POINT LEPREAU REFURBISHMENT - Update 6

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Summary

On July 29, 2005 Premier Bernard Lord announced that the Province of New Brunswick would proceed with the 1.4 Billion dollar project to refurbish the Point Lepreau Generating Station with Atomic Energy of Canada Limited (AECL) as the general contractor. The total project cost is comprised of approximately $1 Billion for the project activities plus the cost of replacement energy for the province during the refurbishment outage. The project work involves:

- completion of the detailed planning, engineering and procurement work that has been underway since the year 2000,
- construction of waste storage structures at the Solid Radioactive Waste Storage Facility in 2006,
- establishment of temporary facilities to support the outage, and
- the maintenance outage itself which is scheduled to run from April 2008 to September 2009.

The major activity during the outage would be the replacement of all three hundred and eighty Fuel Channels, Calandria Tubes and connecting feeder pipes. This activity is referred to as ***Retube***. NB Power Nuclear would also take advantage of this outage to conduct a number of additional repairs, replacements, inspections and upgrades. These collective activities are referred to as ***Refurbishment***. This would allow the station to operate for an additional 25 to 30 years.

The scope of the project was determined from the outcome of a two-year study conducted in 2000 and 2001 that involved a detailed condition assessment of the station to examine issues relating to aging and obsolescence. The majority of the plant components were found to be capable of supporting extended operation without needing extensive repair, replacement or changes. In addition to the condition assessment, a detailed review of Safety and Licensing issues associated with extended operation was performed. This included a review of known regulatory and safety issues, comparison of the station against current codes and standards, and comparison of the station against safety related modifications made to more recently constructed CANDU 6 units. Benefit cost analyses were performed to assist NB Power Nuclear in determining which changes were appropriate to include in the project scope. Extensive discussions with CNSC staff culminated in a comprehensive Licensing Framework being produced. CNSC staff provided feedback to NB Power Nuclear on the Licensing Framework, which was important in terms of achieving clarity of the regulatory position.

The establishment of an overall scope, integrated schedule, budget, licensing framework and project execution plan that were the outputs from this portion of the pre-project work, took into account lessons learned from other projects.

At the onset of the pre-project activities it was determined that to minimize financial risk, all the necessary planning would need to be completed to support an outage as early as the spring of 2006. While this goal was accomplished, it was subsequently determined based on inspection results that it would be advantageous to defer the refurbishment outage to the spring of 2008. The period between January 2002 and July 2005 was utilized to undertake the various reviews and obtain necessary approvals. In addition, work was conducted in a number of key areas to minimize financial risk to the project. These key areas included:

- The design of additional structures to be constructed and operated at the on-site Solid Radioactive Waste Management Facility to support Retube and extended station operation.
- Approval from Federal and Provincial authorities related to the Environmental Assessment covering the planned modifications to the on-site waste facility, activities that generate the waste, other aspects of the project itself, and the incremental effects of continued operation of the station.
- Amendment to the Solid Radioactive Waste Management Facility Operating Licence related to the additional structures.
- An Integrated Safety Review consistent with a Periodic Safety Review as defined by the IAEA
- Refinement of the Retube process by demonstrating through study and testing the performance of the volume reduction tooling, and examined ways of optimizing fuel channel, feeder and calandria tube removal and replacement. This included aspects related to contamination control, ALARA and detailed process modeling and computer simulations.
- An assessment of end of life projection for upper feeder sections.

- Work on the fuel channel design details, including work related to the qualification of Seamless calandria tubes[1].
- Work on the level II PSA. This has included extensive interaction with the CNSC resulting in overall agreement with the PSA methodologies, along with conducting detailed and extensive station walk-downs related to analysis of station fires, floods and seismic capacity.
- Methodologies and specific deterministic Safety Analyses in support of trip coverage improvements and assessment of SDS1 depth for fresh core.
- Human Factors Engineering Program Plan, four HF Design guides and a Human Factors Summary report
- Work on modifications to the shutdown systems including the approach to be taken on the shutdown system trip computer Programmable Digital Comparator (PDC) development. This included extensive interaction with the CNSC leading to their agreement on all the procedures to be used for the software design, verification and validation of the PDC's on both shutdown systems.
- Testing of cables in support of Environmental Qualification extended life
- Development of guidelines for preparing procedures related to lay-up, monitoring and returning systems to service activities
- Production of a draft revision of Operating Policies & Principles to support the defuelled core state
- Extensive Community Relations Program related to refurbishment
- Establishment of a formal program by the NB Power project management team to monitor and manage project risks

