Summary Report:

The Future of Coal in Ontario? Towards a Clean, Secure and Competitive Energy Portfolio

By Bryne Purchase

Introduction

Hydrocarbons or fossil fuels (oil, coal, and natural gas) represent 80% of the world's total primary energy supply (all hydrocarbons plus nuclear and all renewable energy combined). Especially since 1850, the world has grown extraordinarily wealthy on their use. In fact, per capita income to-day is closely correlated with per capita energy use.

Unfortunately, hydrocarbons also account for 80% of the global greenhouse gas production and most of the localized air pollutants which, depending on their concentrations, can impair human health. Yet the global demand for fossil energy is expected to continue to grow. Even with an astonishingly huge projected growth in some renewable energy sources (for example, wind) fossil fuels are projected to supply 81% of all global primary energy use by 2030.

Coal has a central role to play in all of this. It currently accounts for 25% of the world's total primary energy supply and 40.9 percent of world electricity generation; and coal represents 59% of the remaining available energy from the world's hydrocarbon reserves. Accordingly, coal is forecast by a US government agency to be the fastest growing global fuel source through 2030. Its share of world primary energy use is expected *to rise* to 26 percent of total energy and 41.5% of electricity production by 2030.

In the United States, coal already accounts for 50% of electricity generation (and 23% of US total energy use). "There are the equivalent of more than five hundred, 500 megawatt, coal-fired power plants in the United States with an average age of 35 years[1]". And there is a massive US coal-fired construction program being proposed (159 plants representing 96,000 MW), many of them in the Great Lakes basin. Coal's share of US electricity generation is projected to rise to 58% by 2030. In Canada, several provinces - Alberta, Saskatchewan and Nova Scotia - already generate 70 per cent of their electricity from coal.

The other economic super-power, China, is even more heavily dependent on coal. In fact 70 percent of China's total primary energy comes from coal. With respect to electricity, "China is currently constructing the equivalent of two, 500 megawatt, coal-fired plants per week and a capacity equal to the entire UK power grid each year[2]". To put this in perspective, this is the equivalent of one Nanticoke-sized coal plant per month (Ontario's largest coal-fired plant and 61 percent of Ontario's existing coal-fired capacity). India gets 55 percent of its primary energy from coal.

Notwithstanding these global mega-trends, in 2003, the new Premier of Ontario, Dalton McGuinty, reaffirmed an election promise to exit Ontario's coal-fired electricity generation by 2007. At the time, coal-fired generation represented 7,560 megawatts (MW) of capacity – roughly 25% of Ontario's total capacity of roughly 30,000 MW.

[1] The Future of Coal: Options for a Carbon-constrained World, MIT., 2007
[2] Ibid.

Accordingly, "coal exit" was a major public policy initiative, with vital implications for the future reliability, cost-effectiveness and environmental impact of the electricity supply to Ontario homes and businesses.

Premier McGuinty's "coal exit" initiative was taken ostensibly to reduce the smog (particulate matter, nitrous oxide and sulfur dioxide) and mercury-related emissions coming from the coal-fired plants and hence the effects of such emissions on the health of Ontarians. Somewhat later, although not a direct health issue, the reduction of carbon dioxide emissions– the principal anthropogenic contributor to global warming - was emphasized by the Government as an even more important added benefit of coal plant closure.

Smog production and greenhouse gas air emissions are associated with all fossil fuels (coal, oil and natural gas) used in everything from space heating to driving trucks and automobiles to making pulp, steel and cement, as well as to the production of electricity. Moreover, transportation is a far bigger source of air emissions than coal; and by some estimates 50% of the smog in southern Ontario comes from US sources. There are a huge number of large air-polluting plants that are physically located south of the border, but that are still in Ontario's air-shed. Yet, politically, the issue of environmental quality had become highly identified with Ontario's intention to simply exit from coal-fired generation of electricity.

