V. Pickering

Assessing and making recommendations on Pickering A Units 1, 2 and 3 was the most technically complex and urgent matter to confront us.

Unit 4 was one of four units at Pickering A that were taken out of service in 1997 because of regulatory concerns, and so that resources could be focused on upgrades at other nuclear facilities. Unit 4 was the first of the Pickering A units to return to service. We were asked to advise on the potential refurbishment of the remaining three.

The facts around the refurbishment of Pickering A Unit 4 are well known:

- The final cost of the project, at $1.25 billion, was roughly three times the estimate put forward in 1999.
- The scheduled date for completion slipped by more than two years, from mid-2001 to late September 2003.

In its report last fall, the Pickering A Review Panel, which is referred to as the Review Panel in this report, stated that "management of the project from initial planning to execution was seriously flawed. The Review Panel found that well-established industry practices and steps for carrying out a project of this size and complexity were not followed." It also recognized that the "ultimate responsibility must lie with the OPG Board and senior management and how they exercised their oversight responsibilities." After the release of the report, OPG's Chair, Chief Executive Officer and Chief Operating Officer resigned. The board and CEO have been replaced on an interim basis.

During the time we carried out our work, the interim board of directors of OPG decided to stop all planning and preparation activity on Units 2 and 3 so that they could concentrate their resources on Unit 1. We agree with this decision. In our view, further development work on Units 2 and 3 should not go ahead until it is clear that OPG will be able to succeed at the Unit 1 project.

Our focus in this chapter is therefore on whether Pickering A Unit 1 should proceed. Our assessment of this question is necessarily based on the information available to us at this time. Large construction projects by nature carry risk. Because of the sheer amount of money involved, approvals must be contingent on continued oversight and continued management of project risk. This applies to all well-run projects, whether in the private

or public sector. Controls and checkpoints are essential both before and after construction starts.

In our view the two key questions we had to address are:

- Does the project make economic sense?
- Can the project be done on time and to budget?

The economic analysis showed us that proceeding with the $500 million investment necessary to complete Unit 1 would result in an electricity cost that is between $20 and $30 less per megawatt hour than the cost of electricity from a combined cycle gas plant, the next best alternative for baseload generation.

The revenues from the electricity generated by the project would be sufficient to repay the $500 million investment required, demonstrating a robust business case in favour of proceeding, with a net present value of between $95 million and $235 million.

Achieving this outcome requires completing the project on time and to budget. We reviewed the project intensively with the OPG Unit 1 Project Team and with an independent project oversight team (the Schiff team described below). We asked a series of key questions to assess the readiness of the project.

Ultimately we arrived at the conclusion that the OPG interim board, OPG management, and the Unit 1 Project Team have developed a plan to reduce or eliminate the major sources of the delays and cost overruns that occurred on Unit 4. We believe that the risk on this project has been managed down to a reasonable level but that stringent oversight must continue to ensure project risk remains at an acceptable level.

Based on the above, we are recommending that the Unit 1 project proceed.

Following this overview is a section detailing the economic analysis of the Unit 1 Project followed by a section on the project management status. Our formal recommendations can be found at the end of the chapter.

The economics of the project

For the economic analyses, we drew on the advice of CIBC World Markets Inc. and PJBTO Associates Ltd. With their help, we reviewed the economics of the Pickering A Unit 1 project, examining the project from two perspectives. In the Alternative Supply

Analysis, we compared it to an alternative option for baseload supply. We also carried out a business case analysis.

The estimated remaining cost to complete the Unit 1 project is a range of $450 million to $600 million, with the base case estimate being $500 million. The question we asked is whether investing this $500 million made economic sense.

Key Findings

Alternative Supply Analysis

- This analysis used a measure called the Levelized Unit Energy Cost (LUEC) that is often used to compare costs consistently across generation options that have different operating lives and cost characteristics.

- On a go-forward cost basis, the electricity cost for the Unit 1 project using LUEC analysis is projected to be between $20 to $30 cheaper per MWh (or 2 to 3 cents cheaper per KWh) than that of a combined cycle gas plant running as base load.

Business Case Analysis

- This analysis used a Net Present Value (NPV) approach, which estimates the net value in today's dollars of all the outflows and inflows of a project over a specific number of years into the future. It uses a "discount rate" for future flows that reflects perceived risk.

- The NPV for the project based on go-forward costs and using an electricity price projection based on the current market structure ranges from $95 million to $235 million, depending on the discount rate used. An NPV of zero or greater indicates the project is financially feasible.

Below, we first explain the assumptions underlying the analyses and then present the results in more detail.

