NUCLEAR POWER: WHERE'S THE BUSINESS CASE?

OSEA

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Looking ahead to a sustainable, prosperous future

What kind of Ontario do you want to live in? What type of legacy do you want to leave your children, and future generations? What role will energy fill in that future? How can we make our energy system more sustainable?

The Ontario Sustainable Energy Association (OSEA) is opening the dialogue on how we can create a more sustainable and prosperous Ontario, through a series of reports, regional conferences and webinars.

The International Energy Association has concluded that the biggest challenge facing a more integrated, distributed and sustainable energy system is the unfair competitive advantage created by heavy subsidies for conventional energy. We hope this report reveals facts you perhaps did not know.

We also hope this report will compel you to want to learn more about how you can become a conserver by lowering your energy bills, and about how you and your community or company can be part of the exciting transformation occurring in Ontario and around the world.

Together we can plot a course where every Ontarian has the opportunity to be a generator and conserver of clean green energy. Together we can ensure a bright future for all Ontarians.

Kris Stevens
Executive Director
Ontario Sustainable Energy Association

About Us

The Ontario Sustainable Energy Association (OSEA) is a non-partisan, member-based, non-profit dedicated to inspiring and enabling the people of Ontario to improve the environment, the economy and their health by conserving and producing clean, renewable energy in their homes, businesses and communities. Members include individuals, manufacturers, installers, developers, municipalities, First Nations, farmers, co-operatives and other community organizations supportive of, and engaged in, sustainable energy in Ontario.

INTRODUCTION

THE ONTARIO POWER AUTHORITY has finalized a 20-year plan to build new generation, upgrade the power grid, and invest in energy efficiency. It is now on the desk of the Minister of Energy, waiting for approval.

This Plan would formally allocate almost 50% of the Ontario 'market share' to nuclear generation for several decades. This would include re-furbishing existing reactors, and building new ones despite not knowing what the new reactor model, vendor, size, builder or capital cost will be.

Construction of the Darlington Nuclear Station went 350% over budget

Even if power demand grows as the OPA predicts, this will leave only a small market share for future renewable projects of all types. But if demand rises more slowly, or remains static due to gains from aggressive efficiency investments, the portion for new renewables will be even smaller. Green developers will end up competing against each other for a sliver of market share.

Equally important, a 50% allocation to nuclear now will effectively hard-wire the provincial grid in favour of large, centralized generation and high-voltage lines – at the expense of investments in the distribution circuits to accommodate new renewables and the advent of electric vehicles.

Either a minor market allocation, or a lack of investment in the Hydro One distribution circuits, will undercut efforts to build out and sustain Ontario's green manufacturing sector and related jobs. These will only be as robust as the scale of opportunities to build new green generation.

If there is a solid business case for building new nuclear plants, the OPA has not made it. It does not have a firm, contractual bid from a vendor. So it does not know the cost.

No formal offers have been disclosed. So the public, and green power competitors, do not know the cost.

For this reason alone, the Minister of Energy must remove any nuclear "set-aside" in the OPA plan until these costs are known, publicly disclosed, and debated. Given the current supply/demand balance, there is 5-year window to defer any decision.

ONTARIO HYDRO'S HAUNTED PAST

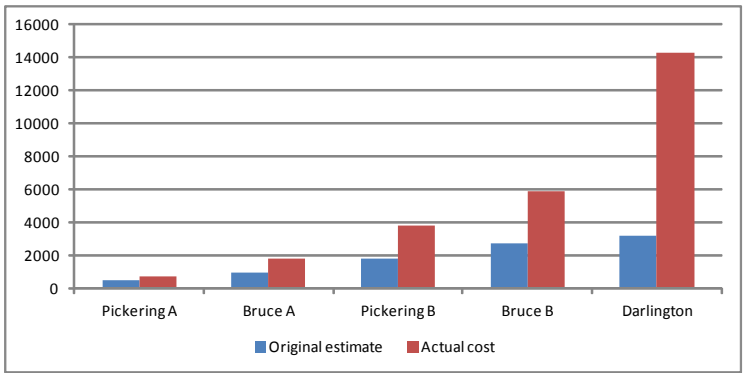
There is, however, a solid business case *against* investing in more nuclear. Ontario's past experience, and current global examples, confirm this is a bad investment choice. And the best recent evidence suggests this will be the most expensive and risky option, not the cheapest and most prudent.

