Direct Decommissioning of the Pickering Nuclear Generation Station:
Economic and Other Benefits

**by Ralph Torrie, Torrie Smith Associates,
with research assistance from Brian Park
for Ontario Clean Air Alliance Research**

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Foreword

Ontario Clean Air Alliance Research commissioned Torrie Smith Associates to look at the economic implications of de-commissioning the Pickering Nuclear Station.

The Pickering Station is Ontario's oldest commercial-scale nuclear station. Construction on the eight reactor plant started in 1966 and took almost 20 years to complete. As with every other nuclear project in Ontario's history, construction costs went massively over budget, with Pickering B costing more than double the initial estimated cost.

Pickering has had a checkered operational history with numerous performance issues. In 1997, four Pickering A reactors were shut down for repairs after a scathing safety review. In the end, only two units were eventually re-started (Units 1 and 4) with the other two "A" reactors mothballed.

Today, the Pickering Nuclear Station is one of North America's highest-cost nuclear stations. In 2014, Pickering's fuel and operating costs alone (8.16 cents per kWh[1]) were more than double the average market price of electricity (3.60 cents per kWh[2]). As a result, the Independent Electricity System Operator was required to provide Ontario Power Generation (OPG) with "out-of-market" payments of approximately $900 million to subsidize Pickering's operating deficit.[3]

The Pickering Nuclear Station is one of North America's highest-cost nuclear stations and the aging plant is currently operating beyond its original "design lifetime."

Currently, the plant is operating beyond its original "design lifetime" which came to a close in 2015. In other words, systems are being pushed past the operational period for which they were originally designed despite the materials problems caused by the intensely inhospitable environment inside the reactor cores that have taken their toll over years of operation.

The Pickering Station is now surrounded by a large and growing urban area, and is closer to a major urban centre – Toronto – than any other nuclear plant in North America. Recently, OPG was ordered to proactively distribute potassium iodide (anti-radiation) pills in the 10 kilometre potential radioactive fallout zone around the plant and to ramp up efforts to distribute them throughout the 50 kilometre potential fallout zone around the station that includes the entire City of Toronto and parts of its northern and eastern outer suburbs.

The Ontario Government now says that it wants the Pickering Plant to continue operating until 2024. This is a reversal of its earlier position that the plant should close no later than 2020. There is no question that the earlier deadline makes much more sense for both performance and safety reasons.

When the reactors are permanently shutdown, the question becomes: "What happens next?" No jurisdiction has ever decommissioned a CANDU nuclear station. But with Pickering permanently closed, we cannot simply walk away from its highly radioactive remains.

Torrie Smith's analysis finds that there are major advantages to proceeding with decommissioning work immediately rather than following OPG's proposed approach of leaving the plant dormant for 30 years before proceeding.

There are significant risks to relying on investment growth to pay for decommissioning costs.

The first advantage is cost and cost certainty. Torrie Smith calculates that direct decommissioning can save $800 million to $1.2 billion on the total cost of decommissioning, in part by avoiding the costs of securing and maintaining the site for 30 years. It also ensures that the financial risk of a first-of-its-kind project is not pushed forward for 30 years, but dealt with today.

The entire estimated cost of Pickering can be covered by the Decommissioning Fund, including the net cost of moving forward the work. Relying on investment growth to cover deferred decommissioning costs is high risk, particularly in a slow growth economy. In our view, it is better to use funds set aside specifically for decommissioning to deal with the problem at hand.

The second advantage is a smooth transition from an operating facility to a decommissioning project. This would better ensure continued employment for many Pickering workers and would also ensure that existing expertise and plant-specific knowledge was readily available to assist with the decommissioning work. Thirty years from now, there will be few, if any, people left in the workforce with firsthand experience of Pickering's difficult operating history. Essentially, we will need to train a whole new set of workers to undertake work on a plant with which they have no familiarity.