Key Parameters

To understand the economics of the project, key pieces of information are needed. These include the investment that must be made in the project, as well as such elements as the project's operating life and annual costs. The table below sets out the key parameters. The terms are explained below.

Key Parameters for the Unit 1 Project

Financial Parameters	Estimated Range (March 2, 2004)	Base Case Estimate (March 2, 2004)
Going Forward Project Cost	$450-600 million	$500 million
Expected In-Service Date	August 1 to December 1, 2005	September 1, 2005
Capacity Factor	75% - 90%	85%
Average Annual Cost	$77 - $108 million	$86 million
Operating Life Ending	December 2013 to December 2019	December 2017

Going Forward Project Cost: This comprises all costs to complete construction, commission and return the Unit 1 reactor to service, including contractor charges as well as internal OPG project-related spending. If approved, about $300 million will be spent in 2004 and $200 million in 2005.

Expected In-Service Date: This is the date on which Unit 1 would begin operating, assuming a construction start of June 1, 2004. The base case estimate assumes 12 months for building followed by three months to complete all final steps and reviews before starting the reactor.

Capacity Factor: This is an industry measure of the percentage of time a plant is operating and producing electricity. A 100% capacity factor would mean Unit 1 was always on. Most reactors go out of service for planned and unplanned maintenance. The less often this happens, the better the economics.

Average Annual Cost: This is the cost for fuel, operations, maintenance, management, repairs, and capital expenditures to sustain the plant's condition.

Operating Life Ending: This estimates how long Unit 1 will produce electricity after it returns to service.

OPG is currently working on producing a tighter estimate of project cost, essentially to reduce the expected range of the outcome. This is expected to be ready at the end of this month.

Weighted Average Cost of Capital and Discount Rate: In performing the analysis, our advisors tested the Unit 1 project using a "weighted average cost of capital" in a range of 10 to 15%. This established the discount rates used to calculate the present value of future cash flows in the project. Generally, the higher the discount rate, the higher the perceived risk of a project. The 10% rate reflects OPG's corporate discount rate and might also reflect OPG's cost of capital under rate regulation. The 15% rate reflects the higher risk profile that might be attributed to a nuclear refurbishment project.

Price of Power: The business case analysis depended heavily on the projected price of electricity. We used a price projection provided by OPG that is based on the current market structure.

We have also tested some options using projected prices at the level that would likely be needed to attract a new 515 MW combined cycle gas plant. This type of gas plant would be the next best alternative to refurbishing Unit 1, because it could be built reasonably quickly and would provide a similar level of output for baseload supply. The projected prices for electricity that would be needed to make the gas plant investment attractive are higher than in our business case analysis. Since higher prices in future would improve the economics of the project, this makes the case for Pickering A Unit 1 even stronger.

Sunk Costs

Total costs of work to date, or "sunk costs," on Unit 1 are significant. With any complex construction project, money has to be invested up front in exploratory work to ensure the budget is accurately developed and potential obstacles are identified. As well, because returning all four units at Pickering A was originally conceived as a single project with multiple phases, some work was completed on Unit 1 while the Unit 4 work was going on. The Unit 1 sunk costs are about $325 million, placing the total project cost in the range of $775 to $925 million. The base case estimate is $825 million.

Our main focus in each analysis has been on the go-forward cost of the project, compared with the electricity and returns that can be generated from that go-forward investment.

However, it is also important to look at the economics of the project on a total cost basis. Both of our analytical approaches therefore included some analysis using total costs.

Alternative Supply Analysis

As the Task Force indicated, Ontario has an immediate need for additional generation capacity. This analysis compares the cost of the Unit 1 project to an alternative generation option that could supply the same amount of power and be built in a relatively short time.

As noted, LUEC allows the costs of generation options with different characteristics to be compared on a consistent basis. It represents the constant price that must be charged for each unit of electricity generated over the life of that option to exactly recover all life-cycle costs, including the cost of capital. The comparison is most useful when the options serve the same role in the electricity system. In this analysis, for example, both options – Unit 1 and a 515 combined cycle gas plant – provide baseload capacity. While renewables such as wind power might be built as quickly, their operating characteristics present challenges to considering their capacity as baseload.

Using the parameters described earlier, and employing a 10% discount rate, we estimate the going forward LUEC of the Pickering A Unit 1 project to be roughly in the range of $40 to $45 per MWh. The gas plant, in contrast, has a projected LUEC of $65 to $70 per MWh.

This would result in savings to electricity consumers of $75 to $115 million a year. At a 10% discount rate, the present value of the savings over the 12-year operating life of the refurbished Unit 1 ranges from approximately $500 million to $800 million.

This analysis shows clearly that the Pickering A Unit 1 project would be less costly to the ratepayers of Ontario than any other baseload generating source that can be developed in the time available.

