD BE A REDUCTION OF OVER 14% FROM THE 1990 LEVEL.

- Emission standards for new vehicles to be phased in between 2009 and 2016 to reduce their GHG emissions by 30%.
- 100% carbon sequestration for any coal-fired electricity plant.
- A low-carbon fuel standard to reduce GHG emissions by at least 10% by 2020.
- A new "Green Building Code."

In April 2007, B.C. joined the Western Climate Initiative, starting a process to establish a regional emission trading system with five western U.S. states and several other Canadian provinces.[42]

In June 2008, B.C. released its Climate Action Plan, laying out a strategy for achieving an estimated 73% of its 2020 target. By the end of year, the government set interim reduction targets of 6% below 2007 levels by 2012, and 18% below 2007 levels by 2016.[43]

In July 2008, B.C. joined Quebec to become the second Canadian jurisdiction to implement a carbon tax. The tax applies to gasoline, diesel fuel, natural gas, other home heating fuel, propane, coal and other fossil fuels. It will also apply to fuels for ships, trains and airplanes. The tax is geared to a level of $10 per tonne of GHG emissions, rising by $5 per tonne over four years, and reaching $30 per tonne by 2012.[44] This represents a tax of 2.41 cents per litre for gasoline, rising to 7.24 cents by 2012. The tax is designed to be revenue-neutral through reductions of other taxes, and with protection for low-income households through a "Climate Action Credit" of $100 per adult and $30 per child, paid quarterly.[45]

alberta

With only about 10% of Canada's population, the province of Alberta is responsible for about 32% of the country's greenhouse gas emissions, resulting in provincial per capita emissions of 69.5 tonnes.

In 2002, Alberta established a framework plan for reducing emissions. However, the plan adopted intensity-based reduction targets of 22% by 2010, and 50% by 2020, which still resulted in absolute increases in emission levels in 2020 above the 1990 level of 171 million tonnes.[46]

In July 2007, the Specified Gas Emitters Regulation was introduced. Like the proposed federal regulatory Framework, it has intensity-based targets for facilities emitting over 100,000 tonnes of GHG per year—up to 12% of its average 2003–2005 emissions by July 1–December 31 2007. However, again like the federal Framework, Alberta has compliance mechanisms that allow polluters to avoid actual reductions:

- Climate Change and Emissions Management Fund. Regulated facilities could pay $15 per tonne of emissions exceeding provincial targets. For the initial compliance period of July 1–December 31, 2007, the Fund accounted for 68% required emissions. During the initial compliance period, emitters paid $40 million into the Fund.
- Tradable Emission Performance Credits. Regulated facilities with emission intensities below their targets can earn credits which can be sold to other emitters.
- Domestic Offset Credits. Offset credits can be purchased from projects in Alberta that have been verified as having reduced emissions after January 1, 2002 when not required by law to have done so. During the initial compliance period, emitters bought 2.6 million offset credits.

In January 2008, Alberta revised its climate change plan. The plan targeted a 2020 emissions reduction of 50 million tonnes below the business-as-usual(BAU) projection, instead of the previous 60 million–tonne target.[47] If we assume that Alberta's effective 2020 target is 250 Mt, this represents about a 31% increase above the 1990 level of 171.5 Mt. The 2050 target in the plan is a 200 Mt reduction below the estimated business-as-usual level—equivalent to a 14% reduction below the 2005 level. Alberta's emissions in 2005 were 230.6 Mt, therefore the target is about a 13% increase above the 1990 level of 171.5 Mt.

ontario

Ontario is Canada's most populous province with 12.7 million people. With about 39% of Canada's population, Ontario was responsible in 2006 for about 26.7% of the country's GHG emissions in 2006 (about 190 Mt), resulting in provincial per capita emissions of about 15 tonnes.[48]

In August 2007, Ontario adopted a climate change plan calling for Ontario's GHG emissions to be reduced to 6% below 1990 levels by 2014; 15% below 1990 levels by 2020; and 80% below 1990 levels by 2050.[49]

The plan anticipates that the main reduction will come from the phaseout of coal generation in 2014. The coal phaseout was originally promised by the government of Premier Dalton McGuinty for 2007, then delayed until 2009, and subsequently until 2014.

In February 2009, the McGuinty government proposed its Green Energy Act, with, amongst other measures, a feed-in tariff regime for renewable energy technologies. [50] However, the plan has been condemned by Greenpeace as "greenwashing" if the government is not prepared to roll back its nuclear power plans.[51]

quebec

With a population of 7.6 million people, Quebec has about 23% of Canada's population, but was responsible for only 11.5% of GHG emissions (81.7 tonnes) in 2006.[52]

In June 2006, Quebec released a climate change plan calling for a 10-million-tonne GHG emission reduction by 2012. According to the plan's calculation, this would have left the province about 4 million tonnes short of Quebec's share of Canada's Kyoto commitment (6%

references

42 GOVERNMENT OF BRITISH COLUMBIA, "BC TO PARTICIPATE IN NORTH AMERICAN CLIMATE REGISTRY", NEWS RELEASE, MAY 8, 2007.
43 BRITISH COLUMBIA MINISTRY OF ENVIRONMENT AND BRITISH COLUMBIA CLIMATE ACTION SECRETARIAT, "GOVERNMENT SETS GHG TARGETS FOR 2012 AND 2016", NEWS RELEASE, NOVEMBER 28, 2008.
44 THE TAX WILL INCREASE TO $15/T ON JULY 1, 2009; $20/T ON JULY 1, 2010; $25/T ON JULY 1, 2011; AND $30/T ON JULY 1, 2012.
45 GOVERNMENT OF BRITISH COLUMBIA, "B.C.'S REVENUE-NEUTRAL CARBON TAX," BACKGROUNDER, JULY 1, 2008.
46 GOVERNMENT OF ALBERTA, *ALBERTANS & CLIMATE CHANGE: TAKING ACTION*, OCTOBER 2002, P. 11.
47 GOVERNMENT OF ALBERTA, *ALBERTA'S 2008 CLIMATE CHANGE STRATEGY: RESPONSIBILITY / LEADERSHIP / ACTION*, JANUARY 24, 2008, PP. 23–24. NOTE THAT THE 2008 TARGET FOR 2020 IS LESS STRINGENT THAN THE 2002 TARGET OF A 60 MT REDUCTION BELOW THE BAU LEVEL.
48 ENVIRONMENT CANADA, *NATIONAL INVENTORY REPORT: GREENHOUSE GAS SOURCES AND SINKS IN CANADA 1990–2006*, APRIL 2008, P. 532.
49 GOVERNMENT OF ONTARIO, *GO GREEN: ONTARIO'S ACTION PLAN ON CLIMATE CHANGE*, AUGUST 2007, P. 6.
50 ONTARIO MINISTRY OF ENERGY AND INFRASTRUCTURE, "ONTARIO'S BOLD NEW PLAN FOR A GREEN ECONOMY", NEWS RELEASE, FEBRUARY 23, 2009.
51 GREENPEACE CANADA, "GREENPEACE BLOCKS NUCLEAR STATION TO TELL SMITHERMAN: DON'T NUKE GREEN ENERGY", NEWS RELEASE, MARCH 12, 2009. HTTP://WWW.GREENPEACE.ORG/CANADA/EN/PRESS/PRESS-RELEASES/NEWS-RELEASE-PICKERING.
52 ENVIRONMENT CANADA, *NATIONAL INVENTORY REPORT: GREENHOUSE GAS SOURCES AND SINKS IN CANADA 1990–2006*, APRIL 2008, P. 528.

image FIRST GEOTHERMAL POWER STATION IN GERMANY PRODUCING ELECTRICITY. WORKER IN THE FILTRATION ROOM.

below 1990 levels by 2012).[53] However this shortfall was met by federal government funding, and the province has agreed that it will meet the target of 6% below 1990 by 2012.[54] Quebec has so far made no commitment for a 2020 target to reduce emissions.

In October 2007, Quebec implemented its version of a carbon tax on about 50 companies that sell fossil fuels in bulk to Quebec retailers. The tax rate varies for each fuel, depending on GHG intensity. The tax is designed to raise $200 million annually, which will be put into a Green Fund for measures to reduce GHG emissions—mainly through public transit.

canadian energy policy

As a federation of 10 provinces and three territories, Canada's energy policy is constitutionally fractured. Provinces and territories own ground resources (apart from aboriginal lands and national parks), and have primary responsibility for policy within their jurisdictions. The federal government has jurisdiction over Canada lands,[55] inter-provincial and international undertakings, nuclear power and uranium, and transboundary environmental impacts.

Energy resources vary widely between provinces. For example:

- Alberta has a disproportionate share of oil and gas reserves.
- Quebec, B.C., Newfoundland, Ontario and Manitoba have significant hydro-electric resources.
- Newfoundland and Nova Scotia have an agreement with the federal government for revenue-sharing from offshore oil and gas.

It is worth noting that the North American Free Trade Agreement (NAFTA) also provides open access to U.S. markets for Canadian energy.

While the Government of Canada ostensibly aims to achieve a balance between economic growth, competitiveness and environmental responsibility, it is clear that environmental priorities have taken a back seat to perceived economic benefits.

The federal government must provide greater leadership on climate change policy and the transition to a sustainable energy path through the promotion of efficiency and renewable energy technologies. This can be achieved by initiating co-operation between federal, provincial and territorial governments through the Council of the Federation (Premiers), the Council of Energy Ministers, and bilateral and regional meetings.

federal policies for reduction of co_2 in the energy sector

Below, we have provided some highlights of Canadian climate and energy policy announced in the January 2009 Canadian budget.

ecoEnergy for Renewable Energy. The current ecoEnergy for Renewable Energy program is a $1.48 billion federal program announced in January 2007. It provides an incentive of one cent per kilowatt hour for electricity production over 10 years. The program is for wind, biomass, low-impact hydro, geothermal, solar, photo-voltaic and ocean energy projects. This program replaced the similar Wind Power Production Incentive (WPPI), originally announced in the 2001 federal budget.

This four-year program ends March 31, 2011, but commitments under the program are expected to end in 2009. For every dollar spent by the government, the ecoEnergy for Renewable Energy program leveraged seven dollars of private investment. The program is expected to result in up to 4,000 megawatts (MW) of new renewable electricity generation capacity by 2011.

According to Natural Resources Canada (the federal department responsible for the program), more than 11,000 MW of projects had already registered for the program, as of November 2008.

This program is a key factor in the expansion of Canada's green power industry. The renewable energy industry was seeking an extension and strengthening of this program to $2.8 billion over five years to build at least 8,000 new MW. This would have leveraged a $6 billion investment and created an estimated 8,000 new jobs. However, in its federal budget in January 2009, the Harper government failed to renew the program.[56] The cancellation of the program will strand over 7,000 MW of registered projects.

ecoEnergy Retrofit Program. The government has committed $300 million over two years to the ecoEnergy Retrofit Program.[57] Ironically, this brings funding for the retrofit program to roughly the level of the Liberal program that the Harper government scrapped following its election in 2006 (that program was for $500 million over five years).

However, while funding has increased, the planning horizon has been reduced to two years—the original Harper government ecoEnergy Retrofit announcement was for four years (April 2007–March 2011), so the addition of $300 for two years matches that period, but does not extend it. Two years of funding commitment is problematic—a long-term commitment is needed for this program because it relies on a sizable nation-wide infrastructure of advisors and retrofit contractors. In order to maintain this infrastructure there needs to confidence that the market will extend beyond two years.

Energy Efficiency Retrofits in Social Housing. The January 2009 budget provided $1 billion for renovation of social housing over two years.[58] However, Greenpeace assumes that only half of this amount (about $500 million) will be applied for energy efficiency retrofits.

False Solution: Carbon Capture and Storage (CCS). Under the heading of "Transformation to a Green Energy Economy," the Harper government proposed in its January 2009 budget to spend up to $400 million on so-called "clean-energy technologies." The only technology which is mentioned is carbon capture and storage (CCS).[59] CCS is a technology which has not been demonstrated commercially, and is expected to have an extremely high cost. Greenpeace and other environmental groups have called CCS a "pipe dream" and have opposed taxpayer subsidies.

false solution: nuclear power

In its January 2009 budget, the Harper government committed to a $351 million subsidy for nuclear power through Atomic Energy of Canada Limited (AECL).[60] AECL is a federal Crown Corporation that has received over $20 billion in subsidies since it was founded in 1952.

The 2009 funding is being provided for design of the Advanced CANDU Reactor (ACR)—a new untested reactor design that AECL is hoping to sell to the government of Ontario.

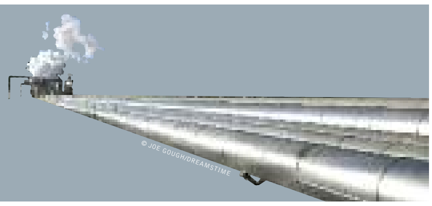
references

53 GOVERNMENT OF QUEBEC, *QUEBEC AND CLIMATE CHANGE: A CHALLENGE FOR THE FUTURE*, 2006–2012 ACTION PLAN, JUNE 2006, P. 30. QUEBEC'S 1990 GHG EMISSIONS ARE NOW CONSIDERED TO HAVE BEEN 82.7 MT.
54 GOVERNMENT OF CANADA, "PRIME MINISTER UNVEILS NEW CANADA ECOTRUST: QUEBEC INVESTMENT THE FIRST OF NEW FUNDING TO DELIVER REAL RESULTS FOR CANADIANS", NEWS RELEASE, FEBRUARY 12, 2007. THE FEDERAL GOVERNMENT PROVIDED QUEBEC WITH $349.9 MILLION IN FUNDING.
55 CANADA LANDS ARE LANDS OUTSIDE OF PROVINCIAL BOUNDARIES, I.E., TERRITORIAL LANDS, OFFSHORE, AND NATIONAL PARKS.
56 GOVERNMENT OF CANADA, *CANADA'S ECONOMIC ACTION PLAN: BUDGET 2009*, JANUARY 27, 2009. HTTP://WWW.BUDGET.GC.CA/2009/HOME-ACCUEIL-ENG.ASP.
57 *CANADA'S ECONOMIC ACTION PLAN: BUDGET 2009,* JANUARY 27 2009, P.P. 131 & 136
58 *CANADA'S ECONOMIC ACTION PLAN: BUDGET 2009,* JANUARY 27 2009, P.P. 133 & 136.
59 *CANADA'S ECONOMIC ACTION PLAN: BUDGET 2009,* JANUARY 27 2009, P.P. 179 & 185.
60 *CANADA'S ECONOMIC ACTION PLAN: BUDGET 2009,* JANUARY 27 2009, P. 180.

the energy [r]evolution in developing countries

2

> **"to those nations like ours that enjoy relative plenty, we say we can no longer afford indifference to the suffering outside our borders; nor can we consume the world's resources without regard to effect."**
>
> PRESIDENT BARACK OBAMA



greenpeace proposal: feed-in tariff support mechanism

This chapter outlines a Greenpeace proposal for a feed-in tariff system (also known in Canada as a "Standard Offer Program")in developing countries. The additional costs of the program would be financed by a combination of new sectoral emissions trading mechanisms and direct finance from technology funds to be developed in the Copenhagen climate deal.

The global Energy [R]evolution scenario demonstrates that renewable electricity generation can have considerable environmental and economic benefits. However, developing countries generally lack the resources required to accomplish the transition to a clean energy economy while meeting the basic energy needs of their populations. A support mechanism is needed to bridge the investment and cost gap between a conventional fossil fuel–based system and a sustainable system based on efficiency and renewable energy.

Greenpeace International conceived a support mechanism for developing countries—the Feed-in Tariff Support Mechanism (FTSM)[61]—to provide financial support from developed nations.

A feed-in tariff incentivizes the production of renewable energy by setting a guaranteed, premium price for that energy. The premium pricing provides investors with a guaranteed return while defraying the up-front investment costs associated with building new clean energy infrastructure. The value of the feed-in tariff can be adjusted for different sources of energy so that less mature industries that require additional subsidies can receive additional support, while more advanced technologies do not.

Several European nations, including Germany, Spain and Denmark, have enacted feed-in tariffs with great success. In Europe, the feed-in tariff is usually financed through a small additional fee on ratepayers' energy bills. However, the extra costs associated with the program remain an obstacle for developing nations, and an alternative funding source would be needed.

The FSTM would be created as a "sectoral no-lose mechanism." Such a program allows developing countries to pledge to set sector-specific emission targets and issue tradable emission credits. However, if the country fails to meet its emission target, there is no penalty—hence the term "no-lose."

Signatories to the Kyoto Protocol are currently negotiating the second phase of their agreement, covering the period 2013–2017. The FTSM could be built around new sectoral no-lose targets for developing countries during these negotiations. Proceeds from the sale of emission credits under a sectoral no-lose target mechanism in developing countries could be used to fund the additional costs of the FTSM in that country. For some countries a directly funded FTSM may be more appropriate than funding through sectoral no-lose targets.

energy [r]evolution means reducing poverty[62]

Energy is central to reducing poverty and providing major benefits in the areas of health, literacy and equity. More than a quarter of the world's population has no access to modern energy services. In sub-Saharan Africa, 80% of people have no electricity supply. For cooking and heating, they depend almost exclusively on burning biomass—wood, charcoal and dung.

Poor people spend up to a third of their income on energy, mostly to cook food. Women in particular devote a considerable amount of time to collecting, processing and using traditional fuel for cooking. In India, two to seven hours each day can be devoted to the collection of cooking fuel. This is time that could be spent on child care, education or income generation. In addition, the World Health Organization estimates that 2.5 million women and young children in developing countries die prematurely each year from breathing fumes from indoor biomass stoves.

The Millennium Development Goal of halving global poverty by 2015 will not be reached without adequate energy to increase production, income, education, and create jobs. Halving hunger will not come about without energy for more productive growing, harvesting, processing and marketing of food.

Improving health and reducing death rates will not happen without energy for the refrigeration needed at clinics, hospitals and vaccination campaigns. The world's greatest child killer, acute respiratory infection, will not be tackled without dealing with smoke from cooking fires in the home. Children will not study at night without light in their homes. Clean water will not be pumped or treated without energy.

The UN Commission on Sustainable Development argues that "to implement the goal accepted by the international community of halving the proportion of people living on less than $1 per day by 2015, access to affordable energy services is a prerequisite."

feed-in tariffs: proven effective clean energy policy

Since the early development of renewable energy, there has been an ongoing debate about the best and most effective type of support scheme. The European Commission published a survey in December 2005 which provides a good overview of the experience so far. According to this report, feed-in tariffs are by far the most efficient and successful mechanism. Globally more than 40 countries have adopted some version of the feed-in tariff mechanism.

references
61 GREENPEACE INTERNATIONAL, *IMPLEMENTING THE ENERGY [R]EVOLUTION,* OCTOBER 2008. AVAILABLE AT: HTTP://WWW.GREENPEACE.ORG/INTERNATIONAL/PRESS/REPORTS/ENERGYREVOLUTIONREPORT.
62 IT POWER/GREENPEACE INTERNATIONAL, *SUSTAINABLE ENERGY FOR POVERTY REDUCTION: AN ACTION PLAN* (2002), AVAILABLE AT: HTTP://WWW.GREENPEACE.ORG/RAW/CONTENT/INTERNATIONAL/PRESS/REPORTS/SUSTAINABLE-ENERGY-FOR-POVERTY.PDF.

image GREENPEACE INSTALLED 40 PHOTOVOLTAIC SOLAR PANELS THAT MUST SUPPLY 30% TO 60% OF THE DAILY DEMAND OF ELECTRICITY IN THE GREENPEACE OFFICE IN SAO PAULO. THE PANELS ARE CONNECTED TO THE NATIONAL ENERGY GRID, WHICH IS NOT ALLOWED BY LAW IN BRAZIL. ONLY ABOUT 20 SYSTEMS OF THIS TYPE EXIST IN BRAZIL AS THEY REQUIRE A SPECIAL LICENSE TO FUNCTION.

image PLANT NEAR REYKJAVIK WHERE ENERGY IS PRODUCED FROM THE GEOTHERMAL ACTIVITY.

Although the specific form of these tariffs differs from country to country, there are certain clear criteria which are essential. For example, a bankable support scheme for renewable energy projects that can provide long-term stability and certainty for both investors and equipment suppliers is essential.[63] Bankable support schemes result in lower-cost projects, for example, because they lower the risk for both investors and equipment suppliers. The cost of wind-powered electricity in Germany is up to 40% less than in the United Kingdom,[64] for example, because Germany's support scheme is more stable and reliable.

The four main elements for successful renewable energy support schemes are:

1. a clear, bankable pricing system;
2. priority access to the grid, with clear identification of responsibility for interconnection, transition, and incentives;
3. clear, simple administrative and planning permission procedures;
4. public acceptance and support.

For developing countries, feed-in tariffs have the potential to meet all of these requirements and are therefore an excellent mechanism for investing in clean energy. The main argument against feed-in tariffs is the short-term cost. This is a particular challenge for developing countries, where many cannot afford costly electricity services. However, with international support, this obstacle can be overcome.

bridging the gap with international financing

Finance for renewable energy projects is one of the main obstacles in developing countries. While large-scale projects have fewer funding problems, small, community-based projects, while having a high degree of public acceptance, face financing difficulties. The experiences from micro-credits for small hydro projects in Bangladesh, for example, as well as wind farms in Denmark and Germany, show how strong local participation and acceptance can be achieved. The main reasons for this are the economic benefits flowing to the local community and careful project planning based on good local knowledge and understanding. When the community identifies the project rather than the project identifying the community, the result is generally faster bottom-up growth of the renewable energy sector.

FTSM aims to facilitate the implementation of feed-in tariff laws in developing countries by providing additional financial resources on a scale appropriate to the circumstances of each developing country. For countries with higher levels of renewable energy capacity, the creation of a new sectoral no-lose mechanism can generate saleable emission reduction units, the proceeds from which can be used to offset any additional costs associated with the feed-in tariff system. In other countries, direct funding may be a more appropriate approach to assisting developing countries with the additional costs to consumers of the feed-in tariff system.

Funding could come through the connection of the FTSM to the international emission trading system via a new no-lose sectoral trading mechanism to be developed in the Copenhagen Agreement. The Energy [R]evolution scenario shows that the average additional costs (under the proposed energy mix) between 2008 and 2015 are between 1 and 4 cents (USD) per kilowatt-hour, so the cost per ton of CO_2 avoided would be between $13 and $50 (USD), indicating that emission reduction units generated under a no-lose mechanism designed to support FTSM would be competitive in the post-2012 carbon market.

