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**Presentation from Ontario
Power Generation (OPG)**

**Présentation d'Ontario
Power Generation (OPG)**

**OPG Update on the Refurbishment
Project at the Darlington Nuclear
Generating Station**

**Mise à jour d'OPG sur le projet de
réfection à la centrale nucléaire de
Darlington**

Commission Meeting

Réunion de la Commission

December 9, 2020

Le 9 décembre 2020

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Darlington Refurbishment Program (DRP) Mid-Term

Update to the Canadian Nuclear Safety Commission

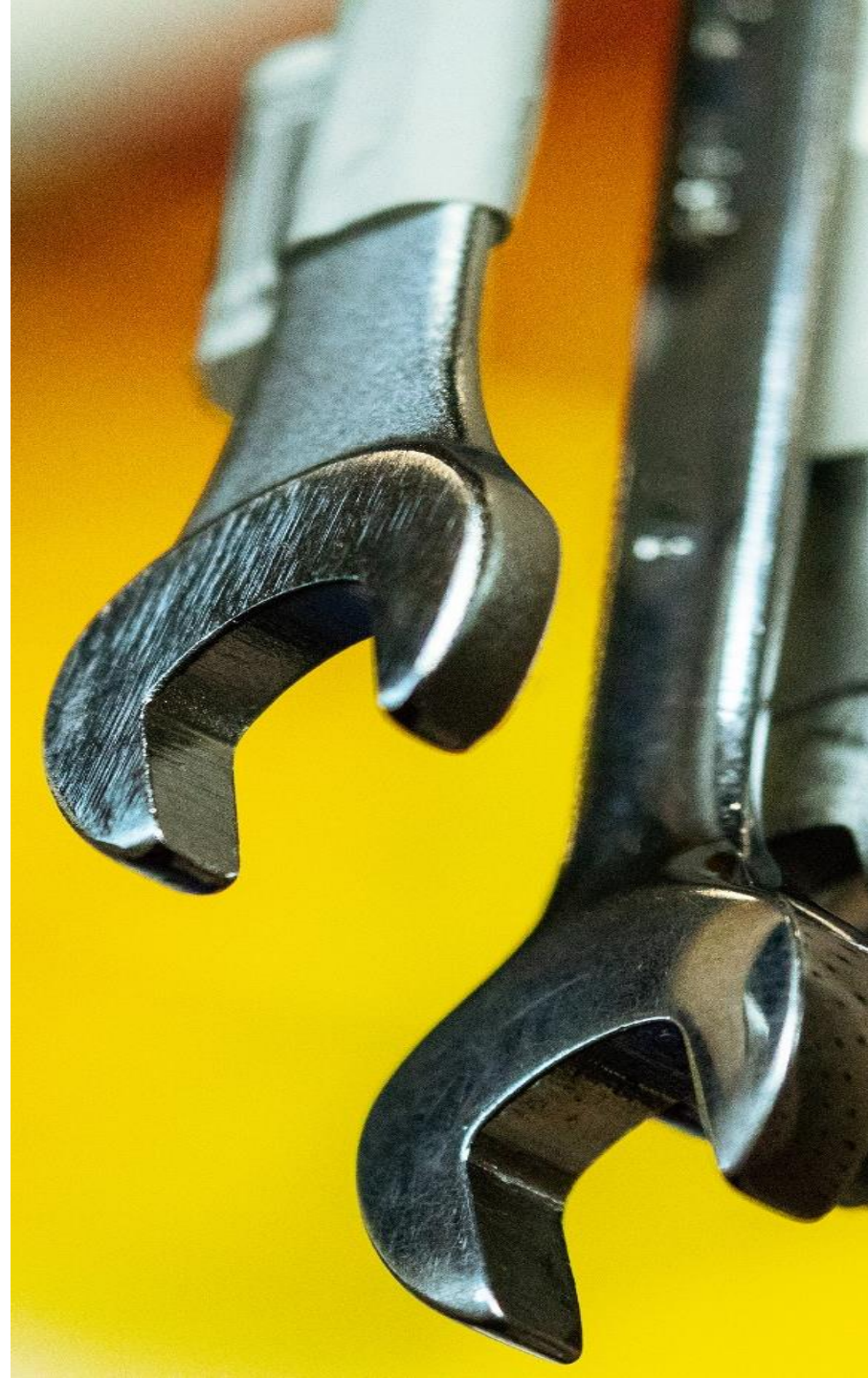
December 2020

Revised Oct 2, 2020

ONTARIOPOWER
GENERATION

Agenda

- 1 | Darlington Overview
- 2 | Darlington Refurbishment Program
Unit 2 Refurbishment Complete
- 3 | Unit 3 Overview & Readiness
- 4 | OPG – Reinvesting in Ontario



Darlington Nuclear

Low cost, reliable, clean baseload generation, as well as delivering substantial economic benefits to the province

In-service early 1990's, providing over 25 years of clean, competitive, reliable power

- Four units
- 3524 MW net output
- Delivers 20 percent of Ontario's electricity
- Power for 2 million homes

Recognized internationally for excellent performance

Strong community support

Unit 1 now holds the world record for continuous operation of a nuclear reactor, surpassing previous record of 962 days

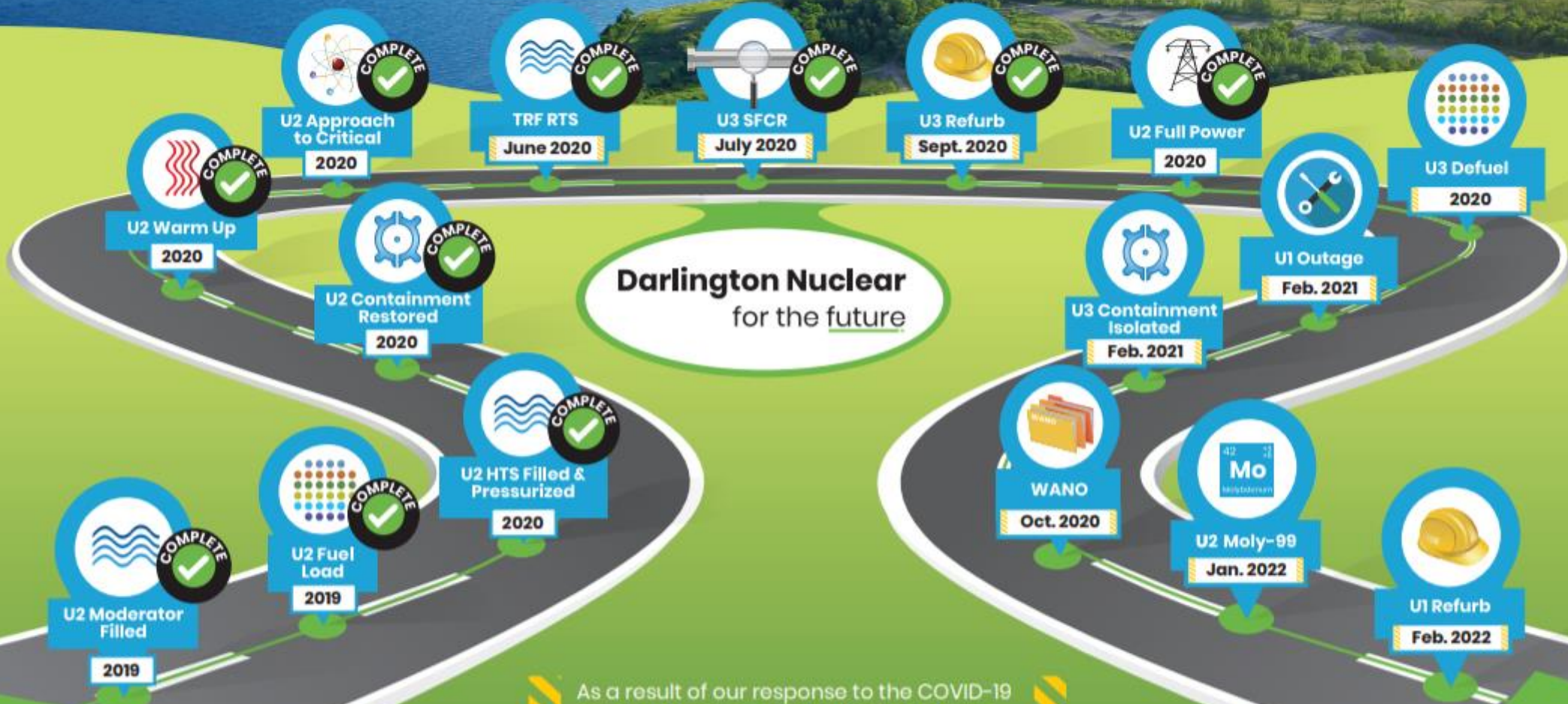
DNRU2 completion sets a new standard for CANDU refurbishment