In addition, extensive discussions took place with CNSC staff relating to the Licensing Framework for the project, including exchange of hundreds of formal project letters and numerous meetings. The activities include the details relating to key project activities such as retube, fuel channel design, shut down system modifications, safety analysis, probabilistic safety assessment, quality assurance, risk informed approach, cost benefit analysis, certified operator training, modifications to operating policies and principles, commissioning principles, approach for restart, etc.

Key milestones on the project are shown in Table-1. Appendix A provides an overview of the outage and Appendix B outlines the project scope. Further details are provided in the following sections of the paper and in the information presented at previous conferences of the Canadian Nuclear Society identified in the Reference section.

Engineering and Procurement Phase

Following formal project approval on July 29, 2005, work on the detailed design, outage-planning and procurement kicked into high gear. This part of the project is referred to as Phase-2. This phase also includes the completion of the PSA and certain additional specific deterministic safety analyses. During this time period, construction of temporary

[1] In 2005 it was determined that it was not possible to qualify the new seamless tube in the time available due to limitations of the rolled joint under accident conditions

facilities to support Retube will also take place, as will the intended modifications to the waste facility.

The following activities are presently underway:

- Finalizing details of the Retube process including modeling, tooling, conceptual design reviews, site facilities planning and establishment of an AECL Office in Saint John, N.B.
- Development of fuel channel and feeder system designs and purchase of long lead reactor components such as pressure and calandria tubes, end fittings, feeders, etc.
- Performing Engineering activities related to design modifications and conduct of additional safety analyses and a Level II Probabilistic Safety Assessment.
- Finalize technical solutions relating to CNSC Generic Action Item 95G02 and containment performance for severe accidents
- Procurement of equipment, specialized tooling and replacement components.
- Finalizing planning for construction of new waste storage structures to house retube waste and other additional waste storage structures for the extended life of the station.
- Planning of necessary temporary construction facilities that are planned to be constructed in 2006 and2007.
- Performing detailed outage planning.
- Developing detailed procedures related to commissioning, system lay-up, monitoring and return to service.
- Preparing operating and training documentation.
- Developing a comprehensive station run up plan

Refurbishment Outage Overview

The refurbishment outage will commence in April 2008 and will extend for an eighteen month period. The work covers activities associated with retubing, project related plant modifications, repairs, replacement and inspections, site capital modifications as well as other routine O&M work. The normal station infrastructure, processes and programs that are in place to support normal operation and maintenance outages will remain in effect, and be augmented as necessary.

As is the existing practice at the site, specific work zones or islands will be identified to allow the contractor, in this case AECL (and its subcontractors), to manage the work within the identified zone boundaries. In this outage, the zones will be identified for the retube and other specific refurbishment project activities. For example, the retube zones will mainly encompass the reactor vault areas and entry points to the reactor building, while another zone will likely be established for work associated with the turbine generator. As Licence holder, NB Power Nuclear will retain oversight responsibility for all project activities, including those that are contracted out as defined by our Nuclear Management Manual and processes.

At the outset of the outage, station systems will be placed in a state of lay-up consistent with good operating experience and the need for that system during the outage. This lay-up will address the physical, chemical, changes to normal surveillance programs and needs for alternate maintenance and surveillance routines. In parallel to the project work,

NB Power Nuclear will conduct other typical outage inspection and maintenance activities as well as station capital work that may be identified for implementation during this outage interval. As the end of the outage approaches, systems that have been laid up will be returned to service, normal surveillance and maintenance activities restored and performance verified to ensure their operational readiness. The refurbishment and plant capital design modifications will be commissioned to demonstrate that the changes meet their design intent and surveillance and maintenance programs will be initiated. To the extent possible, design changes will be commissioned well in advance of the start up activities. Also in preparation for reactor start-up, necessary operating and maintenance documentation will be issued and training performed for technical, maintenance and operations staff. Training for certified operating staff will cover the design modifications and startup with a fresh core