All renewable energy projects must have a clear set of environmental criteria which are part of the national licensing procedure in the country where the project will generate electricity. Those criteria will have to meet a minimum environmental standard defined by an independent monitoring group. If there are already acceptable criteria developed, for example, for projects under the Clean Development Mechanism (CDM) of the Kyoto Protocol, they should be adopted rather than the wheel be re-invented. The board members will be representatives of non-government organizations as well as the governments involved, as well as independent energy and finance experts. The fund should not support speculative investments, but only provide soft loans for FTSM projects.

key parameters for feed-in tariffs under FTSM:

- Tariffs must be variable for different renewable energy technologies, depending on their costs and technology maturity, paid for 20 years.
- Payments must be based on actual generation in order to achieve properly maintained renewable energy projects with high performance ratios.
- Any additional costs for renewable generation will be paid by calculating the wholesale electricity price plus a fixed premium.

to implement FTSM, a developing country must:

- Establish regulations to guarantee access to the electricity grid for renewable electricity projects.
- Establish feed-in tariff laws and regulations based on successful examples.
- Establish regulations to ensure transparency when establishing the feed-in tariff, including full records of generated electricity.
- Set clear regulations for the renewable energy sector, including licensing procedures.

key parameters for the FTSM fund:

- The FTSM fund will guarantee payment of the total feed-in tariffs over a period of 20 years if the renewable energy project is operated properly.
- The FTSM fund will receive annual income from emissions trading or from direct funding.
- The FTSM fund will pay feed-in tariffs annually on the basis of generated electricity.
- Every FTSM-funded project must have a professional maintenance company to ensure high performance.
- Grid operators must monitor and report energy generation data to the FTSM fund for comparison with data submitted by renewable energy projects.

references
63 COMMISSION OF THE EUROPEAN COMMUNITIES, *THE SUPPORT OF ELECTRICITY FROM RENEWABLE ENERGY SOURCES*, COM (2005), P. 627 (DECEMBER 2005).
64 IBID., P. 27, FIGURE 4.

figure 2.1: feed-in tariff support mechanism (ftsm)

FTSM
roles and responsibilities

developing country

Legislation:
- feed-in law
- guaranteed grid access
- licensing

(inter-) national finance institute(s)

Organizing and Monitoring:
- organize financial flow
- monitoring
- providing soft loans
- guarantee the payment of the feed-in tariff

developed country

Legislation:
- CO_2 credits under Clean Development Mechanism
- tax from Cap & Trade
- auctioning CO_2 Certificates


© GREENPEACE/XUAN CANXIONG

image NAN WIND FARM IN NAN'AO, GUANGDONG PROVINCE, HAS ONE OF THE BEST WIND RESOURCES IN CHINA AND IS ALREADY HOME TO SEVERAL INDUSTRIAL-SCALE WIND FARMS. MASSIVE INVESTMENT IN WIND POWER WILL HELP CHINA OVERCOME ITS RELIANCE ON CLIMATE-DESTROYING FOSSIL FUEL POWER AND SOLVE ITS ENERGY SUPPLY PROBLEM.

the energy [r]evolution

3

"the good news is, we have everything we need now to respond to the challenge of global warming. but we should not wait, we cannot wait, we must not wait, we have everything we need—save perhaps political will. and in our democracy, political will is a renewable resource."

FORMER U.S. VICE-PRESIDENT AL GORE

The global warming crisis demands nothing short of an energy revolution. Expert consensus is that an energy revolution must begin very soon and be well underway within the next ten years in order to avert catastrophic climate change impacts. Canada needs a complete transformation in the way it produces, consumes and distributes energy. At the same time, Canada needs to maintain and encourage economic growth. Nothing short of an Energy [R]evolution will minimize the risk of catastrophic global warming. This chapter summarizes the basic principles and goals underlying the Energy [R]evolution scenario.

key principles of the energy [r]evolution

Current electricity generation relies mainly on burning fossil fuels, with their associated CO_2 emissions, in very large power stations which waste much of their primary input energy. More energy is lost as power is moved around the electricity grid network and converted from high transmission voltage down to a supply suitable for domestic or commercial consumers. The system is inherently vulnerable to disruption: localized technical, weather-related or even deliberately caused faults can quickly cascade, resulting in widespread blackouts. Whichever technology is used to generate electricity within this old-fashioned configuration, it will inevitably be subject to some, or all, of these problems.

The Energy [R]evolution scenario represents a major change in the way that energy is both produced and distributed. The scenario sets out to fulfill the following goals:

1. **achieve science-based emissions reductions to minimize climate risk** There is only so much carbon that the atmosphere can absorb. Each year over 25 billion tonnes (25 gigatonnes—Gt) of CO_2 are emitted globally—we are literally filling up the sky. Coal supplies could provide several hundred years of fuel, but coal and oil development must be ended to stay within safe CO_2 emission limits. The global Energy [R]evolution scenario aims to reduce worldwide energy-related CO_2 emissions to a maximum of 10 Gt by 2050 and phase out fossil fuels by 2085.

"THE STONE AGE DID NOT END FOR LACK OF STONE, AND THE OIL AGE WILL END LONG BEFORE THE WORLD RUNS OUT OF OIL."

Sheikh Zaki Yamani, former Saudi Arabia oil minister

2. **ensure equity and fairness** It is imperative to have a fair distribution of benefits and costs within societies and between nations. At one extreme, a third of the world's population has no access to electricity, while the most industrialized countries consume much more than their fair share. The effects of climate change on the poorest communities are exacerbated by massive global energy inequality. If we are to address climate change, one of the principles must be equity and fairness, so that the benefits of energy services—such as light, heat, power and transport—are available for all: north and south, rich and poor. Only in this way can we create true energy security, as well as the conditions for genuine human wellbeing. The Canada Energy [R]evolution scenario aims to achieve energy equity as soon as technically possible. By 2050, average per capita carbon dioxide emissions should be between 1 and 2 tonnes.

3. **implement clean, renewable solutions and energy systems** There is no energy shortage. All we need to do is use existing technologies to harness energy effectively and efficiently. Efficiency and renewable energy measures are ready, viable and increasingly competitive. Wind, solar and other renewable energy technologies have experienced double-digit market growth for the past decade.

   Sustainable decentralized energy systems powered by renewable energy produce less greenhouse gas emission, are less expensive, and are less dependent on imported fuel. Renewable energy systems create jobs and empower local communities. Decentralized systems are more secure and more efficient.

4. **decouple growth from fossil fuel use** Starting in the developed countries, we need to decouple growth from energy use by using energy much more efficiently. Remaining energy growth must be quickly shifted to renewable energy—away from fossil fuels—in order to enable clean and sustainable growth. Economic growth need not be predicated on the increased combustion of fossil fuels.

5. **phase out dirty, unsustainable energy** Canada needs to phase out both coal and nuclear power. This country cannot continue to build coal plants at a time when global warming emissions pose a real and present danger to both ecosystems and people. We cannot ignore the high cost as well as environmental and safety risks of nuclear power in the name of fighting climate change. There is no role for nuclear power in the Energy [R]evolution.

transitioning to clean energy

In 2005, renewable energy sources accounted for 13% of the world's primary energy demand. Biomass, which is mostly used for heating, is the main renewable energy source. The share of renewable energy in electricity generation was 18%. The contribution of renewable energy to primary energy demand for heat supply was around 24%. About 80% of primary energy supply today still comes from fossil fuels, and 6% from nuclear power.[65]

The time is right to make substantial structural changes in the energy and power sector within the next decade. Many power plants in Canada are nearing retirement; and more than half of all operating power plants across the industrialized world are over 20 years old. At the same time, developing countries such as China, India and Brazil, are looking to satisfy the growing energy demand created by their expanding economies.

Within the next ten years, the Canadian energy sector will decide whether to meet demand with fossil fuels and nuclear power, or with the efficient use of renewable energy. The global and Canada Energy [R]evolution scenarios are the blueprints for implementation of a system based on renewable energy and combined heat and power (cogeneration) combined with energy efficiency.

To make this happen, renewable energy and cogeneration will have to grow faster than overall global energy demand. They must replace old generating technologies and deliver additional energy in the developing world on a large scale, yet in smaller, decentralized units.

It is not possible to switch immediately from the current large-scale fossil fuel and nuclear supply to a renewable energy supply. A transition phase is required to build up the necessary infrastructure. While firmly committed to renewable energy, Greenpeace appreciates that natural gas, used in appropriately scaled cogeneration plants, is a valuable transition fuel, and will drive cost-effective decentralization of Canadian energy infrastructure. With warmer summers, tri-generation, using heat-fired absorption chillers to deliver cooling capacity in addition to heat and power, will also be an important way to reduce emissions.

a development pathway

The Energy [R]evolution envisages a development pathway which turns the present energy supply structure into a sustainable system. There are two main stages to this.

step 1: energy efficiency The Energy [R]evolution aggressively exploits energy efficiency. It focuses on current best practices and new technologies which will become available in the future, assuming continuous innovation. Energy savings are equally distributed over the three sectors—industry, transport and domestic/commercial/insitutional. Intelligent use, not abstinence, is the basic philosophy for future energy conservation.

The most important energy-saving options are: improved insulation and building design; super-efficient appliances and electronic devices; replacement of old-style electrical heating systems with renewable heat production (such as solar collectors); and a reduction in energy consumption by vehicles used for goods and passenger traffic. Industrialized countries currently using energy inefficiently can reduce energy consumption drastically without the loss of either housing comfort or entertainment electronics. The Energy [R]evolution scenario uses energy saved in developed countries as a compensation for the increasing power requirements in developing countries. The ultimate goal is stabilization of global energy consumption within the next two decades. At the same time, the Energy [R]evolution scenario aims to create "energy equity" by shifting wasted energy in industrialized countries towards a fair, worldwide energy supply distribution.

The Energy [R]evolution scenario makes a dramatic reduction in primary energy demand compared to the IEA's reference scenario—but with the same GDP and population development. This is a crucial prerequisite for renewable energy growth in the overall energy supply system, and will help compensate for the phase-out of nuclear energy and fossil fuels.

step 2: deliver clean energy for a growing world

1. **decentralized energy and large-scale renewables** In order to achieve higher fuel efficiencies and reduce distribution losses, the Energy [R]evolution scenario makes extensive use of decentralized energy (DE). This is energy generated at or near the point of use.

DE is connected to a local distribution network system, supplying homes and offices, rather than the high-voltage transmission system. The proximity of electricity-generating plants to consumers allows any waste heat from combustion processes to be used in nearby buildings, a system known as cogeneration or combined heat and power (CHP). DE uses nearly all the input energy, unlike traditional centralized fossil fuel plants, which use only a fraction of input energy.

DE can also include stand-alone systems, separate from public networks, like heat pumps, solar thermal panels or biomass heating systems. These can all be commercialized to provide sustainable low-emission heating. Although DE technologies can be considered "disruptive" because they do not fit the existing electricity market and system, with appropriate changes they have the potential for exponential growth.

By 2050, a large proportion of global energy will be produced by decentralized energy sources, although large-scale renewable energy supply will still be needed in order to achieve a fast transition to a renewable-dominated energy system. Large offshore wind farms and concentrating solar power (CSP) plants in sunbelt regions will also have an important role to play.

2. **cogeneration** The increased use of combined heat and power generation (CHP) will improve energy supply efficiency, whether using natural gas or biomass. In the long term, decreasing demand for heat and the ability to produce heat directly from renewable energy sources will limit the further expansion of CHP.

references
65 INTERNATIONAL ENERGY AGENCY, ENERGY BALANCE OF NON-OECD COUNTRIES (2008). AVAILABLE AT: HTTP://WDS.IEA.ORG/WDS/PDF/DOC_WEDBAL_EN_2008.PDF.

image A COW IN FRONT OF A BIOREACTOR IN THE BIOENERGY VILLAGE OF JUEHNDE. IT IS THE FIRST COMMUNITY IN GERMANY TO PRODUCE ALL OF ITS ENERGY NEEDED FOR HEATING AND ELECTRICITY FROM CO_2-NEUTRAL BIOMASS.

3. renewable electricity The electricity sector will pioneer renewable energy in Canada. All renewable electricity technologies are experiencing steady growth worldwide, and over the past 20–30 years, have grown up to 35% annually. By 2050, most electricity will be produced from renewable energy sources. Expected growth of electricity use in the transportation sector will further promote the use of renewable power generation technologies.

4. renewable heating In the heat supply sector, the contribution of renewable energy will increase significantly. Growth rates are expected to be similar to those of the renewable electricity sector. Fossil fuels will be increasingly replaced by more-efficient modern technologies, in particular biomass, solar collectors and geothermal. By 2050, renewable energy technologies will satisfy the majority of heating and cooling demands.

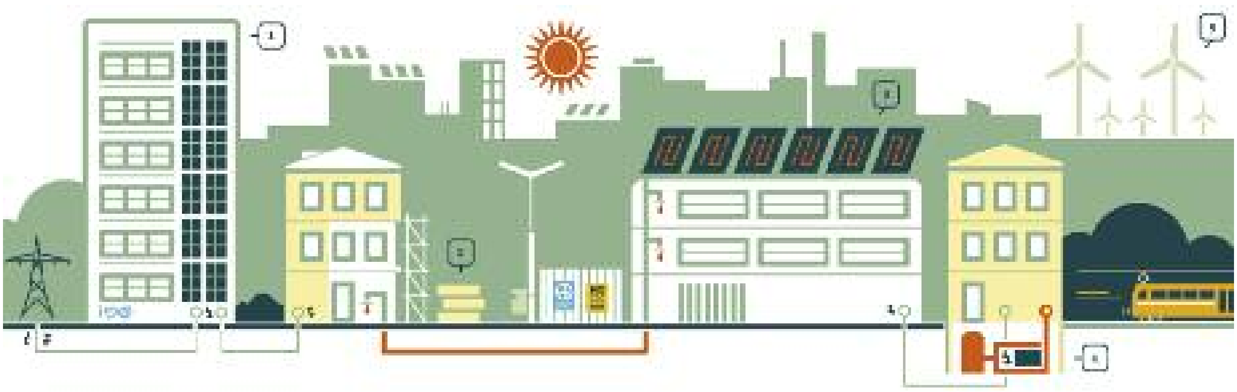
5. transport Before new technologies such as hybrid or electric cars, or new biofuels can play a substantial role in the transport sector, existing efficiency potentials must be exploited. In the Energy [R]evolution scenario, biomass is primarily committed to stationary applications; the use of biofuels for transport is limited by the availability of sustainably grown biomass.[66] Electric vehicles will play an even more important role in improving energy efficiency in transport and substituting for fossil fuels.

Overall, for renewable energy sources to achieve economically attractive growth, a balanced and timely mobilization of all technologies is essential. Such a mobilization depends on resource availability, potential for cost reduction, and technological maturity. In addition to technology-driven solutions, lifestyle changes—like simply driving less and using public transport—have a huge potential to reduce greenhouse gas emissions.

figure 3.1: a decentralized energy future

EXISTING TECHNOLOGIES, APPLIED IN A DECENTRALIZED WAY AND COMBINED WITH EFFICIENCY MEASURES AND ZERO EMISSION DEVELOPMENTS, CAN DELIVER LOW-CARBON COMMUNITIES, AS ILLUSTRATED HERE. POWER IS GENERATED USING EFFICIENT COGENERATION TECHNOLOGIES PRODUCING BOTH HEAT (AND SOMETIMES COOLING) PLUS ELECTRICITY, DISTRIBUTED VIA LOCAL NETWORKS. THIS SUPPLEMENTS THE ENERGY PRODUCED FROM BUILDING-INTEGRATED GENERATION. ENERGY SOLUTIONS COME FROM LOCAL OPPORTUNITIES AT BOTH A SMALL AND COMMUNITY SCALE. THE TOWN SHOWN HERE MAKES USE OF – AMONG OTHERS – WIND, BIOMASS AND HYDRO RESOURCES. NATURAL GAS, WHERE NEEDED, CAN BE DEPLOYED IN A HIGHLY EFFICIENT MANNER.

city



1. **PHOTOVOLTAIC, SOLAR FAÇADES** WILL BE A DECORATIVE ELEMENT ON OFFICE AND APARTMENT BUILDINGS. PHOTOVOLTAIC SYSTEMS WILL BECOME MORE PRICE-COMPETITIVE AND IMPROVED DESIGN WILL ENABLE ARCHITECTS TO USE THEM MORE WIDELY.
2. **RENOVATION CAN CUT ENERGY CONSUMPTION OF OLD BUILDINGS** BY AS MUCH AS 80%—WITH IMPROVED HEAT INSULATION, MORE EFFICIENT WINDOWS AND MODERN VENTILATION SYSTEMS.
3. **SOLAR THERMAL COLLECTORS** CAN PROVIDE WATER AND SPACE HEATING FOR INDIVIDUAL BUILDINGS OR THE DISTRICT.
4. **COMBINED HEAT AND POWER (CHP) STATIONS** WILL COME IN A VARIETY OF SIZES—FITTING THE CELLAR OF A HOUSE OR SUPPLYING WHOLE BUILDING COMPLEXES OR APARTMENT BLOCKS WITH POWER AND WARMTH WITHOUT TRANSMISSION LOSSES.
5. **CLEAN ELECTRICITY** FOR CITIES WILL ALSO COME FROM OFFSHORE WIND FARMS AND SOLAR POWER STATIONS.

reference
66 SEE CHAPTER 4, THE GLOBAL POTENTIAL FOR SUSTAINABLE BIOMASS.

figure 3.2: **centralized energy infrastructures waste more than two thirds of their energy**

61.5 units LOST THROUGH INEFFICIENT GENERATION AND HEAT WASTAGE

3.5 units LOST THROUGH TRANSMISSION AND DISTRIBUTION

13 units WASTED THROUGH INEFFICIENT END USE

100 units >> ENERGY WITHIN FOSSIL FUEL

38.5 units >> OF ENERGY FED TO NATIONAL GRID

35 units >> OF ENERGY SUPPLIED

22 units OF ENERGY ACTUALLY UTILISED

optimized integration of renewable energy

Modification of the energy system will be necessary to accommodate the significantly higher shares of renewable energy expected under the Energy [R]evolution scenario. This is not unlike the 1950s and 1960s, when Canada experienced unprecedented growth in the energy sector. Canada built large centralized coal and nuclear power plants, while promoting the wasteful use of electricity for space and water heating.

A number of developed countries have demonstrated that it is possible to smoothly integrate a large proportion of decentralized energy, including variable sources such as wind. For example, Denmark has the highest percentage of CHP and wind power in Europe. With strong political support for renewable energy, 50% of electricity and 80% of district heat in Denmark is now supplied by CHP. Wind power contributes more than 18 percent of Danish electricity demand, and electricity generation from CHP and wind occasionally exceeds demand. Grid stability is managed by regulating the output of large power stations, as well as through energy imports and exports. A three-tier tariff system enables power generation balancing from decentralized power plants that provide daily electricity consumption.

It is important to optimize the energy system through intelligent management by both producers and consumers, by an appropriate mix of power stations and through new systems for storing electricity.

1. **appropriate power station mix** The right combination of power sources is essential to implement the Energy [R]evolution scenario in Canada. Modern gas power stations, unlike coal or nuclear power stations, are not only highly efficient but easier to regulate for fluctuating energy supply into the grid. Coal and nuclear power stations have lower fuel and operating costs, but higher capital costs. Coal and nuclear power stations must run around the clock at "base load" in order to earn back their investment. Compared to natural gas plants, they take longer to start up and shut down, and their output is more difficult to adjust. Gas power stations have lower capital cost and are profitable even at low output, making them suitable to balance out the variations in energy supply from renewable sources.

By contrast, renewable electricity generation systems can also be involved in supply optimization. Wind farms, for example, can be temporarily switched off when too much power is available on the network or scaled down incrementally by adjusting the angle of the turbines.

2. **load management** Electricity demand can be managed by providing consumers with financial incentives to reduce or shut off their supply at periods of peak consumption. Control technology can be used to manage the arrangement, and is already commonly used for large industrial customers. For example, a Norwegian power supplier even sends private household customers a text message with a signal to shut down during peak times. Each household can decide in advance whether or not they want to participate. In Germany, experiments are being conducted with time-flexible tariffs so that washing machines operate at night and refrigerators turn off temporarily during periods of high demand.

This type of load management has been simplified by advances in communications technology. For example, Italy installed 30 million smart meters to allow remote meter-reading and control of consumer and service information. Many household electrical products or systems, such as refrigerators, dishwashers, washing machines, storage heaters, water pumps and air conditioning, can be managed either by temporary shut-off or by rescheduling their time of operation, thus freeing up electricity supply for other uses.

image GREENPEACE DONATES A SOLAR POWER SYSTEM TO A COASTAL VILLAGE IN ACEH, INDONESIA, ONE OF THE WORST-HIT AREAS BY THE TSUNAMI IN DECEMBER 2004. IN COOPERATION WITH UPLINK, A LOCAL DEVELOPMENT NGO, GREENPEACE OFFERED ITS EXPERTISE ON ENERGY EFFICIENCY AND RENEWABLE ENERGY AND INSTALLED RENEWABLE ENERGY GENERATORS FOR ONE OF THE BADLY HIT VILLAGES BY THE TSUNAMI.

3. energy storage Another method of balancing out electricity supply and demand is through intermediate storage. Intermediate storage can be decentralized, for example by the use of batteries, or centralized. To date, pumped-storage hydro power stations are most often used to store large amounts of electric power. In a pumped-storage system, energy from power generation is used to fill a reservoir then allowed to flow back when required, driving turbines and generating electricity. Intermediate storage already provides an important contribution to energy security, and 280 pumped-storage plants exist worldwide.

In the long term, other storage solutions are needed. One promising solution is the use of compressed air. In this storage system, electricity is used to compress air into deep salt domes 600 metres underground and at pressures of up to 70 bar. When electricity demand peaks, the compressed air is allowed to flow back out of the cavern and drive a turbine. Although this system, known as CAES (compressed air energy storage) currently still requires fossil fuel auxiliary power, a so-called "adiabatic" plant is being developed which does not require fossil fuel. To achieve this, the heat from the compressed air is intermediately stored in a giant heat store. Such a power station can achieve a storage efficiency of 70%. Most exciting, paired with these energy storage technologies, renewable technologies have the potential to become truly clean, renewable base-load power.

4. forecasting The forecasting of renewable electricity generation is also continually improving. Regulating supply is particularly expensive when it has to be found at short notice. However, prediction techniques for wind generation have become considerably more accurate in recent years and are still being improved. The demand for balancing supply will therefore decrease in the future.

5. the "virtual power station"[67] The rapid development of information technologies is helping to pave the way for a decentralized energy supply based on CHP plants, renewable energy systems and conventional power stations. Manufacturers of small CHP plants already offer Internet interfaces which enable remote control of the system. It is now possible for individual householders to control their electricity and heat usage so that expensive electricity drawn from the grid can be minimized—and electricity demand stabilized. This is part of the trend towards the "smart house," where a mini-CHP plant becomes a day-to-day energy management center.

We can go one step further than this with a "virtual power station." "Virtual" does not mean that real energy isn't generated. Instead, the hub of the power station is a control unit which processes data from many decentralized power stations, compares them with demand predictions, generation and weather conditions, retrieves available power market prices, and then intelligently optimizes the overall power station activity. Some public utilities already use such systems to integrate CHP plants, wind farms, photovoltaic systems and other power plants. The virtual power station can also connect consumers directly to the power management process.

"it is important to optimize the energy system through intelligent management by both producers and consumers..."

references
67 GERMAN MINISTRY FOR THE ENVIRONMENT, NATURE CONSERVATION AND NUCLEAR SAFETY, *RENEWABLE ENERGIES: INNOVATIONS FOR THE FUTURE* (2006), AVAILABLE AT: HTTP://WWW.BMU.DE/FILES/ENGLISH/RENEWABLE_ENERGY/DOWNLOADS/APPLICATION/PDF/BROSCHUERE_EE_INNOVATION_ENG.PDF.

how the energy [r]evolution scenario was created

To achieve the dramatic emissions cuts needed to avoid catastrophic climate change—at least 80% in Canada and other industrial countries by 2050—will require a massive uptake of renewable energy. In Canada, renewable energy targets must be greatly expanded both to substitute for fossil fuel and nuclear generation and to create the necessary economy of scale for global expansion. Within the Energy [R]evolution scenario we assume that modern renewable energy sources, such as solar collectors, solar cookers and modern forms of bio-energy, will replace inefficient, traditional biomass use.

Moving from principles to action for a secure, clean energy supply and climate change mitigation requires a long-term perspective. Energy infrastructure takes time to build and new energy technologies take time to develop. Policy shifts often need many years to have an effect. Therefore, any analysis that seeks to tackle energy and environmental issues needs to look ahead at least half a century.