During the 1970's and 1980's, Ontario Hydro used borrowed public funds to build out one of the most ambitious nuclear programs in the world. A total of twenty CANDU reactors were built at Pickering (8), Bruce (8), and Darlington (4). Both the nuclear engineers and politicians promised cheap power, and stellar performance.

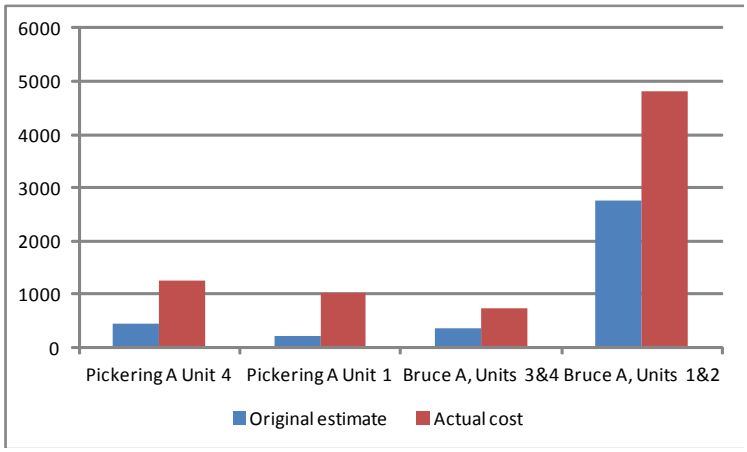
Neither were delivered:

- Not one of the CANDU reactors were built on time and on budget. Instead, the cost overruns increased with each new project. The Bruce B complex was projected to cost $2.7 billion, but cost $5.9 billion. The Darlington reactors were originally projected to cost $3.2 billion, but eventually cost $14.3 billion.

Estimated vs. Actual Cost for New Build Nuclear Projects ($ millions)



Estimated vs. Actual Cost for Nuclear Refurbishment Projects ($ millions)



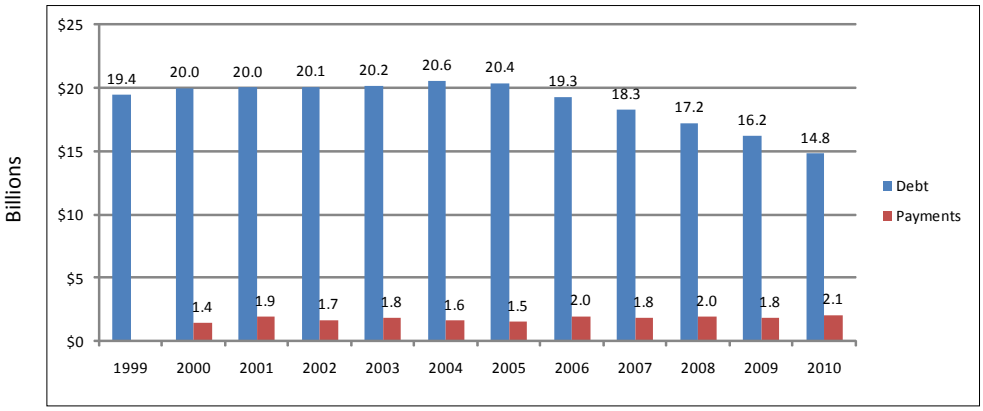
- All of the reactors have been plagued by breakdowns, repairs, and major outages for originally unplanned, mid-life overhauls. These past "refurbishments" have cost more than $6 billion, and required purchasing expensive, imported replacement power.
- Three decades of experience has not solved this problem. The most recent refurbishment, Bruce A, was projected to cost $2.75 billion. The repairs are now expected to exceed $4.8 billion.
- The four large Darlington reactors (the newest in the fleet) will start going down for major mid-life repairs in 2016. This will cost the public $10 billion or more. As each 875 MW reactor goes off line for several years, 875 MW of replacement power will need to be found and purchased.