Premier McGuinty initially made the commitment to exit coal by 2007 — and only in electricity generation, not for example in the manufacture of steel or cement. However, the Premier appears to have done so on the basis of ***no published independent analysis*** of the feasibility of the timelines, or the reasonably estimated economic or environmental costs and benefits of such an initiative compared to alternative policy approaches. Unfortunately but predictably, all subsequent government analysis has been done simply to justify the initial political decision already taken.

It is this fact – the absence of independent prior analysis — that prompted the Queen's University Institute for Energy and Environmental Policy to undertake a conference on the Future of Coal in Ontario. The Institute is dedicated to the proposition that all public policy, and certainly all election promises, should be subject to an independent fact and reason-based analysis prior to being offered to the public. In general, the public should be able to choose from policy alternatives, all of which reflect some minimum standard of intellectual rigor and factual integrity.

The Queen's University Conference on the ***Future of Coal in Ontario?*** focused on four central themes:

- **Global Energy Risks**: If coal is to be replaced in Ontario's electricity generation mix, how reliable, cost-effective and environmentally benign are the alternative sources of fuel supply that are to replace coal?
- **Health and Phase-Out Transition Risks**: What specific factors dominate the decision to close Ontario's coal-fired plants? Are they robust? Does closing coal

plants, rather than retrofitting them, reasonably reflect the interim environmental costs and the various contingencies that may dictate a further life extension? And does closure take account of the fact that Ontario is interconnected with nearby jurisdictions and can affect the reliability of their electricity supply?

- **Environmental Risks: A Policy on Global Warming:** Environmental costs, including the effect of carbon emissions on global warming, are not reflected in the current price of electricity. All policies to address this issue have costs and will raise energy prices. The question is whether the environmental cost of emissions can be incorporated more effectively and efficiently into the price of electricity than by simply banning coal-fired electricity generation?
- **Global Imperatives, Technology Risks and Policy Design:** Given the strategic importance of coal in the global energy market, will new environmentally sustainable and cost-effective coal-based technologies become available to Ontario? And can Ontario, through policy design, foster competing non-coal alternatives that would address the need for an environmentally sustainable, secure, reliable and cost-competitive supply of electricity?

Global Energy Risks

If coal is to be replaced in Ontario's electricity generation, then how reliable, cost-effective, and environmentally benign are the alternative sources of fuel supply that are to replace it? To answer the question, the Conference heard from two experts: Mr David Hughes of the Geological Survey of Canada and Dr Ken Markel of the US Department of Energy. The following draws extensively on their presentations.

North American Natural Gas Peak

Part of the McGuinty Government's plan is to replace coal by becoming more dependent on natural gas as a fuel for electricity generation. Natural gas has the advantage that it burns more cleanly and with less carbon dioxide emissions than does either oil or coal. Indeed, the Government has directed that natural gas generation will increase from roughly 4,350 MW (2003) to 9,400 MW by 2025 in order to replace coal.

This increased dependence on natural gas would be in addition to Ontario's already extensive dependence on natural gas (32% of total energy use). Most of the existing use of natural gas in Ontario is for space and water heating (54%) or industrial purposes (31%). Only 13% of Ontario's natural gas was used in electric power generation in 2004.

The natural gas market has increasingly become a North American market in the last 25 years. Ontarians pay the relevant North American price plus delivery costs. In that context, there are four particular risks associated with an increasing dependence on natural gas.

- In the first instance, production of conventional natural gas in North America has peaked. Increasing attempts to drill for new supply have yielded dramatic diminishing returns.

