Bring Load- following Into Open - 2005 December

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Maybe I have missed them but I have not seen any responses in the public domain from the nuclear industry to the subtle message being put out by Energy Probe's Tom Adams (in CBC News for example) that, "renewable energy and nuclear power won't give Ontario the power it needs during periods of peak demand" since "that's a characteristic that neither the nuclear plants nor the renewable energy stations are able to deliver". He is talking about load following and he is not the only one. The IESO 10 Year Outlook, from 2006 January, that came out last July says that, "Although nuclear units can ramp down and off the system rapidly, existing units are restricted from varying their output up and down for the purpose of load following". A letter to the editor of the 2005 July/August edition of the Canadian Geographic in response to the "Nuclear Resurrection" article in the previous edition said that, "nuclear plants cannot follow as the electrical load of the system rises and falls", this from a person with over 40 years in the power field! Back in 1998 the president of the then AECB warned about the lack of operational flexibility of CANDU units in a deregulated electricity industry. Even Professional Engineers Ontario are saying, in their 2005 Nov./Dec.edition of Engineering Dimensions, that, "Nuclear plants are great base load facilities but have relatively little flexibility in their output".

Anything-but-nuclear Energy Probe has completely reversed direction and is now flogging coal as the best way of meeting Ontario's base, intermediate and peak loads. Forget gas. Coal is it. The nuclear industry is poised for great things and now is not the time to be silent on the load following issue, even if there is little likelihood of the present generation of CANDUs ever being used for load following. There have been missed opportunities. For example AECL could have promoted load following on it's website for the Advanced CANDU Reactor (ACR) and in it's ACR presentations and it could also have been included in presentations by the Canadian Nuclear Association. Although the Canadian Nuclear Society has produced several papers on the effect of load following on fuel I don't believe there has been a paper putting it all together to include the reactor physics of power manoeuvring, the IESO load following and grid frequency control requirements and how they are going to be met by the ACR, and the cyclic effect on plant components and mechanisms. Maybe the present CANDU user utilities have done studies but these are not in the public domain. It's the elephant in the room that no one wants to talk about.

We all know that to produce low cost electricity from the capital intensive nuclear plants means that they have to be run flat out day and night. This has given the impression that nuclear plants are on or off with nothing between. Although, as far as I know, the present CANDU plants were not designed for daily load following, in the past some Ontario units and off-shore units did experiment with load following, with some deep power reductions, but not on a continuous daily basis. Units in the U.S. are mostly run baseload on the theory that if you don't play with them there is less chance of something going wrong. However, with the preponderance of nuclear in France, the French (and German) PWRs have successfully load followed hourly, daily and weekly for many years and the French units are even used for Automatic Generation Control, that is, the second by second control of grid frequency. This may not be the best way to utilize nuclear reactors in Ontario but future circumstances (natural gas unavailable or too expensive, coal verboten, hydro growth limited, drought from climate change affecting hydro-electric availability, and reduction of greenhouse gas emissions) may demand it and plants like the ACR must be designed to do it. Although the plants must have the flexibility to daily load follow, and possibly even to provide operating reserve and grid frequency control if hydro plants are not available to do so, in some cases a plant could operate baseload and excess energy (unutilized base-load generation) exported or used for hydrogen generation, pumped water storage or compressed air storage to help the nuclear plants meet day time peak load demands in a clean Kyoto friendly way such as by using the compressed air and hydrogen in simple power turbines distributed around the province. This mode of operation could involve the turbine steam bypass system in daily use and it may have to be beefed up as a result.

All power plants are subject to more wear and tear when operated in load following mode and nuclear plants are no exception. With a nuclear plant it is the fuel that is most highly stressed. Safety dictates that the plant should respond properly to a design basis accident even after years of load following operation,