- International and Ontario experience shows that as nuclear plants age, their performance declines and their maintenance/repair bills climb. This makes them initially appear far cheaper than they are, and shifts billions in costs into the future. If they were under 40-year warranties, all of them would fail.

By the late 1990's, nuclear power accounted for almost two-thirds of Ontario power generation. But the combined effect of the nuclear cost-overruns and performance failures pushed the old Ontario Hydro into effective bankruptcy under a debt totalling $38 billion.

Most of that was directly attributable to the nuclear fleet, and deemed 'stranded' or unrecoverable by its successor, Ontario Power Generation. So almost $20 billion of that debt was moved to a different government ledger, to be recovered from rate-payers through a debt retirement charge.

Annual Payments to Service and Pay Down the Stranded Debt and Outstanding Balalnce



courtesy OCAA

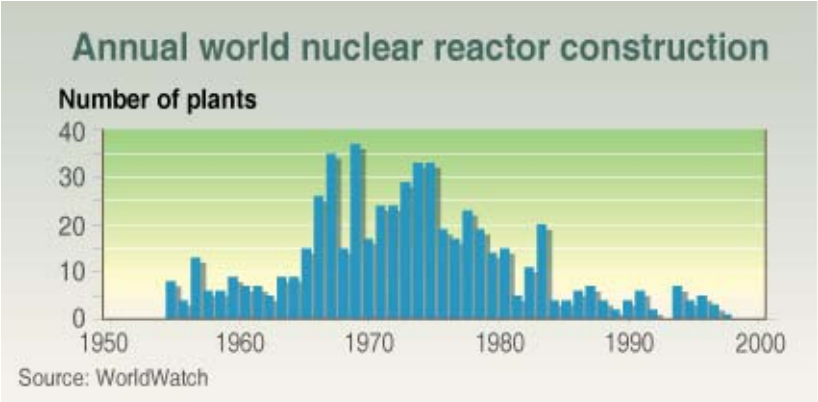
Since then, almost $20 billion in payments have been made, but the nuclear debt has only declined to $14 billion. It likely won't be paid down until 2020.

The two most recent nuclear projects in the Western world (in Finland and France) are far over budget and well behind schedule.

THE INTERNATIONAL EVIDENCE

Even before the catastrophic Fukushima nuclear accident in Japan, the decades-long trend of reactors failing to be built on time and on budget continued.

Even the two most recent reactor construction projects – for experienced European utilities by the French builder/vendor Areva – provides an ominous outlook:



- The Okiluoto project in Finland is $3.54 billion over budget, and five years behind schedule. This Areva reactor was promised as a large, less-complex, next-generation reactor which could be built quickly and cheaply. It will likely not generate any power until 2014.

- This debacle caused a permanent split between Areva and its German partner, Siemens. Siemens has recently declared it will no longer pursue nuclear as a core business. Other large companies, like General Electric, have also made multi-billion investments in divisions which produce green energy technologies, while nuclear divisions chase scarce reactor orders.

- The newest French reactor at Flammanville is four years behind schedule, and 2.7 billion euros over budget. Construction started in 2007, but it will not be completed until 2016. The reactor is being constructed for the French state utility EDF by Areva, which is deeply in debt, recently had its credit rating downgraded, and is selling assets to stay solvent.

- No new reactors have been completed in the U.S. since 1996. Only four are in initial development. Two Georgia reactors are projected to cost $14 billion, and require $8.3 billion in federal government loan guarantees. Two smaller reactors in South Carolina are projected to cost $10 billion. The utility building them recently had its credit rating cut, and its partners are pulling out. The project will not be built without U.S. federal loan guarantees.

IS NUCLEAR POWER SUBSIDIZED? LET US COUNT THE WAYS ...

In a rare moment of candour, a former top advisor to Prime Minister Stephen Harper publicly conceded that Canada's nuclear industry has been a "$30 billion sink-hole" for taxpayers.

