Subsequent License Renewal Paks NPP, Hungary

Status and challenges

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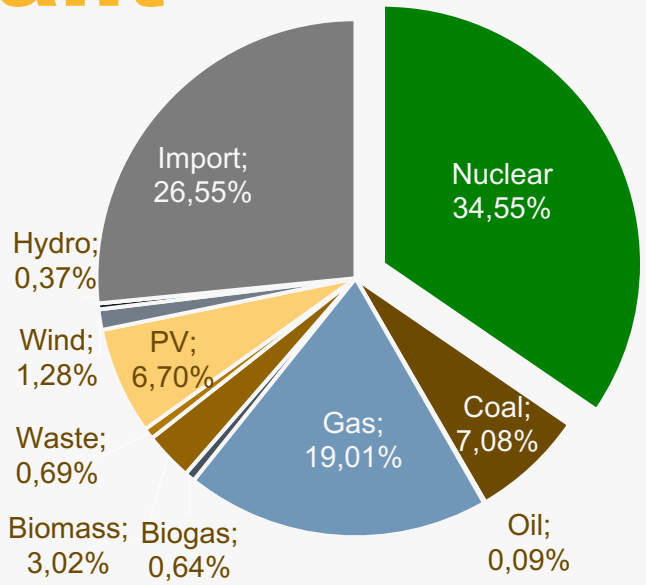
MVM Paks NPP

PAKS Nuclear Power Plant



Public owned Company, the only NPP in Hungary

Connected to grid: 1982-87, design life 30 years

Licenced lifetime: 2032-2037, (+20 years)

