FACT SHEET
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Nuclear Power and Climate Change

Pembina Institute's Life Cycle Study of Nuclear Power

This factsheet is part of series based on the findings of the Pembina Institute's groundbreaking analysis of the lifecycle impacts of nuclear power. Other factsheets in this series address the impacts of uranium mining and look at nuclear power waste streams.

Shouldn't nuclear power be considered as an appropriate response to climate change? Simply put, the answer is "no."

Climate impact far from zero

Nuclear proponents frequently claim that nuclear power is a greenhouse gas (GHG) emission free source of energy. In reality, GHGs are released at each stage of the nuclear energy cycle. And while the GHG emission profile of nuclear power looks attractive when compared with conventional fossil fuel sources, it is far from zero.

Still, if nuclear power could offer a better GHG profile than conventional fossil fuel-based energy sources, shouldn't it be considered as an appropriate response to climate change? Simply put, the answer is "no."

Here are eight reasons why:

1. We must address climate change without creating additional serious long-term environmental problems.
2. Nuclear can't deliver the GHG emission reductions needed now and in the near future to prevent dangerous climate change.
3. Nuclear is one of the most expensive options available for responding to climate change.
4. Nuclear presents security, weapons proliferation and accident risks that are not shared by any other options for addressing climate change.
5. Existing uranium supplies can't support a major nuclear expansion. Increasing the nuclear fuel supply also means additional environmental impacts as well as security and weapons proliferation risks.
6. Nuclear impedes the development of more sustainable options.
7. Nuclear unreliability has lead to increased GHG emissions for Ontario.
8. There are safer, cleaner, more reliable and more affordable options available today for reducing GHG emissions.

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Sustainable Energy Solutions

For more information,
please see the full report *Nuclear Power in Canada: An Examination of Risks, Impacts and Sustainability* at www.pembina.org

Introduction

Nuclear proponents frequently claim that nuclear power is a greenhouse gas (GHG) emission free source of energy. In reality, GHGs are released at each stage of the nuclear energy cycle. Power plant construction is generally accepted as the most significant source of direct releases. Further releases of GHGs occur through the operation of equipment in the uranium mining process, the milling of uranium ore, mill tailings management activities, and refining and conversion operations. Significant releases of GHGs may also occur in the processes of plant refurbishment and decommissioning, management of waste fuel and other radioactive wastes, and the decommissioning and remediation of uranium mine sites.

Estimating the precise amounts of GHG emissions associated with nuclear power is complex. Published estimates of the emissions associated with the CANDU-type reactors used in Canada, for example, vary by a factor of 12 or more depending on the assumptions made about a number of key variables, including uranium ore grade, waste management and facility decommissioning requirements, and the energy sources used to produce inputs (e.g., fuel and materials) for the nuclear energy process.[1]

Overall, while the GHG emission profile of nuclear power looks attractive when compared with conventional fossil fuel sources, it is far from zero. In fact, nuclear power's GHG emission profile is generally substantially higher than that of low-impact renewable energy sources like wind and run-of-river hydro.[2] In fact, a study recently completed for the German Ministry of the Environment concluded that certain high-efficiency fossil-fuel powered sources, such as natural gas-fired combined heat and power facilities, can outperform nuclear power in terms of life cycle GHG emissions per unit of energy output.[3]

Nuclear means trading one set of problems for another

Although nuclear energy potentially generates lower GHG emissions than conventional fossil fuel-based energy sources, it is also associated with a wide range of other environmental impacts, many of which pose uniquely severe risks to human health and the environment. For example, nuclear energy production results in the generation of a series of exceptionally hazardous high-volume waste streams, ranging from tailings at mine sites to waste nuclear fuel from reactors. These wastes, which contain radioactive and hazardous contaminants, and in some cases also pose security and weapons proliferation risks, will require care and management for hundreds of thousands of years. Their long-term nature means that generations far into the future will have to deal with risks and costs associated with the use of nuclear power now. The Intergovernmental Panel on Climate Change (IPCC), the United Nations' expert body on climate change science, has identified the waste management issue as an important constraint on the role of nuclear power as a response to climate change.[4]

Other options available to us for reducing GHG emissions, like low-impact renewable energy and improvements in energy efficiency, have much lower environmental impacts in terms of waste generation and other effects, and don't impose major costs and risks on future generations.