Darlington Nuclear for the Future



Journey of Excellence



As a result of our response to the COVID-19 pandemic, some of our milestones have moved as we continue to ensure the safety and reliability of the Darlington station. Together, we will #PowerOn as we build the foundation for Darlington for the future.

Darlington Nuclear Refurbishment Project

20-year project

- 10 years planning, 10 years execution
- Each Unit will undergo Refurbishment outage of 35-44 months
- Overlapping Refurbishment of U3 & U1 and U1 & U4

Replace major reactor components and upgrade key plant systems

Substantial safety and equipment investments

\$12.8B investment; 14,000+ jobs; \$89.9B boost to Ontario's GDP



Photo Pre-COVID-19

DARLINGTON NUCLEAR REFURBISHMENT PROJECT

30 MORE YEARS OF CLEAN ELECTRICITY
NUCLEAR ENERGY PLAYS A FUNDAMENTAL ROLE IN ONTARIO'S CLEAN-ENERGY EQUATION

THE REFURBISHED
DARLINGTON STATION
WILL REDUCE GREENHOUSE GAS
EMISSIONS BY AN ESTIMATED

297
MILLION TONNES

THAT'S THE EQUIVALENT
OF REMOVING

2 MILLION
Cars per
YEAR

FROM ONTARIO'S ROADS



1 IN 5

HOMES AND BUSINESSES
ARE POWERED BY DARLINGTON -
WITH VIRTUALLY
NO GREENHOUSE GASES



20%

OF ONTARIO'S POWER IS
SUPPLIED BY DARLINGTON -
ENOUGH TO SERVE A CITY OF
2 MILLION PEOPLE



60%

OF ONTARIO'S DAILY
ELECTRICITY NEEDS ARE
SUPPLIED BY THIS PROVINCE'S
NUCLEAR FLEET



8¢ kWh

30 YEARS OF POWER
BELOW AVERAGE COSTS

ONTARIOPOWER
GENERATION

— Refurbishment Scope

Defuel, Fuel Handling, Special Projects



Remove all fuel safely from reactor core
Fuel handling system refurbishment
Special Projects:

- Shutdown system computers
- Vault coolers

Retube and Feeder Replacement



Replace reactor components that have reached the end of their service

Turbine / Generator



Perform extensive preventative maintenance on the Turbine Generator, including an upgrade of the control system to modern configurations

Steam Generators

Steam Generator cleaning provides enhanced performance for the future. Access ports will be installed to improve inspection capabilities



Balance of Plant



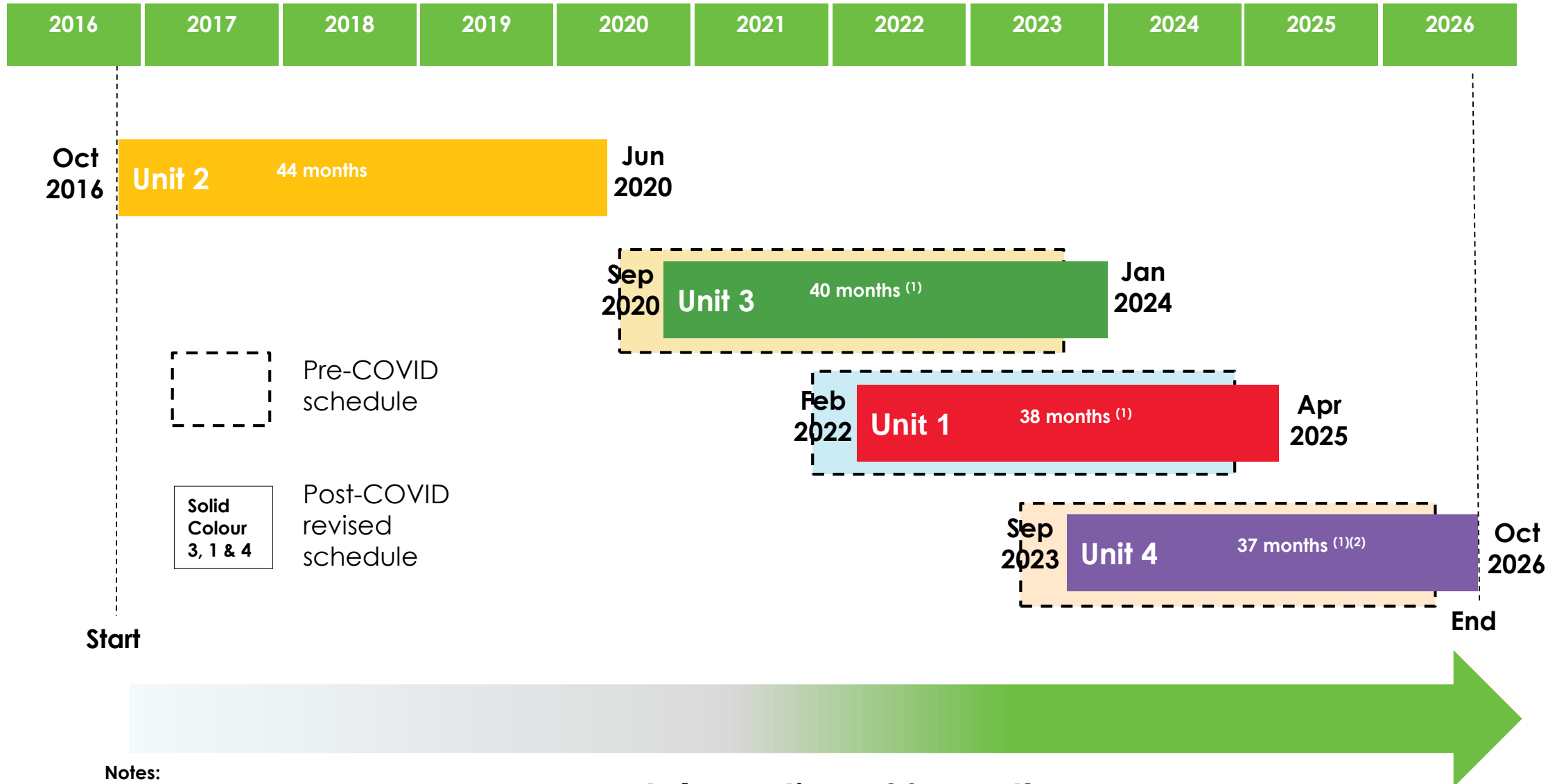
As part of the station lifecycle management program, modifying and replacing a wide variety of plant equipment that is approaching the end of service life or is difficult to repair on a fueled reactor