- Second, new supply to North America must come from natural gas imported to North America in the form of LNG (liquefied natural gas). This gas has significant geopolitical risks associated with its supply and there is little capacity in North America to "store" large quantities. Roughly 75% of world natural gas reserves are in the Middle East and the countries of the former Soviet Union (principally Russia). Accordingly, natural gas may be as vulnerable to politically-inspired disruption as are the world's remaining oil reserves. The European Union countries in particular are grappling with their already heavy and rapidly increasing reliance on natural gas from Russia and the Middle East.
- Third, liquefied natural gas (LNG) imports into North America must overcome: vigorous domestic political opposition to re-gasification terminals located near heavily populated ocean-accessible ports; huge infrastructure costs and time-delay in building new liquefaction facilities in export countries, an LNG tanker fleet expansion and in constructing re-gasification facilities in importing countries; and a large energy loss (15 to 30%) and associated greenhouse gas emission during the liquefaction-transport-re-gasification process.
- Fourth, natural gas prices have risen dramatically since the early 1990's as demand growth confronts a domestic supply near its ultimate peak production. Prices have also become more volatile as surplus North American gas has been absorbed into the market and an inelastic supply interacts with an inelastic demand. As the industry integrates into a global gas market, further volatility of prices may be imparted by any of the above issues.

Global Oil Production Peak

That natural gas fuel has all of these future risks associated with its supply to North America has to be put in the context of yet another global fuel supply risk. Oil accounts for 36.5% of global primary energy consumption (40% in North America). A number of prominent geologists and analysts believe that the world oil supply will soon reach peak production and thereafter begin to decline. There is still considerable debate as to the precise date, but virtually no dispute that the peak is coming, at the latest by 2030.

The unanticipated explosion of economic growth and oil demand in China, India and other developing countries has simply accelerated the rate of depletion. In this process, the global market share and market power of the Persian Gulf producers and OPEC producers in general will increase. OPEC members possess the vast bulk of remaining global reserves (75%), most of which is still available for export.

The implication of the global peak oil production scenario and of the increase in market power of remaining producers, especially in the Middle East, is that world oil prices could rise even more dramatically – with a commensurate increase in geopolitical tensions. Oil is the overwhelmingly dominant feedstock for transportation fuel. Natural gas has made some small inroads into transportation, where it also has the advantage of being a cleaner-burning fuel than oil.

As relative oil prices rise, natural gas will be in increasing demand for transportation purposes as well. There are significant advantages. The substitution of natural gas for oil in transportation could make a huge contribution to the reduction of local air pollutants and greenhouse gas emissions from oil. On the downside, however, Ontario already gets 32% of its energy from this source. It will add to Ontario's exposure to the price and availability of natural gas, if it becomes even more dependent on this fuel for a much larger portion of its electricity production.

Coal and North American Geopolitical Security Risks

North America (United States, Mexico and Canada) is a large and growing net importer of oil from abroad. Surpluses of production over domestic use in Mexico and Canada are more than offset by the net import requirements of the United States. In addition, North America has now become a net importer of natural gas, and this dependence is also expected to increase in future. The geopolitical implications for North Americans have been noted above.

Coal, on the other hand, is North America's long suit. In fact the United States, Russia, China and India all have very large coal reserves. Accordingly, every major future power has a strategic interest in coal. In the United States, at current usage rates there is some 250 years of supply, compared to 11.7 years for oil and 9.7 years for natural gas. Canada has ample reserves as well, principally in Alberta, Saskatchewan and British Columbia. In fact, in Alberta — Canada's energy capital — coal represents 86% of the recoverable energy content of all hydrocarbons. Its abundance, relative global dispersion and lower cost (by a factor of six) per unit of energy content than either oil or natural gas, means that coal will continue to be extensively utilized on a global basis. It also means, of course, that deploying new technology to deal with its environmental impacts – particularly its global warming impact - is a high priority.

Health and Phase-Out Transition Risks

What specific factors dominate the decision to close Ontario's coal-fired plants? Are they robust? Does closing the existing coal plants, rather than retrofitting them, reasonably reflect the interim environmental costs and the various contingencies which may dictate a further life extension? And does closure take sufficient account of the fact that Ontario is interconnected with nearby jurisdictions and can affect the reliability of their electricity supply?