On the basis of a total project cost of $825 million and using a LUEC analysis, Unit 1 is anywhere from $4 to $18 cheaper per MWh than the gas plant, depending on the assumptions used. This would translate into yearly savings to electricity consumers of

$15 to $70 million a year, and the present value of the savings in this case ranges from roughly $100 million to $500 million at a 10% discount rate.

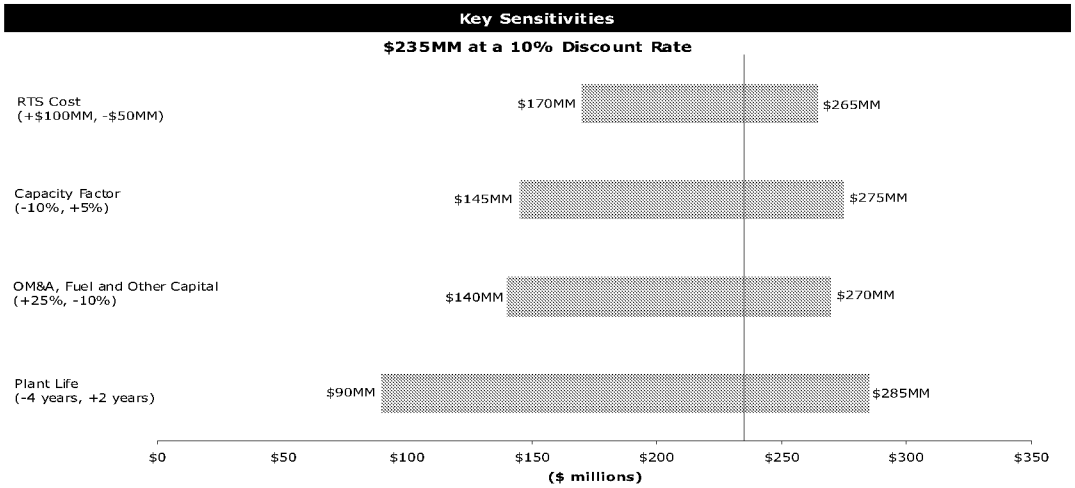
Business Case Analysis

The business case analysis examines the Unit 1 project from the point of view of an investor looking at the net present value (NPV) today of all the money put into an investment and earned by it over time. Because NPV analysis provides a snapshot at a given time, judgement is needed in assessing the results, as these are highly dependent on the assumptions used.

We requested and OPG management provided to us its financial business case analysis. The OPG analysis discounted the cash flows at their corporate weighted average cost of capital of 10%, and projected prices based on the current arrangements for the wholesale electricity market. It also used the key parameters set out at the beginning of this section.

The result of that analysis showed an NPV of $235 million using the base case parameters of the project. This indicates that the Unit 1 project is feasible based on its go forward cost estimate of $500 million.

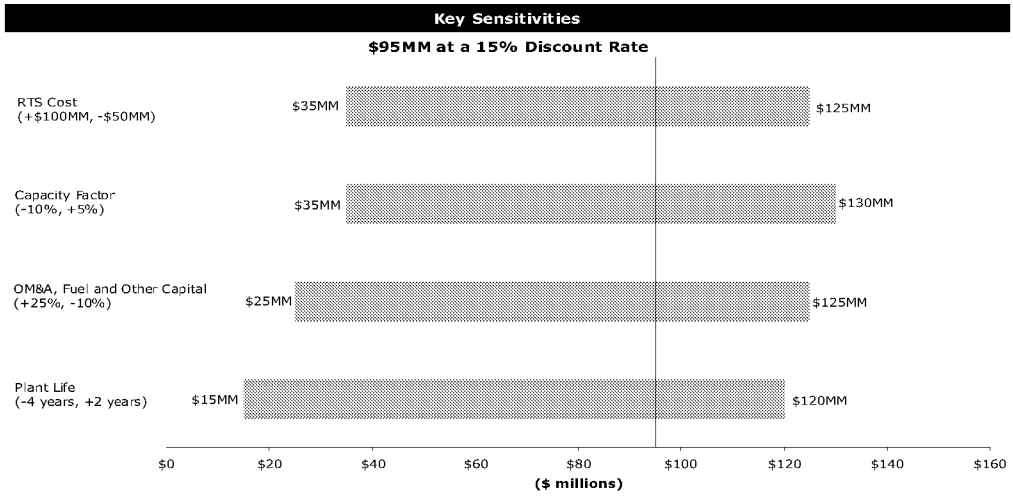
Our financial advisers reviewed the case and tested it for the estimated ranges in the key parameters provided by OPG. This sensitivity testing shows how the NPV would vary if the actual results were lower or higher than the base case estimate. The diagram below shows the results of that testing. As can be seen from this representation, the NPV for Unit 1 is positive for the full extent of all the ranges tested:



If a combination of negative events were to occur, for example:

- a three-month delay in start-up; a $50 million increase in construction costs; 80% capacity factor; operating life shortened by two years; and a 10% increase in average annual costs, the NPV drops to $70 million, still a positive figure but less attractive as an investment.