Cyclic Outage



- Preventive maintenance
- Station backlog
- Valve rehabilitation, PM/CM

Darlington Refurbishment Schedule



Notes:

- (1) High Confidence Schedule
- (2) Unit 4 will commence upon completion of Unit 3 between Sep/23 and Jan/24

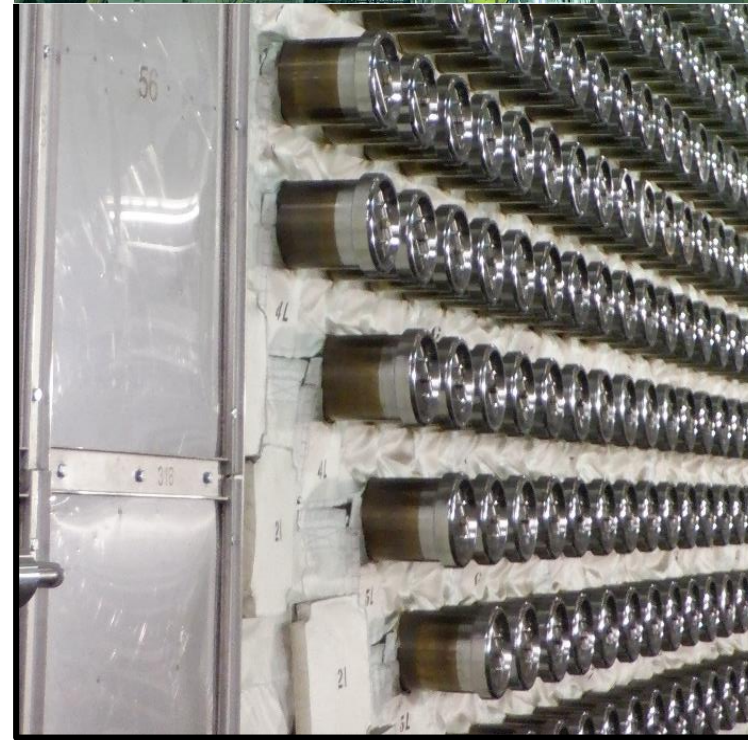
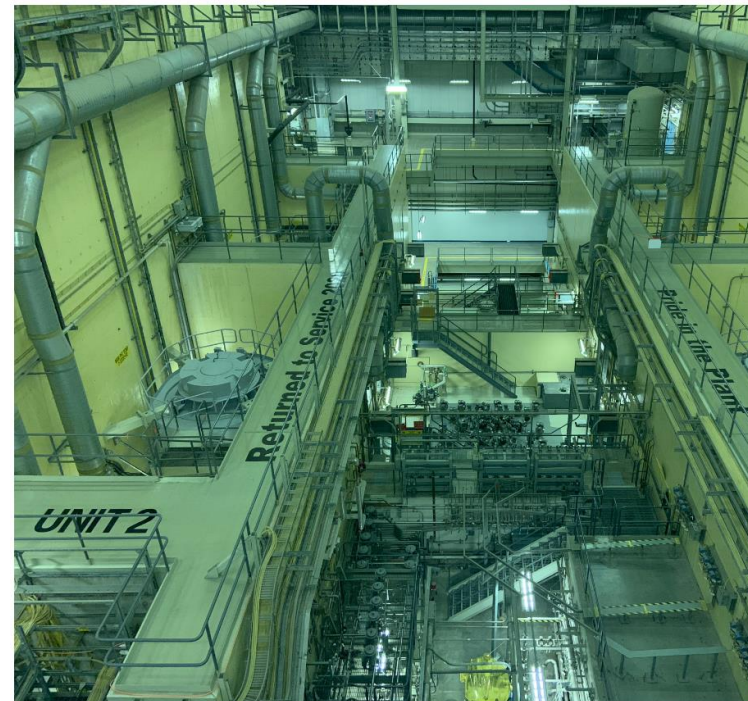
Unit 2

Unit 2 returned to service on June 4, 2020

- 24 Million hours worked with 1 Lost Time Accident (LTA) – final months completed safely with COVID restrictions
- High quality of work
- Will provide 30 more years of reliable, clean, low-cost power to Ontario

Unit 2 operating reliably post-refurbishment

Four unit Refurbishment remains on budget and on time for revised schedule



Unit 2

**100%
Complete**

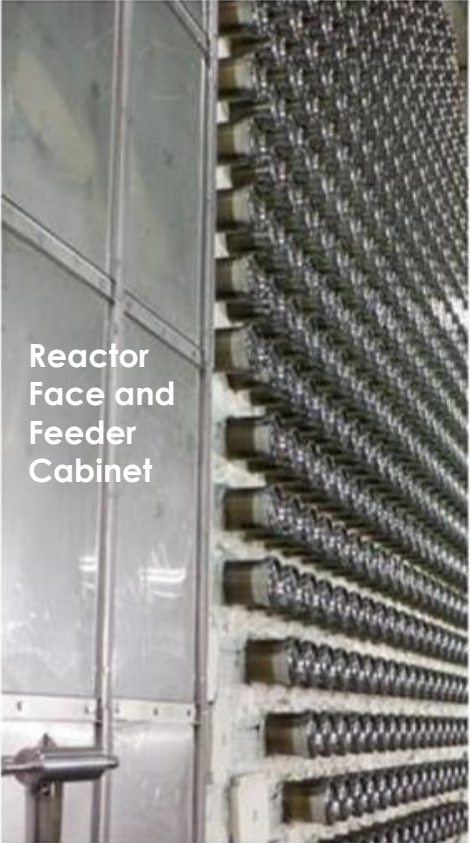
**24
million
hours worked**

**58
Systems
in Service**

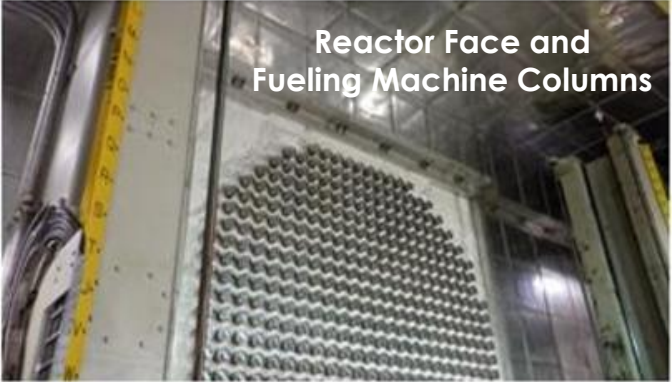
**18
Major safety &
infrastructure
projects**



Unit 2 Reactor Vault



Reactor Face and Feeder Cabinet



Reactor Face and Fueling Machine Columns



Upper Feeders and Header



Reactor Face and Feeder Cabinet



Fueling Machine Bridge



Instrumentation



Vault Corridor



Instrumentation Tubing



Steam Generator Base



Vault Corridor



Vault Corridor

Integrated Implementation Plan (IIP)

100% completion of IIP tasks on time¹

All 93 IIP tasks were completed to allow the Regulatory Hold Points to be cleared and U2 returned to 100% power