for example, nuclear fuel that has been subjected to daily power changes must not fail due to higher temperatures after a Loss of Coolant Accident and cause a radiation release that challenges the integrity of the containment. If analysis and in-core testing have shown that the ACR fuel can survive daily load following with sufficient margin to failure and the plant can meet the IESO load following specification, where are the rebuttals to the industry's critics? Can the ACR also meet the IESO requirements for Automatic Generation Control, which puts more stress on the fuel and reactivity control mechanism than load following? Step changes in power with the turbine leading the reactor would cause an increase in steam generator level that might result in a turbine trip. The future Ontario grid, within the 60 year lifetime of an ACR, could quite possibly be made up of just nuclear and hydro with some significant renewables like wind. This being so, has any thought been given by the designers to increase the robustness of the turbine steam bypass system so that, if it is necessary, it can play a part in mitigating the relatively rapid load fluctuations from the wind portion of the grid? Would a more conservative rated reactor power output help? The IESO should have objected long ago to the government's appeasement of the so called environmentalists by permitting wind on the grid and should have only allowed it to contribute as part of energy storage schemes. Maybe they did but the government was immune to their technical arguments, witness the politically motivated closure of the coal fired plants before reliable low cost generation becomes available. Politicians screw up and move on but engineers are left to clean up the mess. The Brits are learning the hard way about wind, and gas for that matter.

The IESO 10 Year Outlook mentions that, "Ontario's future generation supply mix will place an increasing reliability value on the flexibility of generating assets to provide load following capability, operating reserve and automatic generation control". AECL's input last August to the OPA's response to the MOE's request for advice on Ontario's future energy mix, resulting in the OPA Dec.1 report, considered a 20 year outlook (yet the ACR could have a 60 year life!) and then marketed CANDU into baseload replacement only, with an obscure Figure footnote that said, "Although nuclear generation is typically regarded as a baseload technology, new designs (including those by AECL) incorporate the ability to load follow, allowing them to increase output to service intermediate demand when called upon". The French and German PWRs that are load following today are certainly not new! Besides the lower cost edge what technical attributes does the new ACR have that make it load follow if, by implication, present CANDU's can't?

Even though the OPA solicited advice for base, intermediate and peak loads the AECL input did not even theorize on challenging natural gas for the intermediate and peak load segment of the projected demand, which it will have to do eventually. That is not good enough. The industry must respond to it's critics and show potential customers how CANDU can provide more than baseload for Ontario, and elsewhere.

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POSTSCRIPT.

A by no means exhaustive perusal of the 2005 December 9 OPA Supply Mix Advice Report to the MOE reveals the following items related to CANDU operational flexibility.

1) Part 1.1, page 3, Supply Mix Summary, states, "Planning supply mix would be simple if a single source were superior to others in all areas - environmental impact, reliability and costs - and could meet equally well the needs of base, intermediate and peak load. The reality is that no such single resource exists - a combination of resources and technologies is needed, and tradeoffs and synergies among them must be considered".

2) Part 1.2, page 37, Advice and Recommendations, states, Nuclear has, "Limited load-following capability".

3) Part 2.5, page 136, The Challenges, states, "Coal fired generation is a flexible resource. It offers a range of base-load and peaking/intermediate capability. Particular attention will be required to ensure Ontario's power system continues to have an appropriate balance of these capabilities as replacement resources are introduced".

4) Part 2.6, page 167, Methodology and Assumptions, states, For operational flexibility,"Nuclear plants have generally very little capability".

5) Part 2.7, page 216, Resources and Impacts, states, "In Canada, and also the United States, nuclear is base-loaded (i.e. constantly running). This contrasts to the reactors in France, where reactors are taken off-line or operate at reduced power for the appreciable fraction of time when demand for electricity is well below peak levels (Nuclear represents 77 percent of France's total electricity generation in 2003)".

6) Part 5.1, Written Submission to the Supply Mix Project from IESO, page 6, states, "To bring supply and demand into balance under Unutilized Baseload Generation (UBG) conditions, baseload generation must be shutdown. For example, if a nuclear unit is unable to perform power reductions it will be shutdown, typically resulting in a 48 hour "poison" outage. Such shutdowns, which assist with low demand concerns, can adversely impact the ability to meet demand during subsequent peak periods until the unit(s) return to service. Any consideration of nuclear generation additions should examine the ability of the different nuclear options to reduce power under UBG conditions, with preference going to those technologies which can better accommodate this requirement".

7) Part 5.2, Presentations from Expert Interview Sessions, from OPG, page 4, states, "Different technologies exhibit different attributes that make them particularly suited to fulfilling baseload, intermediate or peaking roles within a power system. Each of these roles is critical in ensuring reliability of supply and operational stability".

8) Part 5.2, Presentations from Expert Interview Sessions, from IESO, Table on Resource Types and Operational Characteristics shows that, Nuclear is POOR for load following capability, POOR for operating reserve, POOR for Automatic Generation Control.