For reasons discussed earlier, our advisers tested the project at the higher discount rate of 15% and with the base case parameters. The resulting NPV was $95 million. The corresponding sensitivity analysis is shown below and the NPV is still positive over all the ranges shown.



With the electricity price projection used in the analysis and the total project cost of $825 million, the internal rate of return would be approximately 10%. On a total cost basis, the project would have a positive NPV if the weighted average cost of capital were set at 10% or below.

Uncertainty of Estimates and Risk

Any financial analysis is dependent on the quality of the inputs to that analysis. As noted, the financial analysis in this report is based on the parameters provided by OPG as part of their business case and are the product of a detailed technical analysis.

We, and our financial advisers, have queried OPG management about these estimates and about their confidence in the information provided. In the end, based on the responses we received, we have accepted them as factually based and reasonable for the purposes of this analysis. OPG management recognizes that given the recent history of missed projections both on construction and elsewhere in their operations, it is critical that their estimates be considered and comprehensive.

It should be noted that within the timeframe available to us, it has not been possible to undertake a detailed assessment of the technical analysis and the estimates provided.

The ranges shown in the first chart in this chapter are a way of describing the risk in the estimates of cost that OPG has prepared. For example, the going forward project cost could be as low as $450 million or as high as $600 million. Within those ranges, the NPV of the project remains positive, suggesting that the Unit 1 project would be financially feasible.

A risk remains however, that the outcomes of Unit 1 could fall outside the ranges that have been projected. We would caution that no analysis can guarantee a positive outcome.

Conclusion

The alternative supply analysis and the business case analysis generally demonstrates a robust business case for making the remaining $500 million investment in Unit 1, contingent, as in all projects, on risks and particularly construction risk, being well managed. Management of the construction risk is addressed in the next sections.

Project Management

To help us assess the project management of the Unit 1 project, we drew on the expert advice of Schiff Hardin LLP. To help with the analysis, Schiff Hardin retained two consultants, J. Wilson & Associates and Meyer Construction Consulting Inc.

Schiff Hardin has expertise in project oversight and controls and specific experience with nuclear refurbishment projects. J. Wilson & Associates and Meyer Construction Consulting provided additional in-depth knowledge of project scheduling and construction cost analysis. (The entire team is referred to as "Schiff" in the balance of this chapter.)

Background: The construction challenge

What presents the greatest challenge in the Unit 1 Project is not so much the nature of the work that has to be done, but the amount and the scheduling of that work.

The scope of the work involves:

- Bringing the unit back to working condition; and
- Ensuring it conforms to current licensing and regulatory standards. (Operators of nuclear facilities must be licensed by the Canadian Nuclear Safety Commission.)

The work is split between:

- Modifications, which require engineering work and will be carried out largely by outside contractors (who are referred to in this chapter as the "Prime Contractors"); and
- Non-modification work, which is essentially plant maintenance and will be done mostly by OPG Operations and Maintenance staff.

Although Unit 1 is a nuclear facility, virtually none of the modification work calls for a specialized technical skill on the part of the Prime Contractors. In fact, almost all of the craft labour (that is, electricians, pipe fitters and so on) will be hired from local union halls.

The number of tasks involved in the work, however, is large: about 8,000 modification and 8,000 non-modification tasks. Scheduling these into an efficient integrated process, especially in light of the security, safety and regulatory procedures at a nuclear facility, is critical to success.

In addition to the sheer volume of work, the major complicating factor for the Prime Contractors is the fact that Unit 1 still contains nuclear fuel.

Because of the design of the Pickering A reactors, which are all CANDU 600 models designed by Atomic Energy Canada Limited, the reactors do not have to be defueled for maintenance outages.

When the reactors were laid-up in 1997, the company intended to return the units to service relatively quickly and so did not defuel them. It is not economically viable now to defuel the unit before construction starts.

Having fuel in the reactors during the project means that radiation safety protection rules for an operating nuclear plant must be followed. Consequently:

- OPG's Operations and Maintenance staff must closely monitor the work of the Prime Contractors.
- The work must be performed under Plant Operations and Maintenance access-to-work procedures.