The third advantage is safety. There is actually no particular reason – other than relying on investment growth to increase decommissioning funds – to wait 30 years to begin the work. The most radioactive component of the site – spent fuel and heavy water used for cooling – will have to removed immediately in any case. Working within the radioactive environment of the closed plant will be no different than it was when staff worked on reactor re-start projects at both Pickering and Bruce. What is different is that a 30-year wait will allow corrosion and decay to take a further toll on the plant, thereby increasing safety risks. It is far better to deconstruct and safely store the remains of the plant now.

All of this makes direct decommissioning the logical way to proceed. Torrie Smith calculates that direct decommissioning will create 16,000 person years of employment, which is greater than the 15,400 person years of em-

ployment that OPG estimates would be created by its proposed Darlington re-build project (assuming all four Darlington reactors are rebuilt). But just as importantly, the funds to decommission Pickering will come from a dedicated Decommissioning Fund whereas the funds for the Darlington Re-Build will come from electricity consumers, meaning the Pickering project will have no impact on electricity rates while the Darlington project will increase rates.

Decommissioning, whether direct or deferred, raises the question of how to store low- to high-level radioactive waste, the often ignored legacy of Ontario's heavy dependence on nuclear power. As Torrie Smith note, the high level waste at Pickering – fuel and heavy water – will have to be removed and stored immediately whichever path is chosen – direct or delayed decommissioning.

Decommissioning raises the issue of how to deal with radioactive waste, an often ignored aspect of Ontario's heavy dependence on nuclear power.

Unfortunately, there are no truly "good" solutions to the problem of waste storage. The industry's preferred solution of deep geologic storage for high-level wastes raises many concerns, from leakage to how to move radioactive waste hundreds or thousands of kilometres. The process to develop such high-level sites is also proceeding at a glacial pace in the face of serious concern from citizens and communities being asked to host such a facility.

Meanwhile, OPG's proposed deep geologic facility for low- and intermediate-level waste at the Bruce Nuclear Station on the shores of Lake Huron has been hugely controversial, located as it is near the source of drinking water for 40 million North Americans. The new federal government has indicated it wants to step back and review plans for this site.

Generally, we believe hardened onsite storage is a better solution. For spent fuel storage, such hardened storage will be a significant step up from the current temporary warehousing of waste. For other materials, the advantage is keeping the problem contained and in sight while the process of radioactive decay slowly reduces the threat posed by lower level wastes.

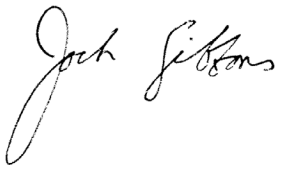
The final critical advantage of embarking on direct decommissioning is developing expertise in the nuclear industry's one and only growth sector: dismantling shut down facilities. Currently, shutdowns have been proposed for two nuclear plants right across the lake in New York State[4] with growing pressure to shut down a third – the Indian Point station outside of New York City.

Vermont recently closed its only nuclear plant and is starting the decommissioning process.[5] The Pilgrim Nuclear Plant in Massachusetts will close in 2019.[6] Overall, the United States has the world's largest, but oldest, fleet of reactors and economic pressures could lead to closure of dozens of units

over the next decade, particularly single reactor plants according to the World Nuclear Industry Status Report[7].

More directly, there are CANDU units in Korea, Romania, Argentina and China where technology-specific expertise in decommissioning may prove valuable in the not-too-distant future.

Ontario can save money, provide a better transition for workers and develop a new, highly marketable area of expertise by proceeding directly with decommissioning of the Pickering Nuclear Station. The time to act is now.



Jack Gibbons
Chair
Ontario Clean Air Alliance Research

Endnotes

1 Ontario Energy Board Docket No. EB-2013-0321, Exhibit JT1.14.

2 http://www.ieso.ca/Pages/Power-Data/price.aspx

3 In 2014 the Pickering Nuclear Station produced 20 billion kWh. 20 billion kWh x (8.16 – 3.60 cents per kWh) = $912 million. Ontario Power Generation, *Performance Report for Pickering Nuclear: 2014 Results*.