U3 has 28 IIP tasks tied to unit Return to Service

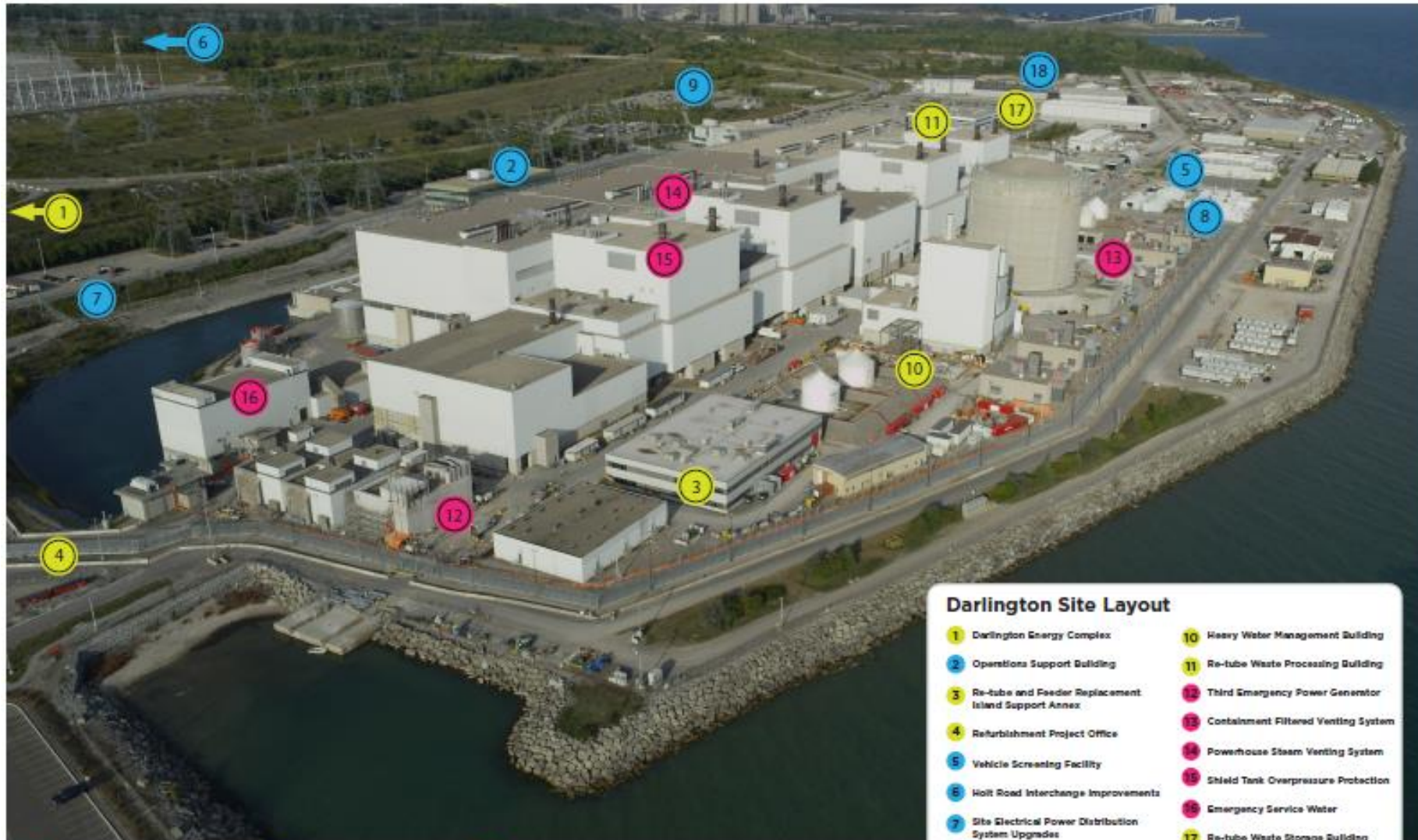
Regular meetings with the CNSC staff to communicate progress and completion of IIP tasks

All IIP tasks tracked and progressing well

¹ Timing of some tasks changed with CNSC concurrence
Data as of date: Sep 21 2020



18 Infrastructure and Safety Projects In-Service



Darlington Site Layout

1 Darlington Energy Complex	10 Heavy Water Management Building
2 Operations Support Building	11 Re-tube Waste Processing Building
3 Re-tube and Feeder Replacement Island Support Annex	12 Third Emergency Power Generator
4 Refurbishment Project Office	13 Containment Filtered Venting System
5 Vehicle Screening Facility	14 Powerhouse Steam Venting System
6 Holt Road Interchange Improvements	15 Shield Tank Overpressure Protection
7 Site Electrical Power Distribution System Upgrades	16 Emergency Service Water
8 Auxiliary Heating Steam Facility	17 Re-tube Waste Storage Building
9 Water and Sewer	18 Darlington Waste Management Facility

● Safety Improvement Projects
 ● Refurbishment Projects
 ● Site Infrastructure Projects

Safety Improvement Opportunities

- Third Emergency Generator
- Containment Filtered Venting System
- Powerhouse Steam Venting System
- Shield Tank Overpressure Protection
- Emergency Service Water



Heavy Water Storage Facility



View of West Annex with Stack and Causeway



Drum Handling & Cleaning Room



Chilled Water and Instrumentation Air System



Active and Inactive Drain Tanks



Drum Traversal Route



D2O Supply Pumps



Building HVAC Controls

p14



100 Mg Storage Tank



Maintenance Catwalk



Feed and Product Pumps

Interface with the CNSC and clearing of the Regulatory Hold Points (RHPs)

All Regulatory requirements for refurbishment of Unit 2 were met:

All licence conditions were met returning Unit 2 to service

Licence Condition 15.3 & 15.4 included completion of IIP commitments and clearing RHPs - All Completed

- All IIP commitments specific to Unit 2 completed
- All RHPs were cleared on time
 - RHP 1: Loading Fuel
 - RHP 2: Removing Guarantee Shutdown State (GSS)
 - RHP 3: Raising reactor power to beyond 1 per cent
 - RHP 4: Raising reactor power to beyond 35 per cent

Return To Service (RTS) Protocol identified a large number of detailed deliverables to the CNSC to clear each RHP. This was accomplished on time and to Staff satisfaction