Role of OPG

OPG is currently acting as the project manager, as well as engineer and general contractor, on the Unit 1 project. Given the results of the Unit 4 project, a central question is the role that OPG should play if the OPG board approves the Unit 1 project.

Because of the nature of the project, OPG staff must be extensively involved. As the licensed operator of the fuelled reactor, it has responsibility for plant safety and for ensuring that the work meets all licensing requirements. Also, OPG staff will carry out the non-modification tasks.

There are compelling reasons why OPG should remain in the role of project manager. Doing otherwise would likely result in higher risks and costs, for these reasons:

- Preparations for Unit 1 are at an advanced stage. Transferring project management to a third party at this point would result in delays and carry a different set of risks. Any third party would have to re-validate engineering and planning assessing, resulting in increased costs.
- Another project manager would likely not be willing to take on financial and scheduling risks that arise from factors beyond its control, such as the requirements arising from the fuelled state of the reactor and the need to use OPG staff for the non-modification tasks.

- Many of the "lessons learned" from the Unit 4 project relate to OPG activities, such as the access to work site permits. OPG may be in a better position to manage critical elements of its own performance than a third-party project manager.

We found that OPG is in the process of overcoming the problems that plagued Unit 4. Based on the assessment Schiff provided to us, we have concluded that the current Project Team is capable of successfully managing the project to completion. Schiff also noted the many steps that the OPG management and Project Team have taken to apply the lessons that were learned from Unit 4.

Given the necessity for a high level of OPG involvement, and the risk and limited benefit of transferring project management at this stage, we have concluded that maintaining OPG as the project manager is the best option available if the Unit 1 project goes ahead.

Furthermore, we think that the capacity OPG is developing in project management will be invaluable in future projects, even where OPG is not the project manager. OPG needs a core set of skills in such areas as scheduling and budget development to effectively manage its relationships with external service providers, including outside project managers. This will primarily benefit construction and refurbishment but could also benefit other parts of the organization.

Project Methodology and Lessons Learned

Setting up and following a robust methodology is critical to any major construction project, whether nuclear or otherwise. A key part of that is learning from past mistakes. This involves:

- Analyzing and fully understanding the root causes of problems that occur on the first part of a multi-phase project;
- Translating that knowledge into a plan for making improvements; and
- Taking action on the plan so that the problems do not recur in the following stages.

This approach was used to analyze the fundamental problems that occurred in virtually every aspect of the Unit 4 project. The table below describes the key lessons that were learned from the root cause analysis of Unit 4 that are being applied by the Unit 1 Project Team.

This also provides a list of key elements common to virtually every large construction project. A version of this table with details of Unit 1 status and Unit 4 history appears in Appendix F.

	PROJECT METHODOLOGY - Key Lessons Learned
A.	Project scope must be fully developed and frozen.
B.	Project budget must be based on completed scope and a defined project schedule.
C.	Steps precedent to construction must be completed before construction starts.
	1. Engineering must be complete
	2. Relevant planning and assessing must be completed for each phase of construction.
	- Planning and assessing prepares CWPs and accurate bills of materials for the ordering of parts and equipment
	3. Detailed schedule must be completed and updated
	4. Materials ordered, stored on-site and ready for delivery to workforce
	5. Efficient and productive relationship is needed between Prime Contractors and OPG Operations & Maintenance
	6. Contingency plans must be in place to deal with the unexpected.
D.	Project controls and metrics must be in place.
	1. A commodity-based "earned value" must be tracked
	2.Performance metrics established for OPG support departments
E.	OPG Project Team must demonstrate capability to manage the project.
F.	Effective contracting strategies must be developed.
G.	Project team must provide accurate information to senior management and the board of directors.

In the following sections, we discuss progress on the project and the plans under way to deal with challenges.

Progress on Unit 1

The report of the Pickering A Review Panel divided the failings of the Pickering A Unit 4 project into five major categories. These were:

- project assumptions;
- project management;
- cost and schedule estimates;
- management effectiveness; and
- cost and performance reporting.

We used these categories to assess the current status of the project and judge whether the Unit 4 problems have been addressed. We are satisfied that OPG has addressed these problems and is managing them. As further assurance, the Project Team is subjecting itself to rigorous ongoing monitoring and oversight.

1. Project Assumptions

The Project Team has carried out a thorough due diligence review of the scope of the Unit 1 project. This included incorporating into the Unit 1 engineering two important elements:

- the relevant field changes that were required on Unit 4; and
- detailed walk-downs of the Unit 1 site both by OPG and contractors to identify omissions and confirm constructability.

All known regulatory requirements have also been included in the scope of engineering work for Unit 1, which was not the case with Unit 4 at a comparable point in the planning. In fact, the scope of the work on Unit 4 was not frozen until almost the end of construction.