Scenarios are important in describing possible development paths, to give decision-makers an overview of future perspectives and to indicate how far they can shape the future energy system. Two different scenarios are used here to characterize the wide range of possible paths for the future energy supply system: a reference scenario, reflecting a continuation of current trends and policies, and the Energy [R]evolution scenario, designed to achieve a set of dedicated environmental policy targets.

The **reference scenario** is based on the reference scenario published by the International Energy Agency in World Energy Outlook 2007 (WEO 2007).[17] The reference scenario only takes existing international energy and environmental policies into account. The assumptions include, for example, continuing progress in electricity and gas market reforms, the liberalization of cross-border energy trade and new policies designed to combat environmental pollution. The reference scenario does not include additional policies to reduce greenhouse gas emissions. As the IEA reference scenario only forecasts energy growth to 2030, Greenpeace extended the reference scenario to 2050 by extrapolating its key macroeconomic indicators. This provides a baseline for comparison with the Energy [R]evolution scenario.

The **energy [r]evolution scenario** has a key target for the reduction of worldwide carbon dioxide emissions down to a level of around 10 gigatonnes per year by 2050 to reduce the risk that global temperatures do not rise more than 2° C from pre-industrial levels. A second objective is a global phase-out of nuclear energy. To achieve these goals, the Energy [R]evolution scenario proposes an ambitious plan to fully exploit the large potential for energy efficiency. At the same time, all cost-effective renewable energy sources are used for heat, electricity generation, and the production of biofuels. The general framework parameters for population and GDP growth remain unchanged from the reference scenario.

references
17 INTERNATIONAL ENERGY AGENCY, *WORLD ENERGY OUTLOOK 2007* (2007). AVAILABLE AT: HTTP://WWW.WORLDENERGYOUTLOOK.ORG/2007.ASP.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scenario principles in a nutshell

- Smart energy consumption, generation and distribution
- Decentralized energy production
- Maximum use of locally available, environmentally friendly fuels

image THE PS10 CONCENTRATING SOLAR TOWER PLANT USES 624 LARGE MOVABLE MIRRORS CALLED HELIOSTATS. THE MIRRORS CONCENTRATE THE SUN'S RAYS TO THE TOP OF A 115 METER (377 FOOT)-HIGH TOWER WHERE A SOLAR RECEIVER AND A STEAM TURBINE ARE LOCATED. THE TURBINE DRIVES A GENERATOR, PRODUCING ELECTRICITY. SEVILLA, SPAIN.

image GROUP OF YOUNG PEOPLE TOUCHING SOLAR PANELS IN BRAZIL.

© GP/FLAVIO CANNALONGA

These scenarios do not claim to predict the future; they simply describe two potential development paths out of the broad range of possible "futures." The Energy [R]evolution scenario is a roadmap for the options available to create a sustainable energy system.

scenario background The scenarios in this report were jointly commissioned by Greenpeace and the European Renewable Energy Council from the Institute of Technical Thermodynamics, part of the German Aerospace Center (DLR). The supply scenarios were calculated using the MESAP/PlaNet simulation model used for the previous Energy [R]evolution study.[68] Energy demand projections were developed by Ecofys Netherlands, based on an analysis of the future potential for energy efficiency measures. The biomass potential, using Greenpeace sustainability criteria, has been developed especially for this scenario by the German Biomass Research Centre. The future development pathway for car technologies is based on a special report produced in 2008 by the Institute of Vehicle Concepts, DLR for Greenpeace International.

The aim of the Ecofys study was to develop a low-energy demand scenario for the period 2005 to 2050 for the IEA regions, as defined in the World Energy Outlook report series. Calculations were made for each decade from 2010 onwards. Energy demand was split up into electricity and fuels. The Ecofys study included industry, transport, and consumer (including households and services) sectors.

Under the low-energy demand scenario, worldwide final energy demand is reduced by 38% in 2050 in comparison to the reference scenario, resulting in a final energy demand of 350 EJ (exajoules). The energy savings are equally distributed over the three sectors of industry, transport and other uses. The most important energy saving methods are efficient passenger and freight transport and improved heat insulation and building design.

The Institute of Vehicle Concepts (IVC) in Stuttgart, Germany, developed a global scenario for cars, covering ten world regions. The goal was to produce a demanding but feasible scenario to lower global car CO_2 emissions within the context of the Energy [R]evolution scenario. The IVC approach takes into account a vast range of technical measures to reduce vehicle energy consumption, but also considers the dramatic increase in vehicle ownership and annual mileage taking place in developing countries. In addition, the IVC examined vehicle technology, alternative fuels, changes in sales of different vehicle sizes (segment split) and changes in usage and driving distances (modal split).

The scenario assumes that a large share of renewable electricity will be available in the future. A combination of ambitious efforts towards higher efficiency in vehicle technologies, a major switch to grid-connected electric vehicles and incentives for vehicle users to save carbon dioxide led to the conclusion that it is possible to reduce CO_2 emissions from "well-to-wheel" by 2050 by roughly 25%[69] compared to 1990 and 40% compared to 2005.

Under the scenario, by 2050, 60% of the energy used in transport will still come from fossil fuels, mainly gasoline and diesel. Renewable electricity will provide 25% of transport energy needs, bio-fuels 13%, and hydrogen will provide 2% by 2050. However, total global energy consumption in 2050 will be similar to 2005 consumption levels, in spite of enormous increases in fuel use in some regions of the world.

The peak in global CO_2 emissions from transport occurs between 2010 and 2015. From 2010 onwards, new legislation in North America and Europe will help break the upwards trend in emissions. From 2020 onwards, the effect of introducing grid-connected electric cars can be clearly seen.

"moving from principles to action.."

references
68 GREENPEACE INTERNATIONAL, *ENERGY [R]EVOLUTION: A SUSTAINABLE WORLD ENERGY OUTLOOK* (2007).
69 THERE IS NO RELIABLE NUMBER AVAILABLE FOR GLOBAL LDV EMISSIONS IN 1990, SO A ROUGH ESTIMATE HAS BEEN MADE.

the world's energy resources

4

4

"the issue of security of supply is now at the top of the energy policy agenda."

GREENPEACE INTERNATIONAL
CLIMATE CAMPAIGN

The issue of energy security is now at the top of the policy agendas of many industrial countries. Concern is focused both on price stability and the security of physical supply. At present, about 80% of global energy demand is met by fossil fuels. There is an unrelenting increase in energy demand, yet finite energy sources. This chapter, based partly on the report *Plugging the Gap*,[70] examines the potential sources of energy to meet the world's growing energy needs.

oil

Oil is the lifeblood of the modern global economy, as the effects of the supply disruptions of the 1970s made clear. Oil provides 36% of the world's energy needs and is the fuel employed almost exclusively for essential uses such as transportation. However, a passionate debate has developed over the ability of supply to meet increasing consumption, a debate obscured by poor information and stirred by unstable oil prices.

the reserves chaos

Public data about oil and gas reserves is strikingly inconsistent and potentially unreliable for legal, commercial, historical and sometimes political reasons. The most widely available and quoted figures, those from industry journals like *Oil & Gas Journal* and *World Oil*, have limited value as they report the reserve figures provided by companies and governments without analysis or verification. Moreover, as there is no agreed-upon definition of reserves or standard reporting practice, these figures vary widely in concept and magnitude. Confusing terminology ("proved," "probable," "possible," "recoverable," "reasonable certainty") only adds to the problem.

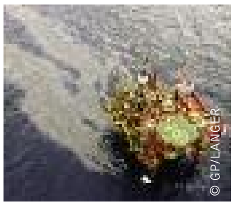
Historically, private oil companies have consistently underestimated their reserves to comply with conservative stock exchange rules and to provide a conservative resource estimate in the marketplace. When an oil discovery is made, often just a portion of the geologist's estimate of recoverable resources is reported and subsequent reporting may increase the reserves from that same oil field over time. On the other hand, national oil companies, mostly represented by the Organization of Petroleum Exporting Countries (OPEC), are not subject to any reporting standards. In the late 1980s, OPEC countries blatantly overstated their reserves while competing for production quotas, which were allocated as a proportion of the reserves. Although some revision was needed after the companies were nationalized, between 1985 and 1990, OPEC countries increased their joint reserves by 82%. Not only were these dubious revisions never corrected, but many of these countries have reported untouched reserves for years, even if no sizeable discoveries were made and production continued at the same pace. Additionally, the former Soviet Union's oil and gas reserves have been overestimated by about 30% because the original assessments were later misinterpreted.

While private companies are now becoming more realistic about the extent of their resources, the OPEC countries hold by far the majority of the reported reserves, and information on their resources is as unsatisfactory as ever. In brief, these information sources should be treated with considerable caution. To fairly estimate the world's oil resources, a regional assessment of the mean backdated (i.e., "technical") discoveries would need to be performed.

references
70 GLOBAL WIND ENERGY COUNCIL (GWEC) AND RENEWABLE ENERGY SYSTEMS LIMITED (RES), *PLUGGING THE GAP—A SURVEY OF WORLD FUEL RESOURCES AND THEIR IMPACT OF THE DEVELOPMENT OF WIND ENERGY* (2006). AVAILABLE AT: HTTP://WWW.GWEC.NET/UPLOADS/MEDIA/RESGWEC-_PLUGGING_THE_GAP_REPORT_01.09.06.PDF.

image PLATFORM/OIL RIG DUNLIN IN THE NORTH SEA, SHOWING OIL POLLUTION.

image ON A LINFEN STREET, TWO MEN LOAD UP A CART WITH COAL THAT WILL BE USED FOR COOKING. LINFEN, A CITY OF ABOUT 4.3 MILLION, IS ONE OF THE MOST POLLUTED CITIES IN THE WORLD. CHINA'S INCREASINGLY POLLUTED ENVIRONMENT IS LARGELY A RESULT OF THE COUNTRY'S RAPID DEVELOPMENT AND CONSEQUENTLY A LARGE INCREASE IN PRIMARY ENERGY CONSUMPTION, WHICH IS ALMOST ENTIRELY PRODUCED BY BURNING COAL.



natural gas

Natural gas has been the fastest-growing fossil energy source in Canada in the last two decades, because it is a relatively clean fossil fuel as compared to coal or oil. It comprises an increasing share among electricity generation fuels. Canada's production of natural gas is third in the world, after Russia and the U.S.[71] Gas is generally regarded as an abundant resource, and public concerns about depletion are limited to oil, even though few in-depth studies address the subject. Gas resources are very concentrated, and a few massive fields make up most of the world's reserves. The largest gas field in the world[72] holds 15% of the "ultimate recoverable resources" (URR), compared to 6% for oil. Unfortunately, information about gas resources suffers from the same bad practices as oil data, because gas mostly comes from the same geological formations, and the same stakeholders are involved.

Most reserves are initially understated and then gradually revised upwards, giving an optimistic impression of growth. By contrast, Russia's reserves, the largest in the world, are considered to have been overestimated by about 30 percent. Owing to geological similarities, gas follows the same depletion dynamic as oil, and thus the same discovery and production cycles. In fact, existing data for gas is of worse quality than for oil, with ambiguities arising over the amount produced partly because flared and vented gas is not always accounted for. As opposed to published reserves, the technical ones have been almost constant since 1980 because discoveries have roughly matched production.

coal

Coal was the world's largest source of energy until it was overtaken by oil in the 1960s. Today, coal supplies almost one-quarter of the world's energy. Despite being the most abundant of fossil fuels, the continued use of coal is currently threatened by environmental concerns. Coal is abundant and more equally distributed throughout the world than oil and gas. Global recoverable reserves are the largest of all fossil fuels, and most countries have at least some. Moreover, existing and prospective big energy consumers like the U.S., China and India are self-sufficient in coal and will be for the foreseeable future. Coal has been exploited on a large scale for two centuries, so both the product and the available resources are well known, and no substantial new deposits are expected to be discovered. In the future, the world will likely consume 20% of its current reserves by 2030 and 40% by 2050. Therefore, even if current trends are maintained, coal supplies would still last several hundred years. Canada produced about 34 megatonnes of hard coal and about 35 megatonnes of brown coal in 2000. Most of Canada's coal is mined in the western provinces of British Columbia, Alberta and Saskatchewan.[73]

table 4.1: overview of fossil fuel reserves and resources

RESERVES, RESOURCES AND ADDITIONAL OCCURRENCES OF FOSSIL ENERGY CARRIERS ACCORDING TO DIFFERENT AUTHORS. **C** CONVENTIONAL (PETROLEUM WITH A CERTAIN DENSITY, FREE NATURAL GAS, PETROLEUM GAS), **NC** NON-CONVENTIONAL (HEAVY FUEL OIL, VERY HEAVY OILS, TAR SANDS AND OIL SHALE, GAS IN COAL SEAMS, AQUIFER GAS, NATURAL GAS IN TIGHT FORMATIONS, GAS HYDRATES). THE PRESENCE OF ADDITIONAL OCCURRENCES IS ASSUMED BASED ON GEOLOGICAL CONDITIONS, BUT THEIR POTENTIAL FOR ECONOMIC RECOVERY IS CURRENTLY VERY UNCERTAIN. IN COMPARISON: IN 1998, THE GLOBAL PRIMARY ENERGY DEMAND WAS 402EJ (UNDP ET AL., 2000).

ENERGY CARRIER		BROWN, 2002 EJ	IEA, 2002c EJ	IPCC, 2001a	EJ	NAKICENOVIC ET AL., 2000	EJ	UNDP ET AL., 2000	EJ	BGR, 1998	EJ
Gas	reserves	5,600	6,200	c	5,400	c	5,900	c	5,500	c	5,300
				nc	8,000	nc	8,000	nc	9,400	nc	100
	resources	9,400	11,100	c	11,700	c	11,700	c	11,100	c	7,800
				nc	10,800	nc	10,800	nc	23,800	nc[a)]	111,900
	additional occurrences				796,000		799,700		930,000		
Oil	reserves	5,800	5,700	c	5,900	c	6,300	c	6,000	c	6,700
				nc	6,600	nc	8,100	nc	5,100	nc	5,900
	resources	10,200	13,400	c	7,500	c	6,100	c	6,100	c	3,300
				nc	15,500	nc	13,900	nc	15,200	nc	25,200
	additional occurrences				61,000		79,500		45,000		
Coal	reserves	23,600	22,500		42,000		25,400		20,700		16,300
	resources	26,000	165,000		100,000		117,000		179,000		179,000
	additional occurrences				121,000		125,600				
Total	resource (reserves + resources)	**180,600**	**223,900**		**212,200**		**213,200**		**281,900**		**361,500**
Total	occurrence				**1,204,200**		**1,218,000**		**1,256,000**		

source SEE TABLE FOR INDIVIDUAL SOURCES.
[a)] INCLUDING GAS HYDRATES.

references
71 INTERNATIONAL ENERGY AGENCY, *ENERGY POLICIES OF IEA COUNTRIES: CANADA 2004 REVIEW*, OECD/IEA, 2004, P. 93.
72 THE NORTH FIELD IN QATAR.
73 INTERNATIONAL ENERGY AGENCY, *ENERGY POLICIES OF IEA COUNTRIES: CANADA 2004 REVIEW*, OECD/IEA, 2004, PP. 109–110.

nuclear

Uranium, the fuel used in nuclear power plants, is a finite resource whose economically available reserves are limited. Its distribution is almost as concentrated as oil and does not match regional consumption. Five countries—Canada, Australia, Kazakhstan, Russia and Niger—control three quarters of the world's supply. As a significant user of uranium, however, Russia's reserves will be exhausted within ten years. Canada is the largest producer of uranium in the world, with 10,000 tonnes produced in 2003.[74]

Global mining capacity will have to be nearly doubled in the next few years to meet current needs.

A joint report by the OECD Nuclear Energy Agency and the International Atomic Energy Agency estimates that all existing nuclear power plants will have used up their nuclear fuel, employing current technology, within less than 70 years.[75] Given the range of scenarios for the worldwide development of nuclear power, it is likely that uranium supplies will be exhausted sometime between 2026 and 2070. This forecast includes the use of mixed oxide fuel (MOX), a mixture of uranium and plutonium.

image NUCLEAR POWER PLANT ON THE NORTH SHORE OF LAKE ONTARIO, IN PICKERING, ONTARIO, CANADA.

references
74 INTERNATIONAL ENERGY AGENCY, *ENERGY POLICIES OF IEA COUNTRIES: CANADA 2004 REVIEW,* OECD/IEA, 2004, P. 143.
75 OECD NUCLEAR ENERGY AGENCY, INTERNATIONAL ATOMIC ENERGY AGENCY, *URANIUM 2003: RESOURCES, PRODUCTION AND DEMAND*, 20TH EDITION (2004).

image SOLON AG PHOTOVOLTAICS FACILITY IN ARNSTEIN, OPERATING 1,500 HORIZONTAL AND VERTICAL SOLAR "MOVERS." LARGEST TRACKING SOLAR FACILITY IN THE WORLD. EACH "MOVER" CAN BE BOUGHT AS A PRIVATE INVESTMENT FROM THE S.A.G. SOLARSTROM AG, BAYERN, GERMANY.

image WIND ENERGY PARK NEAR DAHME. WIND TURBINE IN THE SNOW OPERATED BY VESTAS.

renewable energy

Nature offers a variety of freely available options for producing energy. Their exploitation is mainly a question of how to convert sunlight, wind, biomass or water into electricity, heat or power as efficiently, sustainably and cost-effectively as possible.

On average, the energy in the sunshine that reaches the Earth is about one kilowatt per square meter worldwide. According to the Research Association for Solar Power, power is gushing from renewable energy sources at a rate of 2,850 times more energy than is needed in the world. In one day, the sunlight which reaches the Earth produces enough energy to satisfy the world's current power requirements for eight years. Even though only a percentage of that potential is technically accessible, this is still enough to provide just under six times more power than the world currently requires.

definition of types of energy resource potential[76]

theoretical potential The theoretical potential identifies the physical upper limit of the energy available from a certain source. For solar energy, for example, this would be the total solar radiation falling on a particular surface.

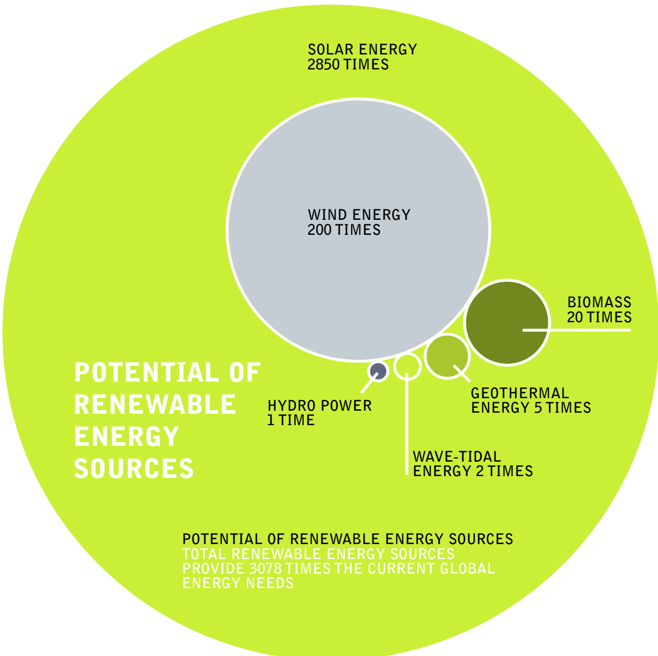
conversion potential The conversion potential is derived from the annual efficiency of the respective conversion technology. It is therefore not a strictly defined value, since the efficiency of a particular technology depends on technological progress.

technical potential The technical potential takes into account additional restrictions regarding the area that is realistically available for energy generation. Technological, structural and ecological restrictions, as well as legislative requirements, are accounted for.

economic potential The proportion of the technical potential that can be utilized economically. For biomass, for example, those quantities are included that can be exploited economically in competition with other products and land uses.

sustainable potential This limits the potential of an energy source, based on evaluation of ecological and socio-economic factors.

figure 4.1: energy resources of the world



source WBGU.

table 4.2: energy resources that are technically accessible today

(THE AMOUNT OF ENERGY THAT CAN BE ACCESSED WITH CURRENT TECHNOLOGIES SUPPLIES A TOTAL OF 5.9 TIMES THE GLOBAL DEMAND FOR ENERGY)

Sun	3.8 times
Geothermal heat	1 time
Wind	0.5 times
Biomass	0.4 times
Hydrodynamic power	0.15 times
Ocean power	0.05 times

source DR. JOACHIM NITSCH.

references
76 GERMAN ADVISORY COUNCIL ON GLOBAL CHANGE (WGBU). AVAILABLE AT: WWW.WBGU.DE.

renewable energy potential by region and technology

Based on the report *Renewable Energy Potentials* from REN 21, a global policy network,[77] the global Energy [R]evolution scenario provides a more detailed overview of renewable energy prospects by world region and technology. The table below focuses on large economies which consume 80% of the world's primary energy and produce a similar share of the world's greenhouse gas emissions.

Solar photovoltaic (PV) technology can be harnessed almost everywhere, and its technical potential is estimated at over 1,500 EJ/year, closely followed by concentrating solar thermal power (CSP). These two cannot simply be added together, however, because they would require much of the same land resources. Onshore wind potential is equally vast, with almost 400 EJ/year available beyond the future electricity consumption. The estimate for offshore wind potential (22 EJ/year) is cautious, as only wind-intensive areas on ocean shelf areas, with a relatively shallow water depth, outside shipping lines and protected areas, are included.

Various ocean or marine energy potentials also reach a similar magnitude, mostly from ocean waves. Cautious estimates reach a figure of around 50 EJ/year. The estimates for hydro and geothermal (energy generated from the Earth's natural heat) resources are well established, each having a technical potential of around 50 EJ/year. To put these figures in context, current global energy demand is around 500 EJ.

In terms of heating and cooling, using direct geothermal energy also has great potential to meet and exceed current world energy demand for heat. The potential for solar heating, including passive solar building design, is virtually limitless. However, heat is costly to transport, and one should only consider geothermal heat and solar water heating potentials which are sufficiently close to the point of consumption. Passive solar technology, which contributes enormously to the provision of heating services, is not considered as a supply source in the Energy [R]evolution scenario, but as an efficiency factor to be taken into account in energy demand forecasts.

table 4.3: technical renewable energy potential by region

(EXCLUDING BIO-ENERGY)

	SOLAR CSP	SOLAR PV	HYDRO POWER	WIND ON-SHORE	WIND OFF-SHORE	OCEAN POWER	GEO-THERMAL ELECTRIC	GEO-THERMAL DIRECT USES	SOLAR WATER HEATING	TOTAL
	ELECTRICITY [EJ/YEAR]							HEATING [EJ/YEAR]		
Canada, Mexico, USA	21	72	4	156	2	68	5	626	23	976
Latin America	59	131	13	40	5	32	11	836	12	1,139
OECD Europe*	1	13	2	16	5	20	2	203	23	284
Non-OECD Europe & Transition Economies	25	120	5	67	4	27	6	667	6	926
Africa & Middle East	679	863	9	33	1	19	5	1,217	12	2,838
East & South Asia	22	254	14	10	3	103	12	1,080	45	1,543
Oceania	187	239	1	57	3	51	4	328	2	872
World	**992**	**1,693**	**47**	**379**	**22**	**321**	**45**	**4,955**	**123**	**8,578**

source REN21.
* OECD-EUROPE COMPRISES ALL EUROPEAN UNION MEMBER COUNTRIES OF THE OECD, I.E., COUNTRIES IN EU15 PLUS THE CZECH REPUBLIC, HUNGARY, ICELAND, NORWAY, POLAND, SLOVAK REPUBLIC, SWITZERLAND, TURKEY.

references

77 REN 21, *RENEWABLE ENERGY POTENTIALS: OPPORTUNITIES FOR THE RAPID DEPLOYMENT OF RENEWABLE ENERGY IN LARGE ENERGY ECONOMIES* (2007). AVAILABLE AT: HTTP://WWW.REN21.NET/PDF/RENEWABLE_ENERGY_DEPLOYMENT_POTENTIALS_IN_LARGE_ECONOMIES.PDF.

image THE BIOENERGY VILLAGE OF JUEHNDE, WHICH WAS THE FIRST COMMUNITY IN GERMANY TO PRODUCE ALL ITS ENERGY NEEDED FOR HEATING AND ELECTRICITY, WITH CO_2-NEUTRAL BIOMASS.

image A NEWLY DEFORESTED AREA WHICH HAS BEEN CLEARED FOR AGRICULTURAL EXPANSION IN THE AMAZON, BRAZIL.

