ONTARIO POWER GENERATION

Records File Information: Records SCI/USI Retention - See Guidance Section

**OPG Confidential**

OPG-FORM-0076-R005*

# Type 3 Business Case Summary

To be used for investments/projects meeting Type 3 criteria in OPG-STD-0076.

## Executive Summary and Recommendations

| Project Information | | | |
|---|---|---|---|
| Project #: | 66600 | Document #: | N-BCS-30740-10003 |
| Project Title: | Machine Delivered Scrape | | |
| Class: | ☐ OM&A ☒ Capital ☐ Capital Spare<br>☐ MFA ☐ CMFA ☐ Provision<br>☐ Others: | Investment Type: | Value Enhancing |
| Phase: | Execution | Release: | Partial |
| Facility: | IMS | Target In-Service or Completion Date: | Spring 2017, P1751 |

**Project Overview**

**We recommend the release of $7,294k, including [redacted] of contingency. This will bring the total release to $14,126k including [redacted] contingency. The estimated total project cost is $ 24,932 k, including [redacted] of contingency.**

The quality of the estimate for this release is Class 2, and for the total project is Class 2.

We plan to purchase from a vendor a Circumferential WEt Scrape Tool (CWEST) to execute pressure tube scrapes. We will deploy the tool with the Universal Delivery Machine (UDM) for Pickering 5-8. This single system; Machine Delivered Scrape (MDS) will replace manual Damp Circumferential Scrape (DCS) for pressure tube rolled joints (RJ), and fueling machine delivered Wet Axial Scrape (WAS) for body of tube (BOT) scrapes.

In-service pressure tube equivalent hydrogen concentration data requires scrape sampling. The data establishes fitness for service for pressure tubes under CSA N285.4-05, Periodic Inspection of CANDU Nuclear Power Plant Components, and CSA N286.8-05, Management System Requirements for Nuclear Power Plants.

The business object of this value enhancing project is to reduce the cost and effort of acquiring this scrape data for Pickering 5-8 by:

- Reducing critical path outage durations
- Reduce outage execution costs
- Reduce personnel dose
- Eliminate high hazard open fuel channel work
- Eliminate feeder ice plugging
- Eliminate non standard fueling machine deployment

$6,832k was previously released for procurement and initial payment for CWEST, and detailed engineering for; UDM software modifications, UDM umbilical, and a commissioning mock-up. Commissioning was planned for the fall P1561 outage, and would include dual scrape collection. Existing tooling (DCS, WAS) results would be compared to MDS results to ensure scrape equivalency. First full usage was targeted for the spring P1681 outage.

The CWEST vendor supplied similar equipment to a non-OPG CANDU operator, and it has been deployed twice in 2011, and twice in 2014. Significant redesigns were completed to address execution performance issues from 2011. Successful non-OPG commissioning in spring 2014, led to a 16 channel deployment in the fall of 2014. This campaign was abandoned after 8 channels, due to unacceptably high scrape cutter breakage, and potential pressure tube damage. Project work within OPG on MDS has been suspended until now as the vendor worked through tool performance.

Until the end of January 2015 OPG had unrestricted access to CWEST technical and performance information, including the subsequent redesign to address scrape cutter failures, and future improvements. Since January, OPG cannot obtain any information or reports relating to the CWEST improvements, testing, and future performance expectations. OPG has neither a definitive date nor firm commitment as to when the information may be available. The vendor and non-OPG CANDU operator indicate they are satisfied with the overall redesign and believe it has been field proven. They are committed to CWEST and a summer 2015 deployment is planned.

*Associated with OPG-STD-0076, Developing And Documenting Business Cases

# Type 3 Business Case Summary

Project #: 66600 Document #: N-BCS-30740-10003

Project Title: Machine Delivered Scrape, <Partial> <Execution> Release

**Project Overview**

Additional funding is required to be released now – but not necessarily completely spent- in order for the MDS project to preserve the option of having MDS available for a commissioning deployment in fall P1671, and first use in P1751.

This partial release of $7,294 will fund the following MDS project deliverables:

- One CWEST tool head by year end 2015.
- Additional CWEST equipment to provide a minimally complete, but fully operational system. Available by year end 2015, OPG will commission, train, and develop operator procedures, to meet P1671 deployment.
- UDM software.

The Master Service Agreement OPG has with the vendor for CWEST purchase includes an option for OPG to terminate the contract for convenience with thirty (30) days written notice for any reason. Expected closure costs would be minimal.

Vendor payment milestones will be negotiated and expressly planned for after the non-OPG deployment.

Upon successful non-OPG deployment in summer 2015 and information release from the CWEST vendor, OPG will complete the remaining scope in this partial release. A full release for the additional project scope is planned by year end 2015. Dual MDS and DCS/WAS will occur in P1671 and first solo use of MDS will occur in P1751. The NPV of this value enhancing project is $5.7M. Additional economic value is possible if non- UDM outages containing scrape campaigns were realigned to MDS deployment for Pickering 5-8 during the period 2018-2019.

In the event of poor performance during the next non-OPG deployment, the MDS project will pause to permit a re-evaluation of OPG options. A delay of one outage for commissioning and full use reduces the expected NPV but it remains positive ($1.5M).

We believe that this partial BCS balances and mitigates significant technical and financial risk to OPG. The strategy is to maintain OPG's interest in CWEST tooling, and identify critical and/or long lead material which requires procurement now. Significant commitment of funds will only occur after a successful non-OPG deployment, and the receipt of required technical and performance information.