4 http://www.bloomberg.com/news/articles/2015-11-02/entergy-to-close-james-a-fitzpatrick-nuclear-power-plant-ighwq4q9 and http://www.poughkeepsiejournal.com/story/news/2015/10/22/new-deal-on-ginna/74380570/

5 http://vydecommissioning.com/

6 https://www.bostonglobe.com/metro/2015/10/13/entergy-close-pilgrim-nuclear-power-station-nuclear-power-plant-that-opened/fNeR4RT1BowMrFApb7DqQO/story.html

7 Mycle Schneider and Antony Froggat, *World Nuclear Industry Status Report 2015*, page 108

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About the Author

Ralph Torrie is an expert in the field of energy, environment and climate change response strategies, with 35 years of entrepreneurial, management and consulting experience that includes hundreds of initiatives in research, business development, and public policy. He is a principal of Torrie Smith Associates, a research and software development firm he founded, and he has an ongoing interest in electric power planning issues in Ontario that dates to his involvement with the Royal Commission on Electric Power Planning in the 1970s. He also spent two years as Assistant Coordinator of the Energy Research Group of the United Nations University and the International Development Research Centre, and six years as a corporate executive, first as Vice President at ICF International and then as Managing Director at Navigant, both publicly traded U.S. based firms with significant Canadian operations.

Acknowledgements

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Introduction

According to current plans, the Pickering Nuclear Generating Station (PNGS) will be the first of Ontario Power Generation's nuclear plants to be permanently shut down.[1] Two of its eight 500 megawatt (MW) reactors have been shut down since 1997 and the other six are operating on ad hoc license extensions that expire in 2018.[2] Under Ontario Power Generation's (OPG's) preferred strategy of "deferred decommissioning," the utility proposes to put the plant in a safe shutdown state and let it sit idle for 30 more years before commencing dismantlement.

In today's dollars, the estimated cost for decommissioning the eight-unit station will be $5 billion, including the cost of mothballing and maintaining the radioactive plant in a safe shutdown state for several decades. This paper explores the economic, employment, and other benefits of an alternative strategy in which the multi-year process of dismantling begins immediately after shutdown and is completed by 2030.

When a nuclear reactor reaches its "end-of-life" and is shut down for the last time, it must be "decommissioned." But dismantling and disposing of a defunct nuclear power reactor is not your average demolition project. First the nuclear fuel is removed and stored as high-level nuclear waste while the water is also drained from the reactor in preparation for the dismantling and disposal of the reactor components, the steam generators and the miles of piping and other equipment that make up a nuclear power plant.

Even with the fuel removed, the interior components of the reactors remain radioactively contaminated – a large part of the plant is essentially radioactive waste. Decommissioning, therefore, requires the use of robotics and shielded working environments whether the plant is dismantled immediately after defueling or 30 years later.

Meanwhile, the low- and intermediate-level radioactive waste that results from the plant's dismantling must be prepared for shipment to either temporary or permanent waste disposal sites (should such a permanent site be developed), all while minimizing public and worker exposure. It is an expensive and labour intensive process and while no CANDUs have yet been decommissioned, OPG's $5 billion estimate for the Pickering Station ($630 million per reactor) is on the low end of the estimated cost range — the estimate for decommissioning the single unit CANDU in New Brunswick is over $900 million.[3]

Ontario Power Generation's planned approach is called "deferred decommissioning" — the reactors are put in a state of "safe shutdown" after defueling and dewatering and then left idle for 30 years or more before final dismantlement and disposal. Most of the costs (and the related job creation) are postponed for more than 30 years.

However, international nuclear regulatory agencies discourage use of the deferred commissioning approach and recommend instead "direct decommissioning," the practice of dismantling the reactors immediately after permanent shutdown. This paper provides an initial review of the economic and other benefits that would go along with the adoption by OPG of the industry best practice of direct decommissioning, beginning with the Pickering Nuclear Generation Station.