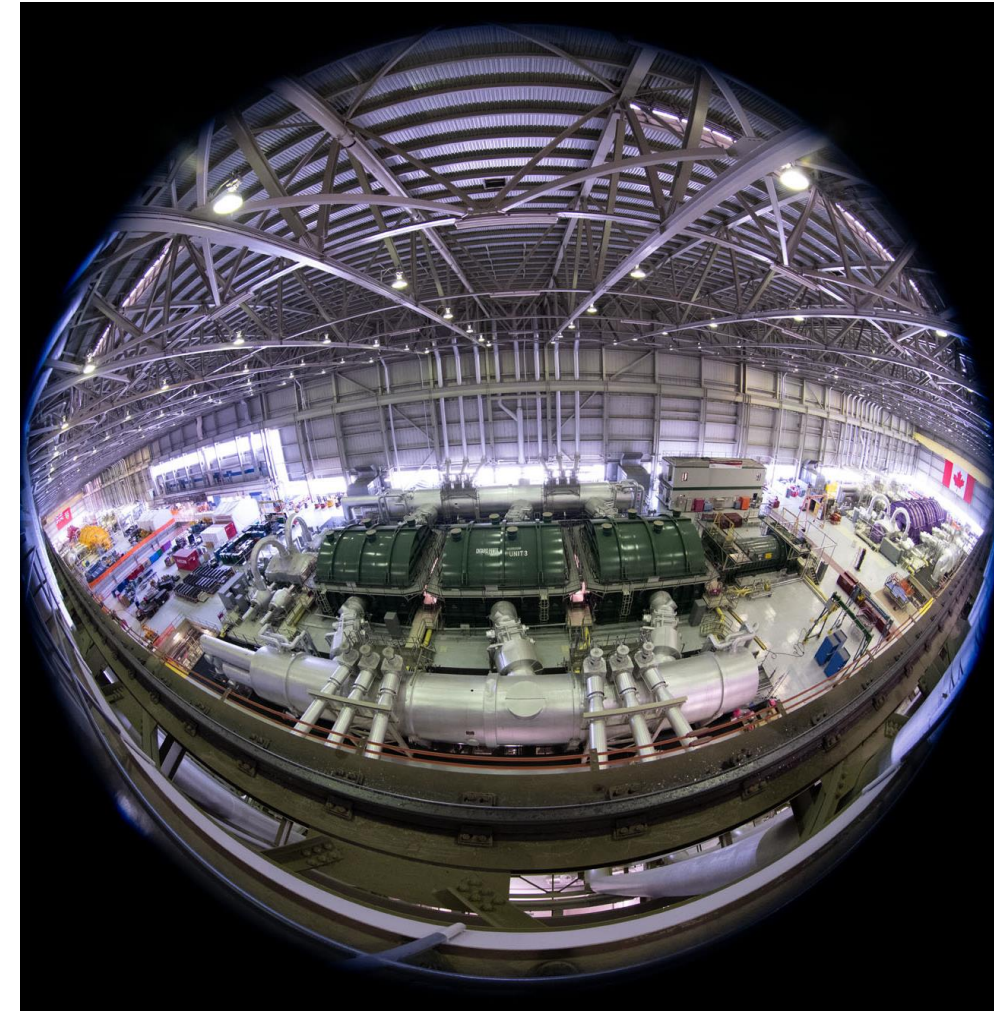
An extensive study of Unit 2 Lessons Learned was undertaken and incorporated into Unit 3 Protocol, allowing enhancement of the Refurbishment project and regulatory interface

Unit 3

Deferred start of Unit 3 Refurbishment due to COVID-19

Unit 3 Refurbishment started September 3, 2020

- Safety continues to be our top priority
 - COVID-19 measures are in place to protect staff and workers
- On-boarding of Trades and pre-requisite field work underway
- Defueling of Unit 3 commenced September 3
- 36 month schedule



Single Fuel Channel Replacement (SFCR)

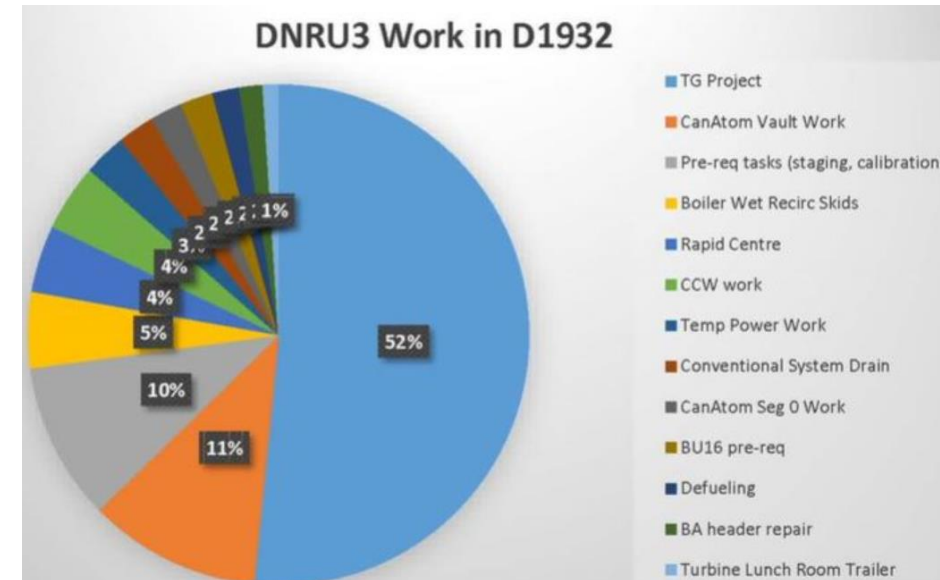
SFCR was a 30-day outage to validate lifespans of Units 1 and 4

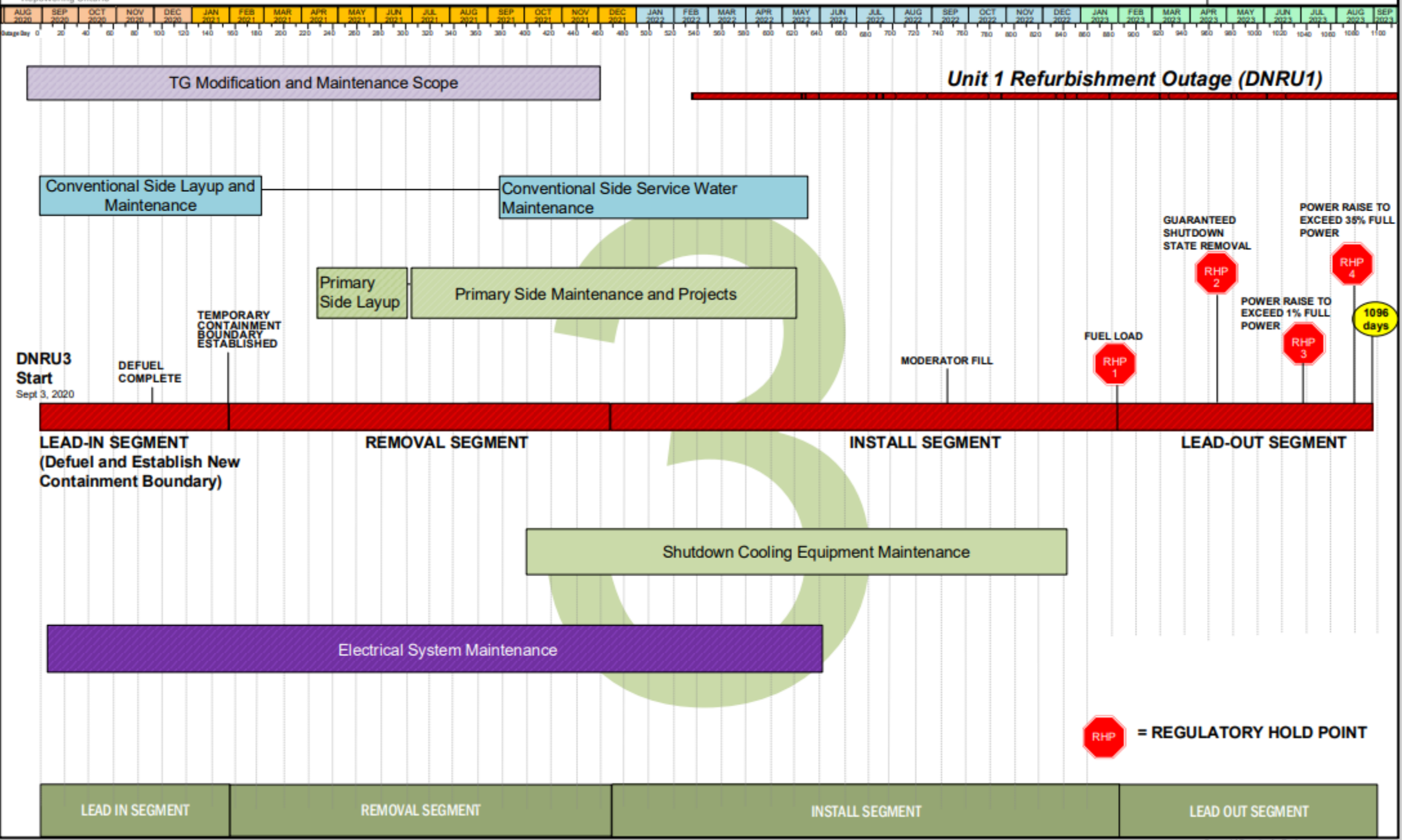
Collaboration and integration with the station determined what DNRU3 work could be done