## Type 3 Business Case Summary

Document #: N-BCS-30740-10003

Project #: 66600
Project Title: Machine Delivered Scrape, <Partial> <Execution> Release

| Project Cash Flows, NPV, and OAR Approval Amount | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| k$ | LTD | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 | Future | Total |
| Currently Released | 3,996 | 2,836 | | | | | | | 6,832 |
| Requested Now | - | 7,294 | | | | | | | 7,294 |
| Future Required | - | 1,066 | 6,700 | 3,040 | | | | | 10,806 |
| **Total Project Cost** | 3,996 | 11,196 | 6,700 | 3,040 | | | | | 24,932 |
| Ongoing Costs | - | 0 | 0 | 0 | | | | | 0 |
| **Grand Total** | 3,996 | 11,196 | 6,700 | 3,040 | | | | | 24,932 |
| **Estimate Class:** | Class 2 | | | **Estimate at Completion:** | [redacted] | | | | |
| **NPV:** | $5.7M | | | **OAR Approval Amount:** | $24,932k | | | | |

**Additional Information on Project Cash Flows (optional):**

The project has invested considerable effort to maintain the same overall cost forecast in this partial BCS as presented in the previous BCS. MDS has worked diligently to control both scope and cost creep. Combined with vendor provided information and realized time and cost savings from completed work, the project is able to submit a net zero change to the overall project cost. Present life to date project spending is largely procurement of the fixed price CWEST system.

| Approvals | Signature | Comments | Date |
|---|---|---|---|
| The recommended alternative, including the identified ongoing costs, if any, represents the best option to meet the validated business need. | | | |
| **Recommended by (Project Sponsor):** Glenn Jager, President, OPG Nuclear and Chief Nuclear Officer | [signature] | | 12 JUNE 2015 |
| I concur with the business decision as documented in this BCS. | | | |
| **Finance Approval:** Beth Summers, SVP & Chief Financial Officer per OPG-STD-0076 | [signature] | | 2 JULY 2015 |
| I confirm that this project, including the identified ongoing costs, if any, will address the business need, is of sufficient priority to proceed, and provides value for money. | | | |
| **Approved by:** Tom Mitchell, President & Chief Executive Officer per OAR 1.1 | for [signature] | | 7 JULY 15 |

# Type 3 Business Case Summary

Project #: 66600
Document #: N-BCS-30740-10003
Project Title: Machine Delivered Scrape, <Partial> <Execution> Release

## Business Case Summary

**Part A: Business Need**

Scrape sampling of CANDU pressure tubes is a required process as part of establishing fitness for service requirements, under CSA N285.4-05, Periodic Inspection of CANDU Nuclear Power Plan Components, and CSA N286.8-05, Management System Requirements for Nuclear Power Plants. Scrape sampling is performed at Pickering NGS via both Body of Tube (BOT) axial scrapes and Rolled Joint (RJ) circumferential scrapes.

Body of Tube scrapes are performed via the Wet Axial Scrape (WAS) method. WAS is deployed using the fuelling machine, in a non-routine configuration.

Rolled Joint Scrapes are performed via the Damp Circumferential Scrape (DCS) method. DCS tooling is deployed manually from the reactor face on the trolley platforms. DCS requires an open, isolated (via ice plug), defueled and drained fuel channel. This high hazard work is both labour and dose intensive.

Both BOT and RJ scrapes require four (4) samples per channel. Current tooling, both WAS and DCS, requires a deployment and chip retrieval cycle once per scrape sample.

Scrape activities are typically on outage critical path.

There is an increasing business need to:

- More rapidly mobilize and demobilize a delivery system for performing the required scrapes
  - Faster mobilization and demobilization reduces personnel dose update, and when on critical path, reduces overall outage duration leading to increased generating opportunity.
- Deliver a Wet Scrape capability for both RJ and BOT types of scrapes, which avoids draining and defueling the channel and open channel work, and can be executed remotely with significantly reduced operator reactor face time
  - The ability to remotely execute wet scrapes means not having personnel on the reactor face working on an open channel (as is currently required for DCS). The result is significant reductions in personnel dose and the nuclear safety concerns associated with ice plugging. Additionally, wet scraping offers significant time savings on critical path which reduces overall outage duration leading to increased generating opportunity.
- Utilize tooling that can execute and safely manage multiple scrapes in a single deployment/channel visit
  - Currently, both WAS and DCS tooling requires a deployment and chip retrieval cycle once per scrape sample. A tool which can obtain multiple scrape samples in a single deployment offers can provide significant time savings, leading to increased generating opportunity.
- Avoid using the fuelling machines in non-routine configurations and for non-routine tasks
  - The use of a fuelling machine to deploy inspection tooling puts time and task burdens on both the fuel handling personnel and fuelling equipment. Outage opportunities for fuelling operations or maintenance activities are reduced and/or limited by inspection requirements.
- Offer outage planning/execution significantly increased flexibility (ie: shorter scrape windows and less worker dose will offer new possibilities for outage scheduling.)
  - Scrape campaigns currently require considerable critical path time to execute and significant numbers of staff in order to complete these high hazard, labour and dose intensive programs. A wet scrape program offering reduced execution times and personnel dose uptakes will offer outage planners new flexibility in scheduling outage logic and an increased availability of staff to perform outage work, who are otherwise currently "dosed out" by traditional scrape techniques.

It is accepted that any proposal cannot make increased use of the fuelling machines (FM), and that a viable solution will result in a net decrease in fuelling machine utilization.

*Associated with OPG-STD-0076, Developing and Documenting Business Cases

# Type 3 Business Case Summary



**Part A: Business Need**

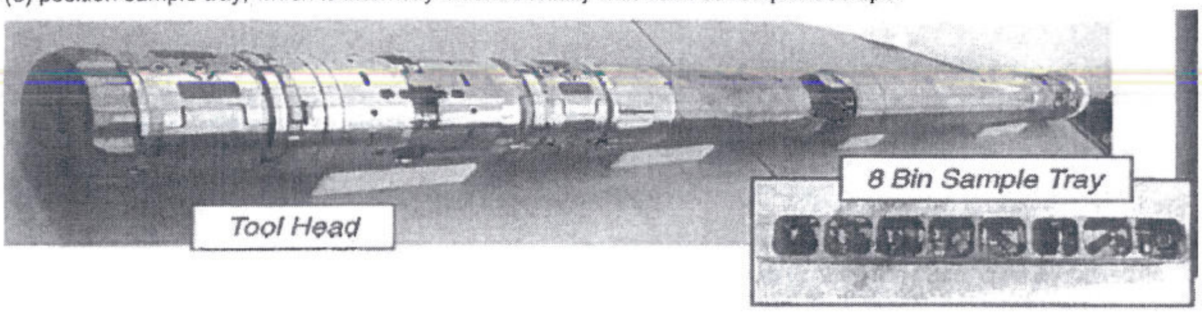
A machine (non-FM) delivered; multiposition circumferential wet scrape tool would allow OPG to meet all of these business objectives while providing additional benefits.