The complexity and risks involved in developing nuclear power stations mean a minimum 10–15 year planning and construction timeline. This means new nuclear units would not be available to offset carbon-intensive coal-fired electricity generation until 2020 at the earliest.

Nuclear can't deliver the GHG emission reductions needed now and in the near future to prevent dangerous climate change.

The complexity and risks involved in developing nuclear power stations mean a minimum 10–15 year planning and construction timeline. This means new nuclear units would not be available to offset carbon-intensive coal-fired electricity generation until 2020 at the earliest. Major progress on reducing GHG emissions is needed well before then to keep warming beneath the 2°C "tipping point" identified by many scientists as a critical climate threshold.[5]

Similarly, the economic review of the impacts of climate change conducted by Sir Nicholas Stern concluded that "stabilizing at or below 550 ppm CO_2e [a level considered the upper bound for preventing the worst impacts of climate change] would require global emissions to peak in the next 10–20 years, and then fall at a rate of at least 1–3% per year…. To stabilise at 450ppm CO_2e, without overshooting, global emissions would need to peak in the next 10 years and then fall at more than 5% per year, reaching 70% below current levels by 2050."[6] The Stern report adds that "It is still possible to avoid the worst impacts of climate change; but it requires strong and urgent collective action. Delay would be costly and dangerous."[7]

Energy efficiency, low-impact renewable energy and other options for reducing GHG emissions can, by comparison, be deployed in much shorter time frames.[8]

Nuclear is one of the most expensive options available for responding to climate change.

Nuclear represents one of the most costly options available for reducing GHG emissions. Using figures from the Ontario Power Authority and CIBC World Markets, the Ontario Clean Air Alliance calculated that offsetting a tonne of emissions from a coal-fired

NUCLEAR POWER: ANY CLIMATE BENEFITS COME WITH BIG PROBLEMS.

Nuclear power is being promoted as a solution to one environmental problem – climate change – for which faster and cheaper solutions are readily available. But in the process nuclear creates a series of other serious environmental problems, for which the solutions are costly and complex – it they exist at all. These problems include:

- **Waste fuel:** Producing 85,000 highly radioactive waste fuel bundles each year. Nearly two million waste fuel bundles are already in temporary storage at Canadian reactor sites, with no long-term management plan in place.
- **Uranium mining wastes:** Producing nearly 600,000 tonnes of radioactive and toxic uranium mine tailings, and up to 18 million tonnes of waste rock each year. Uranium mine tailings storage sites have been described as "perpetual environmental hazards" and will require care and management effectively forever.
- **Water pollution:** Severe contamination of surface and ground- water in vicinity of uranium mines.
- **Releases of radiation and radioactive contaminants:** Routine and accidental releases of radionuclides and radiation to surface water and the atmosphere from power plant operations. Contamination of fish, wildlife and plants in the vicinity of uranium mines with radioactive and toxic pollutants.
- **Air pollution:** Releases of radioactive, toxic, smog and acid rain producing air pollutants throughout the nuclear power production cycle.
- **Accident and security risks:** Risks of major releases of radiation and radioactive contaminants as a result of major accidents or security incidents at nuclear facilities.

generating station using nuclear power costs $29.76. This is significantly more than the cost of using wind power ($18.85) or combined cycle natural gas generation ($4.11).[9] Improving energy efficiency and productivity to reduce GHG emissions would be cheaper still; experience in other jurisdictions demonstrates that such programs can cost far less than supply options[10] (while increasing economic efficiency and lowering net energy costs). With a per capita electricity use that is 60% higher than in neighbouring New York State,[11] Ontario has no shortage of lower-cost opportunities to reduce its need for electricity and the GHG emissions that go with supplying that power.

Determining the true cost of nuclear power is difficult. To attract private investment into nuclear projects, governments have had to provide complex webs of market, price and return-on-investment guarantees, and assume risks and liabilities related to everything from construction cost overruns and waste disposal and decommissioning to accidents and fuel costs. Even with all of these types of extraordinary guarantees in place, Ontario's Provincial Auditor noted that the province's October 2005 deal for the refurbishment of reactors at the Bruce Nuclear Facility still was not rich enough to draw one of the original partners in the private sector Bruce Power consortium — Cameco Ltd., a company whose major business is uranium mining and nuclear fuel production — into the deal.[12]

