THE JOURNAL OF POLICY ENGAGEMENT
Volume 2/Number 2 www.ocepp.ca April 2010
ONTARIO CENTRE FOR ENGINEERING AND PUBLIC POLICY

A rational framework for electricity policy

By Jan Carr, PhD, P.Eng.

Editor's Note: This article is based on "The Evolution of Electricity," presented on September 29, 2009, in the Public Lecture Series of the Waterloo Institute for Sustainable Energy.

EXECUTIVE SUMMARY

Ontario needs to return to rational decision-making when it comes to ensuring that current strategies meet future power generation needs. Current policies, such as the promotion of wind power, reflect public concerns about global warming at the expense of securing a stable and economic energy future. If such publicly popular but economically unsound policies continue, the province's prosperity will be seriously jeopardized.

In this provocative paper, one of the world's leading experts on electricity generation traces the history of electricity development in Ontario and why the continued use of an economic framework for future development is essential to providing power cheaply and efficiently. In fact, he advocates designing tomorrow's electricity supply on the basis of lowest life-cycle costs as the best way to ensure that Ontario's carbon footprint is reduced while maintaining its economic well-being.

The recent rush to "green" Ontario's electricity system has produced a largely ad hoc approach to the selection and investment in power generation technologies that will unnecessarily increase the cost of electricity with far-reaching economic and social effects.

There are several examples of inconsistencies in the choices that policy-makers have made. Wind power has been given priority and a price premium, while nuclear power is arbitrarily capped at its historical capacity and required to compete on the basis of price. Distributed generation is encouraged but not the combined heat-and-power installations that are an attractive option for small-scale generation in urban areas. Similarly, solar energy policy propagates existing technologies and does not encourage promising new higher-efficiency options.

RUSH TO RENEWABLES

Some of the implications of these inconsistencies can be seen from a closer examination of the wind-nuclear comparison. Both types of power generation are emission-free and both depend on the parallel operation of some other type of generation to meet variations in customers' loads—wind because it is intermittent and nuclear because it is difficult to vary the output dynamically. Hydroelectric generation, with its storage reservoirs, would be ideal for this parallel operation, but Ontario's best hydroelectric sites have already been developed and factored into existing system operations. The only remaining realistic option for keeping new electricity supply in moment-by-moment balance with customer requirements is natural-gas-fired generation.

If the objective of increasing renewable energy supplies is to reduce emissions, what proportions of the province's overall electricity needs should be met by wind, nuclear and natural-gas generation? Does this change if the objective is to have the most cost-effective integration of renewables? What level of subsidy to customers for conservation measures would achieve the same result, and is that a better option? These questions cannot be answered when technology and investment decisions result from lobbying efforts by advocacy groups or are guided by public popularity.

The concern is magnified because the move to make greater use of renewable energy supplies coincides with a transition of Ontario's electricity system from its century-old, centrally planned monopoly structure to one with an open, competitive, commercial structure. Overlaying the uncertainties inherent in this transition with those resulting from unclear development goals leaves electric utilities, regulatory agencies, energy services companies and investors facing a bewildering and often contradictory mixture of economic, business and regulatory objectives.

For example, the Independent Electricity System Operator normally brings generators into service beginning with the lowest-cost ones and sequencing through increasingly higher-cost units until all customer

The Sir Adam Beck Generating Station at Niagara Falls: Ontario's best hydroelectric sites, including this enormous facility, have already been developed

Photo: Courtesy Ontario Power Generation

requirements are met. Giving wind power priority, however, it is sometimes necessary to disconnect lower-cost nuclear generation to avoid an oversupply situation. (Wind power in Ontario currently costs in the range of 10 cents per kilowatt hour, whereas nuclear averages about six cents.) The result is a higher cost of electricity with no commensurate benefit such as a reduction in emissions. Should we allow the system operator some discretion when "following orders" increases costs and yields no benefits?

In moving to an increased reliance on new sources of electricity while having a commercial structure that is stalled partway between central planning and competition, Ontario is attempting a massive change to the power generation system that underpins our economic well-being. Ontarians spend some $15 billion annually on electricity, so avoiding inefficiencies of even a fraction of one per cent would make significant economic room for investment elsewhere in the economy and public services.