Since the reactor core will contain a fresh core of fuel, the start up plan will encompass reactor power during the load of fresh fuel at RP $< 1x10^{-14}$ FP with in-core startup detectors, through the change over to out-of-core startup detectors, on to ion chambers and eventually to flux detectors. In addition to a comprehensive flow verification, testing related to reactivity mechanism worth, reactor control adequacy and shutdown system worth will be completed. Potential tests and agreed upon acceptance criteria will be discussed and agreed upon with the CNSC early in the development phase. Successful completion of activities related to these tests and related CNSC approval will be sought prior to proceeding to the next activity beginning along the run up phase.

A high level description of the outage activities is provided in Appendix A. The overall coordination of activities to be performed by AECL and their subcontractors as well as those to be conducted by NB Power Nuclear staff, will be through a common outage management team with the use of a single integrated schedule, consistent with existing practice. The maximum number of contractors at site at any one time is expected to be no greater than what was experienced in previous maintenance outages. The estimated total construction trade resource requirement for the project is five hundred person-years plus technical, engineering and project management support from AECL as General Contractor. Further details are provided below:

Retubing:
The major activity to be performed during the outage is the replacement of all 380 fuel channel assemblies, calandria tubes, and the entire length of connecting inlet and outlet feeder piping from the end fittings back to the headers. This activity is referred to as Retube. Directly related to Retube are a number of support activities such as the removal, storage and eventual refill of the heavy water located in the heat transport and moderator systems, the transfer of radioactive reactor component waste to the on-site Solid Radioactive Waste Management Facility, and commissioning of the retubed reactor core. The Retube related activities run the complete duration of the 18 month outage and as such, work will be performed on an around-the-clock basis.

A key feature of the Retube program is the volume reduction process that will take place at the reactor face during removal of the pressure tubes and calandria tubes. After

removal of the End Fittings, the volume reduction machine grasps and withdraws the pressure tube from the reactor. The machine includes a "checker board shear press" that cuts the pressure tube into small pieces (50 mm^2) and deposits the waste into specialized containers located within a reusable shielded flask. When full, these containers are moved out of the reactor building, transported to the waste facility and loaded into the Retube Canisters. A similar process is used to remove the calandria tube, however this process uses a guide tool inserted from the other side of the reactor face to support the calandria tube as it is being withdrawn. The volume reduction machines are mounted on platforms at the reactor face. There are two machines for each reactor face for pressure tube removal and two machines on one face for calandria tube removal. Personnel will operate the volume reduction machines remotely from the vault area using computer control. The reduced volume of material will significantly reduce the volume of stored waste, minimize and simplify the movement and transport of the flasks and subsequently reduce time and worker radiation exposure.

The machines are shielded to reduce radiation fields while in operation and have appropriate access ports to allow for maintenance and intervention by personnel, if necessary. The volume reduction machines also have negative pressure ventilation and other features to control contamination during their operation. These tools along with the various other tools used to cut feeders and to remove other fuel channel components, were designed with due consideration to keeping dose as low as reasonably achievable (ALARA), as well as consideration of process completion time, reliability, shielding, contamination control, and foreign material exclusion. Demonstration by test was also part of the development process as was detailed computer modeling and integration testing on a mock up.

Non Retube Related Refurbishment Project Activities:
In parallel to the retube activities, a small number of design modifications, repairs, replacements and inspections will be performed as part of the Refurbishment project. The scope of this work was determined from a two-year study that involved a detailed condition assessment of the station to examine issues relating to ageing and obsolescence, as well as a detailed review of Safety and Licensing issues associated with extended operation. The outcome of these reviews determined the scope appropriate to include in the Refurbishment Outage[2]. A brief description of these activities is provided in Appendix B. The limited amount of non-retube work that is required as part of the refurbishment project is a result of the similarity of design features with the latest Candu-6 designs and the fact that Point Lepreau Generating Station has generally kept pace with improvements to programs, processes, station systems, and its maintenance over the years. Another important aspect is that the station will continue to remain in operation right up until the start of the refurbishment outage. In addition to the limited scope, the nature of the work is straightforward, falls within the norm previously conducted at Point Lepreau Generating Station or at other conventional or nuclear stations.