1 Ten of the other 12 large power reactors owned by OPG (at the Darlington and Bruce nuclear stations) will reach their "end of life" dates during the 2020s at which time they will either be decommissioned or "refurbished." The term "refurbishment" refers to the rebuilding of the reactor core "from the inside out" in order to extend its operating life. The early stages of rebuilding are similar to decommissioning insofar as it involves removing the fuel, the pressure tubes and other components inside the primary containment envelope. Rebuilding however is much more expensive and capital intensive (fewer jobs created per dollar spent) than decommissioning as it requires new reactor components to be manufactured, installed, commissioned and licensed for operation. The cost of any reactor rebuild will be added to the future price of electricity in Ontario. The cost of decommissioning, on the other hand, will be paid from the "Nuclear Decommissioning Fund", a special savings fund OPG is required to maintain and which, as of January 2015, had a balance of more than $7.4 billion.

2 OPG has indicated it would like to further extend the life of the aged Pickering Station beyond its current 2018 license expiration, perhaps for as much as another six years.

Deferred Decommissioning – OPG's planned approach

The most recently revised plan and cost estimates for the decommissioning of the Pickering Nuclear Station are based on the current end-of-life dates for the reactors, with the six remaining units shutting down between 2017 and 2019. The two reactors that have been shut down since 1997 have already been defueled and dewatered and the remaining six units would be prepared for dormancy over the 2018-2020 period at an estimated cost of $270 million. The cost of maintaining the plant throughout the dormancy period is estimated by OPG to be $644 million, not counting what has already been spent on Pickering A. In addition, the cost of managing all the low-level radioactive waste that would be generated during the dormancy period is estimated to be in excess of $350 million. These are the premiums associated with the deferred approach to decommissioning and most of this money could be saved by proceeding with direct decommissioning.

After the dormancy period, the reactors and all their auxiliary systems and buildings would be systematically dismantled and the site remediated at an estimated cost of $2.4 billion, not including the cost of managing and disposing of the low- and intermediate-level waste. Managing and disposing of the radioactive waste generated during both the dormancy period and the final dismantlement adds another $1.6 billion to the total cost estimate, including a contribution to the cost of spent fuel management during the period after the plant is shut down and before the availability of a long-term repository.[4]

Adding it all up, OPG's estimated cost for decommissioning and disposing of the Pickering Station totals $4.9 billion, not including costs already incurred prior to 2012 (mainly for the defueling and dewatering of Units 2 and 3). With OPG's proposed "deferred decommissioning" this spending would be spread out over the next several decades, with 50% of the expenditures (and the associated job creation) occurring after 2050. The $4.9 billion expenditure would generate direct employment of 20,000 person-years.[5]

Direct Decommissioning

With the direct decommissioning, many of the activities are the same, but the annual cost of maintaining the plant in a dormant state for decades is eliminated and the activities associated with preparing the plant for dormancy can be eliminated or integrated with the activities required to prepare the plant for dismantling. Low-level waste generation during the dormancy period is also eliminated leading to additional cost savings. The timeline for direct decommissioning is compressed to 12-14 years, as compared with the 42 years required for deferred decommissioning. There will be some offsetting expenditures, but we estimate savings from the elimination of the 30-year dormancy period total at least $800 million and could be as high as $1.2 billion.

Conservatively assuming the lower savings figure, this would reduce the cost of decommissioning the eight-unit Pickering NGS to $4.1 billion, compared to OPG's estimated $4.9 billion for deferred decommissioning.

3 Unless otherwise indicated, we have used 2012$ throughout this report, consistent with the cost estimates provided by OPG. OPG's risk contingency factor of four percent has been pro-rated to component costs. As a rough indicator, 2012$ can be converted to 2016$ by multiplying by 1.05.

4 Except for this relatively small contribution, the cost of long-term management of the highly radioactive spent fuel from the reactors is not counted as a cost of decommissioning. OPG's estimated cost for the long-term management of the spent fuel from the Pickering Station is $4.3 billion.A separate savings fund has been created for the cost of long-term management of the spent fuel.