Engineering for Unit 1 is effectively complete. OPG and contractor field reviews have tested it and found it to be robust. Incomplete engineering was a principal flaw on Unit 4.

2. Project Management

With the scope of the Unit 1 project frozen, the Project Team is developing a detailed, critical path schedule. All parties are expected to sign off on the completed schedule in May.

As well, the Project Team:

- Has set up procedures to track progress on the preparatory phase of the project and is regularly reviewing this information with OPG senior management.

- Has made substantial progress in defining the respective roles and responsibilities of the key participants in the project, internal as well as external. This should be complete before construction starts.

- Is continuing to develop communication protocols and contingency plans. This should be complete before construction starts. Clear lines of communication and clear accountabilities, which are essential to a successful project, were never established on Unit 4.

- Is ensuring that the planning and assessing phase, in which the work scope and tasks are detailed for field construction, is sufficiently advanced that it will not interfere with the start of construction. In contrast, on Unit 4 this was done in the field well after construction had started. The Unit 1 Project Team is committed to completing planning and assessing to support the construction schedule.

- Has ensured that between 70 and 80% of the materials needed for the entire project are already on-site, and specialty long-lead items are either available or on order to meet schedule. Materials availability was a problem on Unit 4.

- Has retained an external Project Adviser, who has extensive construction expertise in both new nuclear and refurbishments, to mentor the team and to advise the Project Manager in dealing with critical issues.

- Has developed a plan to reduce the work-access permitting bottleneck. On Unit 4, inefficient OPG procedures for issuing access to work permits caused delays of up to three to five months. The new approach is discussed in more detail below.

As well, the senior executive at Pickering A (who is the head of the Project Team) has made a written commitment to OPG senior management that construction will not be mobilized until all pre-requisite conditions have been met and tested. The premature start of construction was a major problem in Unit 4.

3. Cost and Schedule Estimates

The Unit 1 budget has been developed at the correct stage, after substantial progress has been made on engineering, Planning and Assessing, and drawing up a project schedule. On Unit 4, budgets were constantly revised because they were prepared before all the necessary steps were complete.

To better define the budget, the Project Team started a process in the fall of 2003 to have Prime Contractors provide estimates on detailed design drawings on a task-by-task basis. An independent review of these estimates revealed a flaw in the process. The estimates are now being adjusted. This process will ultimately provide greater certainty for both cost and schedule.

4. Management Effectiveness

Management and the Project Team have used the Lessons Learned from Unit 4 to create and act on a plan to avoid the recurrence of problems.

Management now clearly recognizes the complexity and risk of a major construction project. An oversight structure has been established that includes an independent oversight team, Schiff, that is responsible and accountable to the board of directors. Regular meetings bring together the Chair of OPG, key members of OPG senior management, Schiff and the Project Team.

As well, the OPG Chair is establishing an oversight panel with external experts in nuclear and construction matters. This oversight panel will meet periodically with the Project Team and Schiff and report to the board of directors.

OPG has made key changes to the Project Team to add the expertise and depth needed for the Unit 1 project.

The degree of oversight adopted with respect to this project is unusually intense and reflects the fact that during the Unit 4 project, the board and senior management did not receive the information required to be able to accurately assess progress on the project.

Project Team members have submitted themselves to an open review of the precise status of progress, and to identifying clearly and as early as possible every known hurdle to success.

5. Cost and Performance Reporting

A new project controls system, with the needed software tools, is being put in place. Project information from the new system already exceeds anything generated for Unit 4.

Work is advanced on a stable work breakdown structure to compare the hours of work performed on the project with the materials estimated, used and installed. This will allow the determination of "earned value" (a basic measure of productivity on a construction project) against hours of work expended, an indicator of how productively labour is being used. The new system should allow earned value to be tracked on a daily basis.

Performance metrics are being set for OPG support and administrative staff, with tracking tools similar to those in use for external contractors.

In sum, there has been and continues to be considerable activity on the part of the Project Team to improve the potential outcome of the project. However, significant challenges remain. The next section discusses these in more detail and outlines the steps being taken to address them.

Remaining Challenges

The following challenges for Unit 1 have been identified to us:

- OPG is the combined owner/project manager/engineer for the Unit 1 project. As a result:
  - OPG carries significant risk for the performance of the project.

- OPG carries additional risk of construction claims for "owner interference" from the Prime Contractors that could add to costs.

- OPG will have a large overhead for support staff once construction starts. Delays in the schedule will thus directly affect OPG's cost.

Unlike the Unit 4 project, managers this time are clearly aware of the risks associated with their role on the project. Thorough work on project management essentials such as engineering and scheduling is the primary way of managing these risks. Despite the risks, it is critical that OPG perform the project management function for reasons discussed above.

