Good Afternoon:

I am sure everyone here is aware that the Darlington Nuclear Generating Station is a four-unit station on the north shore of Lake Ontario with a capacity of 4 x 881 MWe. It was built by Ontario Hydro, and is now owned and operated by Ontario Power Generation.

I am going to spend a few minutes reviewing some of the problems during the project stage that resulted in significant delays and cost overruns, and make a few comments on more recent performance. I want to acknowledge that the person primarily responsible for collecting much of the information I am using was the late Ron Bartholomew, one of my excellent bosses at Ontario Hydro, and perhaps one of the individuals who had the best understanding of overall Ontario Hydro operation during the two decades leading up to Darlington being put into service.

Darlington Schedule

The Ontario Government approved the Darlington project in July 1977 and site preparation work began in 1978. The four units were scheduled to be in service between 1985 and 1988 as system planners judged there was an urgent need due to the electrical load having increased at an alarming rate.

The last unit was not put into service until 1993, 15 years after work started. This is an exceptionally long construction period that was a result of a number of unanticipated problems.

Economy and Need:

After the start of construction, an abrupt change occurred to both economic growth and electrical load growth. At the same time, the Federal Government monetary policy allowed interest rates to rise to nearly 20%! The combination of there being less immediate need for Darlington, and the very high borrowing rates persuaded the politicians of the day to stop or delay the completion of the station on several occasions, only to be followed by a push to speed up the project when electrical load growth accelerated. While project interruptions delayed borrowing more funds at high interest rates, a major part of the project cost had already been committed, and interest on that portion continued to accumulate. Interruptions in a major construction work program also have significant implications when the project is restarted, as very large projects cannot be simply switched back on with the same staff that existed when the work stoppage was put in place. For example, new trades staff may be competent in their trade, but need significant project specific training. Material and components may now not be delivered at the optimum time. In hindsight, it would have been prudent to have allowed completion of the project on schedule in spite of the high cost of money, and then sell surplus electricity to our U.S. neighbours.

Design Problems:

There were two significant design situations that affected schedule. The first was a change at Darlington to significantly increase the use of computer based safety systems. To avoid the possibility of any common errors in the two separate safety shutdown systems the contracted designers used different computer hardware and separate software design teams, working in different computer languages. However the Federal Regulator (then the Atomic Energy Control Board) insisted on proof there were no unsafe “software bugs”. During the debate on how such proof could be demonstrated, the Regulator effectively lost trust in this computer-based design concept. The impossible task of "proving a negative" (and regaining the trust of the Regulator) extended the completion of safety system commissioning by about two years and increased the programming costs by more than a factor of ten. Hence, a design improvement that was supposed to save time and money turned out to have the opposite result! It did, however, pave the way for regulatory acceptance in the future.

The second design problem showed up during early operation when resonant hydraulic vibration in the primary reactor cooling system caused some fuel damage. While this did not present an immediate safety hazard, it took some time to analyze the root cause and correct it. A modification to the design of the primary heat transport pump impellers finally resolved the problem. Correction of this situation on the first two units took about 20 months.

Major Equipment Failures:

There were two significant failures in purchased equipment that affected the schedule, both on the non-nuclear side of the station. The first, and least significant, was a catastrophic failure of a unit voltage transformer, caused by some internal electrical shielding which had been incorrectly installed by the manufacturer. The second equipment failure was much more serious as it involved cracking discovered in the shaft of one electrical generator rotor. Subsequent finite element analysis (by both the manufacturer and Ontario Hydro) and corrective machining of the shafts on all generators, took many months to complete. While the suppliers bore most of the cost of correcting the problems, they were not liable for the cost of project delay.

Staffing Problems:

Due to the extended schedule for reasons listed above, and restrictions on hiring staff who needed extensive training, the coordination of design, construction and commissioning staff with the other activities on the Pickering "B" and Bruce "B" projects became difficult, and that added up to 6 months to the schedule. There was also an unexpected electrician's strike in 1986 that lasted 6 months.

It is not possible to allocate specific projects delay times to the specific root causes just discussed, because they all inter-relate and interact. However, the combined effect was an additional 5 to 6 years on the overall project (compared to original expectations).

Darlington Cost

The 1977 “planning estimate” for Darlington was $5 billion (in dollars of the year). For project variance purposes, the figure used for comparison is the “definitive estimate” done when 15% of the engineering is complete and most of the major equipment purchases have been finalized. The Ontario Hydro Board of Directors approved a definitive estimate of $7.46 billion in 1981 (also in dollars of the year). It is worth noting that during the period 1977 – 1981 the Consumer Price Index increased by 46%, essentially equaling the increase in estimate from $5 billion to $7.46 billion. The final cost of the station in 1993 dollars was $14.33 billion – nearly double the definitive estimate. There were a few main reasons for this huge variance.

Schedule Changes:

In Canada, the accepted accounting practice is to capitalize all of the costs of financing until such time as the assets are placed in service. This was a legislated requirement for Ontario Hydro and was an Ontario Energy Board endorsed method of rate setting policy. Hence, when the schedule is extended and the rates of interest for borrowing are high, capitalized interest becomes a very significant component of total project cost.