**Part B: Preferred Alternative: OPG Purchase and Deployment of CWEST Tooling System**

**Description of Preferred Alternative**

The preferred alternative see OPG negotiate and purchase a multi-positional, circumferential wet scrape tool (CWEST), delivered by the Pickering UDM. Campaign execution and responsibility for tool maintenance would rest with OPG.

The CWEST tool is able to collect eight (8) scrapes from a wet CANDU pressure tube in a single deployment. Delivered to a specific axial position and verified by UT, the tool acquires both the oxide scrape and sample cut. The chips are stored in an eight (8) position sample tray, which is internally indexed axially with each subsequent scrape.




Tooling is designed to CSA N286.2, Design Quality Assurance for Nuclear Power Plants and built to Z299.3, Guide for Selecting and Implementing the CAN3-Z299-85 Quality Assurance Program Standards.

**This preferred alternative will completely eliminate:**

- High Hazard Open Channel Work
- Ice Plugging for channel isolation
- Vented Closure Plugs and Channel Isolation Plus (VCPs & CIPs) requirements
- Channel defueling and associated storage and new fuel costs
- Multi-cycle deployments of tooling to collect required scrape samples on any given channel
- Platform installation and configuration for scrape
- Fuelling machine modifications for WAS (which currently requires non-routine operation)
- Post outage fuel flux imbalance at reactor start-up due to new fuel
- DCS tooling leases – MDS would be all OPG owned equipment
- Radiation Shipments of OPG owned contaminated tooling (Still required for scrape sample transport)

**This preferred alternative will significantly reduce:**

- Personnel Dose (Reactor face work significantly reduced)
- Outage critical path duration for scrape activities
- Labour intensive manual scrape activities
- FM Usage (Still required for fuel push operations, but no special needs or configurations required)
- Additional (External) resource requirements for campaigns
- Inspection/Channel cycle time to collect required scrape samples
- Reactor face shielding requirements
- Risk of development and deployment of new tooling – CWEST has been previously deployed

This alternative eliminates or significantly reduces OPG's reliance on vendor supplied tooling, schedule, maintenance, spare parts, tool rebuilds or other similar beyond-OPG control events. OPEX from the D1321 outage suggests a solid understanding and familiarity with the tooling and process is critical for a successful CANDU scrape campaign. OPG owned tooling means being responsible for maintenance, rebuilds, and spare parts but also that knowledge and experience are built and retained by OPG technical staff.

**Part B: Preferred Alternative: OPG Purchase and Deployment of CWEST Tooling System**

**Description of Preferred Alternative**

This partial BCS will fund the procurement and delivery of a minimal, but fully functional, CWEST system at Pickering NGS by year end 2015. This system will support CWEST commissioning, operator training, MDS procedural development and validation. Specific major deliverables include one (1) CWEST tool head (first of two), a CWEST chip retrieval transfer sleeve and flask, set of manual tools required for CWEST operation, and developmental release of UDM software modifications required to deploy CWEST.

A planned future full release BCS will fund procurement and commissioning of the remaining deliverables for MDS. Specifically, the major deliverables include one (1) CWEST tool head (second of two), the balance of CWEST equipment (eg: balance of flasks and cutters) a production release of modified UDM software, commissioning/functional testing mock-ups, chip retrieval cart, and connectorized UDM umbilical procurement.

A commissioning run of the CWEST tool via UDM is planned for P1671 in the Fall of 2016.*

Formal first usage of the CWEST tool via UDM is planned for P1751 in the Spring of 2017.**

* The P1671 campaign will be considered a commissioning run only. Mandatory scrape scope will be executed using existing scrape tooling, followed by repeat scrapes using MDS to establish scrape "equivalency". No benefits for this outage are considered in this BCS.
** This first usage is where benefits to OPG are planned in this BCS and financial model.

2011 saw the first on reactor usage of CWEST at a non-OPG facility. Two key issues experienced were chip capture and cutter breakages. Chip capture issues were a result of suboptimal internal operating pressure and cutting speeds. Cutter breakages resulted from uncontrolled pressure tube impacting.

The period 2012 through 2013 saw no CWEST usage on reactor. Re-engineering optimized the operating pressures and cut speeds. A rigorous test program validated the design improvements and included the scraping of irradiated pressure tube at McMaster University. A redesigned cutter insert introduced protective mechanical hard stops. The hard stops were to protect the cutter on pressure tube approach and then allow it to enter the pressure tube material in a controlled manner.

Spring 2014 saw the re-engineered CWEST next used on a non-OPG reactor. No significant issues were experienced during the planned five (5) channel "commissioning run". Considered successful, it allowed the utility to make the decision to adopt CWEST for all their scrape campaigns going forward.

Fall 2014 saw the subsequent tool usage in a sixteen (16)-channel campaign. CWEST, however, experienced unexpectedly high rates of cutter failure, during both functional checks and on channel. Cutter breakage and pressure tube concerns forced abortion of the campaign after scraping only eight (8) channels. The failure mode exhibited damage to the underside of the cutter, but not to the critical leading edge. OPG understands that the safety analysis bounds all the flaws/artefacts left in the pressure tube in all instances.

It is important to note that scrape cutters do break. Expectations are not that cutter breakage is zero, but in this case, the rate was abnormally and unacceptably high.

Independent root cause investigations by the utility and the CWEST vendor led to the conclusion that the mechanical hard stops were the cause. Their intended purpose is to contact the pressure tube in advance of the cutter and then control the cutter's advance into the pressure tube. This design did not work as intended. The hard stops were resisting movement and then "snapping" out of place. The cutter, rather than being protected, was being driven into the pressure tube in a manner and with a force unintended for it and breaking the cutter.