O&M and Plant Capital work

[2] As opposed to being included as part of normal on-going station O&M or capital improvements to be implemented either prior to or following the Refurbishment outage.

In parallel to the project work, NB Power Nuclear will conduct other typical inspection and maintenance activities that are required in this outage interval. In addition, work that is presently identified in the site capital budget may be selected for implementation during the refurbishment outage and this will be executed using the existing site project organization. This work will be identified and managed during the refurbishment outage under a single integrated schedule to minimize interference with project activities and to assist in work management and configuration management.

Health Safety & Environment

Work during the outage will be conducted under Point Lepreau Generating Station's processes related to radiation protection, conventional safety, emergency preparedness, environmental management, safeguards, security, etc., thus ensuring consistency with the licence requirements. Key elements of these processes include definition of oversight functions and responsibilities, inclusion of health safety and environment considerations during both the design processes and the outage planning.

A substantial amount of feeder and fuel channel work has been performed at Point Lepreau Generating Station, and thus is covered in existing station processes and procedures. However, as part of the outage planning process, a systematic review of project activities is being undertaken to ensure that any unique hazards associated with the outage work are identified and, where necessary, existing processes, procedures and training will be augmented to ensure the protection of the public, the workers, and the environment.

As part of the safety program, NB Power Nuclear will provide the AECL Refurbishment organization access to Protection Assistants (Green Qualified Staff) to ensure compliance with existing Radiation and Conventional Safety requirements.

Surveillance of Contractor Activities

AECL has been selected by NB Power Nuclear as the General Contractor for the retube and refurbishment scope of work. AECL has the appropriate corporate Quality Assurance Programs in place to meet the requirements to be on the NB Power Nuclear Approved Vendors List. In addition, AECL has prepared the AECL Refurbishment Project Quality Assurance Manual to complete this scope of work. This QA Manual includes design, procurement and implementation activities. AECL will prepare detailed implementation packages for the retube and refurbishment scope of work and these will be reviewed and approved by NB Power Nuclear staff. These packages will provide details on how AECL plans to execute the work scope and indicate how work will be controlled and monitored by AECL staff.

NB Power Nuclear has assigned internal staff as Contract Engineers to manage the oversight of AECL contract execution. In addition NB Power Nuclear will assign internal staff as contract facilitators to each work scope who will work in partnership with the AECL staff to support the execution of the work in accordance with the agreed upon plan. The Point Lepreau Generating Station line organization will provide oversight to

the AECL organization, including audit and surveillance as required to verify compliance with the applicable station processes, practices and procedures.

Procurement of replacement components, as well as tooling and related materials, will be done under the AECL Quality Assurance Program. Consistent with existing station processes, NB Power Nuclear will receive the approved manufacturer's history dockets as part of the formal turnover process once the implementation activities are complete.

Under existing station processes, the NB Power Nuclear project team, through its QA representative, will coordinate with the station's Vendor Quality Assurance Group to provide surveillance of contractor and subcontractor QA programs, vendor source inspections, review of inspection and test plans to ensure that all quality requirements are being met including design, procurement, manufacturing and installation. In addition, the station's Independent Assessment Group will perform periodic assessments and audits of both NB Power Nuclear project activities and contractor activities to provided assurance of quality program implementation and to verify the work results are being appropriately verified and checked,

Recent developments
Within the past few months the following major activities have taken place;

The Purchase Orders for the Pressure Tubes and Calandria Tubes were issued. The bids for the production of End Fittings and for supply of the feeder material were received and are under review. Additionally, tenders have been issued to suppliers for Shield Plugs, Closure Plugs, Spare Bellows, and Positioning Assemblies. Tenders for the low pressure turbine work have been issued and bids for the generator refurbishment have been received and are under review.

A Project Office in Saint John was established by AECL to support the infrastructure of the project. The office includes standard office space, a warehouse and a light assembly facility. The warehouse and fabrication facilities will be used for clean room assembly, feeder fabrication and preparation, Fuel Channel Assembly and preparation, warehousing, logistical support, classroom and mock-up training.

A project specific Regulatory Activity Plan was produced by CNSC staff to guide their review of the project going forward. The plan is based on their generic plan taking into account the specific attributes and stage of maturity and past agreements on the PLGS Refurbishment Project.