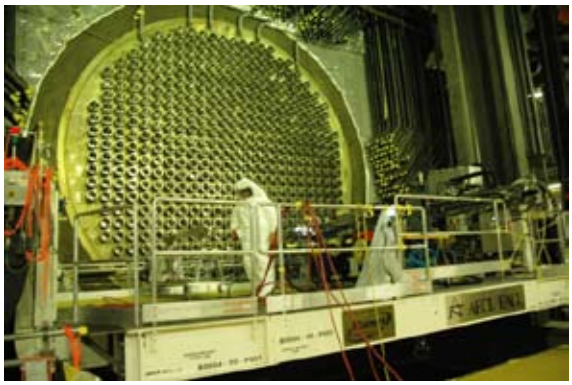
Recently, Ottawa sold its reactor division (AECL) to SNC-Lavalin for $15 million – or a token scrappage fee. There were no other buyers. The French company Areva walked away. Even the board of Bruce Power (which operates 8 Ontario reactors) declined to bid.

This, and the past $38 billion virtual bankruptcy of Ontario Hydro, is evidence enough that vast taxpayer subsidies were not enough to make nuclear competitive. Renewable technologies have received only a fraction of that support.

But the subsidies for nuclear don't end there. While renewable competitors take the blame for overt subsidies (premiums or tariffs paid for green power), nuclear needs permanent and pervasive covert subsidies to survive.

See page 6-7 for a few contrasting examples:

Nuclear plants produce thousands of kilograms of radioactive waste that will have to be carefully stored for centuries.



Halfway through their operating lives, highly radioactive pressure tubes need to be replaced and buried along with spent fuel.

IS NUCLEAR POWER SUBSIDIZED? LET US COUNT THE WAYS ...

From public liability waivers to government funded environmental assessments, nuclear power benefits from a host of hidden subsidies

INSURANCE SUBSIDY

Because no private insurer will provide full catastrophic reactor accident coverage, they can only be built if federal taxpayers assume that risk and cost. The recent Fukushima accident damage has been estimated at $250 billion. So Ontario nuclear plant owners only pay for the equivalent of a "deductible" coverage, while taxpayers backstop the major accident risk and cost.

VS.

FULLY SELF INSURED

No private green power generators pose a catastrophic accident risk. So their insurance costs should be proportionally lower. But they must pay the rates insurers demand in the case of construction accidents, equipment failures, storm damage, vandalism, loss of revenue, etc. So they pay market rates, while nuclear pays publicly subsidized insurance rates.

SUBSIDISIZED R&D

Reactors are designed by federally and provincially subsidized engineers. This year alone, Ottawa paid over $300 million for AECL to continue designing new reactors slated to be built in Ontario. If that occurs, a large increase in OPG managers and reactor technicians will be put on permanent public payroll for decades.

VS.

PRIVATE R&D

Green technologies like solar panels, wind turbines, and farm bio-gas generators are designed by private companies, at their own expense and risk. If they receive FIT contracts, they hire temporary private contractors to build the projects, and no owners or employees ever go on the public payroll. Unlike nuclear staff, they receive market compensation, salaries and benefits.

PUBLIC ASSUMPTION OF FINANCIAL RISK

Nuclear plants cannot be financed with private funding. So when OPG borrows $26 billion or more to build new reactors, the public ultimately bears the full risk and cost. That capital cost must be paid before the reactors can power up even a single toaster. If they prove to perform badly or unsafely, the public must not only bear that loss, it must pay for replacement power the reactors were meant to provide.

VS.

DEVELOP AT OWN RISK

Green power projects with FIT contracts operate under strict 'pay for performance' rules. The developer must borrow all the capital required, on terms and conditions approved by banks or financiers. This imposes fiscal discipline. If the project does not deliver the power as promised – for any reason – it simply does not get paid. **So the public faces no risk for cost overruns, construction delays, bad management, bad technology, or poor performance.**

HIGH INTEREST RATE EXPOSURE

Nuclear plants are very capital-intensive, and so need up to 40 years to pay off capital, mid-life refurbishment and operating costs. The Darlington complex took 15 years to build. So nuclear plants are extremely vulnerable to interest rate increases because of the capital borrowed, and the long construction times. This can add billions to the final cost - at public expense - but there is no protection against this.

VS.