The resulting path forward is to restore the original UT based design basis of the CWEST cutter approach methodology. UT probes (instead of mechanical hard stops) measure the distance between the cutter and pressure tube during approach. At a predetermined distance, they initiate the cutting motion. The optimized cutting speed and pressure proven in previous deployments remains unchanged. Summer 2015 will see this cutter approach design deployed next on a non-OPG reactor.

CWEST is preparing to deploy in the next two (2) 2015 scrape outages at a non-OPG nuclear generating station. The non-OPG utility has indicated that they are satisfied with the overall design of the tool and believe it to be field proven. They consider recent issues as fixable and are committed to CWEST. They are satisfied with the rigour and work that the vendor has applied, including a systematic approach to problem solving, a holistic review of the tool, and thorough testing and

**Part B: Preferred Alternative: OPG Purchase and Deployment of CWEST Tooling System**

**Description of Preferred Alternative**

commissioning of the new design.

The CWEST vendor has demonstrated their willingness to work openly with OPG. Since January 29, 2015, however, OPG has been denied access to CWEST technical information at the direction of the non-OPG customer. OPG is currently unable to confirm the breadth and rigour of testing of the redesigned tooling. This raises the technical risk of design changes and performance expectations. The non-OPG utility has indicated they may lift the blackout after the tool's next usage on reactor. OPG has no definitive commitment on this.

The technical risk raises OPG's financial risk of investing in a tool we cannot confirm meets performance requirements. OPG obtaining the required technical documentation can essentially mitigate this financial risk.

The release – but not necessarily the complete spending - of additional funding is required now in order to issue the next purchase order to the CWEST vendor. This will fund assembly and testing of a single tool head and the minimum equipment required for a fully functional CWEST system. Delivery of this equipment to OPG will be before 2015-year end. It will permit commencement of tool commissioning, operator training, and procedure development. Not advancing this work will preclude CWEST from deployment in P1671. (The limiting factor is the availability of UDM time for MDS system commissioning where missing an available UDM window means a four (4) to six (6) month delay until another opportunity is available.)

Payment milestones in the next purchase order will be expressly planned for after the next non-OPG on reactor usage. Additionally, OPG and the vendor have agreed in principle to the inclusion of performance and scheduled based incentives and penalties to be included in the next and subsequent CWEST purchase orders. The Master Service Agreement OPG has with the CWEST tooling vendor (which establishes the terms and conditions for our PO) includes an option to OPG to terminate the contract for convenience with thirty (30) days written notice, at any time for any reason. Invocation of this clause would cost OPG costs incurred by the vendor to date, plus reasonable closure expenses.

In the time prior to the next non-OPG reactor usage planned for June 2015, the project estimates at risk spending could be up to an additional $1.8M on CWEST deliverables. The total OPG committed investment in CWEST would be approximately $6.4M at the time of next non-OPG deployment.

In the event the next non-OPG on reactor usage suffers any significant setback, the project will pause to re-evaluate OPG's options. A review and understanding will be made of the nature and cause(s) of any setback(s) experienced, the planned path forward and potential costs. This scenario would lead to a deferment beyond P1671 of 1$^{st}$ deployment of an OPG owned CWEST system, should one continue to be pursued, and re-evaluation of the business case and benefits of CWEST to OPG.

The project will continue to seek access to all technical documentation, investigative work into tool failures, lessons learned, relevant OPEX, and all design changes. Escalated requests for support are already within both OPG and the non-OPG utility withholding the information.

# Type 3 Business Case Summary



| Deliverables: | Associated Milestones (if any): | Target Date: |
|---|---|---|
| <u>This Partial BCS</u> | | |
| 1. MDS Gate #3 – Next CWEST usage on non-OPG reactor. | 1. OPG evaluation of CWEST tool performance post next on reactor usage. | 1. July 2015 |
| 2. Assembly, Testing, and Delivery of CWEST Tool Head #1 to OPG. | 2. Delivery of Tool #1 to PNGS | 2. December 7, 2015 |
| 3. Fabrication, Testing and Delivery of CWEST equipment required to provide minimum fully operational CWEST system to OPG. (ie: cutters, manual tools, chip retrieval and transfer system) | 3. Delivery of equipment to PNGS | 3. By December 7, 2015 |
| 4. UDM Software Modifications for CWEST, Developmental Release | 4. Developmental Release to OPG, Production/Final Release to OPG | 4. November 30, 2015 |
| <u>Future BCS</u> | | |
| 5. Commissioning / Functional Testing Mockups | 5. Place PO and RFS | 5. Dec 11, 2015 / June 29, 2016 |
| 6. Chip Retrieval Cart | 6. Place PO and RFS | 6. November 26, 2015 / May 27, 2016 |
| 7. Assembly, Testing, and Delivery of CWEST Tool Head #2 to OPG | 7. Delivery to OPG | 7. May 5, 2016 |
| 8. Integration of CWEST with UDM and Full MDS on UDM Commissioning | 8. Start On UDM Integration and Commissioning | 8. July 11, 2016 (exact timing subject to UDM schedule) |
| 9. Connectorized Umbilical | 9. Place PO | 9. January 15, 2016 |
| 10. Partial AFS prior to P1671 | 10. MDS Partial AFS for P1671 | 10. September 4, 2016 |
| 11. Final AFS post P1751 | 11. MDS Final AFS post P1751 | 11. May 2017, post P1751. |

# Type 3 Business Case Summary



**Part C: Other Alternatives**

Summarize all viable alternatives considered, including pros and cons, and associated risks. Other alternatives may include different means to meet the same business need, and a reduced or increased scope of work, etc.

**Alternative 2: Base Case – Abandon MDS Project**

The benefits of MDS are substantial. Cancellation of the project at this time would provide none of the planned benefits of MDS. Current sunk costs of approximately $4.7M would have to written off against OM&A.