5 Employment estimates in this report are for direct job creation only, and are consistent with CANDU decommissioning studies. Indirect and induced employment generated would more than double the estimated job creation of most OPG expenditures.

While OPG is required to maintain a fund to cover decommissioning costs, current regulations and the deferral of the work into the second half of the century allow OPG to set aside only $2.75 billion for the decommissioning of the Pickering station and then rely on compound interest and passage of time to ensure that there will be sufficient funds in the decommissioning account in 2050 to pay for the work.

With direct decommissioning, costs are reduced, but spending is moved forward in time, effectively increasing the present value of the station decommissioning cost. While the cost of direct decommissioning of Pickering is lower than for deferred decommissioning ($4.1 billion vs. $4.9 billion), the net present value of direct decommissioning is $2.9 billion, compared with $2.75 billion for deferred decommissioning. The increase in present value from moving the expenditures forward is almost completely offset by the real savings from the direct decommissioning approach. The residual $150 million difference is relatively small compared to the $1 billion-plus *surplus* in the Decommissioning Fund[6], so the cost of the switch to direct decommissioning of the Pickering NGS can be covered without any additional charges to Ontario electricity ratepayers.

The direct decommissioning option eliminates the labour required to watch over and keep the reactors safe during the 30-year dormancy period and delivers more than twice as many jobs as deferred decommissioning during the next 15 years. Between 2016 and 2030, the direct decommissioning scenario would generate 16,000 person-years of employment, which is greater than the 15,400 person-years of employment that would be created by the execution phase of the proposed Darlington Re-Build (2016-2026) project.[ii] And, as noted above, the decommissioning jobs would be paid for from the Nuclear Decommissioning Fund that has been established for just this purpose. Unlike nuclear plant rebuilds, decommissioning costs would not contribute to electricity rate increases.

