A recipe for outage success (?)

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- Outage preparation: focus on scope
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Electrabel – A diversified fleet

- 55% of Belgian Electricity production

- Nuclear
- Combined steam and gas
- Conventional
- Cogeneration
- Pumped hydroelectric storage

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2 Nuclear Power Plants – 7 units

- 4 PWR 3-loop (except D12)
  - (12) Doel 1 & 2  1975 - LTO
  - (12) Doel 3  1982
  - (18) Doel 4  1985
- Capacity  2 911 MW

- 3 PWR 3-loop
  - (18) Tihange 1  1975 – LTO
  - (18) Tihange 2  1983
  - (18) Tihange 3  1985
- Capacity  3 016 MW

5 927 MW
Tihange NPP
NPP Goals

NPP Goals = Outage Goals

- Nuclear Safety = No incidents with impact on nuclear safety
- Health and Safety = No accidents
- Electricity generation = Minimize outage length

An outage needs to be the N°1 priority of a Nuclear Power Plant
A NPP needs to be organized in such a way to increase outage success

If multiple units are present:
- A flexible organization is needed to assign your resources where they are needed the most
- Resources need to be allocated towards the unit that is in outage

A strong project team with outage control centre is needed to lead and manage the outage
Introduction Electrabel

Long term outage strategy

Outage preparation: focus on scope

Outages and Long Term Operation

Post-outage learning/conclusions
Evolution of the electricity market

- Wind, Solar, Hydro
- Nuclear
- Coal
- CCGT
- Gas Power Plant

Market Price vs. €/MWh

Offer vs. Demand side

MWh Peak Units
Sometimes, during the summer

More outages during the summer
Evolution of the electricity market
Long Term Outage Strategy – Define types

- **R+ : Refueling Outage**
  - Critical path = shut-down -> opening the reactor -> refueling -> closing the reactor -> start-up
  - Normal activities :
    - Checks and maintenance as demanded by tech specs, ASME, NEIL, ...
    - Corrective maintenance that is estimated necessary
    - Activities with low frequency ( > every 3 outages) are not included in this type of outage
    - **No draining of the primary loops**
  - Tihange 1/3 : 4 weeks
  - Tihange 2 : between 4 and 5 weeks (due to tech specs)
RN: Normal Outage

- Critical path: As R+ but with valve maintenance on primary circuit between unloading and loading of the core
- Normal activities:
  - All the activities of an outage of type R+
  - Activities of low frequency (> every 3 outages) are included
  - Examples: Main overhaul of turbine, generator, primary pumps, safety train maintenance, all corrective maintenance

- Tihange 1/3: 5 weeks
- Tihange 2: between 5 and 6 weeks
RD : Ten-Yearly Outage

- Critical path : function of scope
- Normal activities :
  - All activities of a type RN
  - Main ten-yearly activities : Inspection of welding on primary loop, pressure test of the reactor building, lots of preventive maintenance on valves on the primary circuit
  - All the big projects that can wait until a ten-yearly outage
- Tihange 1/2/3 : 6 weeks or more
Define a sequence of outages, rules:

- All big projects are always planned in an RN or RD
- Every 2 or 3 outages, there has to be an R+
- An outage during the vacation period is by preference an R+
- The outages that include an inspection of the steam generator tubes are by preference an R+ (no mid-loop operation)

Past experience (Doel NPP) shows that a sequencing RN, R+ is the most optimal
Final GOAL:

- This sequence drives the entire organization to a common goal -> all departments must work together to achieve this goal

- Communicate the long term strategy throughout the organization

- Align project portfolio to this strategy

Together towards a common goal
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General rule: Scope definition

Especially important when experienced staff is leaving

WHY

WHAT

HOW

SCOPE
On and off-line maintenance

- If maintenance can be done on a safety equipment in a ‘state’ where the equipment is no longer required by technical specifications - plan it accordingly
  - Example: HP safety injection pump is no longer needed when T° RCS < 90 °C - maintenance needs to be done during the outage
  - Exception: Maintenance on diesels is performed during a ‘diesel outage’. Small outage every 18 months + ten-yearly outages