An application for the renewal of the station Operating Licence for a five year period was submitted to the CNSC in November 2005. The application included specific information on the Refurbishment project as the licence period would encompass the refurbishment outage. The application was heard at the CNSC Commission hearing held on February 16, 2006. The Day-2 hearing date is set for May 18th, with a decision date set for the end of June 2006 when the current Licence expires.

Construction at the waste site began in April 2006. Once the land is cleared and graded, construction of the Retube canisters and additional waste vaults will take place. Construction of the Retube canisters must be complete prior to the onset of the outage as they must be available to accept the waste from the dismantling of the fuel channels and feeders. In conjunction with construction at the waste site, a dedicated access road from the station to the waste site will be constructed. This will avoid potential interferences between station staff / contractor traffic and waste transfers.

Construction on the new office building at site is underway, with a completion date of summer 2007. This reduces the number of temporary facilities to be constructed to support retubing and will lead to the removal of temporary construction trailers inside the protected area when refurbishment project is completed.

References:

1. "Point Lepreau Refurbishment– Update 5" by R.M. White et al., paper presented at the 26th Annual conference of the Canadian Nuclear Society, held in Toronto in June 2005.

2. "Point Lepreau Refurbishment– Update 4" by R.M. White et al., paper presented at the 25th Annual conference of the Canadian Nuclear Society, held in Toronto in June 2004.

3. "Possible Refurbishment of Point Lepreau – Update 3" by R.M. White et al., paper presented at the 24th Annual conference of the Canadian Nuclear Society, held in Toronto in June 2003.

4. "Possible Refurbishment of Point Lepreau – Update 2" by R.M. White et al., paper presented at the 23rd Annual conference of the Canadian Nuclear Society, held in Toronto in June 2002.

5. "Possible Refurbishment of Point Lepreau" by R.M. White et al., paper presented at the 22nd Annual conference of the Canadian Nuclear Society, held in Toronto in June 2001.

6. "Point Lepreau Refurbishment: Plant Condition Assessment", by P.J. Allen et al., paper presented at the 22nd Annual conference of the Canadian Nuclear Society, held in Toronto in June 2001.

7. "Benefit-Cost Analysis in the Point Lepreau Refurbishment Planning Process", by J.R. Humphries et al., paper presented at the 23rd Annual conference of the Canadian Nuclear Society, held in Toronto in June 2002.

8. "An Integrated Safety Review for the Point Lepreau Refurbishment Life Extension", by Dr. C.K. Scott et al., paper presented at the 23rd Annual conference of the Canadian Nuclear Society, held in Toronto in June 2002.

9. "Refurbishment of the Point Lepreau Generating Station (Safety & Licensing program)", by P.D. Thompson, R. Jaitly, N. Ichiyen and M.A. Petrilli, paper presented at the 6th International Conference on Simulation Methods in Nuclear Engineering, held in Montreal in October 2004.

10. "Planning of the Retubing of the Point Lepreau CANDU 6 Nuclear Generating Station", by L. Nosella et al., paper presented at the 24th Annual conference of the Canadian Nuclear Society, held in Toronto in June 2003.

11. "Risk Baseline for Point Lepreau Refurbishment Project", by L. Comanescu et al., paper presented at the 24th Annual conference of the Canadian Nuclear Society, held in Toronto in June 2003.

12. “Level II PSA Program for Point Lepreau Refurbishment Project”, by R.K. Jaitly et al., paper presented at the 24th Annual conference of the Canadian Nuclear Society, held in Toronto in June 2003.

13. “Advances in CANDU PSA for the Point Lepreau Refurbishment Project”, by. R.K. Jaitly et al., paper presented at the 26th Annual conference of the Canadian Nuclear Society, held in Toronto in June 2005.

14. "Progress on Seismic Margin Assessment and Fire PSA for Lepreau Refurbishment", by R.K. Jaitly et al., paper presented at the 27th Annual conference of the Canadian Nuclear Society, held in Toronto in June 2006

15. “Trip Coverage Improvements for the Point Lepreau Refurbishment Project”, by. A. Ranger et al., paper presented at the 26th Annual conference of the Canadian Nuclear Society, held in Toronto in June 2005

16. “Programmable Digital Comparator (PDC) Replacement for SDS1 and SDS2”, by N.M. Ichiyen et al., paper presented at the 24th Annual conference of the Canadian Nuclear Society, held in Toronto in June 2003.