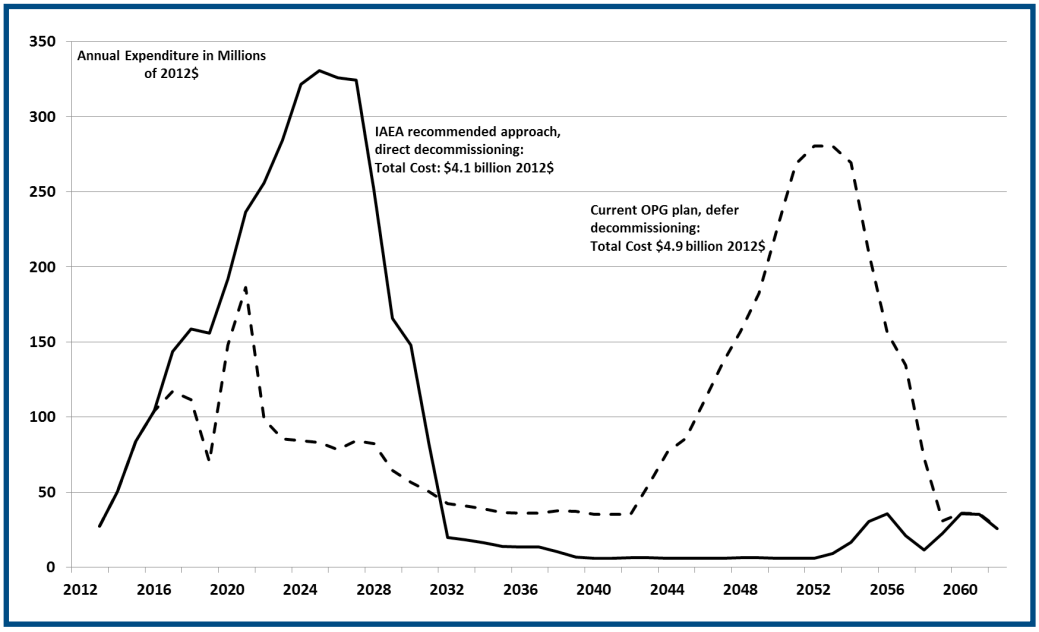
The Benefits of Direct Decommissioning

With direct decommissioning, dismantling is not postponed for decades but proceeds immediately after the reactor has been defueled and dewatered. Historically, the deferred decommissioning approach was preferred, and it prevailed 25 years ago during OPG's nuclear expansion era. Since then, however, as further experience and insights have been gained from nuclear power programs around the world, the strategy-of-choice has shifted to direct decommissioning in recognition of the disadvantages, costs and risks of the long dormancy period that characterizes postponing dismantlement compared to the relative cost savings and lower risks of immediate dismantlement.

Experience with decommissioning in Germany in the 1990s, for example, showed that immediate dismantlement was cheaper, safer and less risky than deferral, and that deferral was not justified on the basis of assumed better dismantling techniques in the future.[iii] Over the past 15 years, the arguments for immediate dismantlement have strengthened such that "the emerging international trend is more towards immediate dismantling than was previously the case (e.g. France, Italy, United Kingdom, Spain, Japan)."[iv]

6 The balance in the Nuclear Decommissioning Fund at the beginning of 2015 was $7.35 billion. The purpose of the Fund is to cover the present value of the deferred decommissioning and because OPG's policy is to defer dismantlement of the reactors for decades into the future, the requirements of the Fund are sensitive to the assumed end-of-life dates for the reactors, the discount rate, and the predicted cost of the future decommissioning. The Fund increases each year according to the return its investments make, less any withdrawals to pay for decommissioning activities, plus any contributions from OPG necessary to cover the utility's asset retirement obligations for the nuclear stations. At the beginning of 2015 the liability was $6.2 billion, putting the fund in a $1.1 billion "surplus" position.

Figure 1. Direct vs. Deferred Decommissioning Expenditures: Pickering Nuclear Station



The International Atomic Energy Agency states clearly in its General Safety Requirements that "the preferred decommissioning strategy shall be immediate dismantling."[v] While the IAEA recognizes there can be special circumstances that militate against immediate dismantlement, there are a number of reasons why immediate dismantlement is preferred, including:

- ***Cost Savings.*** As we have shown for the Pickering G.S., with the deferred decommissioning approach, the cost of preparing the reactors for the dormancy period and then maintaining them in a secure and safe shutdown state for decades adds up to about 25% of the cost of decommissioning, net of waste handling and disposal costs. Direct decommissioning, on the other hand, increases the likelihood that some of the plant's systems, such as ventilation systems and lifting and moving equipment, will be useable in the decommissioning activity, providing additional cost savings. And there is no case for deferring decommissioning on technological grounds as there might have been 25 years ago — the technology required for decommissioning is available and its cost has not been an issue.

- ***Availability of knowledgeable staff***. As pointed out in the Nuclear Energy Agency (NEA) review, "the knowledge of staff that has been involved with the facility over a long period of time will be invaluable during its characterization prior to decontamination and dismantling as well as during dismantling. This is particularly true of staff involved in its construction and in any subsequent modification."[vi]

- ***Radiological Risk.*** The argument that the dormancy period is necessary in order to allow radioactivity levels to subside has not proven out in practice. It would take much more than 30 years before the radiological hazard inside a CANDU would be low enough to avoid the use of remote cutting technologies and worker shielding. Immediate dismantlement also eliminates both the radiological ex-

posure and radioactive waste that would be generated over the 30-year dormancy period. Indeed, the bulk of the low-level radioactive waste generated during deferred decommissioning accumulates during the dormancy period. Notably, radiological hazards have not prevented OPG from proposing to proceed with nuclear plant rebuilding without delay, a process that involves similar and, in some cases, identical tasks to be carried out inside the same contaminated primary containment envelope as is the case for dismantlement.

- ***Local economic impact***. Direct dismantling is more consistent with a smooth transition in the local economy after a power plant shuts down. As discussed above with regard to the Pickering NGS, adoption of a direct dismantling strategy for that plant would cause a major, positive impact on employment at the station that would continue throughout the 2020s.