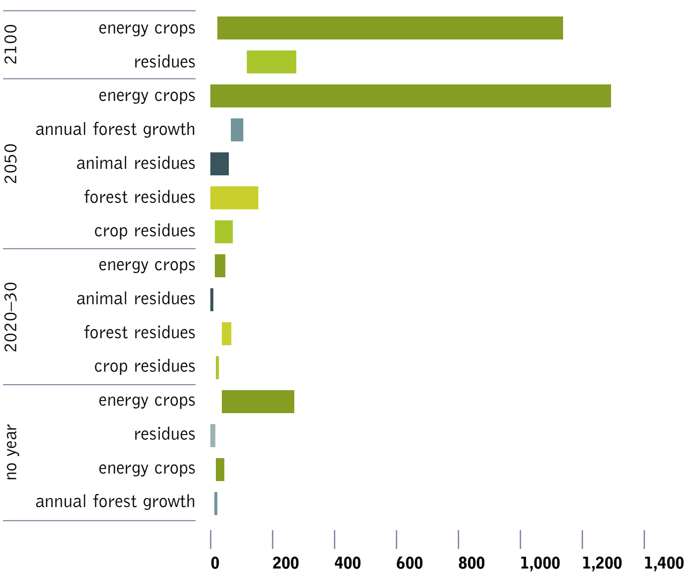
the global potential for sustainable biomass

As part of background research for the Energy [R]evolution scenario, Greenpeace commissioned the German Biomass Research Centre, the former Institute for Energy and Environment, to investigate the worldwide potential for energy crops in different scenarios up to 2050. In addition, information has been compiled from scientific studies of the worldwide potential and from data derived from state-of-the-art remote sensing techniques such as satellite images.

Various studies have looked historically at the potential for bioenergy and come up with widely differing results. Comparison between them is difficult because they use different definitions of the various biomass resource fractions. This problem is particularly significant in relation to forest-derived biomass. Most research has focused almost exclusively on energy crops, as their development is considered to be more significant for satisfying the demand for bio-energy. The result is that the potential for using forest residues (wood left over after harvesting) is often underestimated.

Data from 18 studies were examined, with a concentration on those studies which report the potential for biomass residues. Among these there were ten comprehensive assessments with more or less detailed documentation of the methodology. The majority focus is on the long-term potential for 2050 and 2100. Little information is available for 2020 and 2030. Most of the studies were published within the last ten years. Figure 4.2 shows the variations in potential, by biomass type, from the different studies.

figure 4.2: a comparison of energy potential from biomass sources

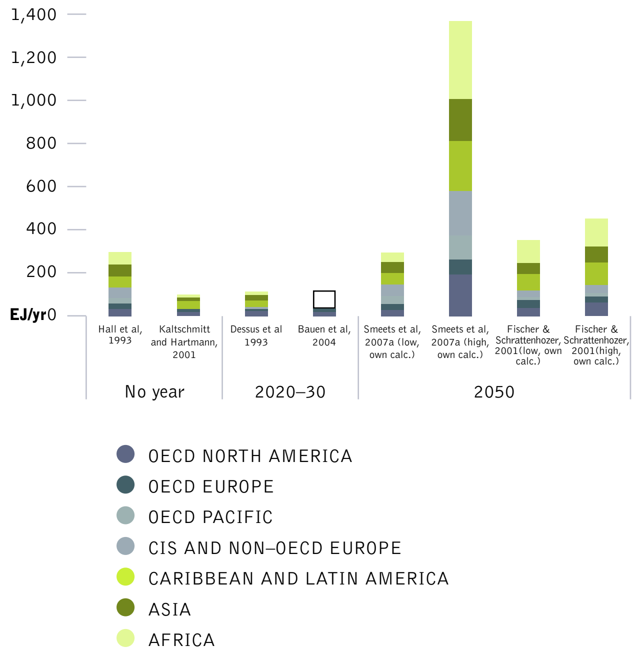


source GERMAN BIOMASS RESEARCH CENTRE (DBFZ).

Looking at the contribution of individual resources to the total biomass potential, the majority of studies agree that the most promising resource is energy crops from dedicated plantations. Only six give a regional breakdown, however, and only a few quantify all types of residues separately. Quantifying the potential of minor fractions, such as animal residues and organic wastes, is difficult, as the data are relatively poor.

figure 4.3: bioenergy potential analysis from different authors

("EFFICIENCY" = REDUCTION COMPARED TO THE REFERENCE SCENARIO)



source GERMAN BIOMASS RESEARCH CENTRE (DBFZ).

potential of energy crops

Apart from the utilization of biomass from waste, the cultivation of energy crops in agricultural production systems is of greatest significance. The technical potential for growing energy crops was calculated on the assumption that demand for food takes priority. As a first step the demand for arable and grassland for food production has been calculated for each of 133 countries, for different scenarios. These scenarios are:

- Business-as-usual (BAU) scenario: Present agricultural activity continues for the foreseeable future
- Basic scenario: No forest clearing; reduced use of fallow areas for agriculture
- Sub-scenario 1: Basic scenario plus expanded ecological protection areas and reduced crop yields
- Sub-scenario 2: Basic scenario plus food consumption reduced in industrialized countries
- Sub-scenario 3: Combination of sub-scenarios 1 and 2

The results of this exercise show that the availability of biomass resources is not only driven by the effect on global food supply but also by the effect on natural resources, and the need for conservation. The assessment of future biomass energy potential is only the starting point of a discussion about the integration of bioenergy into a renewable energy system.

In a next step the surpluses of agricultural areas were classified either as arable land or grassland. On grassland, hay and grass silage are produced, while on arable land fodder silage and short rotation coppice (such as fast-growing willow or poplar) are cultivated. Silage of green fodder and grass are assumed to be used for biogas production, wood from SRC and hay from grasslands for the production of heat, electricity and synthetic fuels. Country-specific yield variations were also taken into consideration.

Global biomass potential from energy crops in 2050 falls within a range from 6 EJ in Sub-scenario 1 up to 97 EJ in the BAU scenario.

The best example of a country which would see a very different future under these scenarios in 2050 is Brazil. Under the BAU scenario large agricultural areas would be released by deforestation, whereas in the Basic and Sub 1 scenarios this would be forbidden, and no agricultural areas would be available for energy crops. By contrast a high potential would be available under Sub-scenario 2 as a consequence of reduced meat consumption. Because of their high populations and relatively small agricultural areas, no surplus land is available for energy crop production in Central America, Asia and Africa. The EU, North America and Australia, however, have relatively stable potentials.

The total global biomass potential (energy crops and residues) therefore ranges in 2020 from 66 EJ (Sub-scenario 1) up to 110 EJ (Sub-scenario 2) and in 2050 from 94 EJ (Sub-scenario 1) to 184 EJ (BAU scenario). These numbers are conservative and include a level of uncertainty, especially for 2050. The reasons for this uncertainty are the potential effects of climate change, possible changes in the worldwide political and economic situation, a higher yield as a result of changed agricultural techniques and/or faster development in plant breeding .

figure 4.4: world-wide energy crop potentials in different scenarios

source GERMAN BIOMASS RESEARCH CENTRE (DBFZ).

projections of future energy demand and cost

5

"most renewable energy technologies will be able to reduce their investment costs 30 to 70% by 2020..."

GREENPEACE INTERNATIONAL
CLIMATE CAMPAIGN

This chapter summarizes the projections for population growth, economic growth, and the costs of various energy sources between now and 2050. These underlying assumptions are critical to the overall scenario.

population projections

An important underlying factor in the Energy [R]evolution Scenario is future population growth. Population growth affects the size and composition of energy demand, directly and through its impact on economic growth and development. *World Energy Outlook 2007* (WEO 2007) uses the United Nations Development Programme (UNDP) projections for population development. This study uses the most recent population projections to 2050 from UNDP.[78]

The world's population is expected to grow by 0.77% on average over the period 2005 to 2050, from 6.5 billion people in 2005 to more than 9.1 billion in 2050. Population growth will slow over the projection period, from 1.2% during 2005–2010 to 0.4% during 2040–2050. However, the updated projections show an increase in population of almost 300 million compared to the previous edition. This will further increase the demand for energy. The population of the developing regions will continue to grow most rapidly. The transition economies will face a continuous decline, followed after a short while by the OECD Pacific countries. OECD Europe and OECD North America are expected to maintain their population, with a peak in around 2020/2030 and a slight decline afterwards. The share of the population living in today's non-OECD countries will increase from the current 82% to 86% in 2050. China's contribution to world population will drop from 20% today to 15% in 2050. Africa will remain the region with the highest growth rate, leading to a share of 21% of world population in 2050. Satisfying the energy needs of a growing population in the developing regions of the world in an environmentally friendly manner is a key challenge for achieving a global sustainable energy supply.

economic growth projections

Economic growth is a key driver for energy demand. Since 1971, each 1% increase in global gross domestic product (GDP) has been accompanied by a 0.6% increase in primary energy consumption. The decoupling of energy demand and GDP growth is therefore a prerequisite for reducing demand in the future. Most global energy and economic models constructed in the past have relied on market exchange rates to place countries in a common currency for estimation and calibration. This approach has been the subject of considerable discussion in recent years, and the alternative of purchasing power parity (PPP) exchange rates has been proposed. Purchasing power parities compare the costs in different currencies of a fixed basket of traded and non-traded goods and services and yield a widely-based measure of the standard of living. This is important in analyzing the main drivers of energy demand or for comparing energy intensities among countries.

Although PPP assessments are still relatively imprecise compared to statistics based on national income, product trade and national price indexes, they are considered to provide a better basis for global scenario development.[79] Thus all data on economic development in WEO 2007 refers to purchasing power–adjusted GDP. However, as WEO 2007 only covers the time period up to 2030, the projections for 2030–2050 are based on our own estimates.

GDP growth in all regions is expected to slow gradually over the coming decades. World GDP is assumed to grow on average by 3.6% per year over the period 2005–2030, compared to 3.3% from 1971 to 2002, and on average by 3.3% per year over the entire modeling period. China and India are expected to grow faster than other regions, followed by developing countries in Asia, Africa and the other transition economies. The Chinese economy will slow as it becomes more mature, but will nonetheless become the largest in the world in PPP terms early in the 2020s. GDP in OECD Europe and OECD Pacific is assumed to grow by around 2% per year over the projection period, while economic growth in OECD North America is expected to be slightly higher. The OECD share of global PPP-adjusted GDP will decrease from 55% in 2005 to 29% in 2050.

references
78 UNITED NATIONS DEVELOPMENT PROGRAMME, POPULATION DIVISION, DEPARTMENT OF ECONOMIC AND SOCIAL AFFAIRS (UNDP), *WORLD POPULATION PROSPECTS: THE 2006 REVISION* (2007).
79 NORDHAUS, W., "ALTERNATIVE MEASURES OF OUTPUT IN GLOBAL ECONOMIC ENVIRONMENTAL MODELS: PURCHASING POWER PARITY OR MARKET EXCHANGE RATES?," *ENERGY ECONOMICS*, VOL. 29:3 (2007).

figure 5.1: relative GDP$_{PPP}$ growth, by world regions

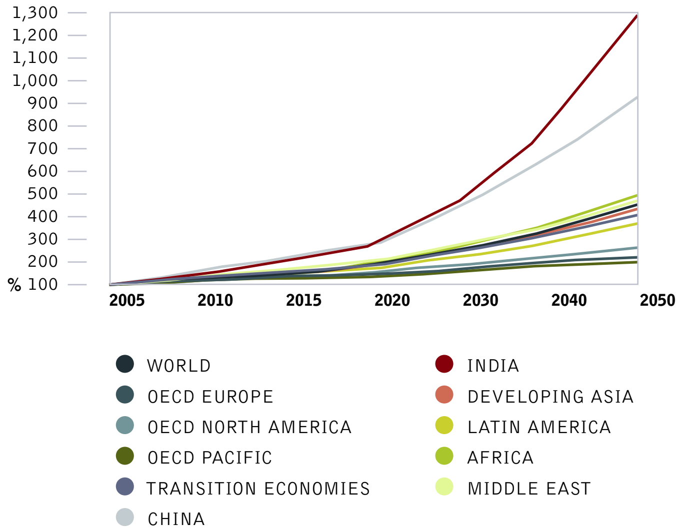
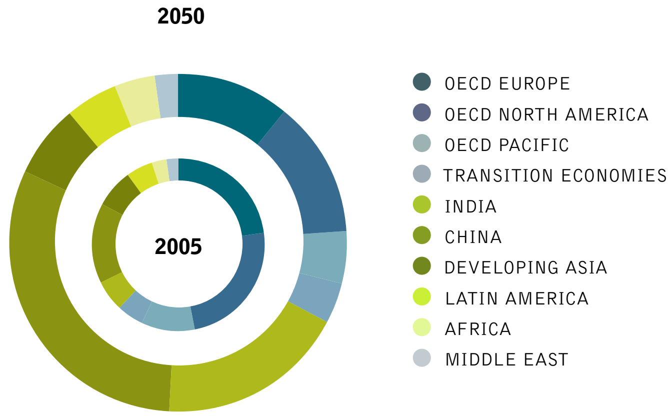


figure 5.2: development of world GDP$_{PPP}$, by regions



fossil fuel and biomass price projections

The recent dramatic fluctuations in global oil prices have resulted in rising forward price projections for fossil fuels. Under the 2004 "high oil and gas price" scenario from the European Commission, for example, oil was projected to cost just $39 per barrel(bbl) in 2030. More recent projections of oil prices in 2030 range from the IEA's US$$_{2006}$62/bbl (US$$_{2005}$60/bbl) (WEO 2007) up to US$$_{2006}$119/bbl (US$$_{2005}$115/bbl) in the "high price" scenario of the US Energy Information Administration's Annual Energy Outlook 2008.

Since the last Energy [R]evolution report was published, however, the price of oil has topped US$100/bbl (Can$135) for the first time (at the end of 2007), and in July 2008 reached a record high of more than US$140/bbl (Can$158). Although oil prices have fallen since then, the above projections might still be thought too conservative, considering long-term global trends in reserves and demand. Considering the growing global demand for oil and gas, the Energy [R]evolution projects a price development path for fossil fuels in which the price of oil reaches US$120/bbl (Can$136) by 2030 and $140/bbl (Can$158) in 2050.

As the supply of natural gas is limited by the availability of pipeline infrastructure, there is no world market price for natural gas. In most regions of the world the gas price is directly tied to the price of oil. Gas prices are assumed to increase to $20–25/GJ (Can$23–28/GJ) by 2050.

table 5.1: the growth of fuel prices

	2005	2006	2007	2010	2015	2020	2030	2040	2050
Crude oil import prices in 2005 $ per barrel	60	68	81						
IEA WEO 2007 / ETP 2008				65	63		68		72
US EIA 2008 "Reference"				81		66	78		
US EIA 2008 "High Price"				87		112	131		
Energy [R]evolution 2008				114	119	125	136	148	159
Gas import prices in 2005 $ per gigajoule (GJ)	2000	2005	2006						
IEA WEO 2007/ ETP 2008									
US imports	5.2		8.4	8.5	8.5		9.1		9.3
Europe imports	3.8		8.5	7.7	7.7		8.5		8.7
Japan imports	6.4		8.1	8.5	8.5		9.1		9.3
Energy [R]evolution 2008									
US imports		6.5		13.1	14.4	16.7	20.9	24.9	27.9
Europe imports		6.6		11.4	12.9	15.1	19.5	23.4	26.1
Asia imports		6.4		13.1	14.3	16.7	20.8	24.9	27.9
Hard coal import prices in 2005 $ per tonne	2000	2005	2006						
IEA WEO 2007/ ETP 2008	43		69	62	63		67	0	67
Energy [R]evolution 2008				162	190	221	285	353	408
Biomass (solid) prices in 2005 $ per GJ	2005								
Energy [R]evolution 2008									
OECD Europe	8.5			9.0	9.6	10.7	11.7	12.0	12.3
OECD Pacific, NA	3.4			3.7	4.0	4.3	4.9	5.3	5.9
Other regions	2.8			3.2	3.6	4.0	4.5	5.2	5.6

image TRANSPORT POLLUTION.

cost of CO_2 emissions

Assuming that a global emissions trading system for greenhouse gases is established, the cost of long-term carbon allowances will need to be included in the calculation of electricity generation costs. Projections of emissions costs are even more uncertain than energy prices, and available studies span a broad range of future CO_2 cost estimates. As in the 2007 and 2008 Global Energy [R]evolution reports, we assume CO_2 costs of $11.4/t CO_2 in 2010, rising to $56.8/t CO_2 in 2050. Additional CO_2 costs are applied to developing countries that are signatories to the Kyoto Protocol after 2020.

table 5.2: rising costs of CO_2 emissions ($/t$CO_2$)

COUNTRIES	2010	2020	2030	2040	2050
Kyoto Annex B countries	11.4	22.7	34.1	45.4	**56.8**
Non–Annex B countries		22.7	34.1	45.4	**56.8**

power plant investment costs

fossil fuel technologies and carbon capture and storage (CCS)

Although fossil fuel power technologies in use today for coal, gas, lignite and oil are at an advanced stage of market development, further cost reduction potentials are possible. The potential for cost reductions is limited, however, and will be achieved mainly through an increase in efficiency, or a reduction in investment costs.[80]

There is much speculation about the potential for carbon capture and storage (CCS) technology to mitigate the effect of fossil fuel consumption on climate change, even though the technology is still under development.

CCS is a means of trapping CO_2 from fossil fuels, either before or after they are burned, and "storing" (as a means of disposal) it in the sea or beneath the surface of the Earth. There are currently three different methods of capturing CO_2: pre-combustion, post-combustion, and oxyfuel combustion. However, development is at a very early stage and CCS will not be implemented—in the best case—before 2020 and will probably not become commercially viable as an effective mitigation option until 2030.

Cost estimates for CCS vary considerably, depending on factors such as power station configuration, technology, fuel costs, project size and location. One thing is certain, however: CCS is expensive. CCS requires significant funds to construct the power stations and the necessary infrastructure to transport and store carbon. The IPCC cost estimates range from $17–85 per ton of captured CO_2,[81] while a recent U.S. Department of Energy report found installing carbon capture systems in most modern plants resulted in a near doubling of costs.[82] These costs are estimated to increase the price of electricity in a range of 21–91 percent.

Pipeline networks will also need to be constructed to move CO_2 to storage sites. This is likely to require a considerable outlay of capital.[83] Costs will vary depending on a number of factors, including pipeline length, diameter, manufacture from corrosion-resistant steel, and the volume of CO_2 to be transported. Pipelines built near population centers or on difficult terrain, such as marshy or rocky ground, are more expensive.[84]

The IPCC estimates a cost range for pipelines of $1.1–9 ton of CO_2 transported. A U.S. Congressional Research Service report calculated capital costs for an 11-mile pipeline in the Midwest at approximately $6.8 million. The same report estimates that a dedicated interstate pipeline network in North Carolina would cost upwards of $5.7 billion, due to the limited geological sequestration potential in that part of the country.[85] Storage and subsequent monitoring and verification costs are estimated by the IPCC to range from $0.6–9 t/$CO_2$ injected and $0.1–0.3 t/$CO_2$ injected, respectively. The overall cost of CCS could therefore serve as a major barrier to its deployment.[86]

references
80 GREENPEACE INTERNATIONAL, BRIEFING: CARBON CAPTURE AND STORAGE (2007). AVAILABLE AT: HTTP://WWW.GREENPEACE.ORG/RAW/CONTENT/INTERNATIONAL/PRESS/REPORTS/CCS-BRIEFING.PDF.
81 ABANADES, J.C., ET AL., 2005, P. 10.
82 U.S. DEPARTMENT OF ENERGY, NATIONAL ENERGY TECHNOLOGY LABORATORIES, *CARBON DIOXIDE CAPTURE FROM EXISTING COAL-FIRED POWER PLANTS* (2007). AVAILABLE AT: HTTP://WWW.NETL.DOE. GOV/ENERGY-ANALYSES/PUBS/CO2%20RETROFIT %20FROM%20EXISTING%20PLANTS%20REVISED%20NOVEMBER%202007.PDF.
83 RAGDEN, P., ET AL., 2006, P. 18. **84** HEDDLE, G., ET AL., 2003, P. 17.
85 PARFOMAK, P., ET AL., *PIPELINES FOR CARBON DIOXIDE (CO_2) CONTROL: NETWORK NEEDS AND COST UNCERTAINTIES*, CONGRESSIONAL RESEARCH SERVICE, P.P. 5-12 (2008). AVAILABLE AT: HTTP://NCSEONLINE.ORG/NLE/CRSREPORTS/08FEB/RL34316.PDF.
86 RUBIN ET AL., 2005, P. 4444.

table 5.3: growth of efficiency and investment costs for selected power plant technologies

		2005	2010	2020	2030	2040	2050
Coal-fired condensing power plant	Efficiency (%)	45	46	48	50	52	**53**
	Investment costs ($/kW)	1,498	1,396	1,350	1,316	1,283	**1,249**
	Electricity generation costs including CO_2 emission costs ($cents/kWh)	7.5	10.2	12.3	14.2	15.1	**17.8**
	CO_2 emissions [a)] (g/kWh)	744	728	697	670	644	**632**
Lignite-fired condensing power plant	Efficiency (%)	41	43	44	44.5	45	**45**
	Investment costs ($/kW)	1,782	1,634	1,566	1,532	1,498	**1,464**
	Electricity generation costs including CO_2 emission costs ($cents/kWh)	6.7	7.4	8.5	9.5	10.6	**11.7**
	CO_2 emissions [a)] (g/kWh)	975	929	908	898	888	**888**
Natural gas combined cycle	Efficiency (%)	57	59	61	62	63	**64**
	Investment costs ($/kW)	783	766	732	692	658	**624**
	Electricity generation costs including CO_2 emission costs ($cents/kWh)	8.5	11.9	14.4	17.4	19.7	**21.5**
	CO_2 emissions [a)] (g/kWh)	354	342	330	325	320	**315**

source DLR, 2008.
[a)] CO_2 EMISSIONS REFER TO POWER STATION OUTPUTS ONLY; LIFE-CYCLE EMISSIONS ARE NOT CONSIDERED.

For the above reasons, power plants with CCS are not included in the Energy [R]evolution scenario's financial analysis. Table 5.3 summarizes our assumptions on the technical and economic parameters of future fossil-fuelled power plant technologies. In spite of growing raw material prices, we assume that further technical innovation will result in a moderate reduction of future investment costs as well as improved power plant efficiencies. These improvements are, however, outweighed by the expected increase in fossil fuel prices, resulting in a significant rise in electricity generation costs.

cost projections for renewable energy technologies

The range of renewable energy technologies available today displays marked differences in terms of their technical maturity, costs and development potential. For example, hydro power has been widely used for decades, but other technologies, such as the gasification of biomass, have yet to achieve market maturity. Some renewable sources, by their very nature, including wind and solar power, provide a variable supply, requiring a revised coordination with the grid network. In many cases these are "distributed" technologies—their output being generated and used locally by the consumer. However, the future will also see large-scale applications in the form of offshore windfarms, photovoltaic power plants and concentrating solar power stations.