17. “Point Lepreau Refurbishment Project, Programmable Digital Comparator (PDC) Replacement for SDS1 and SDS2 – Update 1”, by K.G. Fraser, et al., paper presented at the 26th Annual conference of the Canadian Nuclear Society, held in Toronto in June 2005.

18. "Programmable Digital Comparator (PDC) Replacement for SDS1 and SDS2 - Update 2 - Software Development, Review and Validation Test Rig Development " by K.G. Fraser et al., paper presented at the 27th Annual conference of the Canadian Nuclear Society, held in Toronto in June 2006

19. “Point Lepreau Refurbishment: Environmental Assessment Experiences and the Role of the Public”, by C. Hickman, et al., paper presented at the 25th Annual conference of the Canadian Nuclear Society, held in Toronto in June 2004.

20. “Possible Refurbishment of Point Lepreau: Management of Retube Waste”, by Dr. P. Tume et al., paper presented at the 25th Annual conference of the Canadian Nuclear Society, held in Toronto in June 2004.

21. “Co-ordination of Federal and Provincial Environmental Assessment Processes for the Point Lepreau Generating Station Solid Radioactive Waste Management Facility Modifications”, by C.N Hickman, P.D. Thompson and J. Barnes, paper presented at the Canadian Nuclear Society conference on Waste Management, Decommissioning and Environmental Restoration for Canada’s Nuclear Activities: Current Practices and Future Needs, held in Ottawa in May 2005.

22. “Point Lepreau Refurbishment Review”, prepared by Dr. Robin Jeffrey, April 16, 2004.

23. “Seamless Calandria Tube Development and Qualification”, by Aman Usmani et al., paper presented at the 25th Annual conference of the Canadian Nuclear Society, held in Toronto in June 2004.

24. "Protection of Health Safety and Environment during Point Lepreau Refurbishment" by C. Hickman et al., paper presented at the 27th Annual conference of the Canadian Nuclear Society, held in Toronto in June 2006

25. "Human Factors on the Point Lepreau Refurbishment Project ", by S. Malcolm et al., paper presented at the 27th Annual conference of the Canadian Nuclear Society, held in Toronto in June 2006

26. "Benefits of Turbine Upgrades for Life Extension - Point Lepreau Refurbishment Project ", by N. Datoo et al., paper presented at the 27th Annual conference of the Canadian Nuclear Society, held in Toronto in June 2006

27. "Generator Refurbishment for Life Extension - Point Lepreau Refurbishment Project", by N. Tailor et al., paper presented at the 27th Annual conference of the Canadian Nuclear Society, held in Toronto in June 2006

28. "Retrofitting a Main Control Room Severe Accident Radioactive Contaminants Filter System - Point Lepreau Refurbishment Project ", by J. Loewen et al., paper presented at the 27th Annual conference of the Canadian Nuclear Society, held in Toronto in June 2006

Table-1 Key Project Milestones

DATE	MILESTONE
July 2005	Project Formal Approval
November 2005	Orders placed for Pressure Tubes
January 2006	Orders placed for Calandria Tubes
January 2006	AECL Off-Site Office
March 2006	Orders placed for end Fittings
April 2006	Orders placed for Feeder Material
April 2006	Waste Facilities Construction Commencement
May 2006	Orders placed for Shutdown System Computers
June 2006	Orders placed for Turbine Generator
December 2006	Orders placed for Feeder Fabrication
February 2007	Orders placed for Inverters and Rectifiers
May 2007	Erect On-Site Temporary Facilities
December 2007	Construction to Mobilize to Site
April 2008	Outage Start
June 2008	Turnover of reactor to AECL for Retube
June 2008	Fuel Out/System Drained
June 2008	Reactor Components Removal Commencement
December 2008	Reactor Components Installation Commencement
Mid March 2009	NBP Nuclear Commissioning (non-Retube)
Mid June 2009	Load Fuel
July 2009	Turnover of Reactor from AECL
July 2009	NBP Nuclear Run-up Activities
July 2009	Hydro Test of Primary Heat Transport System
October 2009	Return to Service