Abandonment of MDS would mean continuation of current scrape practices, which involve significantly greater critical path times, higher personnel dose updates and higher execution costs. It also would mean continuation of ice plugging, open channel work, and use of CIPs/VCPs.

Cancellation is less financially attractive than the preferred alternative, resulting in financial write offs as well as having a lower NPV than the preferred alternative.

**Alternative 3: Delay Work – Delay MDS Project by One (1) Year / Two (2) Pickering 5-8 Outages**

With the approval of the first partial BCS in February 2014, and subsequent placement of the initial CWEST PO 237218, the option to delay remains, but at a higher cost with less time to reap benefits.

Delaying MDS by one year at this time would see tooling delivered and commissioned later than planned under the preferred alternative, and result in additional interest costs on monies spent. Benefits would not be realized as soon as possible, reducing the financial and operational benefits associated with CWEST. Delaying the project would have a significant impact on the project and downstream impacts on all the associated support infrastructure already preparing for MDS. (This would include UDM readiness and it's infrastructure/support planning.)

Given the project delay due to tooling performance issues experienced in the Fall 2014 non-OPG nuclear campaign, this option becomes essentially non-viable. Delaying the project by one year would see commissioning occur in the P1871 outage (Fall 2018), which also happens to be the last (currently) planned Pickering 5-8 UDM outage. No direct financial benefits would be realized from the investment.

The P1881 and P1961 planned outages both have mandatory scrape scope, but planning does not currently include use of the UDM, which is required for MDS deployment. These outages are not currently included in the consideration of MDS benefits to OPG. Inclusion of these outages significantly increases the NPV of the benefits to OPG. Planned use of the UDM in these outages has not been approved at the time of writing.

The cash flow impact and reduced payback period results in a reduced NPV to the project and is therefore less attractive than the preferred alternative.

**Alternative 4: Procure 3rd Party CWEST Scrape Services (Deployment and Tooling) At Pickering 5-8**

This alternative would see a third party provider prepare and provide the CWEST scrape tools, deployed using OPG supporting resources and equipment, while providing technical support and operations oversight. Similar to current OPG scrape practices of leasing vendor maintained tooling, this option would include vendor execution of CWEST tooled scrape campaigns.

Despite lower upfront costs and easier cash flow management, this alternative is far less attractive than the preferred alternatives, having a greater overall cost and lower NPV.

A long term contract would ideally be negotiated to meet Pickering's scrape needs reliably through to station closure. A series of fixed prices and outage schedules would help control costs and risk, but require renegotiation when outage schedules change. This is expected to be problematic, due to potential overlapping of outages from other customers.

Operational experience with currently leased tooling reveals inconsistent vendor performance that is expensive and has continually increasing costs negotiated on per outage basis.

Vendors have routinely shown difficulty in meeting our "expected" schedule changes due to schedule slippage or advances in outage windows. There is little confidence that vendor supplied tooling will arrive on time, be in operable condition out of the box, or be supported by vendor staff who have adequate knowledge and experience with the tooling to be considered competent technical support.

Vendor leased tooling exposes OPG to host of risks which we have little to no control over – costs, schedule and technical competence being the most significant. The use of leased tooling to meet our outage schedules and requirements has been difficult to consistently meet both schedule and technical requirements.

This alternative provides similar benefits as the preferred alternative but at almost twice the price.

**Part D: Project Cash Flows, NPV, and OAR Approval Amount**

| k$ | LTD | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 | Future | Total |
|---|---|---|---|---|---|---|---|---|---|
| Currently Released | 3,996 | 2,836 | | | | | | | 6,832 |
| Requested Now | - | 7,294 | | | | | | | 6,294 |
| Future Required | - | 1,066 | 6,700 | 3,040 | | | | | 11,806 |
| **Total Project Cost** | 3,996 | 11,196 | 6,700 | 3,040 | | | | | 24,932 |
| Ongoing Costs | - | 0 | 0 | 0 | | | | | 0 |
| **Grand Total** | 3,996 | 11,196 | 6,700 | 3,040 | | | | | 24,932 |

| | | | |
|---|---|---|---|
| **Estimate Class:** | Class 2 | **Estimate at Completion:** | [redacted] |
| **NPV:** | $6.6 M | **OAR Approval Amount:** | $24,932 k |

**-Additional Information on Project Cash Flows (optional):**

The project has invested considerable effort to maintain the same overall cost forecast in this partial BCS as presented in the previous BCS. MDS has worked diligently to control both scope and cost creep. Combined with vendor provided information and realized time and cost savings from completed work, the project is able to submit a net zero change to the overall project cost. Present life to date project spending is largely procurement of the fixed price CWEST system.

**Part E: Financial Evaluation**

| M$ | Preferred Alternative | Base Case | Delay Work | Alternative 4 | Alternative 5 |
|---|---|---|---|---|---|
| **Project Cost** | [redacted] | $ 4, 597 | [redacted] | $ 44, 742 k | |
| **NPV** | $ 5,672 k | ( $ 3,725 k ) | ( $ 2, 694 k ) | ( $ 12, 476 k ) | |
| **NPV (All UDM) **** | $ 16,640 k | ( $ 3,725 k ) | $ 7, 855 | ( $ 4, 371 k ) | |

**Summary of Financial Model Key Assumptions or Key Findings:**

** NPV is calculated based on R015 of N-PLAN-01060-10002 and benefits claimed for only those outages which have both a mandatory scrape requirement AND planned UDM deployment (required for CWEST). Outages P1881 and P1961 have mandatory scrape scope, but are not currently planning UDM deployment. The "NPV (All UDM)" indicates the project's potential if these additional outages are planned to include UDM and MDS deployment.

The Preferred and Delay alternatives are reported less LTD sunk costs, as of month end February 2015

Abandon MDS alternative shows LTD sunks costs, as of month end February 2015

The delay MDS alternative would see the commissioning run to P1871 (Fall 2018), which is also the final (currently) planned UDM outage at Pickering 5-8.