The time has come to re-embrace economics as the unifying framework within which the electricity system is developed and operated. As in the past, investment in the power system of tomorrow should be based on minimizing the cost of meeting planned objectives. Each decision should be based on minimizing life-cycle cost, consistent with achieving the required performance and complying with environmental and other regulations.

Whether economic decisions are taken in the context of central planning, the free market or some combination is a secondary consideration. What is important is that the many players in the power-supply industry pull toward a common goal and their collective actions fit together into a functional whole.

By reinstating a rational economic approach for power generation decisions, we will ensure alignment between electricity supply and society's energy needs. While intuition tells us such alignment will be beneficial, electricity is a special case because it is so intricately and completely entwined with our lives and livelihoods. That ubiquitous relationship makes alignment not merely beneficial but critical.

This is no mere desire to tidy things up. Rather, it recognizes that electricity plays such a pervasive and fundamental role in modern society that its future cannot be treated offhandedly. There isn't a single product or service that we buy that does not involve electricity. Like the currency in our pockets, electricity is woven into everything we do. Like the currency in our pockets, its availability, cost and value exercise enormous leverage on our well-being and economic success.

To fully appreciate the importance of rational development to electricity policy-making, we first need to appreciate how electricity fits into energy supply and the significance of energy to modern life.

EVOLUTION OF ELECTRICITY

Since the industrial revolution began in the late 1700s, societies have become increasingly reliant on energy derived from sources other than the muscles of humans and animals. In fact, the industrial revolution was in great measure the result of harnessing energy resources on a large scale, which allowed for the leveraging of the economic surplus created by human endeavour. That surplus has progressively become larger and more widely distributed so that today we enjoy unprecedented discretion in how we spend our leisure time.

In the industrial revolution's early days, mining and manufacturing operations were located near falling water, which provided a ready source of energy. Many Ontario communities and industries sprang up around water-driven mills. But many commercial enterprises did not have the flexibility to locate beside energy sources. As a result, wood- or coal-fired steam engines became important since they allowed fuel to be transported to where energy was needed. Coal quickly came into widespread use since it packs more energy per pound than wood and so reduced the cost of energy transport.

But steam engines and water wheels are expensive to build, and economies of scale militated against building small ones. Energy use, therefore, continued to be confined to industrial applications in a relatively few locations. For the most part, individuals and most businesses still relied on the medieval muscle-power model.

During the closing decades of the 1800s and the early part of the 20th century, the electric revolution democratized energy use. For the first time, energy became widely available to individuals and businesses of all sizes. Like many changes, the introduction of electricity was due to the convergence of a number of breakthroughs and opportunities.

One of electricity's innovation threads played out at Niagara Falls, where all the land close to the falls on the U.S. side of the Niagara River was occupied by industries needing ready access to the power generated by the cascading waters. Soon, companies began looking at ways of moving some of the immense amounts of energy that could be developed at the falls to locations farther afield. Transporting the power would, in one stroke, make better use of the crowded and expensive land near the falls and increase the value of distant energy-impoverished land. As we can now see, the winning combination was to generate electricity on the land close to the energy source and distribute it for use elsewhere.

Another electricity innovation thread emerged in cities, where the invention of the incandescent light bulb provided a better alternative for lighting buildings than coal-gas flames. While Thomas Edison is probably most closely associated with the invention of the incandescent bulb, his real genius was adopting an established business model to deploy it. Edison did not attempt to sell electricity but rather, like the gas companies, offered a lighting service.

Instead of distilling coal to make gas to be distributed in pipes to illuminate neighbourhood residences and businesses, Edison burned coal to make electricity to be distributed in wires. In both cases, customers received a lighting service fuelled by coal so their buying decision revolved around the quality of the lighting rather than the technology involved.

These two threads—centralized conversion of an energy resource into electricity and the distribution of electricity to end users—came together just over a century ago to become what we now know as an electric utility. It is instructive to look at some of the implications of this convergence because many future energy options depend on an understanding of how we arrived at the current situation.