Appendix A: Refurbishment Outage Overview

The following provides an outline of the key activities that are planned to take place during the Refurbishment outage.[3]

- Shut down Reactor and place the reactor in guaranteed shut down state.
- Remove all irradiated fuel from reactor and enter "defuelled core state", begin lay-up of designated systems.
- Drain and dry the heat transport system. Move heavy water out of D2O storage tanks in preparation to receive moderator heavy water.
- Prepare vaults and related work areas and platforms for fuel channel removal
- Cut and remove entire length of all inlet and outlet feeders back to the headers, load into waste containers and transfer to waste site and load into Retube vault structures.
- Remove heavy water from moderator system and perform light water rinse / soak and dry calandria vessel. Soak water will be disposed of to active liquid waste.
- Remove all 380 fuel channels and calandria tubes using volume reduction tooling, put waste in shielded flasks and transport to waste site.
- Perform calandria internal inspections and setup for fuel channel & feeder installation.
- Install calandria tubes, fuel channels and upper and lower feeders and perform necessary inspections.
- Refill the moderator system with heavy water.
- Establish guaranteed shut down state conditions.
- Manually load new fuel and install shield and closure plugs in each fuel channel.
- Refill heat transport system and complete the main heat transport system hydrostatic pressure test on that portion of system that has been worked on.
- Complete identified Refurbishment design modifications[4], replacements, inspections, repairs and other routine outage activities[5].
- In parallel with the work, complete issuance of operational documentation to support refurbishment design modifications and conduct necessary classroom and simulator training.
    - Complete return of laid up systems to operational readiness.
    - Complete necessary commissioning tests for design changes made during the refurbishment outage
    - Conduct plant system operational readiness review.
    - Remove GSS and take reactor critical.
    - Complete necessary low power testing, related commissioning activities and begin ascension to full power.

[3] Construction of additional waste structures (under the Waste Facility Operating Licence) to support the outage will start in 2006. Likewise temporary support facilities will be constructed on site starting in 2006.
[4] Summary listing of modifications, replacements, repairs and inspections is provided in *Appendix B*.
[5] Will be initiated in parallel with Retube activities and will run through-out the outage.

Appendix B: Refurbishment Scope Summary

1.0 Design Modifications

Main Generator & Auxiliaries Enhancement
The Main Generator stator and rotor will be rewound or replaced. The dryer in the hydrogen system will be replaced. The Automatic Voltage Regulators and Stabilizers in the Excitation Auxiliary System will be replaced with new digital units and the existing excitation Rectifier units will be replaced with new units.

Replace Turbine Controls with More Modern Controllers
The Turbine Electro-Hydraulic Governor system, Turbine Supervisory System, and the Turbine Mechanical Over-speed protection will be replaced with modern electronic systems. This change will ensure continued high reliability throughout the extended life of the station.

Shutdown System Design Modification
The Programmable Digital Comparators on both shutdown systems have been assessed as impractical to maintain over an extended station life. As a result, it has been decided to replace both the Shutdown System (SDS) 1 & 2 Programmable Digital Comparator (PDC). In addition, improvements to SDS1 and SDS2 trip coverage will be implemented. This will include the addition of new trips on Moderator high and low level on both shut down systems, the addition of an SDS2 high heat transport system pressure trip on reactor outlet headers # 3 and 7, as well as modifications to certain other SDS1 and SDS2 set-points.

Moderator Sub-cooling Margin Improvement
Upgrades to the moderator heat exchanger to achieve 100% of the Re-circulated Cooling Water (RCW) flow will be performed by incorporating additional sealing strips and rods. This will provide the provision for improved moderator sub-cooling margin.

Shield Cooling System Improvement
A rupture disk on the top of the existing inspection port of the Calandria Vault will be added to provide pressure relief capacity to maintain the pressure within the design limits following a postulated severe accident with loss of moderator heat sink. A remotely operated isolation valve in TK3 outlet line (3W-6) will be installed to eliminate a potential breach of containment via the expansion tank (TK-3) under some accident conditions.