- General rule: Limit maintenance during an outage, only do what must be done:
  - Because of technical specifications
  - Because it can only be done during the outage (primary pumps)
  - Because there are industrial safety issues (room with high temperature during operation)
  - Because there is an economic reason to do it during the outage
Outage preparation

- A good preparation = A sound sequence of phases that are represented by milestones.
- Each milestone needs a person responsible

Launch preventive maintenance (T0-12m)

Modifications Freeze (T0-11m)

Scope Freeze (T0-3m)

Readiness Review (T0-1m)

Outage

After action review (T0+2m)
Outage preparation: Focus on scope

- **Scope** = All activities that need to be done during an outage

- **Scope variation**: Number of activities that are added or removed from the outage project in a predefined timelapse

- Theoretically, you want this:

  ![Diagram](image)

  **$T_0$** = scope freeze

  **Outage**

  **Time**
But in reality:
- Defects arise during normal operation which can only be treated during an outage
- Delays in modification process with work orders that are added after scope freeze
- Spare parts that are not delivered on time -> work orders are removed from the scope
- Number of maintenance plans not 100% up to date -> work orders are added manually
- Etc.

$T_0 = \text{scope freeze}$

Outage preparation: Focus on scope

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Outage preparation: Focus on scope

- This scope variation cannot be avoided, but it needs to be minimized.
- A process is needed to avoid scope variation -> additional work packages need to be challenged by senior management.

\[ T_0 = \text{scope freeze} \]
Outage preparation: Scope at Tihange NPP

BEFORE AN OUTAGE

- Freeze scope 3 months before an outage (best practice: 11 months?)
- Weekly follow up of scope evolution, each team that adds or removes a work order needs to justify this scope variation
- Scope challenged by outage project team
- Weekly follow up of scope KPI by top management

DURING AN OUTAGE

- Similar system but daily follow-up of scope variation
- Scope challenged by outage project team
Outage preparation: Scope at Tihange NPP

AFTER AN OUTAGE

- Analyse scope KPI
  - Scope growth
  - Scope survival
  - Scope churn
- Define origin of scope variation
- Corrective actions are taken before the next outage
Tihange 3 – Before the outage

Scope variation before outage (Tihange 3 2015)

- Modifications: 21%
- Maintenance plans: 23%
- Corrective maintenance: 23%
- In-Out: 5%
- None of the above: 28%
Tihange 3 – During the outage

Scope variation during outage (Tihange 3 2015)

- Modifications: 1%
- Maintenance plans: 9%
- Corrective maintenance: 12%
- In-Out: 25%
- None of the above: 53%
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Outages and long term operation

- Tihange 1, lifetime extension for 10 years (->2025) -> LTO Outages ongoing
- Doel 12, lifetime extension for 10 years (->2025) -> Nuclear Regulatory Body has approved Electrabel investment plan (1/10/2015)
- Depending on the necessary projects or renovations needed, LTO Outages are typically much bigger in scope than a normal even a ten-yearly outage
- Electrabel decided to create a dedicated project structure
- Enormous amount of resources needed (160 people at Doel 12)
Outages and long term operation: Matrix

NPP Manager

- Safety Manager
- LTO Manager
- LTO Team
- Operations Manager
- Outage Manager
- Maintenance Manager
- MNT Outage Manager
- MNT Teams
- Engineering
- Nuclear Safety
- Radioprotection

= outage project team
Poste outage learning

The preparation of the next outage begins ...

... during the ongoing outage.
Poste outage learning

- Electrabel uses a system to track experience within the organization (in the future OE SAP – Operating Experience SAP)
- Anyone can create an ‘experience report’ in order to describe a problem or possible improvement
- Solutions can be offered by those who write the reports
- After an outage, reports are classified by theme and a global analysis will be included in the after action review
Last planned vs actual (Tihange)

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A recipe for outage success? -> There is no miracle cure!

The success of an outage depends on a lot of different factors!

But if a choice has to be made, these are the 3 factors that are most important:

- Outage = n°1 priority -> Common goal at the NPP
- Early and good preparation with focus on scope stability
- Learning organization in order to standardize the outages
Questions?