By using the individual advantages of different renewable technologies, and linking them with each other, a wide spectrum of available options can be developed and integrated into existing energy supply structures. This will eventually provide a complementary portfolio of environmentally friendly technologies to supply electricity, heat, and transportation fuels.

Many of the renewable technologies employed today are at a relatively early stage of market development. As a result, the costs of electricity, heat and fuel production are generally higher than those of competing conventional systems although external (environmental and social) costs of conventional power production are not included in market prices. It is expected, however, that compared with conventional technologies, large cost reductions can be achieved through technical advances, manufacturing improvements and mass production. In long-term scenarios spanning several decades, these cost reductions identify economically sensible expansion strategies.

To identify long-term cost developments, learning curves have been applied which reflect the correlation between cumulative production volumes of a particular technology and a reduction in its costs. For many technologies, the learning factor (or progress ratio) falls in the range between 0.75 for less mature systems to 0.95 and higher for well-established technologies. A learning factor of 0.9 means that costs are expected to fall by 10% every time the cumulative output from the technology doubles. Empirical data show, for example, that the learning factor for photovoltaic modules has been fairly constant at 0.8 over 30 years while that for wind energy varies from 0.75 in the UK to 0.94 in the more advanced German market. Assumptions on future costs for renewable electricity technologies in the Energy [R]evolution scenario are derived from a review of learning curve studies, for example by Lena Neij and others,[87] from the analysis of recent technology foresight and road mapping studies, including the European Commission–funded NEEDS (New Energy Externalities Developments for Sustainability)[88] project or the IEA Energy Technology Perspectives 2008, and a discussion with experts from the renewable energy industry.

"large cost reductions can be achieved through technical advances, manufacturing improvements and large-scale production."

references
87 NEIJ, L., COST DEVELOPMENT OF FUTURE TECHNOLOGIES FOR POWER GENERATION—A STUDY BASED ON EXPERIENCE CURVES AND COMPLEMENTARY BOTTOM-UP ASSESSMENTS, *ENERGY POLICY* 36 (2008), PP. 2200–2211.
88 WWW.NEEDS-PROJECT.ORG.

image THE PS10 SOLAR TOWER PLANT AT SAN LUCAR LA MAYOR, OUTSIDE SEVILLE, SPAIN, APRIL 29, 2008.

photovoltaics (pv)

The worldwide photovoltaics (PV) market has been growing at over 35% per annum, and it is starting to make a significant contribution to electricity generation. Development work is focused on improving existing modules and system components by increasing their energy efficiency and reducing material usage. Technologies like PV thin film (using alternative semiconductor materials) or dye-sensitive solar cells are developing quickly and present a huge potential for cost reduction. The mature technology of crystalline silicon, with a proven lifetime of 30 years, is continually increasing its cell and module efficiency (by 0.5% annually), whereas the cell thickness is rapidly decreasing (from 230 to 180 microns over the last five years). Commercial module efficiency varies from 14 to 21%, depending on silicon quality and fabrication process.

The learning factor for PV modules has been fairly constant over the last 30 years; with a cost reduction of 20% each time the installed capacity doubles, indicating a high rate of technical learning. Assuming a global installed PV capacity of 1,600 GW between 2030 and 2040, and electricity output of 2,600 TWh, we can expect generation costs of around 5.7–11.4 cents/kWh (depending on the region). During the following five to ten years, PV will become competitive with retail electricity prices in many parts of the world and competitive with fossil fuel costs by 2050. The importance of photovoltaics comes from its potential for either decentralized or centralized applications, its flexibility for use in an urban environment, and its huge potential for cost reduction.

concentrating solar power (csp)

Solar thermal concentrating power stations (CSP) can only use direct sunlight and are therefore dependent on high irradiation locations. North Africa, for example, has a technical potential which far exceeds local demand. The various solar thermal technologies (parabolic trough, power towers and parabolic dish concentrators) offer good prospects for further development and cost reductions. Because of their simpler design, "Fresnel" collectors are considered an option for additional cost reduction. The efficiency of central receiver systems can be increased by producing compressed air at a temperature of up to 1,000°C, which is then used to run a combined gas and steam turbine.

Thermal storage systems are a key component for reducing CSP electricity generation costs. The Spanish Andasol 1 plant, for example, is equipped with molten salt storage with a capacity of 7.5 hours. A higher level of full load operation can be realized by using a thermal storage system and a large collector field. Although this leads to higher investment costs, it reduces the cost of electricity generation. Significantly, this storage technology can allow CSP plants to function as baseload energy, producing power 24 hours a day even when the sun is not shining.

Depending on the level of irradiation and mode of operation, it is possible to achieve long-term future electricity generation costs of 6.8–11.4 cents/kWh. This presupposes rapid market introduction in the next few years.

table 5.4: photovoltaics (pv) costs

	2005	2010	2020	2030	2040	**2050**
Global installed capacity (GW)	5.2	21	269	921	1,799	**2,911**
Investment costs ($/kW)	7,491	4,268	1,884	1,453	1,294	**1,226**
Operation & maintenance costs ($/kWa)	75	43	18	15	12	**11**

table 5.5: concentrating solar power (csp) costs

	2005	2010	2020	2030	2040	**2050**
Global installed capacity (GW)	0.53	5	83	199	468	**801**
Investment costs ($/kW)	8,547	7,196	5,947	5,028	4,949	**4,903**
Operation & maintenance costs ($/kWa)	341	284	238	204	182	**176**

wind power

Within a short period of time, the development of wind power has resulted in the establishment of a flourishing global market. The world's largest wind turbines, several of which have been installed in Germany, have a capacity of 6 MW. While favorable policy incentives have made Europe the main driver for the global wind market, in 2007 more than half of the annual market was outside Europe. This trend is likely to continue. The boom in demand for wind power technology has nonetheless led to supply constraints. As a consequence, the cost of new systems has stagnated or even increased. Because of the continuous expansion of production capacities, the industry expects to resolve the bottlenecks in the supply chain over the next few years. Taking into account market development projections, learning-curve analysis, and industry expectations, we project that investment costs for wind turbines will fall 30% for onshore and 50% for offshore installations by 2050.

biomass

The crucial factor for the economics of biomass utilization is the cost of the feedstock, which today ranges from a negative cost for waste wood (based on credit for waste disposal costs avoided) to expensive energy crops. The resulting spectrum of energy generation costs is correspondingly broad.

One of the most economical options is the use of waste wood in steam turbine CHP plants. Gasification of solid biomass, on the other hand, which opens up a wide range of applications, is still relatively expensive. In the long term it is expected that favourable electricity production costs will be achieved by using wood gas both in micro-CHP units (engines and fuel cells) and in gas-and-steam power plants. Great potential for the utilization of solid biomass also exists for heat generation in both small and large heating centers linked to local heating networks. Converting crops into ethanol and biodiesel made from rapeseed methyl ester (RME) has become increasingly important in the U.S., as well as Brazil and Europe. Processes for obtaining synthetic fuels from biogenic synthesis gases will also play a larger role.

A large potential for exploiting modern technologies exists in Latin and North America, Europe and the transition economies, either in stationary appliances or the transport sector. In the long term, Europe and the transition economies will realize 20–50% of the potential for biomass from energy crops, while biomass use in all the other regions will have to rely on forest residues, industrial wood waste and straw. In Latin America, North America and Africa in particular, an increasing residue potential will be available.

In other regions, such as the Middle East and all Asian regions, the additional use of biomass is restricted, either due to a generally low availability or already high traditional use. For the latter, using modern, more efficient technologies will improve the sustainability of current usage and have positive side effects, such as reducing indoor pollution and the heavy workloads currently associated with traditional biomass use.

table 5.6: wind power costs

	2005	2010	2020	2030	2040	**2050**
Installed capacity (on+offshore)	59	164	893	1,622	2,220	**2,733**
Wind onshore						
Global installed capacity (GW)	59	162	866	1,508	1,887	**2,186**
Investment costs ($/kW)	1,714	1,555	1,339	1,260	1,237	**1,237**
O&M costs ($/kWa)	66	58	51	49	47	**47**
Wind offshore						
Global installed capacity (GW)	0.3	1.6	27	114	333	**547**
Investment costs ($/kW)	4,268	3,950	2,951	2,497	2,259	**2,145**
O&M costs ($/kWa)	188	174	129	110	100	**94**

table 5.7: biomass costs

	2005	2010	2020	2030	2040	**2050**
Biomass (electricity only)						
Global installed capacity (GW)	21	35	56	65	81	**99**
Investment costs ($/kW)	3,450	3,121	2,872	2,803	2,769	**2,741**
O&M costs ($/kWa)	208	188	173	168	167	**166**
Biomass (CHP)						
Global installed capacity (GW)	32	60	177	275	411	**521**
Investment costs ($/kW)	6,549	5,641	4,381	3,836	3,530	**3,348**
O&M costs ($/kWa)	459	395	308	268	247	**235**

image 100 KW PV GENERATING PLANT NEAR BELLINZONA-LOCARNO RAILWAY LINE. GORDOLA, SWITZERLAND.

image THE POWER OF THE OCEAN.

geothermal

Geothermal energy (energy generated from the Earth's natural heat) has long been used for supplying heat and since the beginning of the last century for electricity generation as well. Geothermally generated electricity was previously limited to sites with specific geological conditions, but further intensive research and development work has enabled the potential areas to be widened. In particular, the creation of large underground heat exchange surfaces (enhanced geothermal systems—EGSs) and the improvement of low-temperature power conversion, for example with the organic Rankine cycle, open up the possibility of producing geothermal electricity anywhere. Advanced heat and power cogeneration plants will also improve the economics of geothermal electricity.

As a large part of the costs for a geothermal power plant come from deep underground drilling, further development of innovative drilling technology is expected. Assuming a global average market growth for geothermal power capacity of 9 percent per year up to 2020, adjusting to 4 percent beyond 2030, the result would be a cost reduction potential of 50 percent by 2050:

- for conventional geothermal power, from 7.9 cents/kWh to about 2.3 cents/kWh;
- for EGS, despite the presently high figures (about 22.7 cents/kWh), electricity production costs—depending on the payments for heat supply—are expected to come down to around 5.7 cents/kWh in the long term.

Because of its non-fluctuating supply and continuous feed to the electricity grid, geothermal energy is considered to be a key element in a future energy supply structure based on renewable sources. Until now we have just used a marginal part of the geothermal heating and cooling potential. Shallow geothermal drilling makes possible the delivery of heating and cooling at anytime, anywhere, and can be used for thermal energy storage.

ocean energy

Ocean energy, particularly offshore wave energy, is a significant resource, and has the potential to satisfy an important percentage of electricity supply worldwide. Globally, the potential of ocean energy has been estimated at around 90,000 TWh/year. The most significant advantages are the vast availability and high predictability of the resource and a technology with very low visual impact and no CO_2 emissions. Many different concepts and devices have been developed, including taking energy from the tides, waves, currents and both thermal and saline gradient resources. Many of these concepts are in an advanced phase of research and development, and large-scale prototypes have been deployed in real ocean conditions.

The cost of energy from initial tidal and wave energy farms has been estimated to be in the range of 17–62 cents/kWh, and for initial tidal stream farms in the range of 12.5–25 cents/kWh. Generation costs of 11.4–28.4 cents/kWh are expected by 2020. Key areas for development will include concept design, optimization of the device configuration, reduction of capital costs by exploring the use of alternative structural materials, economies of scale, and learning from operation. According to the latest research findings, the learning factor is estimated to be 10–15% for offshore wave and 5–10% for tidal stream. In the medium term, ocean energy has the potential to become one of the most competitive and cost-effective forms of generation. In the next few years a dynamic market penetration is expected, following a similar curve to wind energy.

Because of the early development stage, any future cost estimates for ocean energy systems are uncertain, and no learning-curve data are available. Present cost estimates are based on analysis from the European NEEDS project.[89]

table 5.8: geothermal costs

	2005	2010	2020	2030	2040	**2050**
Geothermal (electricity only)						
Global installed capacity (GW)	8.7	12	33	71	120	**152**
Investment costs ($/kW)	19,794	17,070	13,121	11,520	10,771	**10,192**
O&M costs ($/kWa)	732	632	486	426	398	**377**
Geothermal (CHP)						
Global installed capacity (GW)	0.24	1.7	13	38	82	**124**
Investment costs ($/kW)	19,863	14,812	10,794	9,023	7,866	**7,162**
O&M costs ($/kWa)	734	548	398	334	291	**264**

table 5.9: ocean energy costs

	2005	2010	2020	2030	2040	**2050**
Global installed capacity (GW)	0.27	0.9	17	44	98	**194**
Investment costs ($/kW)	10,260	5,868	3,303	2,542	2,122	**1,895**
Operation & maintenance costs ($/kWa)	409	235	133	101	85	**75**

references
89 WWW.NEEDS-PROJECT.ORG.

hydro power

Hydro power is a mature technology, yet there is still great potential to exploit new schemes (especially small-scale run-of-the-river projects with little or no reservoir impoundment) and to improve and re-power existing sites. The significance of hydro power is also likely to be encouraged by the increasing need for flood control and maintenance of water supply during dry periods. The future is in sustainable hydro power that integrates power plants with river ecosystems while reconciling ecology with economically attractive power generation.

table 5.10: hydro costs

	2005	2010	2020	2030	2040	**2050**
Global installed capacity (GW)	878	978	1178	1300	1443	**1565**
Investment costs ($/kW)	3,133	3,269	3,484	3,632	3,768	**3,882**
Operation & maintenance costs ($/kWa)	125	131	140	145	151	**155**

summary of renewable energy cost development

Figure 5.3 summarizes the cost trends for renewable energy technologies as derived from the respective learning curves. It should be emphasized that the expected cost reduction is basically not a function of time, but of cumulative capacity, so dynamic market development is required. Most technologies will be able to reduce their specific investment costs between 30 percent and 70 percent of current levels by 2020, and between 20 percent and 60 percent once they have achieved full development after 2040.

Reduced investment costs for renewable energy technologies lead directly to a reduction of heat and electricity generation costs, as shown in Figure 5.4. Generation costs today are around 11.4–28 cents/kWh for the most important technologies, with the exception of photovoltaics. In the long term, costs are expected to converge at around 5.7–13.6 cents/kWh. These estimates depend on site-specific conditions such as the local wind regime or solar irradiation, the availability of biomass at reasonable prices, or the credit granted for heat supply in the case of CHP.

figure 5.3: future investment costs for renewable energy technologies
(NORMALIZED TO CURRENT COST LEVELS)

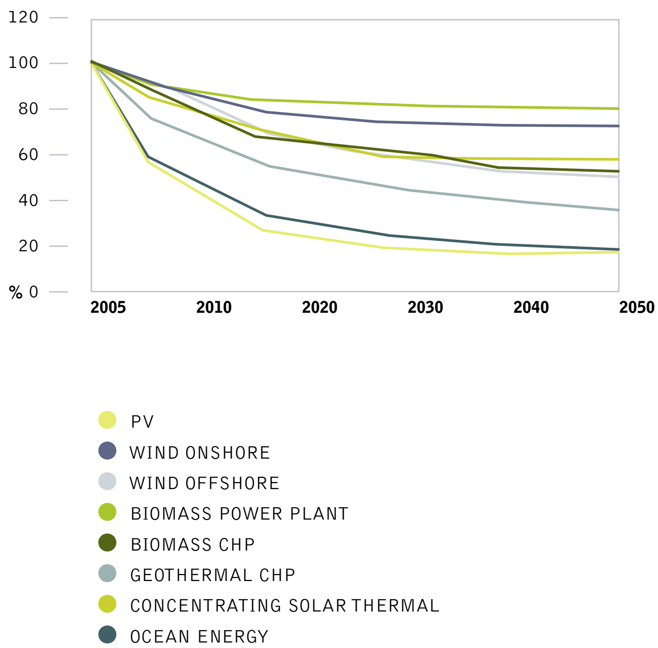
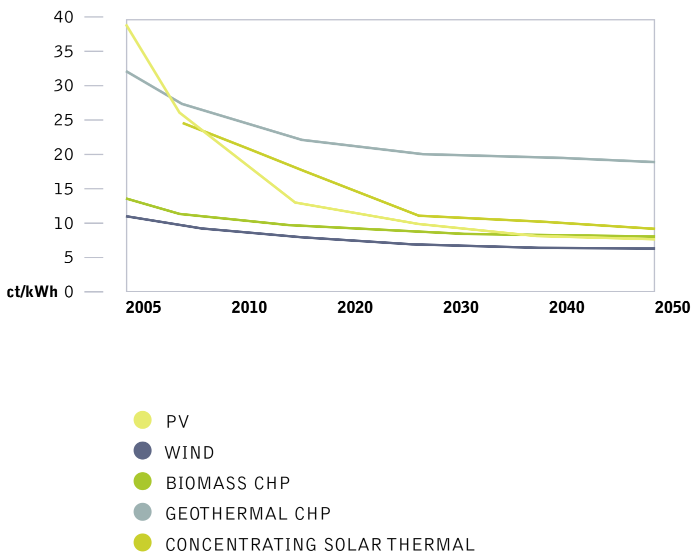


figure 5.4: future electricity generation costs for renewable energy technologies
(OECD NORTH AMERICA)

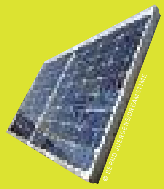


key results of the canada energy [r]evolution scenario

6

"in the Energy [R]evolution scenario, primary energy demand decreases 50% by 2050."

HU JINTAO,
PRESIDENT OF CHINA

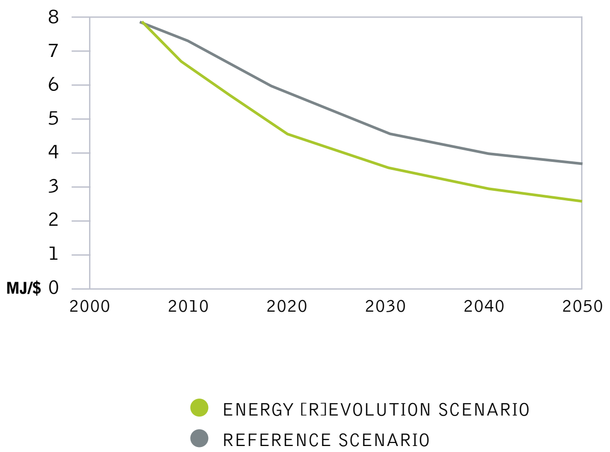


The development of future global energy demand is determined by three key factors:

- Population development: the number of people consuming energy or using energy services.
- Economic development, for which gross domestic product (GDP) is the most commonly used indicator. In general, an increase in GDP triggers an increase in energy demand.
- Energy intensity: how much energy is required to produce a unit of GDP.

Both the reference and Energy [R]evolution scenarios are based on the same projections of population and economic development. The future development of energy intensity, however, differs between the two, taking into account the measures to increase energy efficiency under the Energy [R]evolution scenario.

figure 6.1: canada: energy intensity under the reference and energy [r]evolution scenarios



projection of energy intensity

An increase in economic activity and a growing population does not necessarily have to result in an equivalent increase in energy demand. There is still a large potential for exploiting energy efficiency measures. Under the reference scenario, we assume that energy intensity will be reduced by 1.25% on average per year, leading to a reduction in final energy demand per unit of GDP of about 56% between 2005 and 2050. Under the Energy [R]evolution scenario, it is assumed that active policy and technical support for energy efficiency measures will lead to an even higher reduction in energy intensity of almost 73%.

energy demand by sector

Combining the projections on population development, GDP growth and energy intensity results in future development pathways for Canada's energy demand. These are shown in Figure 6.2, for both the reference and Energy Revolution scenarios. Under the reference scenario, total primary energy demand decreases by less than 10%, from the current 11,654 PJ/a to 10,848 PJ/a in 2050. In the Energy Revolution scenario, primary energy demand decreases by 50% compared to current consumption and is expected by 2050 to reach 6,142 PJ/a.

Under the Energy Revolution scenario, electricity demand is expected to decrease in the industry, residential and service sectors, but to grow in the transport sector due to increase use of electric vehicles (see Figure 6.3). Therefore total electricity demand will rise from 511 TWh/a in 2005 to 535 TWh by 2050. Compared to the reference scenario, efficiency measures avoid the generation of about 129 TWh/a. This reduction in energy demand can be achieved in particular by introducing highly efficient electronic devices using the best available technology in all demand sectors. Employment of solar architecture in both residential and commercial buildings will help to curb the demand for air conditioning and electric heating.

Efficiency gains in the heat supply sector are even larger. Under the Energy [R]evolution scenario, demand for heat supply will decrease by 42%, from 2,954 PJ/a in 2005 to 1,710 PJ/a in 2050 (see Figure 6.4). Compared to the reference scenario, consumption equivalent to 341 PJ/a is avoided through efficiency gains by 2050. Energy-related renovation of existing buildings, as well as the introduction of efficiency standards (including the shift to zero-energy buildings), means that the same comfort and energy services will be accompanied by a much lower future energy demand.

In the transport sector, it is assumed under the Energy [R]evolution scenario that energy demand will decrease by 38% to 1,356 PJ/a by 2050, saving almost 60%, or 1,946 PJ/a, compared to the reference scenario. This reduction can be achieved by the introduction of highly efficient vehicles, by shifting the transport of goods from road to rail and by changes in mobility-related development patterns.

figure 6.2: canada: final energy demand by sector for the two scenarios

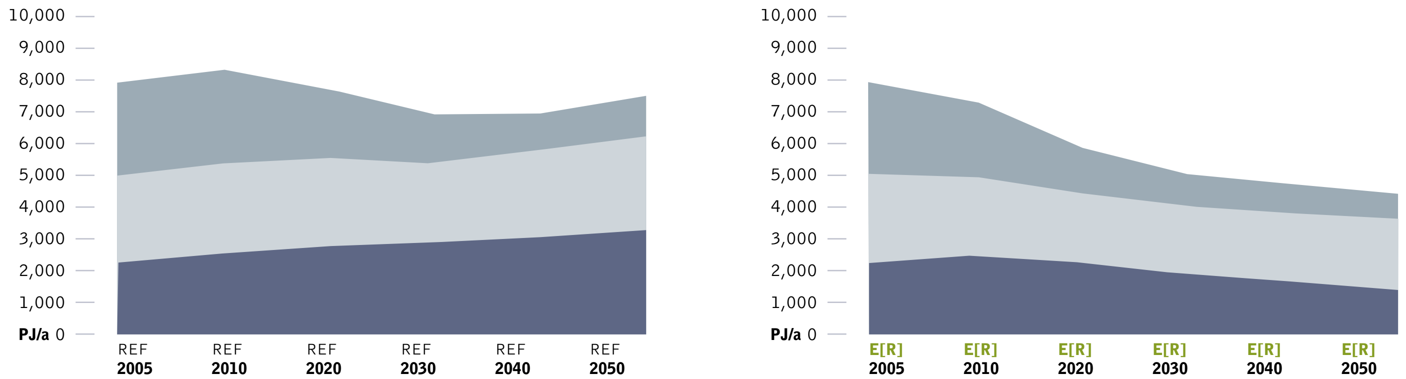


figure 6.3: canada: electricity demand by sector

(EFFICIENCY = REDUCTION COMPARED TO THE REFERENCE SCENARIO; OTHER SECTORS = SERVICES, HOUSEHOLDS)

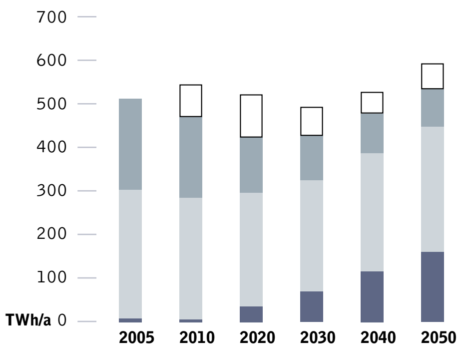


figure 6.4: canada: heat demand by sector

(EFFICIENCY = REDUCTION COMPARED TO THE REFERENCE SCENARIO; OTHER SECTORS = SERVICES, HOUSEHOLDS)

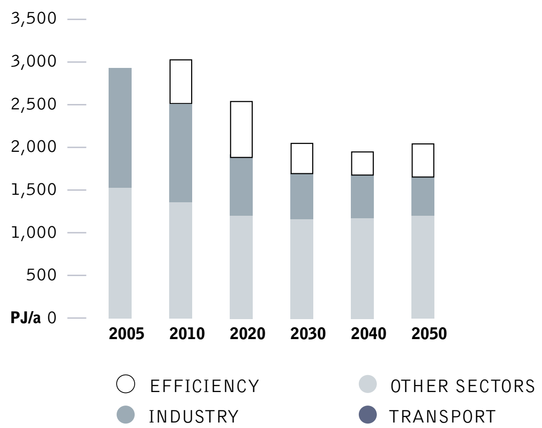
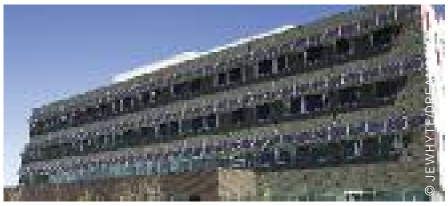


image GREEN OFFICE BUILDING UTILIZING THE LATEST ENVIRONMENTAL TECHNOLOGY. THE SOLAR PANELS PROVIDE ENERGY FOR ELECTRICITY AND SHADE OVER THE WINDOWS TO HELP LOWER AMBIENT TEMPERATURE WITHIN THE BUILDING. CALGARY, CANADA.

image WINDMILLS AT PINCHER CREEK, ALBERTA, CANADA.



electricity generation

The development of the electricity supply sector is characterized by a dynamically growing renewable energy market and an increasing share for renewable electricity. This will compensate for the phasing out of nuclear energy and reduce the number of fossil fuel–fired power plants required for grid stabilization. By 2050, 93.5% of the electricity produced in the Canada will come from renewable energy sources. New renewables—mainly wind, bioenergy and solar photovoltaics—will contribute over 30% of electricity generation.