For preferred alternative, first usage is planned for P1751 and is the first outage for which benefits are considered. P1671 is considered a commissioning run only, and will have mandatory scrape scope performed using existing scrape tools. No benefits to OPG are considered for P1671. Inclusion of scope in P1671 was accepted by the Pickering Site Management Board on January 20, 2015, pending AISC approval of the BCS.

The P1671 commissioning run is required to support the establishment of scrape "equivalency", the direct comparison between manual DCS and MDS data models. Said data models trend [Heq] uptake and are used in establishing fitness for service and unit end of life calculations.

This BCS accounts for additional benefits brought by MDS to Pickering 5-8. The increased NPV is the result of several changes from the last BCS, notably the increased number of scrapes required in R015 of N-PLAN-01060-10002, the FC LCMP, and the inclusion of additional critical path work not previously considered, most notably four (4) days per outage for defueling activities not required using MDS.

**Part F: Qualitative Factors**

Some of the qualitative / non-quantified benefits to this project include:

Elimination of Ice Plugging and Open Channel Work & Reduction in Operator/Plant Risk

This qualitative factor is a significant driver for the station and stakeholders.

Ice plugging and open channel work is high hazard work for both personnel and the plant. It puts the station into an undesirable configuration with respect to reactor safety. It leaves the station reliant on an ice plug to hold back the heat transport system. The worst case scenario of ice plug failure is a loss of coolant accident (LOCA) through the open channel (ie: channel with no closure plug). This is an extremely serious, reportable event. A LOCA carries significant ramifications for personnel, plant, OPG's corporate reputation, and the nuclear industry as a whole. In light of the recent Fukishima seismic event and concerns, the use of ice plugging is a condition which is desirable to move away from.

The formation of ice plugs carries additional risks to the plant and the reactor. The formation of ice plugs requires the storage, transportation, use and handling of liquid nitrogen. In the feeder cabinet, where ice plugs are formed and used, there is the operator risk of oxygen depletion within the work environment. From an equipment standpoint, there is the risk of thermal stress to the feeder on which the ice plug is being formed. This could potentially rupture the feeder, resulting in a LOCA. To repair such a rupture, additional ice plugs would have to be formed around the rupture so that the damaged feeder piping can be replaced, which is not itself a trivial task.

Ice plugging is both dose and labour intensive. In some cases, it is the direct cause of restrictions on other outage work proceeding while ice plugging work is going on. The preferred alternative would permit scrape activities to be performed wet – that is, without having to ice plug and drain/defuel the channel. This means the pressure boundary of the reactor would be maintained by the delivery machine (ie: UDM) and NOT an ice plug. Additionally, the high intensity gamma beam and contamination issues resulting from an open channel where operators are working could be eliminated.

Reduced FM non-routine operation

This is a Pickering station priority to focus on reliable fuelling machine operations and maintenance of fuelling machines when not fuelling. Delivery of current Wet Axial Scrape (WAS) tooling, while necessary, takes the fuelling machines away from their principal fuelling tasks. WAS also requires the application of a TMOD to execute. The reduction of non-routine fuelling machine use is critical to getting the fuelling machines back to reliable and predictable service/performance levels.

Minimize Reactor Face Work

Current Damp Circumferential Scrapes (DCS) are executed manually from a bridge platform. Channels are individually shielded. The implementation of the recommended alternative would see execution of scrape activities done via remote controlled tooling, with minimal operator presence on the reactor face being required. This qualitative factor is a significant contributor to operator dose reduction.

Elimination of the flux imbalance issues at reactor startup after 10 channels of fuel replaced

Current scrape practices require the channel to be fully defueled. Upon reactor startup, each channel sampled is now loaded with twelve (12) new fuel bundles. This creates a flux imbalance that has to be dealt with upon startup. Implementation of the recommended alternative would mean not having to defuel any channels, as fuel would only be required to be pushed into the far fuelling machine and end fitting during sampling activities before being returned to the channel. (This is the current practice with UDM delivered tool inspections.)

Opportunity to save future critical path through addition of UDM and MDS to planned outage scope

N-PLAN-01060-100002 R15, the fuel channel life cycle management plan, documents the requirement for scrape scope in P1881 and P1961 but with no UDM planned deployment. As the UDM is required to deploy CWEST, an analysis was undertaken to evaluate the impact on these outages of including the planned deployment of the UDM. After allowing for both the standard mobilization and demobilization UDM times, these are still several days of critical path savings to be realized by adding the UDM to these outages and performing scrape with MDS rather than manually deployed tooling.

The addition of UDM deployed MDS brings additional benefits. UDM can now deploy the ANDE/GAP tooling instead of CIGAR, for additional time savings achieved through ANDE's superior inspection times. Secondly, added UDM time offers MCED the opportunity to reconsider both the scope and timing of other required engineering inspections – such as SLAR – which could mean deferral of imminent work into future, more appropriate outages. These benefits are already under discussion with the Generation Planning team.