LOW INTEREST RATE EXPOSURE

All green power plants of all kinds require large amounts of construction capital, and typically take 20 years to pay off debts and earn net profits. However, they take only about 3 years to build. So they are far less exposed to interest rate hikes, and inflation. Under the FIT contracts, developers get a capped price during the entire 20-year contract term, so the public faces zero risk from interest rate hikes. If they do rise, the developer pays the price – not the public.

HIDDEN PUBLIC SUBSIDIES

Nuclear plants pay no land purchase costs where reactors are built, pay lower taxes, use government-backed bonds to borrow funds at preferred rates, and benefit from high-voltage lines built at public expense. For example, the Bruce nuclear owners demanded – and got – the province to pay $650 million to build a new transmission line to their door. The public also pays for OPG nuclear environmental assessment hearings.

VS.

COST TRANSPARENCY

Private green power developers must buy or lease lands to build their projects, pay full tax assessments and corporate taxes, borrow money at market rates, pay virtually all the costs of grid connections and extensions to distribution circuits, and for all environmental assessments. Solar and wind companies must also provide an approved and costed project de-commission plan. But OPG and Bruce Power simply intend to wait 50 years before assessing how to dismantle and dispose of 20 intensely radioactive reactor cores.

BUT DOSEN'T ONTARIO NEED NUCLEAR FOR BASE-LOAD POWER?

Nuclear power plants are designed to operate 24/7, or in "base-load" mode. For technical reasons, they cannot be quickly switched on and off, and are not suited to follow power up peaks and down valleys as demand fluctuates daily and seasonally.

So they run while Ontario has a constant or "firm" demand of about 14,000 megawatts. But nuclear is not the only – or best – base-load option.

The two best options are reducing power wasted at Ontario's large industries which operate 24/7, and installing combined-heat-and power (CHP) technologies at those same industries to self-generate base-load power. Prime candidates are smelters, mines, pulp mills, large car manufacturing plants, chemical refineries, and major food processing plants. Even hospitals, office towers, apartment blocks and large shopping malls are good candidates.

Combined heat and power systems can produce baseload power safely and efficiently

Most large industries in Europe have already made such energy efficiency investments to reduce costs, and use CHP technology to both supply plant needs and sell surplus power into local grids. This has made them more competitive, and helped retain jobs.

A recent study has confirmed that similar investments in Ontario would generate "negawatts" far faster and cheaper than building new nuclear plants. So instead of a "set aside" for nuclear, the OPA should create feed-in tariffs for efficiency and CHP so our key industries can invest in making themselves more competitive while meeting future power demands.

It makes no sense to build new, expensive nuclear plants to send power long distances to industries which currently waste power, and can generate their own. And recent advances in "smart grid" storage technologies will soon allow renewable power to be saved and sent into the grid exactly when needed.

ONLY GREEN POWER DELIVERS WHAT ONTARIO AND THE WORLD WANTS

Clearly, there are subsidies on both sides of the nuclear/green energy equation. The ultimate goal should be to get rid of them all, as soon as possible.

The scale and value of subsidies is heavily weighted towards nuclear – even without considering its serious environmental and public safety risks. And most nuclear subsidies are hidden, while those of FIT projects are explicit.

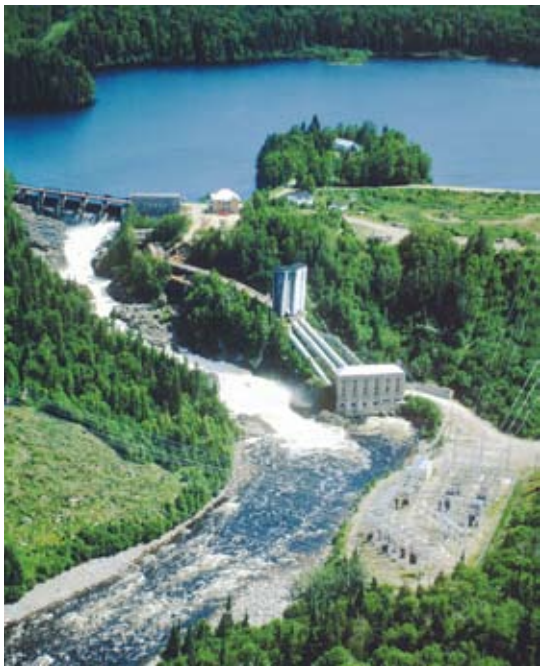
The green energy sector will welcome the end of subsidies, and a German-style FIT 'degression' formula which ensures tariff prices go down to zero during the next decade. That is the essential FIT purpose – to foster renewables until their dirty or dangerous rivals no longer thrive because the playing field is steeply tilted in their favour.