In the case of Darlington the interest component of the total cost (due to both planned schedule and unplanned schedule changes) was a staggering $6.2 billion or about 43% of the total project cost! This compares to an interest component of $0.8 billion, or about 13% of total project cost, for the 4 unit Bruce "B" station that, while built in the same general era, had a much shorter construction time, and was placed into service in 1989, a few years earlier than Darlington.

Financial Policy Changes:

Far less significant than the schedule changes, were some corporate accounting changes that affected the final cost. One was a decision to capitalize all of the training costs and the other was a decision to spread the cost of common station facilities over all four units (instead of expensing them in total when they were placed into service with the first unit). Both of these accounting policy changes had the effect of delaying some costs from entering the rate base. This may have delayed some rate increases, but had the effect of increasing the amount of capitalized interest, and hence the project cost. The total impact of these changes added about $1.3 billion to the total project cost.

Re-engineering and Extra Construction Costs:

The cumulative total cost of re-work required for items such as described earlier was in the order of $1.0 billion.

These 3 sources of cost increase generally account for the huge $6.9 billion unfavourable variance on total project cost. It would be difficult, if not impossible, to accurately assess blame for the delays and cost overrun on Darlington, but it seems extremely unlikely that future projects would

suffer from such a convergence of unhappy difficulties.

Darlington Performance

Not only did Darlington have a painful "birth" but also circumstances at Ontario Hydro in the 1990s resulted in some unhappy early years. To make a long story short, the Government(s) of the day ordered a disastrous downsizing effort, which was followed by an unrealistic 8-year rate freeze. The downsizing was really aimed at the Design and Construction arm of the organization, since further new major projects were not anticipated, but as implemented, many experienced operations and operating support staff left the organization. The resultant shortage of trained and qualified nuclear operating and maintenance staff was felt at all stations including Darlington.

The Darlington management team did what they were trained to do, namely focus their scarce resources on public safety, worker safety and keeping the fuel appropriately cooled. That meant neglecting many performance related activities such as preventative and predictive maintenance as well as outage activity optimization. Capital improvement funds were limited and were mostly spent on issues driven by regulatory requirements rather than production improvements. The result was a reduction in station electrical output performance.

I am obviously not in a position to speak for Ontario Power Generation, but there is every indication that the earlier situation has been corrected, and now with more adequate resources, Darlington is performing to expectations in virtually all respects.

Reliability:

In 2008 Darlington Station achieved a Capability Factor of 94.5%. This is outstanding performance and the electricity produced was more than 17% of Ontario’s needs. 2009 output is likely to be somewhat lower since Darlington completed a major containment system outage in June that required the shutdown of all units. This outage is only scheduled for once every 12 years and the good news story was that it was successfully completed in a timely fashion.

Production Cost:

Ontario Energy Board reports show recent Production Unit Energy Cost for Darlington at about 3 c/kWh. This is competitive with other good nuclear plants and well below any fossil fired alternative.

Safety:

The U.S. based Institute for Nuclear Power Operations (INPO), and the international World Association of Nuclear Operators (WANO) both do comprehensive assessments of the overall quality of operation at nuclear stations. Ontario Hydro and OPG have been active participants in these programs from their beginning.

In the late 1980's, Ontario Hydro requested INPO's assistance in evaluating Ontario Hydro nuclear stations. These were the first INPO assisted evaluations outside the USA. A number of significant issues were identified, and in spite of efforts to make corrections (with limited resources), the problems eventually led to the shut down of several units in the mid-90's, and a major, and very expensive, Nuclear Asset Optimization Program led by a group of American consultants. That program, and additional OPG effort, have led to major improvements.

A number of specific safety measures are used such as radiation dose to the staff or public, worker safety, special safety system availability, etc. These, and many other operational areas are reviewed and reported on annually by the Canadian Nuclear Safety Commission. For 2008 Darlington received an overall rating from the CNSC of "Fully Satisfactory".

In 2007 Darlington was awarded INPO's prestigious Performance Improvement Award and received their best ever performance review from WANO. In July of this year, an international Plant Manager and Nuclear Vice President workshop was held at Darlington at WANO's request to showcase the station's excellent performance. These are outstanding achievements by OPG, and all Darlington staff, and confirm high quality, safe operation.

In spite of it's troubled start, Darlington remains a vital part of Ontario's electrical supply, and will continue to pay back the people of Ontario for many years.

As a final comment, there have been some suggestions that Darlington's early problems were due to the basic CANDU design. There is no basis for this and the CANDU technology has been supported as sound by respected independent authorities such as Carl Andognini, who led the American performance recovery team in the late 1990's, and the OPG review team Chaired by John Manley.

Whatever decision is made about future nuclear power stations in Ontario, perhaps it is worth repeating one of Manley's comments on Darlington, following his review:

"What we've learned to some extent is those cost overruns were not simply a product of technology, they were in some case a product of political interference…we do see for example new builds in China, CANDU reactors being built ahead of schedule and on budget. If we can do it in China surely to goodness we can do it in Ontario."