- ***Provincial and federal government benefits***. Money for funding the decommissioning of OPG's reactors is collected as part of the price of electricity in Ontario, and as of January 2015 OPG's Decommissioning Fund had a balance of more than $7 billion. Putting some of this money back into the Ontario economy now by proceeding with the direct decommissioning of the Pickering Nuclear Station will create jobs and stimulate economic activity while returning significant tax revenue to both the provincial and federal governments.

- ***Financial Risk.*** The approach taken in Ontario in which OPG is only required to set aside today's present value of the future cost of the postponed dismantling of its reactors runs the risk that in the decades ahead the Decommissioning Fund will not earn the necessary real rate of return to ensure there are sufficient funds to cover the cost of decommissioning the Pickering reactors in the 2050s. Once the reactors shut down, they will no longer be contributing revenue to the cost of decommissioning so any shortfall that develops because of underperformance of the fund will have to be made up by future ratepayers or the Province of Ontario. Over the long dormancy period, the Decommissioning Fund will be subject to all the risks attached to any long-term investment, which is why the OECD Nuclear Energy Agency review concluded that "regardless of country or fund management arrangements, however, accumulated reserves held for long periods of time are exposed to considerable risk from inflation, money market losses, economic crises and conflicts involving major changes of state institutions. This leads to the clear international view that, as regards to the security of funding, decommissioning should be carried out as soon after closure as the necessary funds are available"[vii] and that "***it is not good practice to use the lower current-day funding requirements associated with a net present value calculation as justification for taking a deferred dismantling approach***"[emphasis added].[viii]

The financial risk of the present-value approach is exacerbated by the risk that the decommissioning cost estimates are themselves too low. This is a difficult risk to assess as OPG does not publish the details of its decommissioning plans and there is no actual CANDU decommissioning experience to use as a reference point. Indeed, another reason for proceeding with direct decommissioning of the Pickering NGS would be to reduce the uncertainty in the cost estimates so that any necessary adjustments to the Decommissioning Fund can be made while the other reactors are still operating.

At the height of OPG's nuclear expansion activity, Atomic Energy of Canada Ltd. conducted a "detailed study of the various procedures and costs associated with decommissioning a CANDU reactor"[ix] and then concluded that the deferred decommissioning option for a 600 MWe CANDU, assuming a 30-year dormancy period, would cost $60 million in 1975 dollars or about $240 million in 2010 dollars. By 2010, the decommissioning cost estimate for the 600 MWe CANDU plant at Point Lepreau had nearly quadrupled — to $900 million — and the firm that prepared the estimate warned that:

> *It has been TLG's experience that the results of a risk analysis, when compared with the base case estimate for decommissioning, indicate that the chances of the base decommissioning estimate's being too high is a low probability, and the chances that the estimate is too low is a higher probability.*[x]

Conclusions

Direct decommissioning has emerged as the internationally preferred strategy for nuclear power plants and this review suggests that such an approach would deliver financial, economic, employment, and safety benefits to Ontario. At no cost to Ontario power consumers, injecting money from the Decommissioning Fund into the Ontario economy at this time in order to proceed with the dismantling and disposal of the Pickering Nuclear Generation Station would:

- ✓ create needed economic stimulus and employment;
- ✓ save $800 million in the overall cost of decommissioning the station;
- ✓ generate 16,000 person-years of direct employment between 2016 and 2030, and more than twice this many when indirect and induced employment impacts are included;
- ✓ significantly reduce the volume of radioactive waste that would otherwise be generated by the plant over the next 40 years;
- ✓ return hundreds of millions in tax revenue to Ontario and other levels of government; and
- ✓ generate the experience Ontario will need to properly manage its own nuclear fleet while positioning it as a world leader in the fast-growing global market for nuclear decommissioning technologies and services.