The government's original political commitment was to exit coal by the end of 2007. After 18 months in office they changed that to 2009. Now the exit target has become 2014, based on a feasible scenario developed by the Ontario Power Authority. But how likely is the new scenario? To address some of these questions, the Conference heard from Mr Dave Goulding, Mr Tom Adams and Professor Ross McKitrick.

Dave Goulding focused primarily on the need to have Ontario's supply mix plans evolve in co-operation with our neighbours in order to ensure regional system reliability.

Unfortunately, there is little evidence that the political calculus that produced the Government's proposed generation mix included consideration of the plans of Ontario's neighbours. Goulding noted that it is not acceptable to "lean on the ties" — that is to depend on inter-ties to neighbouring jurisdictions for a solution to a chronic problem.

The point is material to the issue of the fate of the existing Ontario coal plants because they have been highly flexible, capable of ramping up or down in response to a strongly variable electricity demand over the day, week and month. The four remaining plants - Nanticoke (3920MW), Lambton (1975 MW), Atikokan (215MW) and Thunder Bay (310MW) - are strategically located in the province to minimize transmission costs and support overall grid reliability in Ontario and neighbouring U.S. states. They are dependable plants with known technology and high operational readiness. In addition, coal can be stored on site and comes from a relatively plentiful, secure, low cost and nearby source.

The coal-fired plants also make Ontario's electricity supply more reliable by virtue of greater diversification in our generation supply mix; in fact these plants represent an historically important "base-load" back-up to Ontario's much larger commitment to nuclear powered generation (13,500MW). When nuclear plants have experienced "forced outages," coal-fired generation has been there to pick up the short-fall. What will be the base-load contingent supply during the crucial nuclear refurbishment/new build period after 2014?

Professor McKitrick, using the Government's own cost-benefit analysis comparing plant closure (replaced with gas and nuclear) to retrofitting Lambton and Nanticoke with extra pollution control, concluded that the plants should remain open. The Government's case for closure was based largely on a huge air quality and health impact from Ontario's coal use. McKitrick presented evidence that:

- Closing the coal plants has minimal effect on Ontario's air quality, and only slightly more effect than would be achieved by adding more air pollution control equipment;
- The effects of particulate matter and ozone on human health may be significantly overstated by some epidemiological studies;
- Toronto's air quality, measured by several contaminants has been much improved since the 1960's and 1970's and already meets North American standards; and
- Plant closing imposes a larger economic cost on low income consumers, puts electricity supply at risk and may slow economic growth.

Tom Adams focused on the added risks associated with replacing coal with natural gas and wind power and continued heavy reliance on nuclear through refurbishment and/or new build. He argued for new coal plants as a reliable, cost-effective source for base-load electricity that also has ramping capability.

- The examples of nuclear construction delays and cost overruns in North America are legion. The ability to build to schedule and cost in China is not applicable to Ontario. Moreover, the first "next-generation" nuclear facility being built in

Finland is already behind schedule, over-budget and plagued with supplier errors. To compound matters, the Ontario program will be competing for skilled labour and suppliers with nuclear new-build world-wide and with huge energy projects elsewhere in Canada.

- Wind power has seen rising costs in Ontario (from 8 cent per kwh to 8.6 and currently at 11 cents/kwh, far above the 4 to 5 cent cost of existing coal-fired generation). In addition evidence suggests wind is not available when needed most and is extremely variable, making system load balancing far more challenging.
- The largest new bet is on natural gas with all the price and availability risks associated with the fuel noted above. Although natural gas has much less greenhouse gas emission than coal or even oil, it is still a major contributor to greenhouse gas production globally.