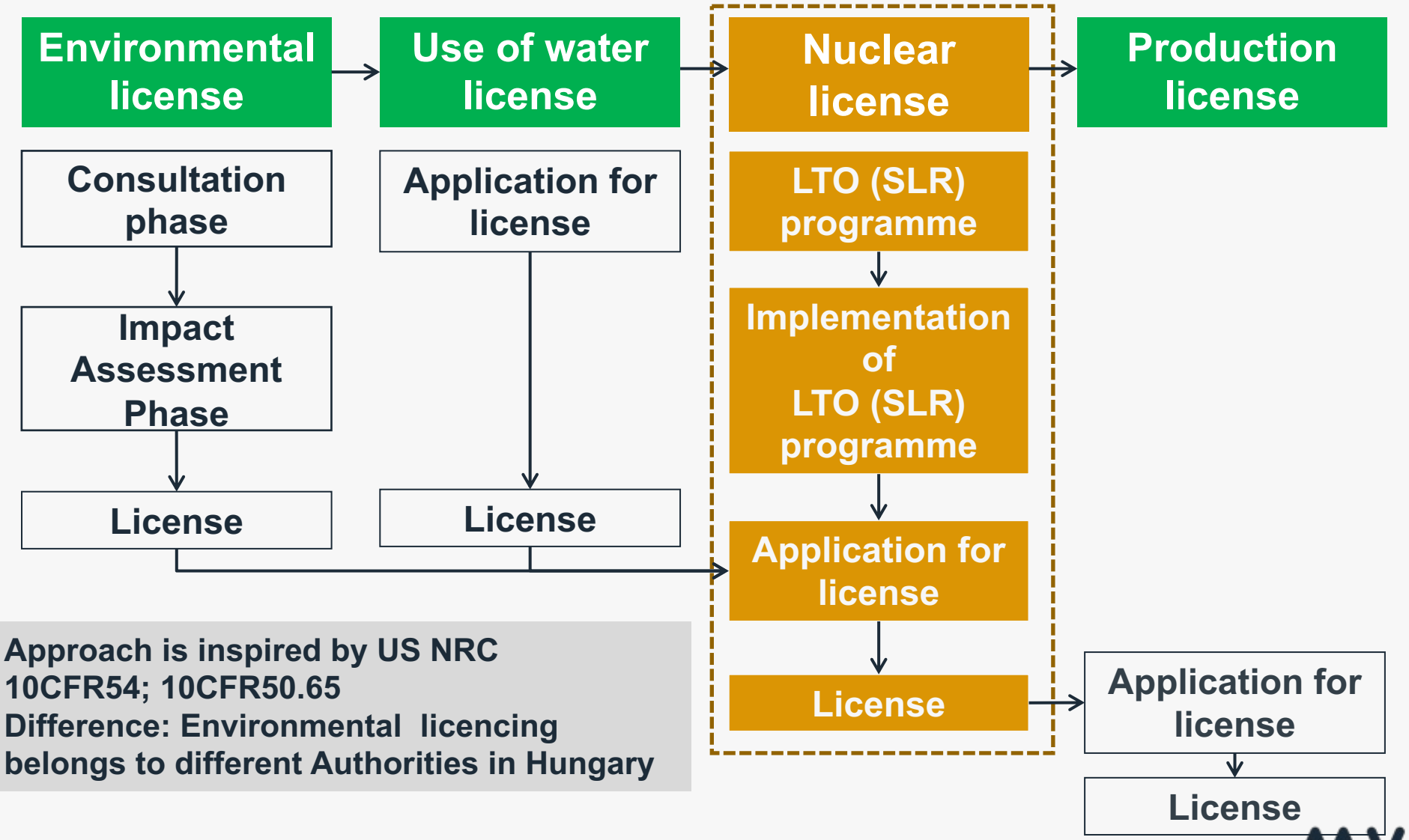
Power uprated to 506-509 MW

15 month fuel cycle, 4.7% Uranium with Gd

History of the SLR related activities

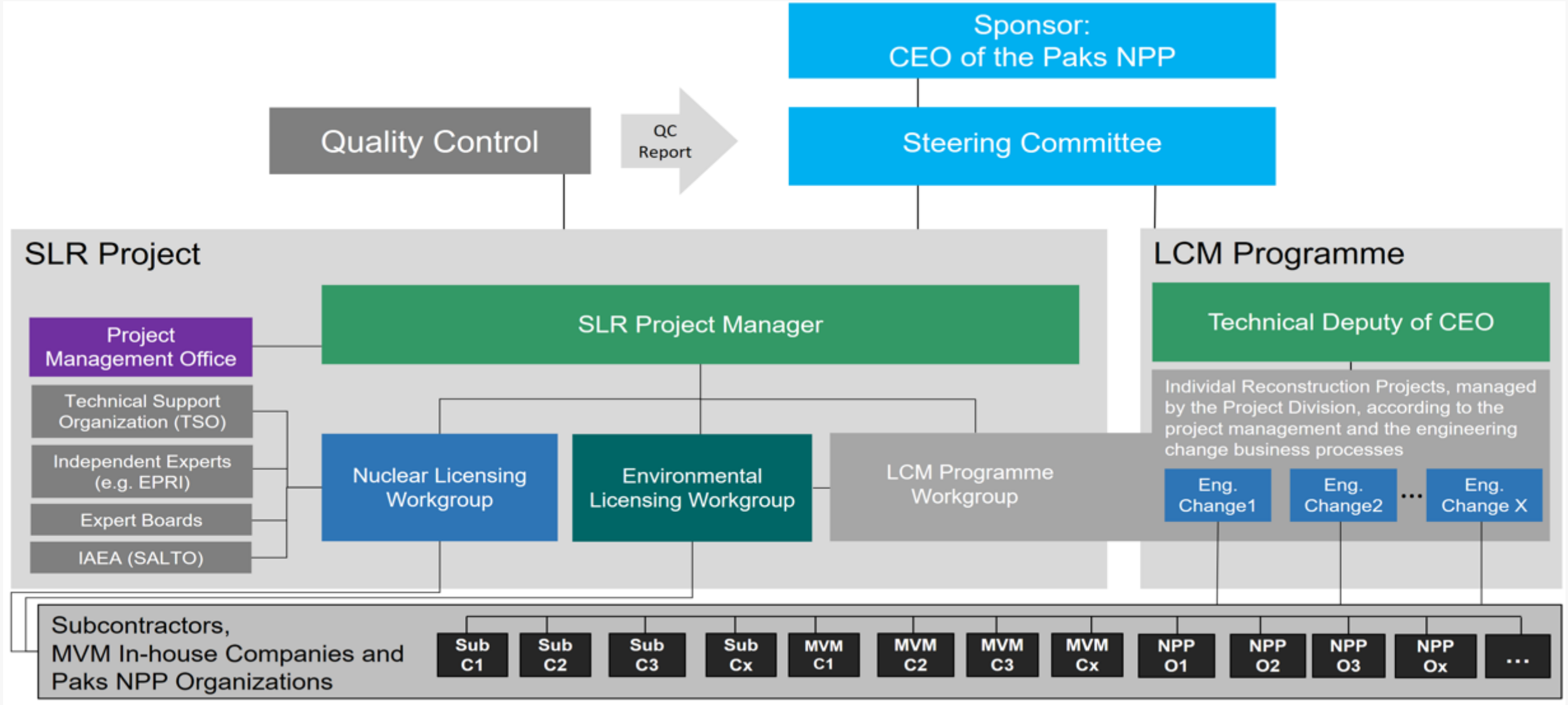
- 2012-2017 1st Licence Renewal of the 1-4 Units +20 years until 2032-37;
- 2016: Hungarian Energy Strategy: Net Zero by 2050 (Paris Climate Agreement);
- 2020-21: Feasibility study for 10 years LTO;
- 2021 Q3: Energy Crisis
- 2022 Summer: Government resolution (2189/2022.) for the 2nd LR;
- 2022 September: Formulation of SLR project and Steering Committee;
- 2022 Q4: Development of detailed project plan;
- 2023 Q1: Feasibility study for 20 years LTO,
  Determination the replacement/upgrading scope/cost;
- 2023 January: Formulation of technical expert committees (mechanical, civil and environmental);
- 2023 October: Notification to European Commission according to the EURATOM Treaty Article 41.
- 2023 December: IAEA extra-budgetary contract for the SALTO peer review and Paks SLR support