But the renewable sector cannot thrive – and the Ontario government cannot meet its employment and economic development goals – if hidden nuclear subsidies remain in place, and the OPA embeds these for decades more by mandating a 50% market share.

In short, renewables cannot compete against nuclear plants that are heavily subsidized. And nuclear cannot compete against renewables if it isn't.

Therefore, it is time for the Ontario government to end its preferential and costly investments in nuclear power. If a private sector company wants to finance, build, insure and operate a nuclear plant with zero government subsidies or guarantees, and pay upfront performance bonds for safely dismantling reactors and disposing of lethal nuclear wastes, it can do so.

However, until such a firm, formal contractual bid is obtained by the OPA, and publicly disclosed as FIT prices are, no further nuclear subsidies or market-share "set-asides" should be granted.



Run of river hydro and farm biogas are green power options. Below: A green powered city is within our grasp.

Even if a private CANDU bid does occur, that would not assure the survival of the nuclear sector because orders for reactors typically come once in a decade – or less. And there is zero prospect for CANDU's to be sold in the U.S. or Europe. So it makes no sense to invest $26 billion or more into expensive, "one-off" custom-designed reactors which cannot sustain a manufacturing base here, and have dubious sales prospects abroad.

But solar panels, wind turbine blades and a myriad of made-in-Ontario components from inverters to steel pylons to engineering services are ramping up to supply annual orders for fast-growing *continental* and *international* markets. Ontario's green power sector is building an industry based on mass produced products for global markets, not feast-or-famine nuclear technology, which countries like Germany, Italy, and Japan have foresworn since Fukushima.

So they are confident renewables can deliver new Ontario power at a better price, compete by selling technologies the world wants, and sustain diverse green manufacturing jobs here for decades to come.

THE BUSINESS CASE *FOR* GREEN POWER

The landmark green power purchase program – the feed-in-tariff – has been cast by some as a scheme to make all Ontarians pay premium prices to a lucky few companies that build highly-subsidised wind and solar projects.

So what's the real deal? The answer comes by conducting the basic investment audit task: counting all the costs, and all the benefits.

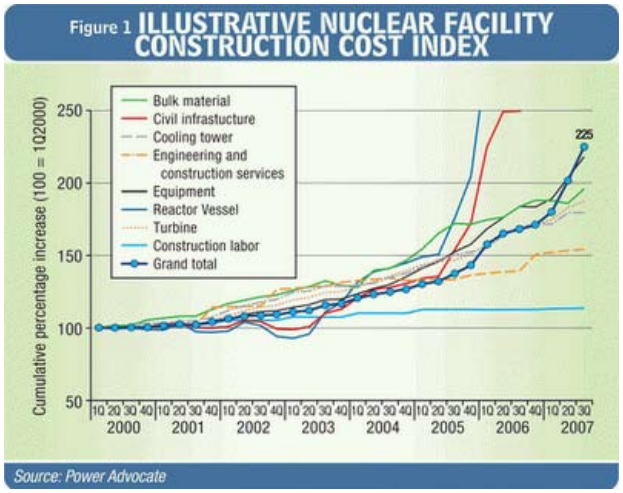
First, the FIT program was designed to buy enough new, non-polluting power to replace Ontario's 40-year old coal plants – which were among the continent's dirtiest emitters. This has brought cleaner air to everyone, at a cost of adding about $5 each month to a typical 2012 household hydro bill.