The initial decision to close the Ontario coal-fired plants by 2007 caused an immediate "supply crisis". After all, it committed to removing close to 25% of Ontario's generation capacity in four years. The result was that the government rushed into a number of replacement contracts without the benefit of competition or regulatory oversight. In the case of wind power, prices are higher as noted above. The projected prices for natural gas-fired plants not secured through competition are not publicly disclosed, but it is most likely that lack of competition resulted in higher prices. The Provincial Auditor should be invited to investigate. In the case of Bruce nuclear, which was also negotiated without competition, the Provincial Auditor made numerous criticisms. In that deal, on behalf of electricity consumers, the Government — despite the evidence of a spectacular recent rise in nuclear fuel prices — took a fuel risk that it has no ability to mitigate. Moreover the Government accepted some of the construction cost risk, again with no operational ability to mitigate that risk.

Aside from new or refurbished generation, transmission expansion and enhancement risks are far more serious than is sometimes recognized. While these risks are more political and regulatory in nature, they are nonetheless real constraints on any future plan for the Ontario grid. For example, the Government's deal with Bruce Power is "take or pay". Unless a new high voltage transmission line is built out of Bruce, Ontario electricity consumers will be paying for electricity they cannot consume.

The government has the legislative powers it needs to override local political opposition to new transmission, but will it do so? The same concerns relate to native land claims in Ontario. Will the government be more willing to act to resolve these issues than has appeared likely in the past? The risks continue to mount, and to be pushed onto some future hapless government *and* electricity consumers.

Environmental Risk: A Policy on Global Warming

Environmental costs, including the effect of carbon emissions on global warming, are not reflected in the current price of electricity. All policies to address such matters have costs and will raise energy prices. The question is whether the environmental cost of emissions

can be incorporated more effectively and efficiently into the price of electricity than by simply banning coal-fired electricity generation?

Needless to say, an environmental policy that applied to all sources of air emission, from automobiles to electricity production, would have a far more consequential impact on environmental quality in Ontario than one simply dedicated to a single fossil fuel (coal) and in single application (electricity production). The Conference attendees heard from three experts, Professors Don Dewees, Ross Mckitrick and Stephen Hill. Their principal focus was on greenhouse gas emissions, which the Ontario government now argues is the primary reason for their coal exit policy.

Professor Dewees reviewed the advantages and disadvantages of the following policy options: a ban on coal; a regulatory cap on the quantity of emissions; a regulated quantity cap plus the trading of equivalent emission allowances; and a charge (price or tax) on each unit (eg ton) of emission. In general he argued that the only advantage of the ban on coal in this instance was its simplicity. The disadvantages were that it was easily postponed (as in fact it has been repeatedly), and required the costly destruction of the existing generation facilities as well as the use of more costly and less reliable energy substitutes. On the other hand, both the emissions trading schemes or an emission charge were both more effective and much less costly than any simple regulated quantity restriction on all emitters.

Large industrial polluters typically prefer cap-and-trade models to emissions charges, because they are most often given the initial quota of emissions rights, whereas the tax requires payment on *all* emissions. Environmentalists sometimes prefer this model also because it appears to give predictability to the quantity of emissions permitted – although this is frequently eroded in political bargaining and special pleading.

All three presenters favoured a charge (or tax) on carbon. There are a number of reasons for this preference. It is cost-effective in that all emitters will reduce emissions up to the point where their own marginal cost of abatement equals the tax. This is efficient because there are highly variable marginal costs of abatement from each emitting source, yet each ton of emission has exactly the same effect on global warming. As well, an emissions charge is administratively simple if applied upstream, and it utilizes an existing tax bureaucracy with an incentive to enforce. It also provides cost certainty to businesses - as opposed to cap-and-trade that is associated with highly volatile emission permit prices. Very importantly, carbon taxes provide added revenues to governments that can be recycled to reduce other taxes (such as income or payroll taxes) and targeted to those most adversely impacted by the higher fuel cost.