- OPG procedures for issuing access to work permits could cause delays. As the licensed operator of the facility, OPG is responsible for managing these permits, which are necessary for safety reasons. However, the efficiency of the permit procedures is essential.

  - Having only one sign-in window for work crews on Unit 4 resulted in delays of two to three hours every day, which had a very large impact on the total construction time.

  - For Unit 1, OPG has added four Maintenance Authorities, in addition to the permit window, who will also be able to issue work access permits and will be available two hours before the start of each shift. The Project Team will need to monitor this approach closely once construction starts.

  If the bottleneck problem is not reduced, it could significantly extend the schedule and as a result, the cost.

- The preparation of Comprehensive Work Packages (CWPs) is behind schedule. CWPs, which are prepared by the Planning and Assessing department, are used as the instructions for work in the field. The initial goal was to complete this stage before the tentative start date for construction of June 1.

  Based on the rate at which the work is now being carried out, it is expected that CWPs will be 80% complete by June 1 and fully complete in July 2004. If this

schedule is met, there should be no impact on the construction, which is planned to start June 1 using the CWPs needed to support that phase of the work.

- The processes that OPG initially directed the Prime Contractors to use for detailed design package estimates were flawed.
  - Standards and factors in the estimating guide that OPG gave to contractors proved to be excessive and resulted in unduly high estimates and unduly long durations for the work.

  Once the problem was identified, OPG held a series of meetings with contractors. Most of the contractors are now committed to making the estimates more accurate and if anything, the initial estimates should prove to be high.

- The form of contract with the Prime Contractors is still under negotiation.
  - The Project Team is seeking a form of contract that would allow the Unit 1 project to set a reliable budget.
  - Extensive efforts are being made to address issues such as access to work site that could have an impact on the form of contract.

- Project controls have been introduced and include software new to the company.
  - OPG and its Contractors are getting used to the new system and, despite the learning curve and some unresolved software issues, are generally positive.

Is the Project Ready?

We have just described the significant challenges to this project. More challenges will arise. Every complex and large construction project carries risk that cannot be avoided. The question for us is whether the risks on the project are being and will continue to be adequately managed, and whether the projected budget and schedule will be met.

We have examined the root cause analysis of Unit 4, and the application of the "Lessons Learned" to the Unit 1 project. We have reviewed the progress made against the issues described by the Review Panel. Following are the questions that we felt we had to answer to be able to arrive at a recommendation on Unit 1.

- Is the information we have received about the project useful in making a recommendation, and are we confident about the quality and timeliness of it?

  - We have met with the Project Team.

  - Committee staff have been present at meetings between the Project Team and the Prime Contractors.

  - We have met with Schiff frequently and received detailed information from them about the status of the Unit 1 project, as summarized above and in Appendix B.

  - Schiff was consistently available to clarify any questions we had. They updated information to us almost to the day this report went to printing.

  Based on those facts, we are confident about the quality, timeliness and usefulness of the information we have received.

- Given the information available to us, do we believe the root causes of the problems on Unit 4 have been addressed on the Unit 1 project?

  - As the material above on "Lessons Learned" sets out, OPG senior leadership and the Project Team have identified the root causes of the Unit 4 problems.

  - They have taken action to address the problems.

  - In most cases, their actions have significantly reduced the risk of recurrence.

  - There are remaining challenges that are still being dealt with, as outlined above.

  Based on these facts, we believe that the root causes that have been identified are being successfully addressed. The oversight structure that has been established provides additional assurance that this is the case.

- Do we believe that the Project Team has the capacity to manage the project?

- The Project Team has successfully completed the engineering phase, which was the source of much of the delay on Unit 4.
- The team has made progress in applying lessons learned.
- The team has added management depth to the construction division.
- Schiff has concluded that the current Project Team is capable of successfully managing the project to completion.

We concur with Schiff that the evidence is there to show sufficient capacity for this project.

- Are the projected budget and schedule well founded?
  - There has been a thorough due diligence of the scope, and the scope includes all of the regulatory requirements.
  - A detailed schedule is in development and the current version has been tested with contractors.
  - Budget development is based on completed engineering, on walk-down estimates, on substantial completion of planning and assessing, and on a detailed schedule.

  It is our conclusion that the budget and schedule development has been thorough and can be substantially relied upon.

- Are there appropriate project controls and oversight going forward?
  - Project control systems have been established.
  - Performance metrics have been developed for contractors to allow calculation of earned value on a daily basis.
  - Performance indicators are in development for all OPG support departments to track productivity and efficiency.
  - Schiff will continue to report to the board of directors. Schiff, along with the Project Team will also meet regularly with an oversight panel with both

board of director and external expert membership to review progress in detail.