DNRU3 mitigated schedule risks by commencing work on:

- vault work without interfering with outage activities
- first steps for the extensive turbine and generator project
- remove many interferences to ensure the drain/dry of the heat transport system


Using OPEX, lessons learned from Unit 2, and collaborating with station teams, decreased DNRU3 schedule, cost and resource risk

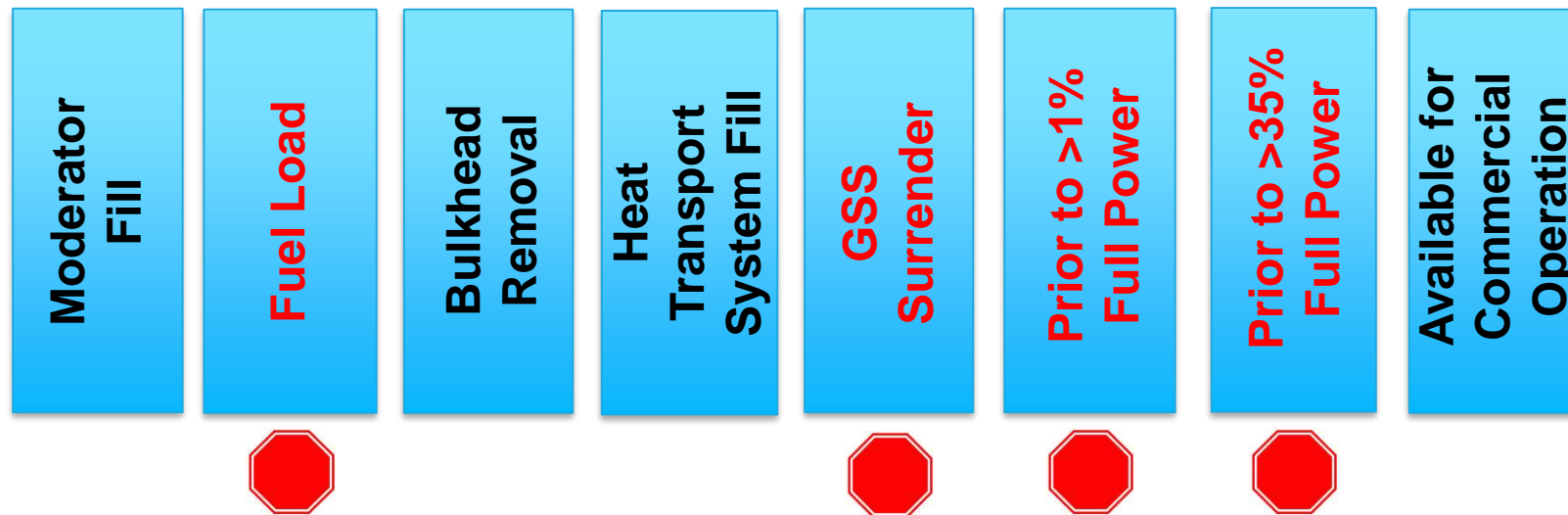




Restart Control Hold Points (RCHP)

Unit 3

- 8 Restart Control Hold Points will need to be cleared, including 4 CNSC RHPs ()
- Completion Assurance Documents (CADs) will be produced for each of 8 RCHPs, including 4 RHPs



Lessons Learned Process



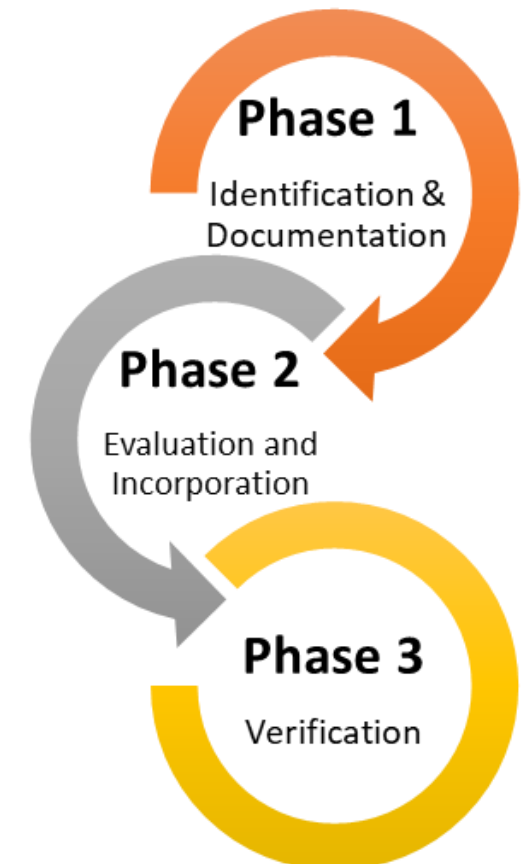
OPG and our Contractors have developed effective Lessons Learned (LL) processes

- Capture and implement the knowledge and experience gained on Unit 2 planning and execution, and
- Building those lessons into Unit 3 for continuous improvement.

New Unit 3 CNSC Protocol: based on LL and clearing of Unit 2 Regulatory Hold Points

Some of those lessons learned include:

1. Industrial Safety and Radiological Practices
2. Tooling changes/upgrades
3. Critical task training
4. LEAN/Kaizen process improvements
5. Workstream optimization and organizational alignment



U3 Keys to Success



Industrial Safety



Radiological Safety



Construction Planning Approach



Revised Feeder Strategy



Tooling Program



Training Effectiveness



ONE Team Model



Lean Kaizen

Industrial Safety

Strong conventional safety performance

- Over 24 Million hours worked with one lost time accident
- Total Recordable Injury Frequency (TRIF) is 10x lower than Ontario construction industry

Continue to strive for zero Injuries

- **Safety First** in everything we do
- Proactive safety related stand ups
- Extensive mock-up training
- New to nuclear and supervisory training
- OPG and Contractor safety plans & field oversight

COVID-19 Measures:

- Implemented a Work from Home strategy in March
- Staggered return to workplace
- Limiting staff in the station to support physical distancing
- Staggered and staged work schedules and lunch breaks
- Increased use of Personal Protective Equipment (PPE) and elevated cleaning practices



Radiological Safety

OPG set aggressive targets

- Improved performance on Unit 2
- Lessons Learned captured and implemented

For Unit 3 Significant investments in workers and Technology

- Powered Air Purifying Respirators (PAPRs)
- Enhancements to alpha monitoring program
- Streamlined Radiation Protection requests process via Radiation Protection Information Dosimetry (RaPID) Access Program
- Optimized qualification requirements to perform low level radiation risk work



Radiation Protection Initiative

Status to Date:

- Alpha program recommendation **Complete for U3**
- Powered Air Purifying Respirators (PAPRs) selection process **Completed** – procurement begins in Q3
- **Streamlined** RP requests process (Rapid Access Program)
- Emphasis on building good relationships between RP and Trades



Construction Planning Approach

Adopted standard Window Execution Readiness process

- Comprehensive Work Packages (CWPs) incorporate Lessons Learned from Unit 2 and are ready 16 weeks prior to the start of the execution work
- Safety, Radiation Protection, Material, and Resource planning are integrated with readiness reviews

An optimized shift schedule has been implemented to improve project efficiency and manage worker fatigue

Training program has been enhanced to better represent field conditions in the full-scale reactor mock-up and to train on abnormal conditions

- Integrated Radiation Protection, Safety Planning, and Quality activities into training.