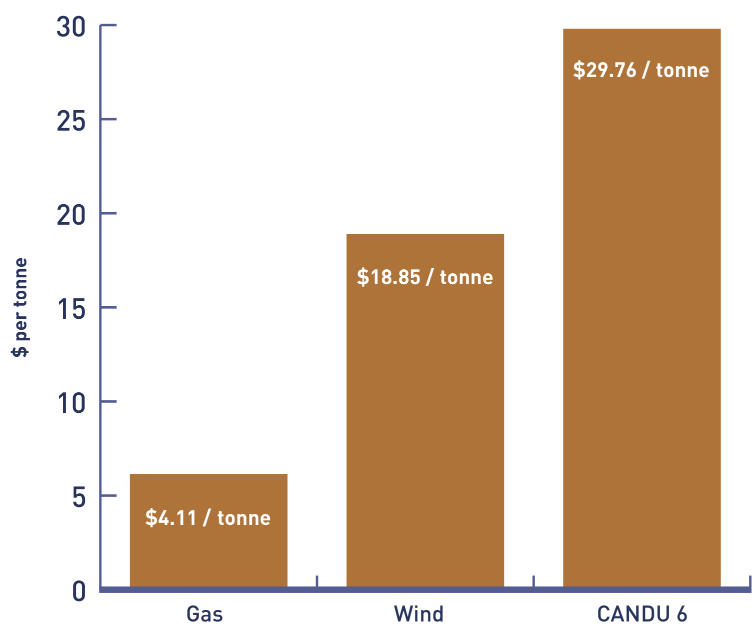
Other low GHG emission options don't need these sorts of extraordinary guarantees of profits and absorption of risks and liabilities by ratepayers and taxpayers to attract private capital investments.

Nuclear presents security, weapons proliferation and accident risks that are not shared by any other options for addressing climate change.

A global expansion of nuclear power on the scale necessary to have a significant impact on climate change would involve an enormous expansion of the availability of nuclear materials, technologies and expertise. Recent experience in Iran and North Korea has highlighted the security and weapons proliferation risks that would accompany such a path.

COMPARATIVE COST FOR GREENHOUSE GAS REDUCTIONS

The Ontario Clean Air Alliance used data from CIBC World Markets and the Ontario Power Authority to calculate the cost per tonne for greenhouse gas (GHG) emissions for three energy sources: natural gas (combined cycle), wind and nuclear. Nuclear power-driven GHG emission reductions were by far the costliest.



> **"Should a state with a fully developed fuel-cycle capability decide for whatever reason to break away from its non-proliferation commitments, most experts believe it could produce a nuclear weapon within a matter of months."**
> *Mohamed Elbaradei, International Atomic Energy Agency*

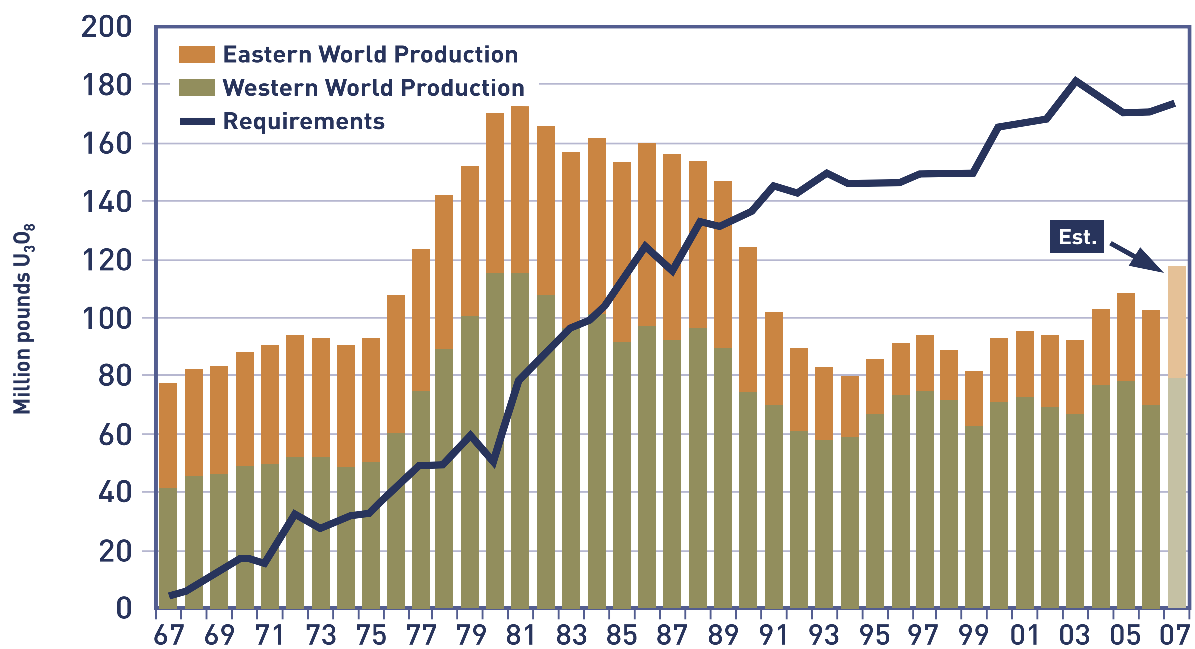
A serious accident or incident at a nuclear facility could result in the release of large amounts of radioactive material to the atmosphere, which could then spread over large areas.