We conclude that there has been substantial progress in project controls and project oversight issues.

- Unexpected delays frequently occur on major construction projects. Are there contingency plans to manage risks that might cause delays?
  - A team has been established to manage emerging risks.
  - This structure will allow for a rapid response to unforeseen events.
  - Common occurrences that arise with construction projects, like equipment failures, have been anticipated, and work arounds are being prepared.
  - We understand that the Project Team is continuing to develop clear roles, responsibilities and lines of communication.
  - This will allow the right individuals to be notified and to take action to reduce the impact on the critical path of the schedule.

  We conclude that the Project Team is taking steps to ensure that unforeseen risks can be addressed quickly and effectively as they emerge.

- Given that all construction projects carry some degree of risk, has the risk of cost overruns and schedule delays been reduced to a reasonable level?
  - The best way to manage that risk is through a diligent and thorough preparation, through clear roles and accountabilities, and through using oversight to provide appropriate checks and balances.
  - OPG is working on a contractual strategy to ensure budget and schedule adherence.
  - Schiff has stated that "Despite any of the aforementioned risks, the Unit 1 Project is eminently feasible, and the potential problems the Project may

encounter should not exceed the risks OPG has identified and anticipates for the Project."

It is difficult to determine the residual risk on any particular project, but it is clear to us that a consistent effort has been made to reduce or eliminate the possible impacts of major sources of delay and thus of cost.

We have evaluated the evidence and concluded that the Project Team is making a sustained effort to manage the Unit 1 project in a professional manner. Early signs of success verify this conclusion. Impediments to that success have also been encountered, but the Project Team is openly discussing and addressing these.

Nuclear projects are by nature more complex to administer than others, but having reviewed the above questions, we think that the degree of risk on this project has been managed down to a reasonable level. However, this effort must continue. Risk is not static and must be reassessed on a continuing basis. Notwithstanding our conclusion that the project risk is reasonable at this time, certain milestones must be met before construction starts.

Milestones

The OPG board of directors will soon face a decision on full-funding approval. Schiff has advised that approval be conditional on meeting the following fundamental milestones no later than the start of construction:

- Scope of the project must be frozen;
- Contracts with the Prime Contractors must be agreed-to in principle or be in place;
- Prime Contractors and OPG must agree to a detailed, critical path schedule;
- The Project's baseline budget including contingency reserves must be fixed ;
- Project Control metrics must be in place and capable of tracking earned value of the work;
- OPG and its contractors must have in place a cost reporting system which tracks major commodity work (quantity and unit cost);

- The Project Team must have a stable staffing plan that details the ramp-up of resources necessary to meet the needs of the construction phase;
- Contingency plans for potential schedule delays must be established;
- A Communication Plan which dictates day-to-day interaction and emergent issue management must be prepared and accepted by the Project Team and the Prime Contractors;
- A detailed description of major roles and responsibilities must be fully developed and accepted by the Project Team and Prime Contractors;
- The process for change order review and approval must be in place and accepted by the Prime Contractors;
- The modification work scope must be fully allocated among the Prime Contractors and accepted by the same;
- The OPG procurement department must have all materials for the first three months of the construction phase kitted and ready for delivery to the work force;
- The OPG procurement department must have all long lead items on order or in OPG's possession so as to support the schedule;
- OPG Operations and Maintenance must develop and disseminate streamlined written permitry rules that both meet the needs of plant safety while at the same time being acceptable to the Prime Contractors so that their means and methods are not unduly disrupted;
- OPG's Planning and Assessing Department must have completed the CWPs for the first four months of the Project;
- Necessary pre-requisite work on the breathing air, control room air conditioning, cranes, scaffolding and basic services needed to support construction must be complete; and

- OPG management must establish a process for reporting project status on a regular basis to the OPG board.

As we have discussed in this chapter, we are confident that the Project Team and the oversight bodies are closely focused on ensuring these milestones are met and they will continue to manage the project so that risk remains an acceptable level.

Recommendations

Based on the information available to us at this time, we make the following recommendations:

Recommendation V.1

That OPG proceed with the project to return Pickering A Unit 1 to service.

Recommendation V.2

That the board of OPG maintain the highest level of oversight for the duration of the project, including monitoring by third-party experts with direct account-ability to the board.

Recommendation V.3

That the board of OPG wait until there is clear evidence of success on the Unit 1 Project before proceeding with any further development work on Unit 2 or 3.

Recommendation V.4

That the same level of due diligence applied on the decision to proceed with Unit 1, including a business case analysis, be applied to any decision on Units 2 and 3.