Endnotes

i OPG's plans and detailed cost estimates for decommissioning are not public, but we were provided with the following summary cost information in response to a Freedom of Information request: "2012 ONFA Reference Plan Update Program Summary Cost Estimate Report" (W-REP-00400-0004-R00, 2011-11-22), "2012 ONFA Reference Plan Update Station Decommissioning Summary Cost Estimate Report", (W-REP-09600-00010-R01, 2011-11-22), "2012 ONFA Reference Plan Update L&ILW Operations Summary Cost Estimate Report", (05386-REP-0400-00003, November 2011), "2012 ONFA Reference Plan Update L&ILW Long Term Management Summary Cost Estimate Report", (00216-REP-00400-00004, November 2011) "2012 ONFA Reference Plan Update Used Fuel Storage Cost Estimate Report" (06819-REP-00400-00003-R01, 2011-11-28), and "2012 ONFA Reference Plan Update Long Term Used Fuel Management Summary Cost Estimate Report", (W-REP-0400-00005-R01, 2011-11-22).

We were also able to draw on the decommissioning plans for the Point Lepreau NGS in New Brunswick and for the Gentilly 2 NGS in Quebec, both of which are accessible on public web sites:

TLG Services, Inc., "Decommissioning Cost Study for the Point Lepreau Generating Station", prepared for New Brunswick Power Nuclear, Document N29-1632-002, Rev. 0, June 2010. Accessed on the web site of New Brunswick Energy & Utilities Board, http://www.nbeub.ca/opt/E/get_document.php?doc=30.52.pdf&no=5369.

TLG Services Inc., "Preliminary Decommissioning Plan for the Gentilly 2 Nuclear Generating Station", prepared for Hydro-Quebec, 2000. Accessed from the web site of Quebéc Bureau d'audiences publiques sur l'environnement, http://www.bape.gouv.qc.ca/sections/mandats/gentilly-2/documents/liste_documents-DA-DB-DC.htm.

ii According to OPG, the Darlington Re-Build Project would create 30 million person hours of field work, which is equivalent to 15,400 person-years of employment. See http://www.opg.com/generating-power/nuclear/stations/darlington-nuclear/darlington-refurbishment/Pages/Semi-Annual-Performance-Report.aspx.

iii European Commission, "Decommissioning of nuclear installations in the European Union: Supporting document for the preparation of an EC communication on the subject of decommissioning nuclear installations in the EU", compiled by P. Vankerckhoven, DG XI/C.2, Directorate-General Environment, Nuclear Safety and Civil Protection, 1999. EUR 18860 EN.

iv NEA/OECD, "Selecting Strategies for the Decommissioning of Nuclear Facilities: A Status Report", NEA No. 6038, 2006.

v International Atomic Energy Agency, "Decommissioning of Facilities", Section 5 of General Safety Requirements Part 6 (GSR Part 6), issued 2014.

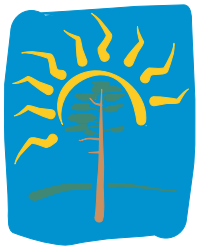
vi NEA/OECD, "Selecting Strategies for the Decommissioning of Nuclear Facilities: A Status Report", NEA No. 6038, 2006, p.21.

vii NEA/OECD, "Selecting Strategies for the Decommissioning of Nuclear Facilities: A Status Report", NEA No. 6038, 2006, p. 19.

viii NEA/OECD, "Selecting Strategies for the Decommissioning of Nuclear Facilities: A Status Report", NEA No. 6038, 2006, p. 10.

ix G.N. Unsworth, "Decommissioning of CANDU Power Stations", Report AECL-6332, April 1979.

x TLG Services, Inc., "Decommissioning Cost Study for the Point Lepreau Generating Station", prepared for New Brunswick Power Nuclear, Document N29-1632-002, Rev. 0, June 2010. Accessed on the web site of New Brunswick Energy & Utilities Board, http://www.nbeub.ca/opt/E/get_document.php?doc=30.52.pdf&no=5369. Section 3, p.8.



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