Electricity has become a commodity where once it was either a specialized vehicle for moving energy between industrial sites or an intermediate step in providing domestic lighting service from coal. With the arrival of electric utilities, a system developed that allowed the harnessing of many different energy sources to be distributed very broadly for a variety of uses.

Its ready availability in both large and small quantities allowed electricity to become intricately and ubiquitously intertwined with all elements of everyday life. In effect, electricity has become an energy currency widely used as an intermediary in exchanges among a variety of sources and a multitude of end uses.

We don't have to look very far for examples of just how dependent our societies have become on reliable sources of electricity. In August 2003, a blackout affected 50 million people for four days in southern Ontario and the northeast United States. In Toronto, transit shut down, with thousands trapped underground in stranded subway trains. Automobile traffic became thinner as cars ran out of fuel and gas stations lacked electricity to operate pumps. The resulting reduced traffic volume was a blessing in disguise since electrically powered traffic control systems had stopped working.

High-rise buildings, shopping centres and indoor public spaces became inoperable. As fuel supplies for their emergency generators were exhausted, these vast interior spaces became uninhabitable since they relied on electrically powered lighting, ventilation and elevators. Life as we know it became unsustainable just a few hours into the blackout.

One of the consequences of commoditizing anything is that it increasingly isolates the end user from the supplier. In fact, of course, that is the very definition and essence of a commodity—a good or service that is not differentiated among suppliers. In such circumstances, price becomes the only differentiator guiding purchasing decisions.

As a result, suppliers focus on reducing production costs in concert with consumers' desire to pay no more than necessary. It is necessary to emphasize this point because our current electricity system is the most economical one possible—a result ensured by the commoditization of electricity followed by a century of commercial investment and operation.

What are the characteristics of today's electricity system with respect to the continued evolution of our energy future? It is highly centralized. And it is based on large generating stations transmitting bulk power over long distances to major load centres, where it is subdivided and distributed to individual end users.

This has proved to be the lowest-cost approach, given that storing electricity is quite difficult and expensive. The most common method, the rechargeable battery, involves a chemical energy conversion process. In fact, virtually all so-called electric storage technologies involve conversions to other forms of energy. But these conversions are expensive, both for the equipment and materials involved and for the loss of energy in the process.

In other words, electricity is a manufactured product that, as it turns out, is more expensive to store than to manufacture, a product where the warehouse is more expensive than the factory. Under those conditions, economics drives it toward being a just-in-time product. Today, our electricity systems have no storage capability at all. Instead, they are planned, designed and operated to respond to the constantly varying requirements of users by employing a variety of different types of generators.

Some generators are optimized to provide large quantities of energy at a low cost, while others are designed to respond rapidly to changing needs. Between these extremes are the generators built to follow shorter- and longer-term trends by producing moderate

Photo: Courtesy Ontario Power Generation

The Pickering Nuclear Generating facility, east of Toronto. What proportions of Ontario's electricity needs should be met by nuclear, wind and natural-gas generation?

amounts of electricity that distinguish, for example, morning from afternoon requirements.

To keep costs as low as possible, the large "baseload" generators, which are optimized to operate flat out, should clearly use a low-cost fuel. But since their initial construction cost can be spread over a large number of production units, substantial capital costs can be accommodated. On the other hand, the rapidly responding "peaking" generators are often idle and are not required to produce much electricity. Therefore, they need to be designed for low construction cost but are not critically disadvantaged by using expensive fuel.

Orchestrating this range of resources into the most economical supply for consumers requires a central system operator. The role of the operator is to ensure that on a moment-by-moment basis, supply exactly matches demand throughout the system in the most economical fashion.

SHAPING THE FUTURE OF ELECTRICITY

One of the reasons we have deviated from economic rationality in electricity policy is because it did not produce the type of electricity supply that reflects public concerns about climate change. The public consensus is that the globe's climate is changing due to the release of carbon dioxide from human activities—primarily the burning of carbon-based fuels. In this regard, it is worth making three points.

First, this cause-and-effect model is very simplistic in the context of the complex multilateral interactions that are typical in natural systems. Clearly, we have more to learn about climate change.