Table 6.1 shows the comparative evolution of the different renewable energy technologies in Canada over time. Up to 2020, wind will be the main contributor. After 2020, the continuing growth of wind will be complemented by electricity from biomass, photovoltaics and some ocean energy.

table 6.1: canada: renewable electricity capacity under the energy [r]evolution scenario

(IN GW)

	2005	2010	2015	2020	2030	2040	2050
Wind	1	2	5	9	15	25	35
PV	0	0	1	3	5	8	13
Biomass	1	2	2	3	5	6	7
Ocean energy	0	0	0	2	4	6	9
Total	**2**	**4**	**9**	**17**	**28**	**44**	**64**

figure 6.5: canada: electricity generation structure under the two scenarios

(EFFICIENCY = REDUCTION COMPARED TO THE REFERENCE SCENARIO)

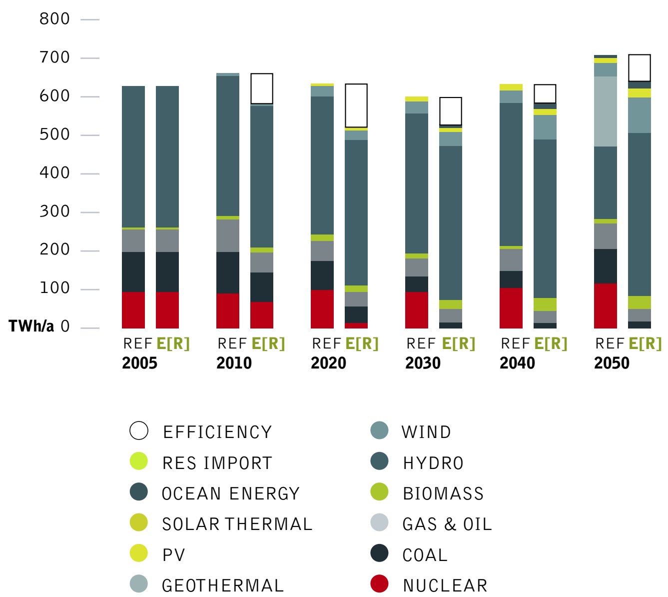
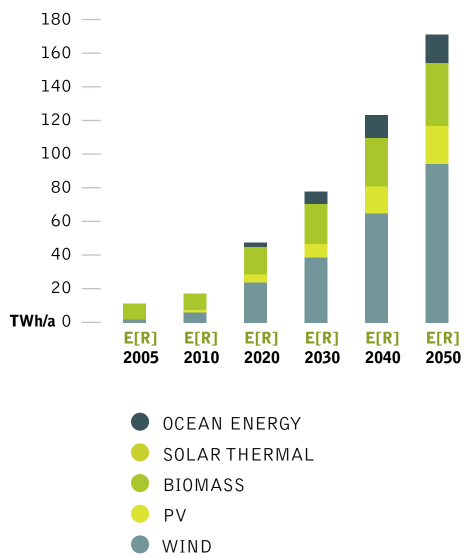


figure 6.6: canada: renewable electricity capacity under the energy [r]evolution scenario

(BY INDIVIDUAL SOURCE)



future costs of electricity generation

Figure 6.7 shows that electricity generation costs under the Canada Energy [R]evolution scenario are about 0.57 cents/kWh lower than under the reference scenario from the very beginning. This cost difference remains roughly the same over the whole scenario period, while costs under both scenarios increase from about 5.7 cents/kWh today to about 9 cents/kWh in 2050. Assuming average costs of 1.7 cent/kWh for implementing energy efficiency measures, the Energy [R]evolution scenario will save $5.9 billion for Canada´s electricity bill in 2020. If costs for CO_2 emissions were added to Canada´s reference scenario, the saving would be even higher. Increasing energy efficiency and shifting energy supply to renewables leads to significantly lower long-term costs for electricity supply in the Energy [R]evolution scenario.

heat and cooling supply

Today, renewables provide 12% of Canada's primary energy demand for heat supply, the main contribution coming from the use of biomass. The lack of district heating networks is a severe structural barrier to the large-scale utilization of geothermal and solar thermal energy. Dedicated support instruments are required to ensure a dynamic development.

In the Energy [R]evolution scenario, renewables provide 64% of Canada's total heating demand in 2050.

- Energy efficiency measures help to reduce the currently growing demand for heating and cooling, in spite of improving living standards.
- For direct heating, solar collectors, biomass/biogas as well as geothermal energy are increasingly substituting for fossil fuel-fired systems.
- A shift from coal and oil to natural gas in the remaining conventional applications will lead to a further reduction of CO_2 emissions.

figure 6.7: canada: electricity generation costs under the two scenarios

(CO₂ EMISSION COSTS IMPOSED FROM 2020, WITH AN INCREASE FROM USD$20/$T_{CO_2}$ IN 2020 TO USD$50/$T_{CO_2}$ IN 2050)

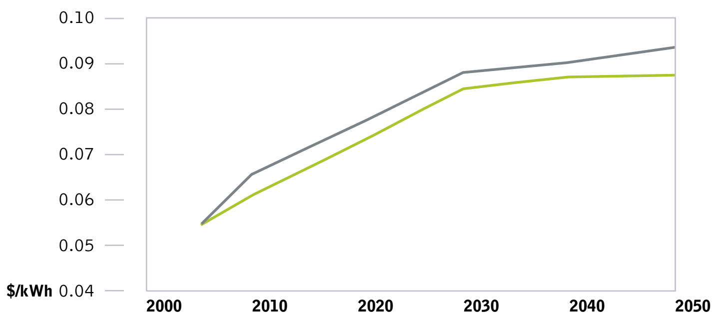


figure 6.8: canada: total electricity supply costs

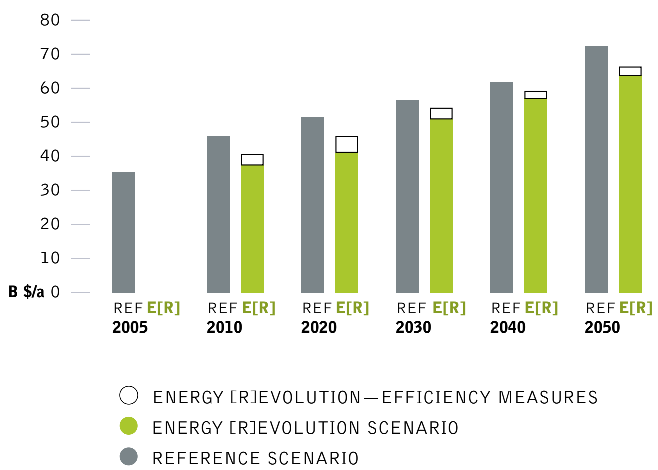


figure 6.9: canada: heat supply structure under the two scenarios

(EFFICIENCY = REDUCTION COMPARED TO THE REFERENCE SCENARIO)

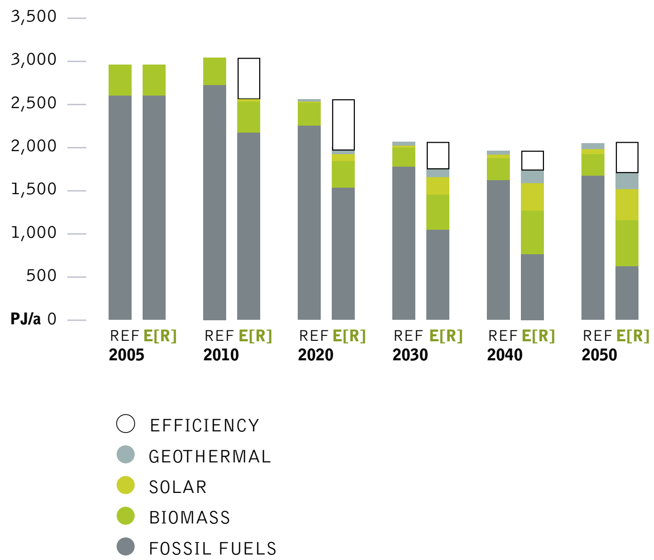


image A CANOLA FIELD IN SASKATCHEWAN, CANADA.

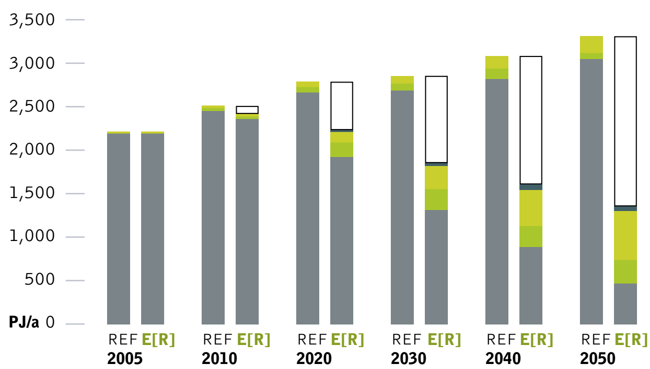
image WINDMILLS IN FARM FIELDS, SOUTHERN ONTARIO, CANADA.

transport

A key initiative in Canada is the introduction of incentives for smaller cars. In addition, a shift to efficient modes of transport, including rail, light rail and bus is important, especially in the expanding large metropolitan areas. Together with the rising price of fossil fuels, these changes reduce the growth in car sales projected by the reference scenario. In the Energy [R]evolution scenario, the car fleet—in quantitative terms—remains on today´s level until 2050. However, small, fuel-efficient cars will replace currently used heavy and inefficient cars. The energy demand of the transport sector is reduced by 39%. Highly efficient propulsion technology, including hybrid, plug-in hybrid and battery-electric powertrains, will bring large efficiency gains. A fifth of the transport energy demand by 2050 is covered by electricity.

figure 6.10: canada: transport under the two scenarios

(EFFICIENCY = REDUCTION COMPARED TO THE REFERENCE SCENARIO)

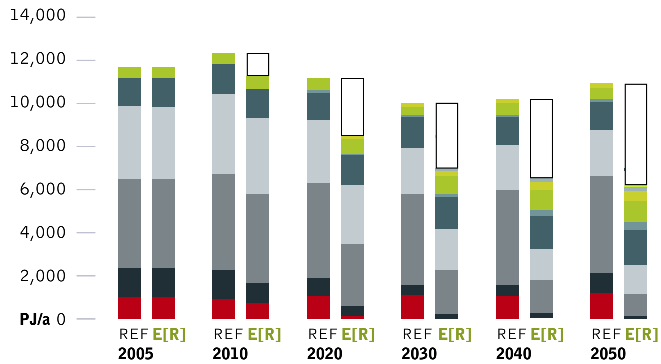


primary energy consumption

Taking into account the assumptions discussed above, the resulting primary energy consumption under the Energy [R]evolution scenario is shown in figure 6.11. Compared to the reference scenario, overall primary energy demand will be reduced by 45% in 2050. About 58% of the remaining demand in Canada will be covered by renewable energy sources.

figure 6.11: canada: primary energy consumption under the two scenarios

(EFFICIENCY = REDUCTION COMPARED TO THE REFERENCE SCENARIO)

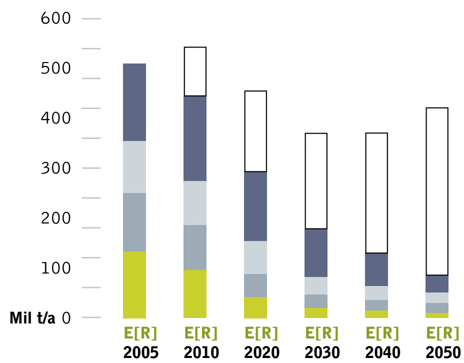


development of CO_2 emissions

While Canada's emissions of CO_2 will decrease by only 11% by 2020 and 18% by 2050 under the Reference Scenario, under the Energy Revolution Scenario they will decrease from 509 million tonnes in 2005 to 86 million tonnes in 2050, 83% under 2005 and 82% under 1990 levels. Annual per capita emissions will drop from 15.8 tonnes to 2.0. In spite of phasing out nuclear energy and increasing demand, CO_2 emissions will decrease in the electricity sector. In the long run, efficiency gains and the increased use of renewable electricity will even reduce CO_2 emissions in the transport sector. With a 38% share of total CO_2 emissions, transport will be the largest emitting sector in 2050.

figure 6.12: canada: CO_2 emissions by sector under the energy [r]evolution scenario

(EFFICIENCY = REDUCTION COMPARED TO THE REFERENCE SCENARIO)



investment in new power plants

The overall level of investment required in new power plants up to 2030 will be in the region of $215 to 237 billion. The main driver for investment in new generation capacity in Canada will be the ageing of existing power plants.

Utilities will make their technology choices within the next five to ten years, based on national energy policies, in particular: market restructuring, as well as renewable energy and greenhouse gas reduction targets. A possible future emissions trading scheme will have an important influence on whether the most investment goes into fossil fuel power plants or into renewable energy and cogeneration. The investment volume required to realise the Energy [R]evolution scenario is $237 billion, approximately 10% higher than in the Reference Scenario, which will require $214 billion.

While 16% of investment under the reference scenario will go in fossil fuels and nuclear power plants at about $52 billion up to 2030, the Energy [R]evolution scenario shifts about 84% of investment towards renewable energy. The fossil fuel share of power sector investment is focused mainly on combined heat and power, and efficient gas-fired power plants.

The average annual investment required in the power sector under the Energy [R]evolution scenario between 2005 and 2030 is approximately $9.5 billion. Most investment in new renewable power generation will go towards wind power, followed by solar photovoltaic.

figure 6.14: canada: change in cumulative power plant investment in the energy [r]evolution scenario

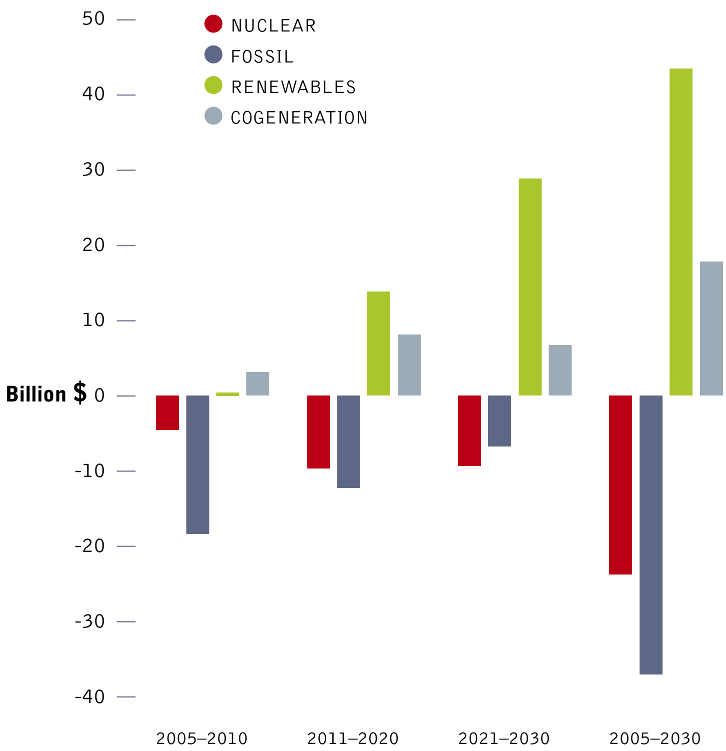
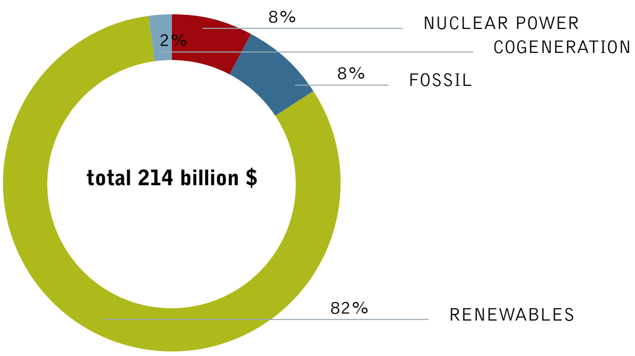


figure 6.13: canada: change in cumulative power plant investment

reference scenario 2005–2030



energy [r]evolution scenario 2005–2030

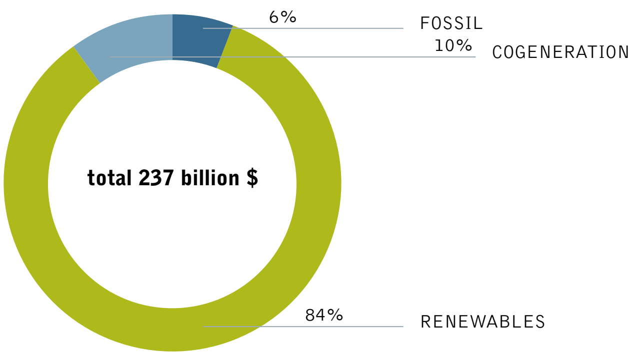
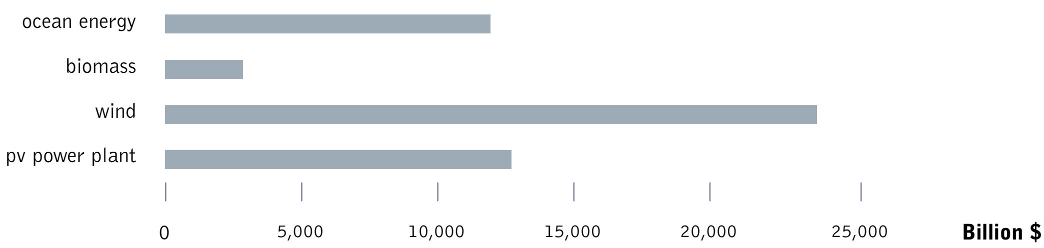


image A GAS PLANT IN COCHRANE, ALBERTA, CANADA.

image A WINDMILL ON A PRAIRIE AT PINCHER CREEK, ALBERTA, CANADA.

figure 6.15: canada: renewable energy investments in the energy [r]evolution 2005–2030



renewable power generation investment

Under the reference scenario, investment in renewable electricity generation will be $156 billion. This compares to $200 billion in the Energy [R]evolution scenario. How investment is divided between the different renewable power generation technologies depends on their level of technical development and regionally available resources.

Technologies such as wind power will take a larger investment volume and a bigger market share. The market volume attributed to different technologies also depends on policy frameworks within Canada's provinces. Figure 6.15 provides an overview of the investment required for each technology.

For solar photovoltaic, the main market will remain in the southern parts of the provinces as well as in rural areas for some years to come. Because solar photovoltaic energy is a highly modular and decentralized technology which can be used almost everywhere, its market will eventually spread across Canada. Solar photovoltaic is expected to reach grid parity (generation costs on the same level as consumer electricity prices) soon after 2015 and will experience an enormous growth thereafter.

The main development of the wind industry will take place especially in coastal areas, but also on the Great Lakes in Ontario and on the prairies in Alberta, Saskatchewan, and Manitoba. Offshore wind technology will take a larger share from around 2015 onwards. The main offshore wind development will take place around the Atlantic coast. Bioenergy power plants will be distributed across the whole of Canada, as there is potential almost everywhere for biomass and/or biogas (cogeneration) power plants.

fossil fuel power generation investment

Under the reference scenario, the main market expansion for new fossil fuel power plants will be in gas power plants, followed by coal power plants, which will have a volume of $12.8 billion and $8.6 billion, respectively. In the Energy [R]evolution scenario, the overall investment in fossil fuel power stations up to 2030 will be $13.6 billion significantly lower than the reference scenario's $26.1 billion.

The largest investments in coal power plants within Canada will take place in western Canada. While in the reference scenario the current growth trend (2000–2010) will continue until 2030, the Energy [R]evolution scenario assumes that in the second and third decades (2011–2030) growth slows down significantly.

fuel cost savings with renewables

The total cost for fossil fuels in the reference scenario between 2005 and 2030 amounts to $358 billion, compared to $269 billion in the Energy [R]evolution scenario. This means that fuel costs in the Energy [R]evolution scenario would already be about 25% lower by 2030 and about 50% lower by 2050.

Although the investment in gas-fired power stations and cogeneration plants remains relatively high in both scenarios, the financial support for coal-fired power plants for electricity generation in the Energy [R]evolution scenario is more than 75% below that in the reference scenario.

Because renewable energy has no fuel costs, the total fuel cost saving in the Energy [R]evolution scenario is $89.7 billion, or $3.6 billion per year. A comparison between extra fuel costs associated with the reference scenario and the extra investment costs of the Energy [R]evolution scenarios shows that the average annual additional fuel costs in the reference scenario are 4-times higher than the additional investment requirements in the Energy [R]evolution.

In fact, the saved costs in fossil and nuclear power plants to the year 2030 would be as high as $1.58 billion. This would cover the entire additional investment in renewable energy capacity required to implement the Energy [R]evolution scenario. These renewable energy sources will produce electricity without any further fuel costs beyond 2030, while the costs for coal and gas will continue to be a burden on national economies.