LR (SLR) Process



- Approach is inspired by US NRC 10CFR54; 10CFR50.65
- Difference: Environmental licencing belongs to different Authorities in Hungary

SLR Project organisation



Nuclear Licensing Legislation

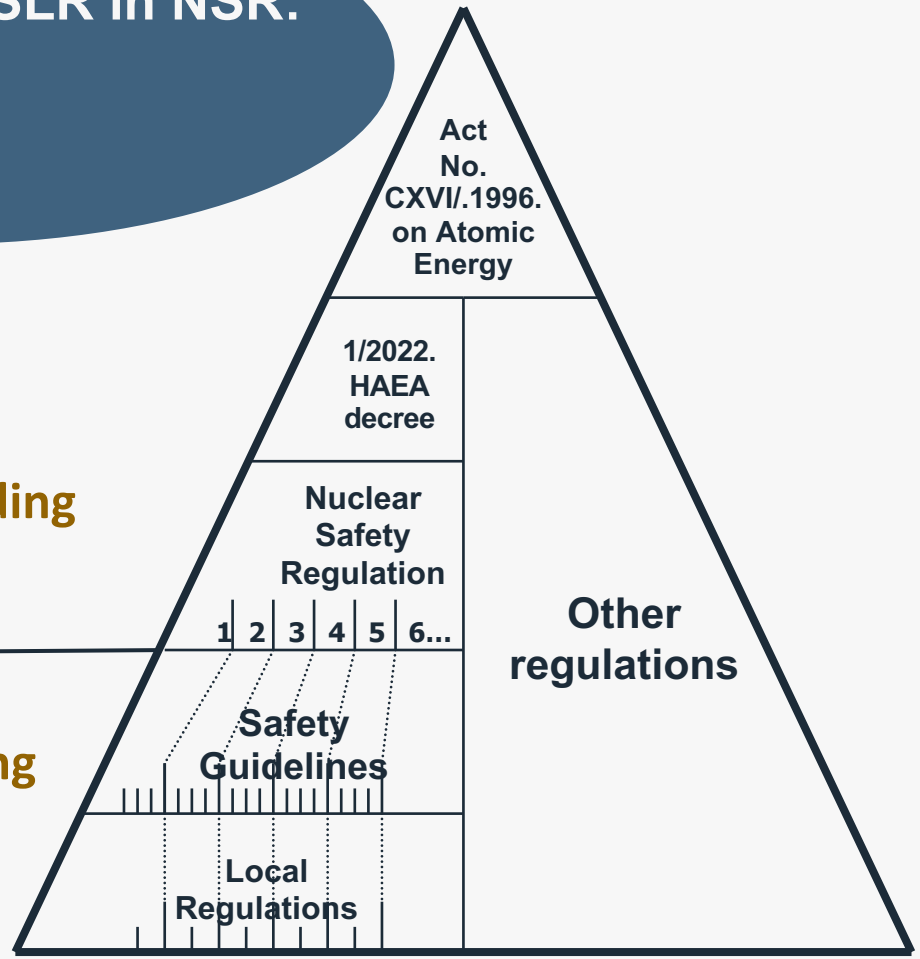
Adoption for LR/SLR in NSR:
- **10CFR54**
- **10CFR50.65**

Guideline 1.28
Regulatory procedures on the operation beyond the design lifetime

Guideline 4.14
Activities to be implemented by the operator to support the License Renewal application for operation beyond design lifetime

Legally binding

Non - binding



SLR requirements still not defined!

Nuclear licensing requirements
(§ 21 of OAH Decree 1/2022. (IV. 29.))

Phase 1: Submission of SLR programme to HAEA

(1) The licensee shall notify the nuclear safety authority of his intention to extend the current operating life of the nuclear power plant units – **not later than four years before the end of their license expiration** – **and** at the same time submits his SLR implementation programme including the safety related LCM programme elements.