Enhancements to CWP close-out and documentation strategies including increased automation and progress monitoring

Revised Feeder Strategy

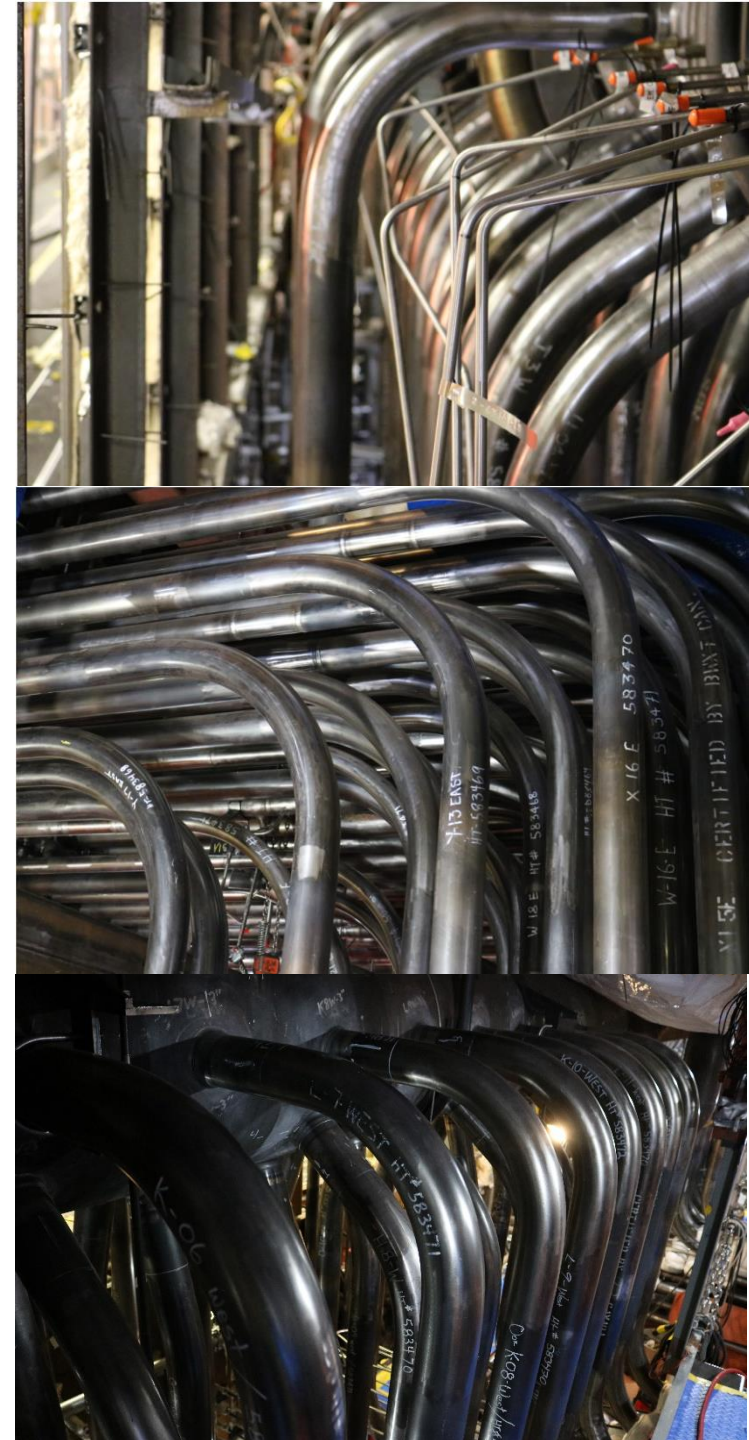
Feeder supplier oversight augmented to ensure quality of feeders as delivered

Implemented Improvements on tooling for installation including minimization of foreign material

Improved the field productivity progress tracking

Created a Welding Centre of Excellence to implement improvements to the welding program to lower overall weld failure rate

Focus on “**Right the First Time**” strategy to minimize re-work



Tooling Program

Investments made in tooling improvements to implement lessons learned from Unit 2 to reduce schedule which improves safety and reduces both Dose and costs

Pressure Tube/ Calandria Tube Removal

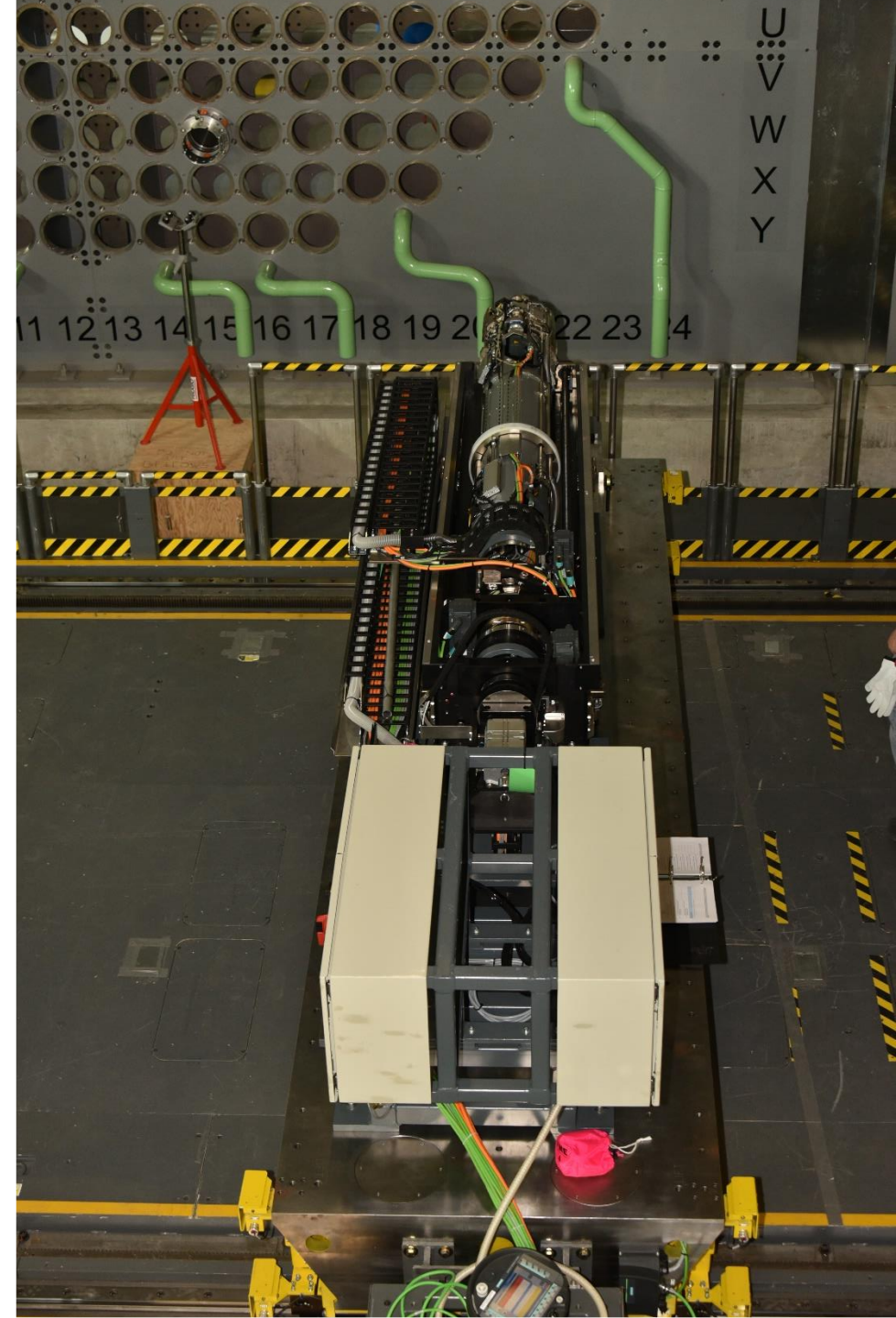
- Integration Testing **On Track** for completion Oct 2020