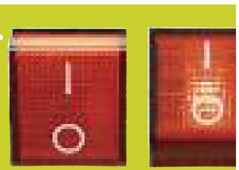
table 6.2: canada: fuel and investment costs in the reference and the energy [r]evolution scenarios

INVESTMENT COST	CAN $	2005–2010	2011–2020	2021–2030	2005–2030	2005–2030 AVERAGE PER YEAR BILLION$/A
REFERENCE SCENARIO						
Total Nuclear	billion $	5.80	10.00	9.83	25.62	1.02
Total Fossil	billion $	18.26	5.19	2.73	26.18	1.05
Total Renewables	billion $	30.52	66.71	59.83	157.07	6.28
Total Cogeneration	billion $	1.30	3.31	1.06	5.67	0.23
Total	billion $	55.88	85.21	73.45	214.54	8.58
E[R] SCENARIO						
Total Fossil	billion $	5.02	2.34	5.93	13.29	0.53
Total Renewables	billion $	31.05	80.46	89.09	200.60	8.02
Total Cogeneration	billion $	4.23	11.54	7.84	23.62	0.94
Total	billion $	40.30	94.34	102.86	237.51	9.50
DIFFERENCE E[R] VERSUS REF						
Total Fossil & Nuclear	billion $	-19.04	-12.85	-6.63	-38.51	-1.54
Total Cogeneration	billion $	0.53	13.75	29.26	43.53	1.74
Total Renewables	billion $	2.93	8.23	6.79	17.95	0.72
Total	billion $	-15.58	9.13	29.42	22.97	0.92
FUEL COSTS						
REFERENCE SCENARIO						
Total Fuel Oil	billion $	14.27	26.54	9.63	50.44	2.02
Total Gas	billion $	26.65	66.30	64.90	157.84	6.31
Total Coal (incl. lignite)	billion $	33.69	71.97	44.85	150.52	6.02
Total Fossil Fuels	billion $	74.61	164.80	119.38	358.79	14.35
E[R] SCENARIO						
Total Fuel Oil	billion $	10.85	6.31	0.11	17.26	0.69
Total Gas	billion $	20.18	49.20	49.17	118.54	4.74
Total Coal (incl. lignite)	billion $	31.73	58.71	43.10	133.54	5.34
Total Fossil Fuels	billion $	62.76	114.21	92.37	269.34	10.77
SAVINGS REF VERSUS E[R]						
Fuel Oil	billion $	3.43	20.23	9.52	33.18	1.33
Gas	billion $	6.46	17.10	15.73	39.30	1.57
Coal (incl. lignite)	billion $	1.96	13.26	1.76	16.97	0.68
Total Fossil Fuel Savings	billion $	11.85	50.59	27.01	89.45	3.58

policy recommendations

7

"...renewable energy technologies would already be competitive if they received the same research and development funding and subsidies as fossil fuels and nuclear power..."



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While Canada's federal and provincial governments must each craft effective climate and energy policies specific to their own resources and needs, this chapter provides a general overview of the common elements of some of the most effective clean energy policies that have been implemented globally to date.

towards an efficient global energy market

Policies and measures to promote energy efficiency exist in many countries. Energy and information labels, mandatory minimum energy performance standards, and voluntary efficiency agreements are the most popular efficiency measures. While effective government policies usually contain two elements, those that push the markets (such as standards) and pull the market (incentives), efficiency standards have proven to be the most effective, low-cost way to achieve a transition to greater energy efficiency. For example, Japan has an energy efficiency program that sets mandatory targets, subject to ongoing revision, and provides incentives to manufacturers and importers of energy-consuming equipment to continuously improve the energy efficiency of products within selected market segments.

support innovation in energy efficiency, low-carbon transport systems, and renewable energy production Innovation will play an important role in making the Energy [R]evolution more attractive, and is needed to realize ambitious, ever-improving efficiency and emissions standards. Programs supporting renewable energy and energy efficiency development and diffusion are a traditional focus of energy and environmental policies because energy innovations face barriers all along the energy-supply chain (from research and development, to demonstration projects, to widespread deployment).

set stringent and ever-improving efficiency and emissions standards for appliances, buildings and vehicles In the residential sector in industrialized countries, standby power consumption ranges from 20 to 60 watts per household, equivalent to 4 to 10% of total residential energy consumption. Yet the technology is available to reduce standby power to 1 watt and a global standard, as proposed by the IEA, could mandate this reduction. Japan, South Korea and the state of California have already adopted energy standby standards.

develop and implement market transformation policies that overcome current barriers and other market failures to reduce energy demand In addition to setting and implementing efficiency standards, market transformation policies promote the manufacture and purchase of energy-efficient products and services. The goal of this strategy is to create lasting structural and behavioural changes in the marketplace, resulting in increased adoption of energy-efficient technologies. A key element is to overcome market barriers that inhibit the manufacture and purchase of energy-efficient products.

renewable energy: no fuel, no emissions, no problems

At a time when governments around the world are in the process of liberalizing their electricity markets, the increasing competitiveness of renewable energy should lead to higher demand. Without political support, however, renewable energy remains at a disadvantage, marginalized by distortions in the world's electricity markets created by decades of massive financial, political and structural support to conventional technologies. Developing renewables will therefore require strong political and economic efforts.

At present, renewable energy generators have to compete with old nuclear and fossil fuel power plants that produce electricity at lower cost because ratepayers and taxpayers subsidize their operation. Political action is needed to overcome these distortions and create a level playing field.

In fact, renewable energy technologies would already be competitive if they received the same research and development funding and subsidies as fossil fuels and nuclear power, and if environmental costs were reflected in energy prices. Removing public subsidies to fossil fuels and nuclear and applying the "polluter pays" principle to energy markets would go a long way towards leveling the playing field and would drastically reduce the need for government support of renewable energy. Until these disparities are corrected, renewable energy technologies will need additional support measures from Canadian policymakers in order to compete with conventional fuels.

Support mechanisms for different Canadian energy sectors and technologies can vary according to regional characteristics, priorities and initial policy goals. But some general principles apply to any kind of support mechanism. These criteria are:

effectiveness in reaching the targets Experience shows that it is possible with the right design of support mechanisms to reach agreed-upon, national renewable energy targets. Any national system should focus on the effective deployment of new renewable energy projects to increase the percentage of installed capacity and meet renewable energy targets.

long-term stability Whether price- or quantity-based, Canadian policymakers need to make sure that investors can rely on the long-term stability of any support scheme. It is absolutely crucial to avoid stop-and-go markets caused by frequent regulatory changes. Market stability will be created when Canada implements long-term plans and funding for renewable energy projects.

simple and fast administrative procedures Complex licensing procedures constitute one of the most difficult obstacles that renewable energy projects have to face. Canadian policymakers should remove administrative barriers at all levels. A user-friendly "one-stop-shop" system should be introduced that includes a clear timetable for project approval.

encouraging local and regional benefits and public acceptance The development of renewable technologies can have a significant impact on local and regional areas, resulting from both installation and manufacturing. The public must be involved in order to facilitate the acceptance of renewable technologies. Local projects should encourage regional development, employment and income generation.

demands for the energy sector

Greenpeace and the renewable energy industry have a clear agenda for changes which need to be made in Canadian energy policy to encourage a shift to renewable sources. The main demands are:

- Phase out all subsidies for fossil fuels and nuclear energy.
- Account for the social and environmental costs of energy production through "cap and trade" emissions trading and/or carbon taxation.
- Mandate strict efficiency standards for all energy-consuming appliances, buildings and vehicles.
- Establish legally binding targets for renewable energy and combined heat and power generation.
- Reform the electricity markets by guaranteeing priority access to the grid for renewable power generators.
- Provide defined and stable returns for investors, for example by feed-in tariff programs.
- Implement better labeling and disclosure mechanisms to provide more environmental product information.
- Increase research and development budgets for renewable energy and energy efficiency.

Conventional energy sources receive an estimated $250–300 billion (USD)[90] in subsidies per year worldwide, resulting in heavily distorted markets. Subsidies artificially reduce the price of power, keep renewable energy out of the market place and prop up noncompetitive technologies and fuels. Eliminating direct and indirect subsidies to fossil fuels and nuclear power would help move Canada towards a level playing field across the energy sector. The 2001 report of the G8 Renewable Energy Task Force argued that "readdressing them [subsidies] and making even a minor re-direction of these considerable financial flows toward renewables, provides an opportunity to bring consistency to new public goals and to include social and environmental costs in prices." The Task Force recommended that "G8 countries should take steps to remove incentives and other supports for environmentally harmful energy technologies, and develop and implement market-based mechanisms that address externalities, enabling renewable energy technologies to compete in the market on a more equal and fairer basis."[91]

Renewable energy would not need special Canadian policy provisions if electricity producers (as well as the energy sector as a whole) had to "pay to pollute." Removing subsidies from fully mature, conventional electricity would save taxpayer money and dramatically reduce the need for renewable energy support.

The following steps provide a description of what needs to be done to eliminate or compensate for current distortions in the Canadian energy market.

removal of energy market distortions Electricity generation in Canada has typically been conducted by monopolies owned by provinces, which provide backing for capital investment loans and pass on costs to ratepayers on their electricity bills. Some provincial monopolies have pursued green options such as wind power (e.g., Hydro Quebec), whereas others (e.g., Ontario Power Generation) have not. Market restructuring introduces opportunities and risks for green energy. However, whether the electricity sector is monopolistic or competitive, a major barrier preventing renewable energy from reaching its full potential is the lack of pricing structures that reflect the full social cost of producing energy. A variety of strategies is necessary.

internalization of the social and environmental costs of polluting energy The real cost of energy production by conventional energy includes expenses absorbed by society, such as health impacts and local and regional environmental degradation—from mercury pollution to acid rain—as well as the global negative impacts from climate change. Hidden costs include the waiving of nuclear accident insurance that is too expensive for nuclear power plant operators.

The 1976 Nuclear Liability Act, for example, limits the liability of Canadian nuclear operators to $75 million, effectively making taxpayers liable to compensate third parties for damages above that limit resulting from a nuclear accident in Canada. There has been ongoing discussion about revision of the Act to increase the limit on the plant-owners liability.

Environmental damage should, as a priority, be rectified at source. Ideally, therefore, production of energy should not pollute, and it is the energy producers' responsibility to prevent it. If energy producers do pollute they should pay an amount equal to the damage to society as a whole. However, the environmental impacts of electricity generation can be difficult to quantify. How do we put a price on Pacific Island homes lost as a result of melting icecaps or on deteriorating health and human lives?

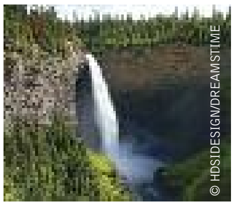
An ambitious project, funded by the European Commission—ExternE—has tried to quantify the true costs, including the environmental costs, of electricity generation. It estimates that the cost of producing electricity from coal or oil would double and that from gas would increase by 30% if external costs, in the form of damage to the environment and health, were taken into account.[92] If those environmental costs were levied on electricity generation according to their impact, many renewable energy sources would not need any support. If, at the same time, direct and indirect subsidies to fossil fuels and nuclear power were removed, the need to support renewable electricity generation would seriously diminish or cease to exist.

introduce the "polluter pays" principle As with the other subsidies, external costs must be factored into energy pricing if the market is to be truly competitive. This requires that governments apply a "polluter pays" system that charges the emitters accordingly or applies suitable compensation to non-emitters. Adoption of

references
90 UNITED NATIONS DEVELOPMENT PROGRAMME, *WORLD ENERGY ASSESSMENT: ENERGY AND THE CHALLENGE OF SUSTAINABILITY* (2000).
91 *G8 RENEWABLE ENERGY TASK FORCE: CHAIRMEN'S REPORT,* JULY 2001. HTTP://WWW.G8.UTORONTO.CA/MEETINGS-OFFICIAL/G8RENEWABLES_REPORT.PDF.
92 BICKEL, P., FRIEDRICH, R. (2005), *EXTERNE EXTERNALITIES OF ENERGY – METHODOLOGY 2005 UPDATE*, INSTITUTE OF ENERGY ECONOMICS AND THE RATIONAL USE OF ENERGY (IER), UNIVERSITY OF STUTTGART, STUTTGART.

image HELMCKEN FALLS, IN BRITISH COLUMBIA, CANADA.

image A STORAGE FACILITY THAT USES WOOD CHIPS TO POWER ELECTRICAL TURBINES. COGENERATION OF ELECTRICITY USING ALTERNATIVE FUEL SOURCES, CANADA.



polluter- pays taxation to electricity sources, or equivalent compensation to renewable energy sources, and exclusion of renewables from environment-related energy taxation, is essential to achieve fairer competition in the world's electricity markets.

electricity market reform Renewable energy technologies could already be competitive if they had received the same attention as other sources in terms of research and development funding and subsidies, and if external costs were reflected in power prices. Essential reforms in the electricity sector are necessary if new renewable energy technologies are to be accepted on a larger scale.

These reforms include:

removal of electricity-sector barriers Complex licensing procedures and bureaucratic hurdles constitute one of the most difficult obstacles faced by renewable energy projects in many countries. Canadian regulatory agencies should set a clear timetable for approving renewable energy projects at all levels. In addition, Canadian regulators should propose more detailed procedural guidelines to strengthen existing legislation and at the same time streamline the licensing procedure for renewable energy projects.

A major barrier is the short-to medium-term surplus of electricity-generating capacity in many countries. Due to over-capacity it is still cheaper to burn more coal or gas in an existing power plant than to build, finance and depreciate a new renewable power plant. Even in those situations where a new technology would be fully competitive with new coal or gas fired power plants, the investment will not be made. Until we reach a situation where electricity prices start reflecting the cost of investing in new capacity rather than the marginal cost of existing capacity, Canadian policy support for renewable energy will be required, to level the playing field.

Other barriers include the lack of long-term planning at national, regional and local levels; lack of integrated resource planning; lack of integrated grid planning and management; lack of predictability and stability in the markets; no legal framework for international bodies of water; grid ownership by vertically integrated companies; and a lack of long-term research and development funding.

There is also a complete absence of grids for large-scale renewable energy sources, such as offshore wind power or concentrating solar power (CSP) plants; weak or non-existent grids onshore; little recognition of the economic benefits of embedded/distributed generation; and discriminatory requirements from utilities for grid access that do not reflect the nature of the renewable technology.

The reforms needed to address market barriers to renewables include:

- Streamlined and uniform planning, licensing, and permitting procedures and a system to integrate cost-efficiency into energy network planning.
- Access to the grid at fair, transparent prices and the removal of discriminatory access and transmission tariffs.
- Fair and transparent pricing for power throughout an energy network, with recognition and remuneration for the benefits of embedded generation.
- Unbundling of utilities into separate generation and distribution companies.
- Grid management authority must carry the costs of grid infrastructure development and reinforcement, rather than individual renewable energy projects.
- Disclosure of fuel mix and environmental impact to end users to enable consumers to make informed choices regarding power sources.

priority grid access Rules on grid access, transmission and cost sharing are often inadequate. Legislation must be clear, especially concerning cost distribution and transmission fees. Renewable energy generators should be guaranteed priority grid access. Where necessary, grid extension or reinforcement costs should be borne by the grid operators, and shared between all consumers.

support mechanisms for renewables The following section provides an overview of the existing international support mechanisms and operational experience. Support mechanisms remain a second best solution for correcting market failures in the electricity sector. However, introducing them is a practical political solution to acknowledge that, in the short-term, there are no other practical ways to apply the "polluter pays" principle.

Overall, there are two types of incentives to promote deployment of renewable energy. These are **fixed price systems**, where the government dictates the electricity price (or premium) paid to the producer and lets the market determine the quantity, and **renewable quota systems** where the government dictates the quantity of renewable electricity and leaves it to the market to determine the price. Both systems create a protected market against a background of subsidized, depreciated conventional generators whose external environmental costs are not accounted for. These policies provide incentives for technology improvements and cost reductions, leading to cheaper renewables that can compete with conventional sources in the future.

The main difference between price-based and quota-based systems is that the latter aims to introduce competition between electricity producers. However, competition between technology manufacturers, which is the most crucial factor in bringing down electricity production costs, is present regardless of whether government dictates prices or quantities. Prices paid to wind power producers are currently higher in many European quota based systems (UK, Belgium, and Italy) than in fixed price or premium (feed-in tariff) systems (Germany, Spain, Denmark).

- **fixed price systems** Fixed price systems include investment subsidies, fixed feed-in tariffs, fixed premium systems and tax credits.

  Investment subsidies are capital payments usually made on the basis of the rated power (in kW) of the generator. It is generally acknowledged, however, that systems which base the amount of support on generator size rather than electricity output can lead to less efficient technology development. There is therefore a global trend away from these payments, although they can be effective when combined with other incentives.

  Fixed feed-in tariffs (FITs), widely adopted in Europe, have proved extremely successful in expanding wind energy in Germany, Spain and Denmark. Operators are paid a fixed price for every kWh of electricity they feed into the grid. In Germany the price paid varies according to the relative maturity of the particular technology and reduces each year to reflect falling costs. The additional cost of the system is borne by taxpayers or electricity consumers.

The main benefit of a FIT is that it is administratively simple and encourages better planning. Although the FIT is not associated with a formal power purchase agreement, distribution companies are usually obliged to purchase all the production from renewable installations. Germany has guaranteed payments for 20 years. The main problem associated with a fixed price system is that it does not lend itself easily to adjustment—whether up or down—to reflect changes in the production costs of renewable technologies.

Fixed premium systems, sometimes called an "environmental bonus" mechanism, operate by adding a fixed premium to the basic wholesale electricity price. From an investor perspective, the total price received per kWh is less predictable than under a feed-in tariff because it depends on a constantly changing electricity price. From a market perspective, however, it is argued that a fixed premium is easier to integrate into the overall electricity market because those involved will be reacting to market price signals. Spain is the most prominent country to have adopted a fixed premium system.

In Canada, the renewable energy market has been driven by the highly successful ecoEnergy for Renewable Power program. It is a $1.48 billion program operated by Natural Resources Canada that provides an incentive of one cent per kWh for electricity production over ten years. This four-year program ends March 31, 2011, but commitments under the program are expected to end in 2009.

In its budget of January 2009, the Harper government failed to renew the program. The renewable energy industry was seeking an extension and strengthening of this program to $2.8 billion over five years to build at least 8,000 MW of new capacity. This would have leveraged a $6 billion investment and created an estimated 8,000 new jobs.

In the United States, the market has been driven by a federal production tax credit (PTC) of approximately 1.9 cents per kWh (USD), adjusted annually for inflation. President Obama has pledged to renew the PTC for three years, at a cost of about $13 billion (USD).

- **renewable quota systems** Two types of renewable quota systems have been employed: tendering systems and green certificate systems.

Tendering systems involve competitive bidding for contracts to construct and operate a particular project, or a fixed quantity of renewable capacity in a country or state. Although other factors are usually taken into account, the lowest-priced bid invariably wins. This system has been used to promote wind power in Ireland, France, the UK, Denmark and China.

The downside is that investors can bid an uneconomically low price in order to win the contract, and then fail to deliver the project. Under the UK's NFFO (Non-Fossil Fuel Obligation) tender system, for example, many contracts remained unused. The system was eventually abandoned. If properly designed, however, with long contracts, a clear link to planning consent and a possible minimum price, tendering for large-scale projects could be effective, as it has been for offshore oil and gas extraction in Europe's North Sea.

Tradable green certificate (TGC) systems operate by offering "green certificates" for every kWh generated by a renewable producer. The value of these certificates, which can be traded on a market, is then added to the value of the basic electricity. A green certificate system usually operates in combination with a rising quota of renewable electricity generation. Power companies are bound by law to purchase an increasing proportion of renewables input. Countries that have adopted this system include the UK, Sweden, and Italy.

Compared with a fixed tender price, the TGC model is more risky for the investor, because the price fluctuates on a daily basis, unless effective markets for long-term certificate (and electricity) contracts are developed. Such markets do not currently exist. The system is also more complex than other payment mechanisms.

Which one out of this range of incentive systems works best? Based on past experience it is clear that policies based on fixed tariffs and premiums can be designed to work effectively. However, introducing them is not a guarantee for success. Almost all countries with experience in renewable energy support policies have, at some point in time, used feed-in tariffs, but not all have contributed to an increase in renewable electricity production. It is detailed policy design, in combination with other measures, which determine success.

renewables for heating and cooling Largely forgotten, but equally important is the heating and cooling sector. In many regions of the world, such as Europe, nearly half of the total energy demand is for heating/cooling, a demand which can be addressed easily at competitive prices.

Canadian policies should make sure that specific targets and appropriate measures for renewable heating and cooling are part of any national renewables strategy. These should foresee a coherent set of measures dedicated to the promotion of renewables for heating and cooling, including financial incentives, awareness-raising campaigns, training of installers, architects and heating engineers, and demonstration projects. For new buildings, and those undergoing major renovation, there should be an obligation to use a minimum share of renewable energy for heat consumption.

Canadian policy measures should stimulate the deployment of cost-effective renewable heating and cooling, available already with today's technologies. At the same time, increased research and development efforts should be undertaken, particularly in the fields of heat storage and renewable cooling.

references
93 GOVERNMENT OF CANADA, *CANADA'S ECONOMIC ACTION PLAN: BUDGET 2009*, JANUARY 27, 2009. HTTP://WWW.BUDGET.GC.CA/2009/HOME-ACCUEIL-ENG.ASP

8

glossary of commonly used terms and abbreviations

CHP Combined heat and power
CO_2 Carbon dioxide, the main greenhouse gas
GDP Gross domestic product (means of assessing a country's wealth)
MBtu Mega–British thermal unit; = 1,000 Btu
IEA International energy agency
PPP Purchasing power parity (adjustment to GDP assessment to reflect comparable standard of living)
RES Renewable energy source

J Joule, a measure of energy
kJ Kilojoule; = 1,000 joules,
MJ Megajoule; = 1 million joules,
GJ Gigajoule; = 1 billion joules,
PJ Petajoule; = 10^{15} joules,
EJ Exajoule; = 10^{18} joules

W Watt, measure of electrical capacity
kW Kilowatt; = 1,000 watts,
MW Megawatt; = 1 million watts,
GW Gigawatt; = 1 billion watts
kWh Kilowatt-hour, measure of electrical output
TWh Terawatt; = 10^{12} watt-hours

t Tonne, measure of weight
Mt Megatonne; = 1,000 tonnes
Gt Gigatonne; = 1 billion tonnes

Mtoe Megatonne of oil equivalent

conversion factors—fossil fuels

FUEL				
Coal	23.03	GJ/t	1 cubic	0.0283 m^3
Lignite	8.45	GJ/t	1 barrel	159 liter
Oil	6.12	GJ/barrel	1 US gallon	3.785 liter
Gas	38000.00	kJ/m^3	1 UK gallon	4.546 liter

conversion factors—different energy units

FROM / **TO:** MULTIPLY BY	TJ	Gcal	Mtoe	Mbtu	GWh
TJ	1	238.8	2.388×10^{-5}	947.8	0.2778
Gcal	4.1868×10^{-3}	1	$10^{(-7)}$	3.968	1.163×10^{-3}
Mtoe	4.1868×10^{4}	10^{7}	1	3968×10^{7}	11630
MBtu	1.0551×10^{-3}	0.252	2.52×10^{-8}	1	2.931×10^{-4}
GWh	3.6	860	8.6×10^{-5}	3412	1

definition of sectors

All definitions below are adapted from the Key World Energy Statistics of the IEA World Energy Outlook series.

Industry sector: Consumption in the industry sector includes the following subsectors (energy used for transport by industry is not included -> see under "Transport")

- Iron and steel industry
- Chemical industry
- Non-metallic mineral products, e.g., glass, ceramic, cement, etc.
- Transport equipment
- Machinery
- Mining
- Food and tobacco
- Paper, pulp and print
- Wood and wood products (other than pulp and paper)
- Construction
- Textile and leather

Transport sector: Fuels used in transport, such as road, railway, aviation, domestic and navigation. Fuel used for ocean, costal and inland fishing is included in "Other sectors."

Other sectors: Agriculture, forestry, fishing, residential, commercial and public services.