HTS Pump Trip on High Thrust Bearing Temperature
A software design change will be implemented to trip the heat transport system pumps on a high thrust bearing temperature signal. This will reduce the reliance on the operator to trip the main heat transport pumps in the event of a loss of service water to prevent a potential consequential loss of coolant due to loss of cooling to the pump shaft seals.

Main Control Room Filter System
A filtering system will be added to the Main Control Room ventilation system. This will increase the likelihood of the main control room remaining habitable in the event of a severe accident by filtering the air supply from potential airborne radioactive contaminants.

Modify Assembly to Allow Independent Movement of In-core Start-Up Detectors
This design change ensures that independent movement of the three in-core start-up counters is provided by the electrical cables attached to each counter in separate compartments. This will allow two detectors to continue to function while one is being moved.

Replace Certain RTD Cables
Safety related RTD circuits located within the Reactor Building will be removed from the existing PVC insulated cables and replaced using qualified cables. This will prevent a potential drift of RTD signals due to cross talk from power cables under accident conditions of high temperature and humidity.

Replace Underground Fuel Storage Tank with New Design
The underground fuel storage tank for the Emergency Power System diesels will be replaced, as it is not expected to last for the extended life of the station. In addition to the original requirements, the new tank will be designed to meet the current New Brunswick environmental standards for underground fuel storage tanks.

Replace Valves in the Moderator Systems
A number of gate valves in the Main Moderator System will be replaced with a qualified design of metal seated butterfly valves. This new design should eliminate leakage past the seats and allow these important isolation valves to carry out their function for the extended life of the station.

2.0 Component Replacement & Repairs

In addition to the design changes identified above, certain component replacement and repairs will take place. These involve:

Replacement of Inverters and Rectifiers in the Uninterruptible Power Supply System (UPS)
The Staticon Inverter and the Rectifier equipment associated with the Uninterruptible Power Supply system will be replaced as the present equipment has been assessed as being impractical to maintain over an extended station life.

Raw Service Water (RSW) System Refurbishment
In order to ensure long term continued reliable operation of the Raw Service Water System, the following refurbishment work to address the age related degradation in the RSW system will be performed:

- Inspect and refurbish various valves
- Replace various expansion joints
- Replace certain sections of piping
- Inspect / recoat certain sections of piping.

Re-Circulated Cooling Water (RCW) System Refurbishment
In order to ensure long term continued operation of the Re-circulated Cooling Water System, various valves in the system will be inspected and refurbished as necessary and the six expansion joints will be replaced. To enable this work to be performed, a temporary cooling system for the Spent Fuel Bay will be provided.

Refurbish Shutdown Cooling Pump By-Pass Valves
Certain Shutdown cooling bypass valves will also be inspected and refurbished as necessary.

Dousing Tank and D_2O Storage Tank Liner Refurbishment
The NORMAC liner on the dousing tank will be re-applied to repair small blisters that have formed during past Reactor Building pressure tests. In addition the heat transport storage tank epoxy liner will be replaced in D2O storage tank TK3 as it is suspected of being degraded.

3.0 Inspections During Refurbishment Outage

In addition to changes and repairs discussed above, certain specific inspections are planned for the refurbishment outage, as this is the only time such inspections would be able to be performed. These include inspections of the calandria vessel internals as well as parts of the Raw Service Water and Re-circulating Cooling Water system.

4.0 Routine Scheduled Outage Work

It should also be noted that in terms of additional outage scope, normal outage work (PMS, testing, call-ups and repairs, etc), will also be conducted, but the full extent of that work will not be known until 2007.

5.0 Additional Safety & Licensing Studies:

The additional studies relating to the following will be performed:

- Deterministic safety analysis to cover off certain additional accident scenarios identified in CNSC Consultative Document C-6 Rev. 01
- Deterministic analysis to address the condition of fresh fuel in the core
- Deterministic analyses in support of the design changes
- Completion of the level II probabilistic safety assessments
- Further examination into whether additional instrumentation to increase the defense in depth for severe accidents is cost beneficial
- Further examination into whether or not increasing the defense involving containment response to severe accidents is cost beneficial
- Additional analyses to resolve CNSC Generic Action Item 95G02
- Completion of some additional fatigue analyses