Modified Installation Worktables

- Integration testing **Complete**

Bellows Cut Tool Mods

- Factory Acceptance Testing (FAT) **Complete**
- Mod Kits available to install on Contaminated Tools



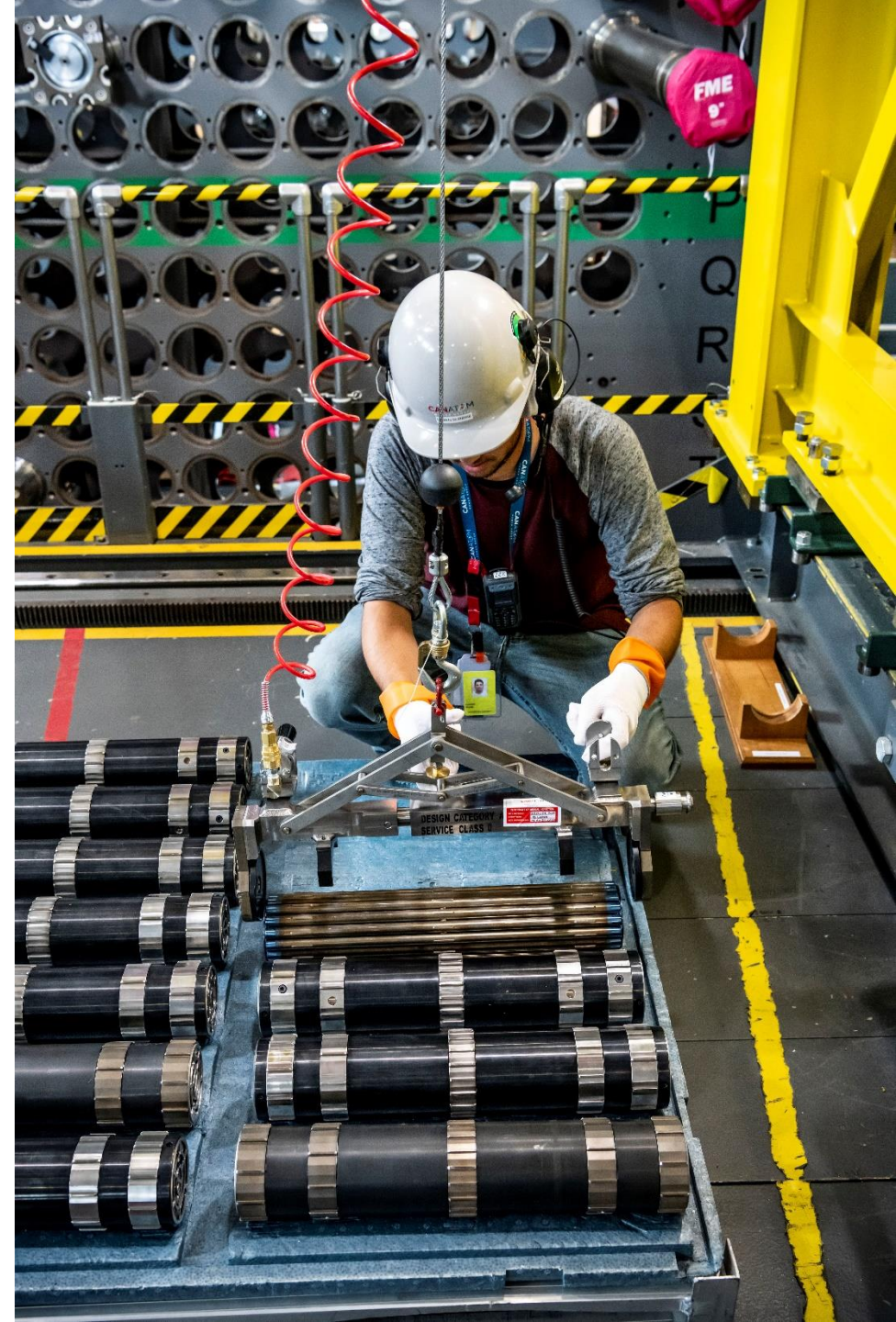
Training Effectiveness

Performed a Unit 2 Post Training Effectiveness Evaluation, as part of our continuous improvement efforts, to prepare for Unit 3/1/4 refurbishments

Training is leveraging the full scale reactor mock-up to enhance training, including:

- Replicating station environment,
- Collaboration with the trades to develop training materials,
- Training on individual steps within the process to develop expertise,
- Integrated full-team training, with all support staff, to build proficiency for each work series, and
- Introducing irregularities to allow the team to practice on dealing with potential field issues.

These changes will positively impact efficiency, as well as both safety and quality



OneTeam: One Goal

Deliver overlapping Refurbishments, on-time, on-budget, with safety & quality.

HOW?

Build on the DNRU2 experience & **Lessons Learned**

Create a **High Performance Culture**

Improve our **Processes & Technology**

Detailed **planning, preparation & training**

Empowered, collaborative teamwork (**OneTEAM!**)



Lean Kaizen

Leveraging operating experience and lessons learned from Unit 2, team is embracing a culture of continuous improvement and change through facilitative leadership

- Developed training strategy for Project manager/Area Managers, Series Leads, General Foreman and Superintendents on LEAN/Kaizen methodology and tools
- Empowered front line staff and leaders to conduct their own improvements
- Transform organization into a high performance team and identify areas to improve efficiency (cost and schedule), quality, and safety performance.

To date, over \$1 Million in direct savings / year have accumulated through these sessions. A number of additional Kaizen sessions are planned in the coming months in advance of some critical work series for Unit 3.



Ontario Power Generation

Creating a Stronger, Cleaner, and More Prosperous Future for all of Ontario

- Province's largest clean power generator and clean tech innovator
- A diverse mix of generating sources, which includes nuclear, hydropower, thermal and solar
- Powering the future of the transportation sector through electrification
- Advancing new technologies, like small modular reactors, micro-grids and large-scale energy storage projects
- Helping to build the next generation of Ontario's skilled trades and technology workforce
- DNGS will produce isotopes (Mo-99 & Co-60) for the medical industry to help save lives
- By partnering with impactful organizations, OPG is investing in the future – **today!**

Reinvesting in Ontario


\$15M In programs

To educate pool of skilled and qualified workers




2,000 Suppliers

Helping us build and modernize generating assets



\$2B Yearly

In property, plants and equipment



\$90B GDP boost

By investing in the Darlington Refurbishment

ONTARIO POWER
GENERATION