| Part G: Risk Assessment | | | | |
|---|---|---|---|---|
| Risk Class | Description of Risk | Risk Management Strategy | Post-Mitigation | |
| | | | Probability | Impact |
| Cost | There is a risk that costs will increase due to risks identified below. | Per specific identified risk. | High | Medium |
| Scope | There is a risk that scope will increase due to risks identified below. | Per specific identified risk. | High | Medium |
| Schedule | 1. There is a risk that operators will take longer than anticipated to become familiar with the tool.<br><br>2. There is a risk that the time required to build an OPG toolset is longer than quoted. | 1.Multiple training opportunities have been established, from including OPG "observers" at the vendor's facility during manufacturing and testing, to formal classroom and hands on training with CWEST.<br><br>2.OPG has worked closely with the vendor to establish realistic timeframes for delivery. A staged approach to delivery has been arranged. "Pain and gain" type clause to be negotiated into tool head procurement PO to reinforce delivery on commitments. | Medium | Low |
| Resources | There is a risk that the MDS schedule will continue to slip due to a lack of qualified engineering resources to progress the work. | With limited success to date, MDS continues to seek the engagement of temporary, NBA or rotation qualified staff to support the project.<br>Posted department positions are taking time to fill and have competing demands. | High | Medium |
| Quality/ Performance | There is a risk that CWEST will suffer additional setbacks during next non-OPG on channel use. (circa June 2015) | OPG has been invited to witness the mobilization and deployment phases of CWEST at non-OPG facility. OPG has observed two previous deployments in 2014.<br>MDS has had project staff at the vendor's facility for twice weekly face to face updates on CWEST and technical developments. Requests for technical documentation to provide confidence in tool testing and readiness continue to be made. | High | Medium |
| Technical | 1.There is a risk that traceability of the collected chips will be lost.<br><br>2.There is a risk that the UT cutter approach methodology doesn't work any better than the failed Fading Hard Stops.<br><br>3. There is a risk that design differences between Pickering NGS and non-OPG NGS may require CWEST design changes and/or render CWEST unusable at Pickering.<br><br>4. There is a risk that OPG will not have | 1.This issue was one of the focus areas of the tool redesign activities conducted between 2012-2013. Events of 2014 leading to the elimination of Fading Hard Stops and chip miscapture will be demonstrated on non-OPG reactor in 2015.<br><br>2. UT cutter approach methodology was successfully used on non-OPG reactor in 2011. Engineering redesign of the tool has changed only those elements deemed unsatisfactory. Next on non-OPG reactor usage in 2015 will confirm or highlight additional areas for | High | Medium |

## Type 3 Business Case Summary



**Part G: Risk Assessment**

| Risk Class | Description of Risk | Risk Management Strategy | Post-Mitigation | |
|---|---|---|---|---|
| | a Mark I Connectorized UDM umbilical cable with which to deploy CWEST for P1671.<br><br>5. OPG continues to be denied access to CWEST technical documentation at the direction of the vendor's non-OPG customer and IP owner. | improvement.<br><br>3. (i) Issues relating to scraping the far end rolled joint region and concerns with UDM positional accuracy and available space to remaining in channel fuel bundles are being worked down with the support of both Pickering Fuel Handling and IMS DAMS UDM specialists. (ii) Differences of CWEST clamping in the non-OPG UDM liner versus the Pickering end fitting liner differences are actively being worked through with the support of Engineering Mechanics. | | |
| | | 4. OPG has two (2) existing Mark I (original) connectorized umbilical cables. One was damaged during Spring 2015 outage campaign and may not be repairable. The second, already used for approximately half of its design life, may be consumed before P1671. Engineering activities to procure new cables are well underway. Manufacturing time is not less than 18 months. Engineering and supply chain are actively involved in supporting the mitigation of this risk.<br><br>5. MDS continues to have twice weekly face to face meetings with the vendor to discuss updates on CWEST technical developments and to continue to push for access to key documents. This issue has already been escalated internally within both OPG and the non-OPG utility. | | |

**Additional Risk Analysis:**

Retired Risk Summary

1.CWEST failure in 5 channel commissioning run in A1431 – 35 of 35 samples collected. Considered successful.

2. Circumferential scrapes providing same analysis as axial scrapes – MCED has agreed to accept the risk related to replacing axial scrapes with circumferential, as the rolled joint region is far more significant, in that they are the life limiting element of the unit, than the body of tube.

3. Vendor negotiations taking longer than anticipated – PO was issued 12 weeks later than planned due to IP negotiations for an OPG owned toolset and usage rights of OPG and OPG subsidiaries; vendor schedule has shifted but they have a recovery plan and are still able to meet the project's schedule and milestones requirements.

**Part H: Post Implementation Review (PIR) Plan**

| Type of PIR Report | Target In-Service or Completion Date | Target PIR Completion Date |
|---|---|---|
| Simplified PIR | Spring 2017, P1751 | November 2017 |

| Measurable Parameter | Current Baseline | Target Result | How will it be measured? | Who will measure it? (person/group) |
|---|---|---|---|---|
| Dose Uptake | 10.0 rem (6 DCS & 10 BOT) | 5.5 rem (6 DCS & 10 BOT) | Campaign Dosimetry | DAMS, SME |
| Execution Cost | $3500k/campaign (6 DCS & 10 BOT) | $1600k/campaign (6 DCS & 10 BOT) | Campaign Budget/Actual Costs + Fuel costs saved | DAMS, SME |
| Outage Critical Path | 400hrs (6 DCS & 10 BOT) | 150hrs (6 DCS & 10 BOT) | Campaign Schedule | DAMS, SME |
| Ice Plugging | Yes | No | Campaign Execution | DAMS, SME |
| Open Channel Work | Yes | No | Campaign Execution | DAMS, SME |
| Use of Fuelling Machine in non-standard configuration | Yes | No | Campaign Execution | DAMS, SME |

** - all parameters measured comparing current manual scrape practices to MDS scrape activities.

**Part I: Definitions and Acronyms**

ADL - Affected Documents List
AEL - Affected Equipment List
AFS - Available for Service
AISC - Asset Investment Screening Committee
ANDE - Advanced Non Destructive Examination
BCS - Business Case Summary
BOE - Basis of Estimate
BOT - Body of Tube
CANDU - CANadian Deuterium Uranium
CGSB - Canadian General Standards Board
CIP - Channel Isolation Protocol
COG - Candu Owner's Group
COMS - Constructability, Operability, Maintainability, Safety
CQTS - Cutter Qualification Tool Station
CSA - Canadian Standards Association
CWEST - Circumferential Wet Axial Scrape Tool
CWEST - Circumferential Wet Scrape Tool
DAIA - Design Agency Interface Agreement
DAMS - Delivery and Reactor Maintenance Systems
DCS - Damp Circumferential Scrape
DTL - Design Team Leader
EC - Engineering Change
ECC - Engineering Change Control
EOL - End of Life
ESA - Electrical Safety Authority
ET - Eddy Current Testing
FH - Fuel Handling
FM - Fuelling Machine
FMSR - Fuelling Machine Service Room