How to gain public acceptance, however, is ***the*** key implementation issue when it comes to emissions pricing, in particular a carbon tax. All policies to reduce emissions (including the coal ban) ultimately raise costs/prices. In fact the coal ban will have a larger cost. The impact will be greatest on low income people and energy-intensive industry. A carbon charge can be designed to offset these effects. But, unlike the coal ban for future implementation, carbon pricing models have *very transparent* and *immediate*

effects. There will inevitably be strong resistance, especially if the public mistakenly believes that addressing global warming will require no change in their behavior or in the structure of the economy.

Stephen Hill argued that, on the basis of his own survey data, the public would be more accepting of a carbon tax than a cap-and-trade system. He found that the degree of acceptance depends on the public's belief in the seriousness of the global warming problem. But his survey indicated the public does believe that taxes, as opposed to cap-and-trade, would actually work to address the problem. They also believe that the tax revenues generated by the charge should be devoted to programs (and presumably tax cuts) that further address the "green" agenda.

Professors Dewees and Hill propose that the tax start low and be increased over time. The question, however, is where precisely to start and how to change the tax over time. Professor McKitrick presents evidence that the taxes proposed are typically between $16 and $50 per ton of carbon dioxide, with the median less than $10. However, he recommends that the tax rate be tied to the key climate change parameter, the Annual Mean Tropical Troposphere Temperature Anomaly. He would start at $4.70 per ton of carbon dioxide. Whether the tax rises or not would depend on whether the world in fact did grow warmer due to anthropogenic causes.

It should be noted that sub-national jurisdictions in both Canada and the United States (California and the New England states are examples) frequently lead when it comes to innovation in public policy. Unfortunately, all of the issues associated with a province implementing a carbon tax were not directly addressed. In the meantime, however, the Province of Quebec has shown leadership and introduced such a tax.

Ontario, under the McGuinty government, missed a unique opportunity to innovate when the Premier chose to break a different election promise — not to raise taxes — and implemented an Ontario health tax. The new health tax is on the income earned by Ontarians from their work or investment. The health tax yields $2.6 billion whereas the province's gas tax yields $2.3 billion. Why not double the provincial gas tax and eliminate the health tax as a first step? The Ontario tax on gasoline is already much lower than Quebec taxes on gasoline which includes a sales tax.

Global Imperatives, Technology Risk and Policy Design

Given the strategic importance of coal in the global energy market, will new environmentally sustainable and cost-effective coal-based technologies become available to Ontario? And can Ontario, through policy design, foster competing non-coal alternatives that would address the need for an environmentally sustainable, secure, reliable and cost-competitive supply of electricity? Several presenters touched on this important issue including Dr Ken Markle, Dr David Bayless, Dr David Keith, and Dr David Layzell.

Coal is a huge and rapidly growing part of global energy supply (25%). Any attempt to replace or substantially reduce coal use through scaling up of alternatives will also have significant environmental implications. Professor Keith reminded us that wind power has grown extensively and its technology has vastly improved. However, wind intermittency and location make uneconomic its integration into existing electricity grids beyond a 10 percent threshold. While the economics vastly improves and thresholds could grow to 50% in systems which co-evolve, there are global warming effects from the reduction of the kinetic energy in the wind which must also be considered. Nuclear has minimal land use per unit energy yield, but its construction cost history is problematic and a vast scale-up globally would raise legitimate nuclear weapons proliferation concerns.

Existing technologies are readily available to sharply reduce the criteria pollutants (S0x, NOx, particulates and Hg) which have an adverse effect on human health. This can be done, as noted, even by retrofit of existing coal-fired generating plants with readily available technology. New plants making use of super-critical pulverized coal technology (such as the Genesee 3 plant in Alberta) dramatically reduce particulates (99.9%), sulfur dioxide (77%) and nitrous oxide (70%) compared to conventional pulverized coal. Such plants even reduce CO2 emissions per megawatt hour (18-20%) because of their greater efficiency in the use of coal.