Weapons proliferation concerns are virtually non-existent with other energy options, and security issues are generally limited to the impact of incidents on energy production facilities themselves. Unlike nuclear power, accidents and incidents with other energy sources are unlikely to have major long-term off-site health or environmental effects. The IPCC identifies safety and weapons proliferation concerns as constraints on the role of nuclear power as a response to climate change.[13]

Existing uranium supplies can't support a major nuclear expansion. Increasing the nuclear fuel supply means additional environmental impacts and security and weapons proliferation risks.

A major challenge of relying on nuclear power as a response to climate change is the question of fuel supply. Global supplies of uranium, particularly high-grade ores that are a significant factor in the apparently attractive GHG emission profile of Canadian nuclear facilities relative to conventional fossil fuels, are limited. The more than tenfold increase in the price of uranium over the past six years reflects the extent of the existing global shortfall in uranium sup-

URANIUM DEMAND ALREADY OUTSTRIPPING SUPPLY



Source: www.uxc.com

Moving to lower-grade uranium ores would increase nuclear power's GHG emission profile and create other severe environmental impacts, such as water and air pollution, as well as waste generation associated with uranium mining and milling.

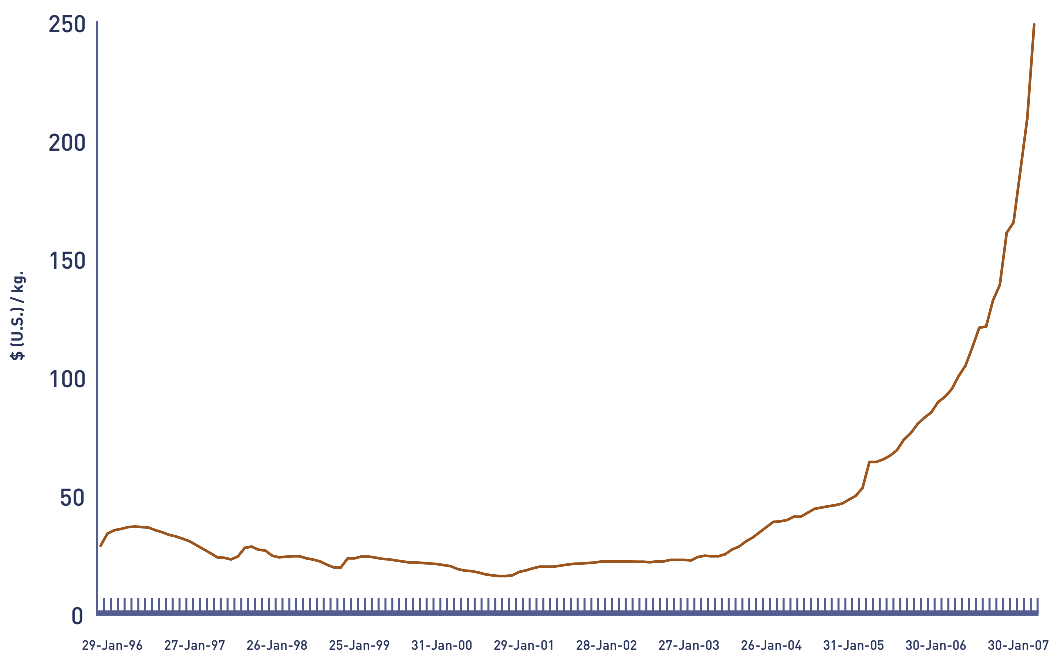
ply.[14] A global expansion of the use of nuclear energy on a scale necessary to significantly affect climate change would place severe pressure on the known high-grade ore sources.[15]

Moving to lower-grade uranium ores would increase nuclear power's GHG emission profile and create other severe environmental impacts, such as water and air pollution, as well as waste generation associated with uranium mining and milling. These impacts would increase roughly in proportion to the decline in ore grade (i.e., ten times the impacts with ore grades of one-tenth the quality).