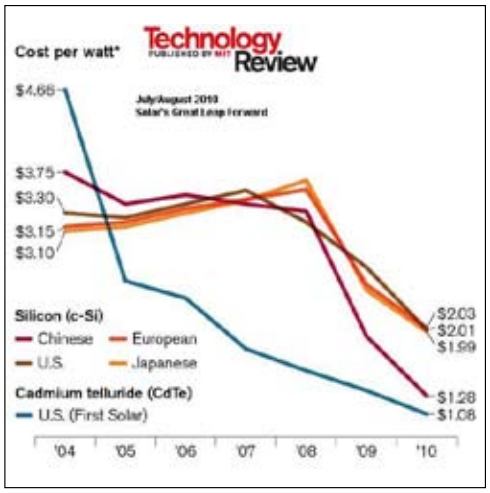
Second, the FIT program is a blend of many different prices paid to large and small generators of new solar, wind, water, wood and farm biogas energy. The tiniest rooftop solar projects get paid the highest price – but generate only a tiny amount of annual kilowatt-hours. The bigger the project, the lower the price paid by the public.

Third, the FIT program is designed to ratchet down prices as global component costs decrease due to mass production and improved technology. In contrast to nuclear, solar and wind costs are declining sharply. Annual 2-year reviews will ensure the public pays less and less for each new series of FIT contracts. The first round was the most expensive.

Fourth, the FIT program itself is only a small part of the renewable energy build-out now underway in Ontario. New large hydro projects at Niagara (1.6 billion kWh per year) and on the Mattagami River in northern Ontario will soon add far more power for the next century – at a price of less than 2 cents per kilowatt-hour. When all the FIT purchases are blended with this clean, high-volume, low-cost hydro power, the total average cost for new green energy will be far less than any other new form of generation.

Now that's a bargain that will moderate power costs, keep Ontario competitive, and leave a cleaner, safer world for our children and grandchildren.





Appendix A:

THE CANDU REACTOR DESIGN FLAW

A CANDU order cannot sustain economic development in Ontario

All operating CANDU reactor models, and the proposed Enhanced CANDU 6, embed a reactor physics phenomena which prevent them from being approved by the Nuclear Regulatory Commission in the United States.

It is called 'positive void reactivity'. In the event of a sudden loss of core coolant during operation, the fission process will *accelerate*. The generation of neutrons and heat would climb exponentially in a matter of seconds. This could lead to over-heated fuel bundles, residual coolant evaporating, fuel bundle cladding catching fire, hydrogen gas production, localized fuel melting, an uncontrolled reaction, a hydrogen explosion, and the release of radioactivity.

This 'positive void reactivity" design flaw is due to the unique CANDU use of pressure tubes and heavy water (deuterium) as the neutron moderator. All other commercial reactor models in the U.S., Europe and Japan are designed to have 'negative void reactivity', so that in the event of a sudden major coolant loss, the neutron production rate *de-accelerates* within seconds.

For this reason, all CANDUs in Ontario have been fitted with extra shut-down systems designed to deploy in seconds. The Pickering, Bruce and Darlington nuclear complexes also have a concrete vacuum building to contain potential radioactive releases from each reactor core.

The U.S. Nuclear Regulatory Commission has not, and will not, licence any commercial reactor design with a PVR. This is in part because the 1986 Chernobyl accident was triggered by a PVR transient following operator errors which caused a sudden loss of core coolant. The PVR triggered the runaway reaction in the RBMK-1000 reactor, then hydrogen explosions breached the reactor dome, and devastating clouds of radioactive elements escaped for months. The Chernobyl complex had no vacuum building.

It is also because this PVR design flaw (in any reactor model) adds an extra dimension of public risk, and requires the use of additional fast shutdown systems and a vacuum building. AECL withdrew a U.S. NRC licensing application for its ACR-1000 reactor after NRC staff concluded it would have a PVR.

This CANDU reactor design flaw has important safety, cost and industrial/ employment implications for the government of Ontario.

Since the recent sell-off of AECL's reactor division to SNC-Lavalin, federal funding to complete the ACR-1000 has been terminated. The only viable Canadian-built reactor is the Enhanced CANDU 6, which SNC-Lavalin now has the rights to develop and market.

But, like the original CANDU 600, the Enhanced CANDU 6 will have the 'positive void reactivity' design flaw. If two or more are selected for the proposed Darlington

new-build project, these Enhanced CANDU 6 reactors cannot be licensed to operate without the additional fast shut-down systems and a vacuum building system to contain radioactive steam.