| Part I: Definitions and Acronyms |
|---|
| FMSR - Fueling Machine Service Room |
| FTL - Field Team Leader |
| GSS - Guaranteed Shutdown State |
| IMS - Inspection and Maintenance Services |
| INS - Instruction |
| LCMP - Life Cycle Management Plan |
| LOCA - Loss of Cooling Accident |
| MCED – Major Components and Equipment Division |
| MCST - Multiposition Circumferential Scrape Tool |
| MDR - Modification Design Requirements |
| MDS - Machine Delivered Scrape Project |
| MTL - Modification Team Leader |
| NDE - Non Destructive Examination |
| NDT - Non Destructive Testing |
| NGS - Nuclear Generating Station |
| NPV - Net Present Value |
| OPEX - Operating Experience |
| OPG - Ontario Power Generation |
| PAC - Project Approval Committee |
| PCRAF - Project Change Request Authorization Form |
| PIR - Project Implementation Report |
| PL - Project Leader |
| PM - Project Manager |
| RFQ – Request for Quotation |
| RJ - Rolled Joint |
| RJS - Roll Joint Scrape |
| RMP - Risk Management Plan |
| SCADA - Supervisory Control and Data Acquisition |
| SEF - Storage End Fitting |
| SPI - Schedule Performance Index |
| SRE - System Responsible Engineer |
| SSC - Systems, Structures and Components |
| TMOD - Temporary Modification |
| TOAST - Tool on a Stick |
| UDM - Universal Delivery Machine |
| UT - Ultrasonic Testing |
| VCP - Vented Closure Plug |
| WAS - Wet Axial Scrape |

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## For Internal Project Cost Control

# Type 3 Business Case Summary

Project #: 66600
Document #: N-BCS-30740-10003
Project Title: Machine Delivered Scrape, <Partial> <Execution> Release

**Appendix A: Summary of Estimate**

| | |
|---|---|
| **Project Number:** | 66600 |
| **Project Title:** | Machine Delivered Scrape |

| Choose an item. | LTD | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 | Future | Total | % |
|---|---|---|---|---|---|---|---|---|---|---|
| **OPG Project Management** | 155 | 463 | 563 | 432 | 0 | 0 | 0 | 0 | 1613 | 7.7 |
| **OPG Engineering** (including Design) | 280 | 510 | 600 | 207 | 0 | 0 | 0 | 0 | 1597 | 7.6 |
| **OPG Procured Materials** | 3440 | 7981 | 2305 | 473 | 0 | 0 | 0 | 0 | 14199 | 67.8 |
| **OPG Other** | [redacted] | | | | | | | | | |
| **Design Contract(s)** | | | | | | | | | | |
| **Construction Contract(s)** | | | | | | | | | | |
| **EPC Contract(s)** | | | | | | | | | | |
| **Consultants** | | | | | | | | | | |
| **Other Contracts/Costs** | | | | | | | | | | |
| **Interest** | | | | | | | | | | |
| **Subtotal** | | | | | | | | | | |
| **Contingency** | | | | | | | | | | |
| **Total** | 3996 | 11196 | 6700 | 3041 | 0 | 0 | 0 | 0 | 24933 | |

**Notes**

| | | | |
|---|---|---|---|
| **Project Start Date** | 2014-02-01 | **Total Definition cost** (excludes unspent contingency for Nuclear) | [redacted] |
| **Target In-Service (or AFS) Date** | P1671 "Commissioning Run" with no OPG benefits<br>P1751<br>1st use with OPG benefits | **Contingency included in this BCS** (Nuclear only) | |
| **Target Completion Date** | 2017-12-31 | **Total contingency released plus contingency in this BCS** (Nuclear only) | |
| **Escalation Rate** | 2.0 % | **Total released plus this BCS without contingency** (Nuclear only) | |
| **Interest Rate** | 5.0 % | **Total released plus this BCS with contingency** (Nuclear only) | $ 14,126 k |
| **Removal Costs** | N/A | **Estimate at Completion** (includes only spent contingency for Nuclear) | [redacted] |

| **Prepared by:** | **Approved by:** |
|---|---|
| Michael Clarke, MDS Project Manager — Date Jun 10/15 | for Ryan Howard, NDE Projects Department Manager — Date Jun 11/2015 |

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OPG-FORM-0076-R005

# Type 3 Business Case Summary

Document #: N-BCS-30740-10003

Project #: 66600
Project Title: Machine Delivered Scrape, <Partial> <Execution> Release

## Appendix B: Comparison of Total Project Estimates and Project Variance Analysis

### Comparison of Total Project Estimates

| Phase | Release | Approval Date | Total Project Estimate in Choose an item. (by year including contingency) | | | | | | Future | Total Project Estimate |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 | | |
| Execution | Partial | 2014-02-01 | 6,832 | 14,993 | 3,109 | - | - | - | - | 24,933 |
| Execution | Partial | 2015-04-08 | 3,996 | 11,196 | 6,700 | 3,041 | - | - | - | 24,933 |
| | | | | | | | | | | |
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### Project Variance Analysis

| Choose an item. | LTD | Total Project | | Variance | Comments |
|---|---|---|---|---|---|
| | | Last BCS | This BCS | | |
| **OPG Project Management** | 155 | 1622 | 1605 | (17) | Essentially unchanged. |
| **OPG Engineering** (including Design) | 280 | 822 | 1608 | 786 | Additional OPG engineering support utilized; some work reclassified from "other" to "engineering/design". |
| **OPG Procured Materials** | 3440 | 14172 | 14254 | 82 | Essentially unchanged. |
| **OPG Other** | [redacted] | | | | |
| **Design Contract(s)** | [redacted] | | | | |
| **Construction Contract(s)** | [redacted] | | | | |
| **EPC Contract(s)** | [redacted] | | | | |
| **Consultants** | [redacted] | | | | |
| **Other Contracts/Costs** | [redacted] | | | | |
| **Interest** | [redacted] | | | | |
| **Subtotal** | [redacted] | | | | |
| **Contingency** | [redacted] | | | | |
| **Total** | 3996 | 24943 | 24943 | 0 | |