Nuclear proponents suggest that reprocessing waste fuel could be a way of dealing with both the declining availability of high-grade ores and mounting stocks of highly radioactive waste fuel. Reprocessing, however, has serious waste and security risks of its own and would require the construction of extensive and expensive reprocessing facilities. It would also involve transporting materials between an array of reprocessing and fuel production facilities that could be used for nuclear weapons production. The option of reprocessing Canada's waste nuclear fuel was ruled out by the federally mandated Nuclear Waste Management Organization for these reasons.[16]

Fast breeder reactors (FBRs) that would create a near perpetual uranium–plutonium fuel cycle pose similar challenges and are thought to be decades away from even a prototype stage of development. In addition, research on FBRs was abandoned in the United States in the 1970s when they were shown to increase the risks of nuclear weapons proliferation.

URANIUM PRICE TRENDS — JANUARY 1996-APRIL 2007



Uranium prices have soared as a surplus of uranium from the decommissioning of Soviet-era nuclear weapons has been consumed and high-grade ore bodies have been depleted.

Ideas like extracting uranium from seawater or using thorium as fuel in reactors are even less developed.

In contrast, fuel supply issues are largely avoided by GHG emission reduction strategies centred on energy efficiency and the use of low-impact renewable energy sources.

Nuclear impedes the development of more sustainable options.

The presence of large centralized generating facilities, including nuclear generation stations, has a significant influence on the overall design of electricity systems. Where such types of facilities dominate, grid resources tend to be designed around the transmission and distribution of the electricity they generate. The result is a hub-and-spoke system organized around a relatively small number of large transmission lines from large centralized facilities. The result is an inflexible and inefficient system (with transmission losses starting at around 8% and increasing as loads increase).

Low-impact renewable and distributed generation options, such as combined heat and power, typically involve a large number of smaller generating facilities, many of which may have difficulty feeding directly into a large centralized grid. These types of generating facilities work better with networked rather than centralized grid structures. The United Kingdom's Sustainable Development Commission has pointed out that nuclear power's effect of locking in centralized distribution systems presents a major barrier to the development of more sustainable distributed generation systems.[17]

In Ontario, there has been direct competition between nuclear facilities and low-impact renewable energy sources for grid access. The province has severely restricted its standard offer program for renewable energy sources in the Bruce Peninsula, an area of high wind energy potential, as result of having guaranteed access to grid capacity in the region to the Bruce Nuclear Facility as part of the Bruce Power refurbishment agreement.[18]

Nuclear unreliability has equalled increased GHG emissions for Ontario.

In Ontario, the poor performance and premature aging of nuclear units has led to a dramatic increase in reliance on carbon-intensive coal power. The need to replace the power from the eight reactors shut down for repairs in 1997 meant that emissions of GHGs and sulphur dioxide from the province's coal-fired power plants more than doubled, while nitrogen oxide emissions increased by 170%. In fact, nearly 120 megatonnes of additional GHGs were released from the province's coal-fired electricity plants due to the reactor shutdowns over the 1996–2006 period.[19] Continued reliance on nuclear power means an ongoing risk that reliability failures at nuclear plants will lead to increased use of high GHG emission fossil fuel electricity sources for replacement power.

There are safer, cleaner, more reliable and more affordable options for reducing GHG emissions available today.

Proponents of nuclear energy often present only two options: expanding nuclear power or continuing on a business-as-usual path towards increasing GHG emissions and global climate change. The reality is that we have a wide range of options for significantly reducing GHG emissions without having to resort to the high-cost and high-risk nuclear option.

In previous research, for example, the Pembina Institute has demonstrated how both nuclear power and GHG emission-intense coal-fired electricity can be phased out in Ontario over the next 20 years.[20] A combination of energy efficiency improvements, fuel switching, low-impact renewable energy sources, and high-efficiency uses of natural gas can provide the foundation for a low GHG emission energy path for the province. These are the kinds of options that should be the focus of Ontario's GHG reduction strategy and future energy policies.