Second, it is obvious that there will be a significant impact if, over the course of a few decades, we release into the environment carbon that has been sequestered over many millennia by burning fossils fuels.

Third, since changes in collective behaviour in democracies are facilitated by a sense of crisis, it is good that the simplistic model has taken hold since it creates the conditions necessary for change in our use of fossil fuels.

How do we bring about that change with respect to electricity? This takes us back full circle to the need for adopting an economic framework. We need to put a price on carbon so that its use gets factored into decisions on new supply projects on an economic basis. Whether this is in the form of caps on producers or taxes on users, with or without trading of credits, are secondary details to the main point of assigning a cost to carbon emitted into the atmosphere.

Pricing carbon would have the advantage of continuing a century of economically rational development of the electricity system as an essential underpinning of modern society. To do other than proceed on an economic basis is to risk massive economic dislocations.

The alternative process of picking winners and losers in renewable electricity technologies, based on perceptions and public opinion polls, puts us all at a considerable risk. Inevitably, it will make electricity more expensive than it need be for any particular target carbon diet. Increasing the cost of electricity relative to other sources of energy by making arbitrary technology choices will reduce the role that electricity can play in reforming our energy-use patterns. It will also put our entire economy at a disadvantage when compared to others that stick to economically rational approaches.

The pushback on putting a price on carbon is, of course, that it increases the costs for everything. But given that we have the most economical energy supply possible now, any change we make will put the cost up. The case for pricing carbon is that it promises that costs will go up by only the minimum amount possible because investment decisions will be founded on economic rationality.

We should all be wary of the fact that policy-makers are leaning toward tasking electricity with carrying the lion's share of reducing our carbon diet. This makes sense in that its highly centralized structure simplifies the logistics for making changes. But it doesn't make sense in that the biggest use of fossil fuels is in the transportation sector and not electricity generation.

At its peak, Ontario's electricity sector contributed about 20 per cent of the province's man-made carbon dioxide emissions, and it is on track to producing only five per cent by 2014. Cars and trucks contribute most of the balance, collectively making electricity's contribution relatively small.

It is, therefore, clear that a switch from fossil fuel to electricity will reduce our carbon footprint, and we should be doing all we can to expand its supply and use. That will only happen if we do not put price barriers in the way. And price barriers will be avoided only if we put a price on carbon and refrain from policy initiatives that pick winning and losing technologies—choices that will inevitably cost more than necessary to meet emission targets.

Let me make one final observation on facilitating rational economic development and avoiding subsidies and the taxing of particular technological approaches. The temptation to implement a particular solution by fiat is great because it creates a sense of achievement that is consistent with the sense of crisis driving change. In contrast, relying on economic pressures produces relatively invisible and slow incremental change. But those economically driven changes will be more substantial and sustainable precisely because they have been economically driven.

In fact, to rely on anything other than economic forces could easily result in change consisting of a series of isolated anomalies that create the very disconnects and discrepancies that will lead to retrenchment and a decline in the use of renewable energy sources. And for electricity in particular, its ubiquitous presence will magnify the effect of any such retrenchment on our general well-being.

Jan Carr, PhD, P.Eng., was chief executive officer of the Ontario Power Authority from the time of its establishment in January 2005 until September 2008. Prior to that, he was vice chair of the Ontario Energy Board during its transition from a government department to a self-funding, independently operated tribunal.

Carr, who received a PhD in power systems from the University of Waterloo, has more than 35 years of experience in the electricity sector as a professional engineer, holding senior positions in the design and planning of electricity transmission and distribution systems. He has worked on projects in many parts of the world, including Asia, Africa, Central America and the Caribbean, and he has been a consultant to utilities, governments and other stakeholders on the financial, business, strategic and policy aspects of the electric power industry.

Carr is a member of the board of the Alberta Electric System Operator, which is responsible for long-range planning of the provincial system as well as its operation through a competitive wholesale electricity market. He was a member of the Advisory Committee on Competition in Ontario's Electricity System (the Macdonald Committee) and chaired the Electricity Task Force of the Toronto Board of Trade.