Because the PVR adds an extra dimension of public risk, these additional safety systems must be installed. This will add considerable capital cost to any Enhanced CANDU 6 project, compared to reactor competitors such as AREVA or Westinghouse which build reactors with a 'negative void reactivity' design.

Moreover, because the Enhanced CANDU 6 cannot be licensed to operate in the United States (and quite likely Europe), there is little prospect for it to be commercially successful elsewhere. One reason is because of the PVR-related additional capital expense for added safety systems. The other is that CANDU 6 replacement parts and pressure tubes would be difficult and expensive to obtain, and related qualified technical experience would be costly and rare. For mid-life pressure tube re-tubing, for example, it would be like searching for 20-year old Lamborghini parts and mechanics.

Therefore, the prospects for Ontario to have a manufacturing sub-sector sustained by additional Enhanced CANDU 6 orders outside the province are exceedingly low. Orders for this reactor may come once a decade, or longer, or never. They will not come from the U.S., or Germany, Italy, Austria, Belgium or Switzerland (which have ruled out new nuclear) or France or Russia (which have competing reactor models) or India (which has developed a CANDU clone it plans to design and build there).

If the Enhanced CANDU 6 is not selected, and additional reactors are built at Darlington which are supplied by AREVA or Westinghouse, most of the high-value manufacturing and jobs will occur outside Ontario, and OPG would be left to operate a reactor type is has no operating experience with.

EXCERPT FROM NUCLEAR REGULATORY COMMISSION STAFF REPORT ON AECL PRE-LICENCING APPLICATION (2004)

ACR-700 Pre-application Reviews Issued for Two Focus Topics

On July 1, 2004, RES issued the technical documentation on Focus Topics 3 and 9 for the Advanced CANDU (Canadian Deuterium Uranium) Reactor 700 (ACR-700) design to NRR for use in the Pre-Application Safety Assessment Report (PASAR). Regarding Focus Topic 3, "Preliminary Determination of Database Adequacy for Thermal-Hydraulics of the Advanced CANDU Reactor (ACR-700)," the RES staff has completed a preliminary review of the Atomic Energy of Canada, Ltd., (AECL) experimental database for adequacy in supporting code assessment and model development, and for its adequacy in resolving safety issues anticipated in the Design Certification review. The staff identified three areas that will require additional review which involve header flow test setup, horizontal fuel bundles, and multiple pipe break failures.

Regarding Focus Topic 9, "Confirmation of Negative Void Reactivity," RES completed best-estimate neutronic calculations that predict the coolant void reactivity to be substantially positive in large-break loss-of-coolant accidents (LOCAs). Discussions between the staff and AECL on these, and other issues will continue as work on the pre-application reviews progresses.

During the past four decades, Ontario has paid a heavy price for the hidden subsidies nuclear plants consume:

NO REACTORS WERE BUILT ON TIME OR ON BUDGET. POOR PERFORMANCE AND REPAIRS ADDED BILLIONS MORE

NUCLEAR COSTS DROVE THE OLD ONTARIO HYDRO INTO BANKRUPTCY, HOLDING $38 BILLION IN DEBT

ALMOST $20 BILLION IN DEBT CHARGES HAVE BEEN PAID SINCE 1999, BUT THEY WON'T STOP UNTIL 2020

NEW REACTORS AT DARLINGTON WILL COST AT LEAST $26 BILLION TO CONSTRUCT. IF HISTORY REPEATS, THAT BILL COULD BE $36 BILLION.

The provincial finances are in grave shape. Higher health care and education costs are looming. There are precious few public dollars to spare. This is the worst time to commit half of Ontario's future generation to nuclear, and take on decades more of public debt.

Since we have surplus power and other base-load supply options, this is the time for all MPPs to pause, reflect, and insist that nuclear pay its own way – without another cent in public subsidies.

Construction cost over-runs at the Darlington nuclear plant were $11 billion. Mid-life repairs will cost $10 billion more. Those costs exceed the payments for all current FIT contracts for the next two decades.