Endnotes

1 See, for example, Integrated Sustainability Analysis, *Life-Cycle Energy Balance and Greenhouse Gas Emissions of Nuclear Energy in Australia* (Sydney: University of Sydney, 2006), 8, which estimates emissions from CANDU reactors to range from 10–120 kg CO_2e per MWh of output, implying a potential range of emissions for Canadian production between 700,000 and 8.4 million tonnes CO_2e per year. See also, Ontario Power Authority, *Supply Mix Analysis Report Volume 2* (Toronto: Ontario Power Authority, 2005) Table 2.7.40 which used an estimate of 12 kg CO_2e per MWh output, implying 840,000 tonnes CO_2e per year from domestic production.

2 See Integrated Sustainability Analysis, *Life-Cycle Energy Balance and Greenhouse Gas Emissions of Nuclear Energy in Australia*, (Sydney: University of Sydney, 2006), 8 for a comparison of GHG emissions of various energy sources.

3 See www.bmu.de/pressemitteilungen/pressemitteilungen_ab_22112005/pm/39226.php

4 Working Group III, Intergovernmental Panel on Climate Change. *Summary for Policymakers: IPCC Fourth Assessment Report* (Bangkok: IPCC, 2007), 18. http://www.ipcc.ch/SPM040507.pdf

5 See Matthew Bramley, *The Case for Deep Reductions* (Ottawa: Pembina Institute and David Suzuki Foundation, 2005), 16–18.

6 Sir Nicholas Stern, *Stern Review: The Economics of Climate Change, Executive Summary* (London: HM Treasury, 2007) xi, www.hm-treasury.gov.uk/media/8AC/F7/Executive_Summary.pdf (accessed May 1, 2006).

7 Ibid., xxvii.

8 See Mark Winfield et al., *Power for the Future: Towards a Sustainable Electricity System for Ontario* (Toronto: Pembina Institute and Canadian Environmental Law Association, 2004), 33, Table 5.9 for a discussion of time to service for energy efficiency and energy supply options.

9 Jack Gibbons, *Rolling the Dice: A Review of the Ontario Power Authority's High Risk Strategy for Meeting Our Electricity Needs* (Toronto: Ontario Clean Air Alliance, February 2007), 12, Table 7, www.cleanair.web.ca/resource/rollingdice.pdf.

10 See Winfield et al., Tables 3.10 and 5.7.

11 Gibbons, 19, Figure 8.

12 See generally Office of the Auditor General of Ontario, *Special Review for the Minister of Energy: The Bruce Power Refurbishment Agreement* (Toronto: Queen's Printer, 2007), 6.

13 Working Group III, Intergovernmental Panel on Climate Change. *Summary for Policymakers: IPCC Fourth Assessment Report* (Bangkok: IPCC, 2007), 18. http://www.ipcc.ch/SPM040507.pdf

14 For a detailed discussion of uranium supply issues see www.uxc.com.

15 It is estimated that the high-grade uranium ore reserves in Northern Saskatchewan are sufficient to support current levels of consumption for approximately 40 years.

16 Nuclear Waste Management Organization, *Assessing the Options: Future Management of Used Nuclear Fuel in Canada* (Toronto: NWMO, 2004), 27–28.

17 Sustainable Development Commission. *Is nuclear the answer?* www.sd-commission.org.uk/pages/060306.html (accessed May 1, 2007).

18 See Ontario Power Authority, *Standard Offer Program: Transmission Constraints*, www.powerauthority.on.ca/sop/Page.asp?PageID=829&ContentID=4061&SiteNodeID=162&BL_ExpandID=161 (accessed March 15, 2007).

19 Jack Gibbons, *OPG: Ontario's Pollution Giant* (Toronto: Ontario Clean Air Alliance, 2007), 22, Table 12, www.cleanair.web.ca/resource/opggiant.pdf (based on a 1996 baseline).

20 See Winfield et al.

About the Pembina Institute

The Pembina Institute creates sustainable energy solutions through research, education, consulting and advocacy. It promotes environmental, social and economic sustainability in the public interest by developing practical solutions for communities, individuals, governments and businesses. The Pembina Institute provides policy research leadership and education on climate change, energy issues, green economics, energy efficiency and conservation, renewable energy and environmental governance.

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