Super-critical technology used in a combined-heat-and-power application results in even further gains in energy efficiency and reductions in emissions. Combustion along with oxygen injection or the gasification of the coal in the context of combined cycle electricity production (Integrated Gasified Combined Cycle — IGCC) represent next generation technologies with even greater efficiency and lower emissions.

Even in a world dedicated to a dramatic reduction of greenhouse gas emissions, carbon will still be emitted. If a carbon tax is in place, emitters will pay the tax penalty. Carbon capture and storage is not necessary, or even physically possible, everywhere at reasonable transport cost. The opportunities for Ontario to use its own storage or to transport C02 to nearby US sites is not yet known. But storage must take place on a large scale throughout the world. As Professor Bayless noted, the management of carbon has emerged as the key issue for the future expanded use of coal.

Carbon management involves not only separation, capture and sequestration (storage) but also carbon avoidance and recycling. All of this must be accomplished at reasonable cost. Indeed, cost reduction targets are a crucial element of the US Department of Energy's advanced coal power systems plan outlined by Dr Markle. FutureGen, focused on IGCC technology, is a major US government research and technology development and commercialization initiative involving private sector partners and international collaboration.

Carbon capture and storage (CCS) at a reasonable added cost is the ultimate goal. Current estimates suggest that CCS is economic with carbon dioxide at $30 per ton. Roughly 80% of the cost is in capture and compression of the gas and the rest in transport and storage. As Professor Keith pointed out we have plenty of existing tools, with experience in coal

gasification, hydrogen production and C02 transport, injection for enhanced oil recovery, and exhaust gas capture. The research budget is now over $200 million per year. Research evidence seems to suggest that physical and chemical trapping mechanisms will immobilize the carbon and, in fact, make it more secure over time.

A central element in the US, Japanese and European initiatives with respect to clean coal technology is the scale of government research support. Ontario has an opportunity to undertake a similar focused effort, not on clean coal but on the use of biomass ultimately to replace coal-fired generation. Biomass is a renewable energy source that has many of the advantages for power generation that coal has (fuel storage, load following or base-load) but is greenhouse gas neutral. Moreover, it adds to geopolitical security by being a locally-based resource.

Professor Layzell outlined some basic information on an exciting new and Ontario-based fuel source — biomass, which is green-house gas neutral and could be used ultimately to replace coal. It would take roughly 30 million metric tonnes of dry biomass to replace all coal used in Ontario (not just in electricity production). This is only half of Layzell's conservative estimate of the amount of dry biomass that could be produced sustainably each year in Ontario.

Ontario's biomass is spread over a large area and significant processing and transportation infrastructure will have to be developed (new or by utilizing existing ship, pipeline or rail transport). In terms of the cost of the basic energy content, biomass is cheaper than oil or natural gas at current prices. But it is still more expensive than coal plus transportation costs. When processing and transport costs are added to biomass, its total cost exceeds delivered coal by an estimated $5.50/giga-joule of energy.

The imputed value of the CO2 emissions avoided by the use of biomass would have to be over $60 a ton to justify the added cost on this basis alone. That seems unlikely compared to most current estimates, therefore some additional subsidy would be required to facilitate fuel switching. There are justifications, including rural and regional economic development and geopolitical security. Moreover, Layzell showed that this subsidy would be much less than currently provided to wind power, solar or ethanol. Given that biomass could be a base-load technology, it would be interesting to compare this subsidy with that given to nuclear — historical and current. In fact, comparative data should be developed on government subsidy across all fuel sources and related technologies. Only then can a rational policy emerge.