Non-energy use: This category covers use of other petroleum products, such as paraffin waxes, lubricants, bitumen, etc.

appendix: canada reference scenario

table A.1: canada: electricity generation

TWh/a	2005	2010	2020	2030	2040	2050
Power plants	**616**	**649**	**619**	**579**	**615**	**688**
Coal	27	27	27	8	19	63
Lignite	78	78	45	24	24	24
Gas	25	50	33	28	37	52
Oil	19	19	9	2	1	0
Diesel	1	1	1	1	1	1
Nuclear	92	94	98	101	106	115
Biomass	9	10	11	10	10	9
Hydro	364	366	366	366	369	369
Wind	1.5	4	21	27	33	37
PV	0	1	7	11	14	15
Geothermal	0	0	0	0	0	0
Solar thermal power plants	0	0	0	0	0	0
Ocean energy	0	0	1	1	2	3
Combined heat & power production	**12**	**13**	**15**	**16**	**17**	**18**
Coal	0	0	0	0	0	0
Lignite	0	0	0	0	0	0
Gas	12	13	14	15	16	16
Oil	0	0	0	0	0	0
Biomass	0	0	1	1	2	2
Geothermal	0	0	0	0	0	0
CHP by producer						
Main acitivity producers	12	13	14	14	15	15
Autoproducers	0	0	2	2	3	3
Total generation	**628**	**662**	**634**	**595**	**632**	**706**
Fossil	162	187	129	78	97	156
Coal	27	27	27	8	19	63
Lignite	78	78	45	24	24	24
Gas	37	63	47	43	53	68
Oil	19	19	9	2	1	0
Diesel	1	1	1	1	1	1
Nuclear	92	94	98	101	106	115
Renewables	**374**	**381**	**406**	**416**	**430**	**435**
Hydro	364	366	366	366	369	369
Wind	1.5	4	21	27	33	37
PV	0.017	1	7	11	14	15
Biomass	9	10	12	11	12	11
Geothermal	0	0	0	0	0	0
Solar thermal	0	0	0	0	0	0
Ocean energy	0	0	1	1	2	3
Import	19.7	19.7	19.7	19.7	19.7	19.7
Import RES	3.0	3.0	3.0	3.0	3.0	3.0
Export	43.5	43.5	43.5	43.5	43.5	43.5
Distribution losses	46	47	43	38	39	43
Own consumption electricity	47	50	45	41	42	45
Final energy consumption (electricity)	**511**	**541**	**521**	**492**	**527**	**592**
Fluctuating RES (PV, Wind, Ocean)	2	5	29	39	49	55
Share of fluctuating RES	0.2%	0.7%	4.5%	6.6%	7.7%	7.8%
RES share	**59.6%**	**57.5%**	**64.1%**	**69.9%**	**67.9%**	**61.6%**

table A.2: canada: heat supply

PJ/A	2005	2010	2020	2030	2040	2050
District heating plants	**0**	**0**	**0**	**0**	**0**	**0**
Fossil fuels	0	0	0	0	0	0
Biomass	0	0	0	0	0	0
Solar collectors	0	0	0	0	0	0
Geothermal	0	0	0	0	0	0
Heat from CHP	**34**	**33**	**38**	**42**	**48**	**53**
Fossil fuels	34	33	37	40	44	49
Biomass	0	0	1	2	4	4
Geothermal	0	0	0	0	0	0
Direct heating[1]	**2,920**	**3,008**	**2,519**	**2,020**	**1,914**	**1,998**
Fossil fuels	2,564	2,693	2,218	1,735	1,599	1,612
Biomass	356	298	258	222	224	251
Solar collectors	0	8	12	19	40	69
Geothermal	0	9	31	43	51	66
Total heat supply[1]	**2,954**	**3,042**	**2,557**	**2,062**	**1,962**	**2,051**
Fossil fuels	2,598	2,727	2,255	1,775	1,644	1,661
Biomass	356	298	259	224	228	255
Solar collectors	0	8	12	19	40	69
Geothermal	0	9	31	43	51	66
RES share (including RES electricity)	**12.0%**	**10.4%**	**11.8%**	**13.9%**	**16.2%**	**19.0%**

1) heat from electricity (direct and from electric heat pumps) not included; covered in the model under "electric appliances".

table A.3: canada: CO_2 emissions

MILL t/a	2005	2010	2020	2030	2040	2050
Condensation power plants	**129**	**141**	**86**	**43**	**51**	**84**
Coal	24.1	23.2	22.5	6.6	13.8	44.2
Lignite	80.5	81.6	42.8	22.9	22.1	21.3
Gas	11.9	23.2	14.4	11.5	14.1	18.4
Oil	12.3	12.5	5.9	1.3	0.7	0
Diesel	0.4	0.4	0.4	0.3	0.3	0.3
Combined heat & power production	**8**	**7**	**7**	**6**	**6**	**6**
Coal	0	0	0	0	0	0
Lignite	0	0	0	0	0	0
Gas	7	7	7	6	6	6
Oil	0	0	0	0	0	0
CO_2 emissions electricity & steam generation	**137**	**148**	**93**	**49**	**57**	**90**
Coal	24	23	23	7	14	44
Lignite	80	82	43	23	22	21
Gas	19	30	21	18	20	25
Oil & diesel	13	13	6	2	1	0
CO_2 emissions by sector	**509**	**542**	**453**	**368**	**372**	**419**
% of 2005 emissions	100%	106%	89%	72%	73%	82%
Industry	113	116	79	55	40	38
Other sectors	103	103	89	71	71	71
Transport	157	176	192	193	204	220
Electricity & steam generation	137	148	92	48	56	89
District heating	0	0	0	0	0	0
Population (Mill.)	32	34	37	39	41	43
CO_2 emissions per capita (t/capita)	**15.8**	**16.1**	**12.4**	**9.4**	**9.1**	**9.8**

table A.4: canada: installed capacity

GW	2005	2010	2020	2030	2040	2050
Power plants	**152**	**164**	**156**	**149**	**160**	**177**
Coal	5	4	4	1	3	10
Lignite	12.9	12.7	7.3	3.9	3.9	3.9
Gas	11.8	22.9	14.7	12.9	17.1	24.0
Oil	6.9	7.6	3.4	0.7	0.3	0
Diesel	1.8	1.7	1.6	1.5	1.4	1.3
Nuclear	11.3	11.5	11.9	12.2	12.8	13.9
Biomass	1.3	1.4	1.6	1.5	1.5	1.3
Hydro	101	100	98	98	98	98
Wind	0.7	1.8	8.6	11.0	12.5	14.1
PV	0	0.3	3.9	6.1	7.8	8.3
Geothermal	0	0	0	0	0	0
Solar thermal power plants	0	0	0	0	0	0
Ocean energy	0	0	0.3	0.5	1.0	1.5
Combined heat & power production	**4**	**4**	**5**	**5**	**5**	**5**
Coal	0	0	0	0	0	0
Lignite	0	0	0	0	0	0
Gas	4	4	4	4	5	5
Oil	0	0	0	0	0	0
Biomass	0	0	0	0	0	0
Geothermal	0	0	0	0	0	0
	0	0	0	0	0	0
CHP by producer						
Main activity producers	4	4	4	4	4	4
Autoproducers	0	0	0	0	1	1
Total generation	**156**	**168**	**160**	**154**	**165**	**182**
Fossil	42	53	36	25	30	44
Coal	5	4	4	1	3	10
Lignite	13	13	7	4	4	4
Gas	16	27	19	17	22	29
Oil	7	8	3	1	0	0
Diesel	2	2	2	1	1	1
Nuclear	11	11	12	12	13	14
Renewables	**103**	**104**	**113**	**117**	**122**	**124**
Hydro	101	100	98	98	98	98
Wind	1	2	9	11	13	14
PV	0	0	4	6	8	8
Biomass	1	1	2	2	2	2
Geothermal	0	0	0	0	0	0
Solar thermal	0	0	0	0	0	0
Ocean energy	0	0	0	1	1	2
Fluctuating RES (PV, Wind, Ocean)	0.7	2.1	12.7	17.6	21.3	23.9
Share of fluctuating RES	0.5%	1.2%	7.9%	11.4%	12.9%	13.1%
RES share	**65.9%**	**61.6%**	**70.4%**	**75.9%**	**73.8%**	**68.0%**

table A.5: canada: primary energy demand

PJ/A	2005	2010	2020	2030	2040	2050
Total	**11,654**	**12,292**	**11,147**	**9,965**	**10,140**	**10,848**
Fossil	**8,840**	**9,434**	**8,142**	**6,908**	**6,908**	**7,502**
Hard coal	555	570	485	260	315	648
Lignite	725	735	386	207	199	192
Natural gas	3,348	3,729	2,878	2,232	2,074	2,139
Crude oil	4,213	4,400	4,394	4,210	4,320	4,523
Nuclear	**1,004**	**1,026**	**1,069**	**1,102**	**1,157**	**1,255**
Renewables	**1,810**	**1,832**	**1,936**	**1,955**	**2,075**	**2,090**
Hydro	1,309	1,318	1,318	1,318	1,328	1,328
Wind	5	14	76	97	119	133
Solar	0	10	37	59	91	123
Biomass	495	482	480	445	492	445
Geothermal	0	8	23	32	38	50
Ocean Energy	0	0	2	4	7	11
RES share	**14.9%**	**14.4%**	**16.7%**	**18.7%**	**19.6%**	**18.6%**

table A.6: canada: final energy demand

PJ/A	2005	2010	2020	2030	2040	2050
Total (incl. non-energy use)	**8,894**	**9,315**	**8,687**	**7,910**	**8,018**	**8,467**
Total (energy use)	**7,907**	**8,328**	**7,699**	**6,923**	**7,031**	**7,479**
Transport	**2,197**	**2,496**	**2,791**	**2,861**	**3,083**	**3,302**
Oil products	2,173	2,442	2,674	2,695	2,837	3,059
Natural gas	2	2	3	3	4	5
Biofuels	7	33	57	69	104	52
Electricity	15	19	56	91	136	182
RES electricity	9	11	36	64	93	112
Hydrogen	0	0	1	2	3	5
RES share Transport	**0.7%**	**1.8%**	**3.4%**	**4.7%**	**6.4%**	**5.1%**
Industry	**2,901**	**2,882**	**2,146**	**1,552**	**1,225**	**1,236**
Electricity	761	793	678	508	437	472
RES electricity	453	456	434	355	297	291
District heat	11	11	11	11	8	11
RES disrict heat	0	0	0	1	1	1
Coal	157	201	125	72	49	41
Oil products	270	256	190	148	118	121
Gas	1,392	1,392	945	651	467	435
Solar	0	0	3	6	8	11
Biomass and waste	311	228	184	146	126	130
Geothermal	0	1	9	11	11	16
RES share Industry	**26.3%**	**23.8%**	**29.4%**	**33.4%**	**36.2%**	**36.3%**
Other Sectors	**2,809**	**2,950**	**2,762**	**2,510**	**2,723**	**2,941**
Electricity	1,063	1,134	1,143	1,171	1,323	1,479
RES electricity	633	652	733	819	898	911
District heat	23	22	27	31	40	43
RES disrict heat	0	0	0	1	3	3
Coal	22	3	1	0	0	14
Oil products	561	484	401	311	312	288
Gas	1,054	1,185	1,062	858	860	870
Solar	0	8	9	13	32	58
Biomass and waste	85	107	106	105	128	155
Geothermal	0	7	14	21	27	34
RES share Other Sectors	**25.6%**	**26.3%**	**31.2%**	**38.2%**	**40%**	**39.5%**
Total RES	**1,499**	**1,503**	**1,588**	**1,612**	**1,730**	**1,777**
RES share	**16.9%**	**16.1%**	**18.3%**	**20.4%**	**21.6%**	**21.0%**
Non-energy use	**987**	**987**	**987**	**987**	**987**	**987**
Oil	831	831	831	831	831	831
Gas	146	146	146	146	146	146
Coal	10	10	10	10	10	10

appendix: canada energy [r]evolution scenario

table A.7: canada: electricity generation

TWh/a	2005	2010	2020	2030	2040	2050
Power plants	**616**	**563**	**479**	**472**	**518**	**571**
Coal	27	26	25	13	13	9
Lignite	78	49	9	0	0	0
Gas	25	25	15	0	0	0
Oil	19	11	0	0	0	0
Diesel	1	1	0	0	0	0
Nuclear	92	71	12	0	0	0
Biomass	9	10	7	5	2	0
Hydro	364	366	366	401	412	429
Wind	1.5	5	23	37	65	93
PV	0	1	5	9	14	23
Geothermal	0	0	0	0	0	0
Solar thermal power plants	0	0	0	0	0	0
Ocean energy	0	0	3	7	12	17
Combined heat & power production	**12**	**17**	**42**	**53**	**62**	**71**
Coal	0	0	0	0	0	0
Lignite	0	0	0	0	0	0
Gas	12	16	33	34	33	33
Oil	0	0	0	0	0	0
Biomass	0	1	9	19	29	38
Geothermal	0	0	0	0	0	0
CHP by producer						
Main acitivity producers	12	14	21	24	27	31
Autoproducers	0	3	21	29	35	40
Total generation	**628**	**581**	**521**	**525**	**580**	**642**
Fossil	162	127	82	46	47	42
Coal	27	26	25	13	13	9
Lignite	78	49	9	0	0	0
Gas	37	41	48	34	33	33
Oil	19	11	0	0	0	0
Diesel	1	1	0	0	0	0
Nuclear	92	71	12	0	0	0
Renewables	**374**	**383**	**427**	**478**	**534**	**600**
Hydro	364	366	380	401	412	429
Wind	1.5	5	23	37	65	93
PV	0.017	1	5	9	14	23
Biomass	9	11	16	24	31	38
Geothermal	0	0	0	0	0	0
Solar thermal	0	0	0	0	0	0
Ocean energy	0	0	3	7	12	17
Import	19.7	19.7	19.7	19.7	19.7	19.7
Import RES	3.0	2.2	5.9	10.1	13.7	16.6
Export	43.5	43.5	43.5	43.5	43.5	43.5
Distribution losses	45.8	41.3	34	30	31	33
Own consumption electricity	47.3	43.6	36	32	33	34
Electricity for hydrogen production	0	0	6	10	16	16
Final energy consumption (electricity)	**511**	**472**	**422**	**428**	**477**	**535**
Fluctuating RES (PV, Wind, Ocean)	2	5	31	53	91	133
Share of fluctuating RES	0.2%	0.9%	6.0%	10.1%	15.7%	20.7%
RES share	**59.6%**	**65.9%**	**81.9%**	**91.2%**	**91.9%**	**93.5%**
Efficiency savings (compared to Ref.)	**0**	**69**	**99**	**63**	**50**	**58**

table A.8: canada: heat supply

PJ/A	2005	2010	2020	2030	2040	2050
District heating plants	**0**	**33**	**46**	**108**	**150**	**170**
Fossil fuels	0	0	0	0	0	0
Biomass	0	31	42	95	128	140
Solar collectors	0	2	5	14	23	30
Geothermal	0	0	0	0	0	0
Heat from CHP	**34**	**43**	**102**	**135**	**176**	**209**
Fossil fuels	34	40	79	83	89	101
Biomass	0	3	23	52	87	107
Geothermal	0	0	0	0	0	0
Direct heating[1)]	**2,920**	**2,494**	**1,814**	**1,509**	**1,406**	**1,332**
Fossil fuels	2,564	2,138	1,448	950	679	512
Biomass	356	317	266	281	296	299
Solar collectors	0	35	63	189	282	345
Geothermal	0	4	37	89	148	177
Total heat supply[1)]	**2,954**	**2,570**	**1,963**	**1,752**	**1,732**	**1,710**
Fossil fuels	2,598	2,178	1,527	1,033	768	613
Biomass	356	351	331	427	511	546
Solar collectors	0	37	68	203	304	374
Geothermal	0	4	37	89	148	177
RES share (including RES electricity)	**12.0%**	**15.3%**	**22.2%**	**41.0%**	**55.6%**	**64.2%**
Efficiency savings (compared to Ref.)	**0**	**472**	**594**	**309**	**230**	**341**

1) heat from electricity (direct and from electric heat pumps) not included; covered in the model under "electric appliances".

table A.9: canada: CO_2 emissions

MILL t/a	2005	2010	2020	2030	2040	2050
Condensation power plants	**129**	**93**	**36**	**10**	**10**	**6**
Coal	24.1	22	20.5	10	9.8	6
Lignite	80.5	51	8.6	0	0	0
Gas	11.9	12	6.5	0	0	0
Oil	12.3	7	0	0	0	0
Diesel	0.4	0	0	0	0	0
Combined heat & power production	**8**	**8**	**12**	**11**	**12**	**13**
Coal	0	0	0	0	0	0
Lignite	0	0	0	0	0	0
Gas	7	8	12	11	12	13
Oil	0	0	0	0	0	0
CO_2 emissions electricity & steam generation	**137**	**100**	**48**	**22**	**21**	**19**
Coal	24	22	21	10	10	6
Lignite	80	51	9	0	0	0
Gas	19	19	18	11	12	13
Oil & diesel	13	8	0	0	0	0
CO_2 emissions by sector	**509**	**443**	**291**	**181**	**132**	**86**
% of 2005 emissions	100%	87%	57%	36%	26%	17%
Industry	113	85	44	27	21	19
Other sectors	103	89	65	42	30	24
Transport	157	170	139	95	65	33
Electricity & steam generation	137	100	44	17	15	10
District heating	0	0	0	0	0	0
Population (Mill.)	32	34	37	39	41	43
CO_2 emissions per capita (t/capita)	**15.8**	**13.1**	**8.0**	**4.6**	**3.2**	**2.0**

table A.10: canada: installed capacity

GW	2005	2010	2020	2030	2040	2050
Power plants	**152**	**142**	**130**	**133**	**151**	**172**
Coal	5	4	4	2	2	1
Lignite	12.9	8.0	1.5	0	0	0
Gas	11.8	11.4	6.7	0	0	0
Oil	6.9	4.4	0	0	0	0
Diesel	1.8	1.5	0	0	0	0
Nuclear	11.3	8.7	1.5	0	0	0
Biomass	1.3	1.4	1.0	0.7	0.3	0
Hydro	101	100	102	107	110	114
Wind	0.7	2.1	9.4	15.1	24.7	35.4
PV	0	0.3	2.8	5.0	7.8	12.8
Geothermal	0	0	0	0	0	0
Solar thermal power plants	0	0	0	0	0	0
Ocean energy	0	0	1.5	3.5	6.0	8.5
Combined heat & power production	**4**	**5**	**11**	**13**	**14**	**15**
Coal	0	0	0	0	0	0
Lignite	0	0	0	0	0	0
Gas	4	5	9	9	8	8
Oil	0	0	0	0	0	0
Biomass	0	0	2	4	6	7
Geothermal	0	0	0	0	0	0
	0	0	0	0	0	0
CHP by producer						
Main activity producers	4	5	6	7	7	7
Autoproducers	0	1	5	6	7	8
Total generation	**156**	**147**	**141**	**146**	**165**	**188**
Fossil	42	34	21	11	10	9
Coal	5	4	4	2	2	1
Lignite	13	8	1	0	0	0
Gas	16	16	16	9	8	8
Oil	7	4	0	0	0	0
Diesel	2	2	0	0	0	0
Nuclear	11	9	1	0	0	0
Renewables	**103**	**104**	**119**	**135**	**154**	**178**
Hydro	101	100	102	107	110	114
Wind	1	2	9	15	25	35
PV	0	0	3	5	8	13
Biomass	1	2	3	5	6	7
Geothermal	0	0	0	0	0	0
Solar thermal	0	0	0	0	0	0
Ocean energy	0	0	2	4	6	9
Fluctuating RES (PV, Wind, Ocean)	0.7	2.4	13.7	23.6	38.5	56.6
Share of fluctuating RES	0.5%	1.6%	9.7%	16.2%	23.4%	30.2%
RES share	**65.9%**	**70.8%**	**84.0%**	**92.6%**	**93.7%**	**95.0%**

table A.11: canada: primary energy demand

PJ/A	2005	2010	2020	2030	2040	2050
Total	**11,654**	**11,308**	**8,528**	**7,025**	**6,540**	**6,142**
Fossil	**8,840**	**8,607**	**6,136**	**4,231**	**3,329**	**2,555**
Hard coal	555	489	360	227	224	181
Lignite	725	462	77	0	0	0
Natural gas	3,348	3,597	2,752	1,963	1,587	1,355
Crude oil	4,213	4,060	2,948	2,041	1,518	1,019
Nuclear	**1,004**	**775**	**131**	**0**	**0**	**0**
Renewables	**1,810**	**1,926**	**2,261**	**2,794**	**3,210**	**3,587**
Hydro	1,309	1,318	1,368	1,444	1,483	1,544
Wind	5	16	83	133	234	335
Solar	0	39	86	235	355	457
Biomass	495	550	688	892	986	1,057
Geothermal	0	3	26	64	109	133
Ocean Energy	0	0	11	25	43	61
RES share	**14.9%**	**16.3%**	**25.4%**	**38.5%**	**48.2%**	**57.8%**
Efficiency savings (compared to Ref.)	**0**	**954**	**2,587**	**2,926**	**3,602**	**4,704**

table A.12: canada: final energy demand

PJ/a	2005	2010	2020	2030	2040	2050
Total (incl. non-energy use)	**8,894**	**8,859**	**7,109**	**6,068**	**5,671**	**5,363**
Total (energy use)	**7,907**	**7,305**	**5,867**	**5,005**	**4,677**	**4,421**
Transport	**2,197**	**2,412**	**2,216**	**1,840**	**1,598**	**1,356**
Oil products	2,173	2,356	1,920	1,322	902	461
Natural gas	2	2	2	2	2	2
Biofuels	7	37	160	236	231	266
Electricity	15	17	119	256	421	582
RES electricity	9	11	98	233	387	544
Hydrogen	0	0	15	26	42	44
RES share Transport	**0.7%**	**2.0%**	**12.2%**	**26.7%**	**41.1%**	**62.8%**
Industry	**2,901**	**2,329**	**1,394**	**1,012**	**880**	**796**
Electricity	761	661	458	365	327	316
RES electricity	453	435	375	333	301	295
District heat	11	14	46	69	89	111
RES disrict heat	0	6	19	35	44	52
Coal	157	118	24	6	6	4
Oil products	270	175	69	30	12	12
Gas	1,392	1,082	598	363	259	177
Solar	0	23	34	52	62	63
Biomass and waste	311	256	160	119	108	95
Geothermal	0	0	5	7	15	18
RES share Industry	**26.3%**	**30.9%**	**42.5%**	**54.0%**	**60.3%**	**65.8%**
Other Sectors	**2,809**	**2,564**	**2,258**	**2,153**	**2,200**	**2,269**
Electricity	1,063	1,021	942	920	969	1,026
RES electricity	633	672	772	839	891	959
District heat	23	9	47	118	180	210
RES disrict heat	0	4	22	84	146	176
Coal	22	17	0	0	0	0
Oil products	561	458	201	70	49	45
Gas	1,054	946	874	645	456	344
Solar	0	12	30	137	220	282
Biomass and waste	85	99	143	205	233	248
Geothermal	0	3	21	57	93	114
RES share Other Sectors	**25.6%**	**30.8%**	**43.7%**	**61.4%**	**71.9%**	**78.4%**
Total RES	**1,499**	**1,559**	**1,849**	**2,360**	**2,770**	**3,155**
RES share	**16.9%**	**21.3%**	**31.5%**	**47.1%**	**59.2%**	**71.4%**
Non-energy use	**987**	**1,554**	**1,242**	**1,063**	**994**	**942**
Oil	831	772	617	528	494	468
Gas	146	772	617	528	494	468
Coal	10	10	8	7	6	6

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