Conclusions

The Government of Ontario, on the basis of no rigorous analysis of the larger global energy context or the localized operational and health impacts, has chosen to expose Ontario businesses and households to a significant number of energy and environmental risks. Among these are the following:

- The Government's plan for the future electricity generation mix vastly increases the already large exposure of the province to the risks related to high and variable natural gas prices and potentially resource availability in North America. Greenhouse gas is reduced but not eliminated by switching to natural gas, which in any case might be used more efficiently in urban transit than in electricity production.
- The government's supply mix plan leaves the province's heavy dependence on nuclear generation intact, but with no "back-up" base-load capability traditionally supplied by coal-fired generation. The history of nuclear construction is not reassuring and the future nuclear work program must now take place in the context of massive and competing energy projects elsewhere in Canada, North America and indeed the world. The potential for delay due to equipment and skills shortages and also for cost overrun is increased many-fold. This is assuming that the technology and the regulatory processes work as forecast.
- The large increase in wind power is resulting in sharply higher prices, little reliable supply at peak demand, intermittency and growing technical difficulties in balancing load and supplying back-up generation to meet reliability standards as the proportion of wind capacity increases.
- Required transmission additions will necessitate a political conviction not yet demonstrated but left for a future government. Will the future be any more willing to override local or native opposition? If not then Ontario consumers will be paying for nuclear power that could be generated at Bruce but that they cannot consume. What will replace that power in the interim? Transmission to facilitate large-scale hydro electric imports from Manitoba will need similar political courage and skill.
- The Government's plan to close one quarter of Ontario's electricity capacity in an impossibly short timeframe created a "supply crisis" and exposed electricity consumers to greater upfront cost and greater financial risk in rushing to contract for replacement capacity.
- The Government's decision to close the coal-fired plants on an urgent basis by 2007 was presumably based on its estimates of the large health impacts. Given the short timeframe, it did not retrofit the existing coal plants to deal with the smog creating emissions. However, the evidence shows there is very little added air quality or health benefit associated with closing the coal plants, especially compared to simply adding pollution controls. Moreover, the latest epidemiological and clinical research does not appear to support the Government's analysis of health costs.
- Even so, by failing to retrofit, the Government chose to expose Ontarians to the health risks they believed were associated with a failure to meet the 2007 target. That eventuality occurred. The target shutdown date is now 2014 (an additional 7 years of cumulative emissions and population exposure).
- Ontarians now run the added risk that coal exit cannot be implemented even by 2014. The exit plan announced by the Ontario Power Authority is crucially dependent on the timeliness and the financial and operational success of the nuclear refurbishments and/or new build program along with the associated transmission capacity additions.

- The Government's coal exit plan is a hopelessly inefficient and minimalist policy to address global warming. Far better economic and environmental policies are available. It could have implemented a carbon tax, geared to actual warming, across the use of all fossil fuels in the Ontario economy. At the very least it could have raised gasoline and fuel taxes. Moreover it could have used the revenues from such taxes to replace its inefficient health tax on Ontario workers and investors.
- Coal is a huge energy source globally, that is expected to *increase* in use. It is relatively cheap, abundant and geopolitically secure in its supply. Localized air pollutants are amenable to resolution by existing technologies. Coal's key environmental problem is now greenhouse gas production. But the mega-economies of the United States, Europe and Japan are dedicated to large-scale research and technology development in carbon management, in particular capture and sequestration. Ontario's plan simply ignores all this.
- More importantly, however, the Government's plan fails to pursue aggressively an Ontario based bio-energy strategy. Such a strategy could be rationally phased in by co-firing existing coal plants with biomass and adding appropriate pollution control equipment. The existing coal-fired capacity could be left in place longer as a back-up to the nuclear plan. However, the long run goal would be to ramp up the biomass feedstock supply and related transportation infrastructure to replace the coal plants with new facilities utilizing a "carbon neutral" and Ontario-based resource. These bio-plants might be considered not only a substitute for coal but also for nuclear base-load generation of electricity.
- To make this happen would require giving Ontario Power Generation a clear mandate to invest in the entire supply chain. At current prices this would require some subsidy. But the required subsidy per unit energy is less than already given to some other fuels. Further policy development requires more research be done on these issues, including research into the subsidies given to nuclear technology.