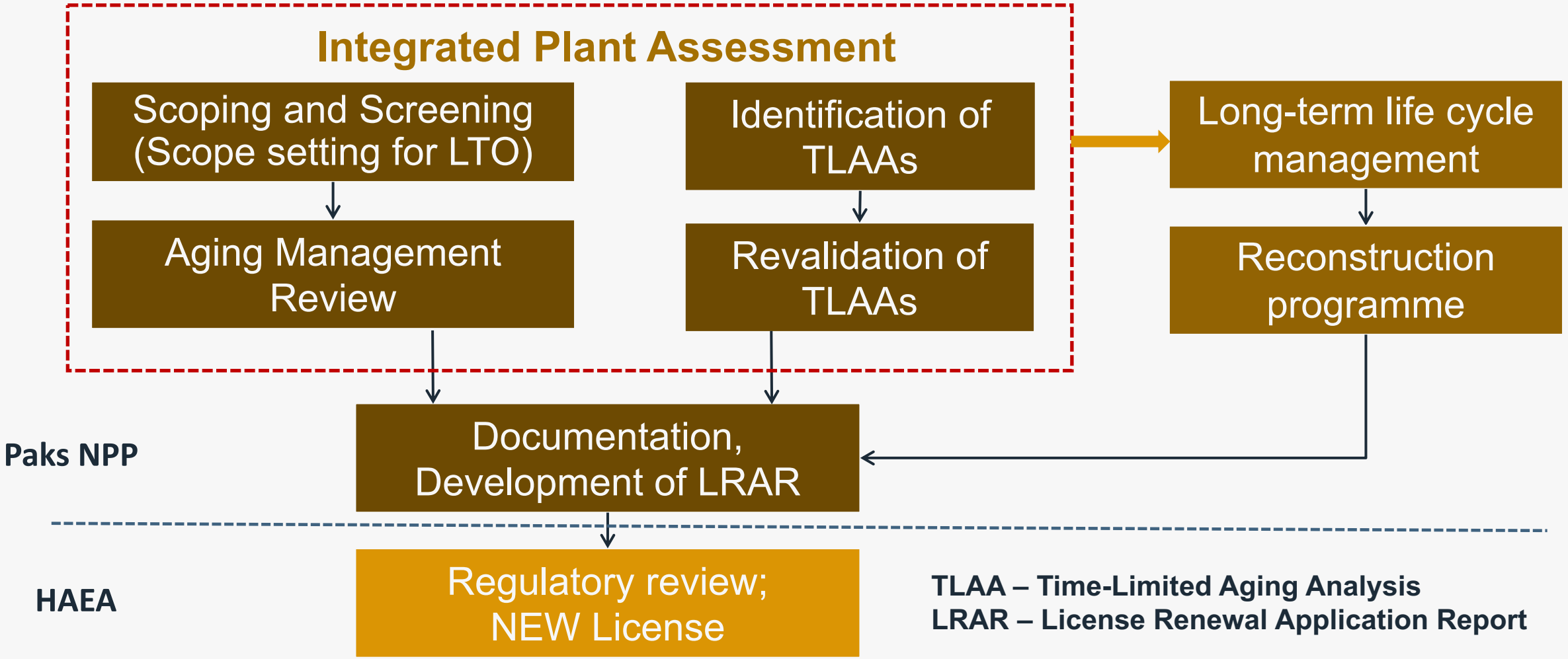
(2) The nuclear safety authority approves the SLR programme and monitors its implementation.

Phase 2: Submission of SLR applications to HAEA

(3) Operation beyond the current operational life is licensed **in a new operating license** issued at the request of the licensee. In the procedure for issuing a new operating license, the nuclear safety authority takes into account the results of the SLR programme and its implementation. The detailed requirements for obtaining the new license are contained in Annexes 1 and 4 of NSC.

NSC Volume 1: § 21 1.2.6.1000. The application for the new license must be submitted **for each nuclear power plant unit no later than one year before the expiration** of their current operating license.

Integrated Plant Assessment (IPA) & License Renewal Application Report (LRAR)



TLAA – Time-Limited Aging Analysis
LRAR – License Renewal Application Report

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Scope setting and screening for AMR

Scope setting:

- Safety related SCs + **NSAS** (~ 20000 SCs/ Unit);
- Justification of the completeness;(diagrams + data base);
- Reproducibility;
- Listed by:
  - ➢ diagram based – mechanical components;
  - ➢ building based – civil structures;
  - ➢ diagram based – I&C and electrical components;

Screening for AMR:

- Long lived Passive SCs;

Methodology for Scoping compiled, independent review started.

Ageing management Review (AMR)

I. Methodology

(10 attributes)

- Methodology & Criteria Document (MCD) development, basis: national, IAEA and USA NRC requirements
- Methodology of AMR of passive SSCs (mechanical, civil and E&IC)
- Definition of the scope of existing Component (group) Specific AMPs (CSAMPs) and „operative" AMPs
- Methodology of AMR for active SSCs
  1. Scope of Program: critical locations & degradation mechanisms
  2. Mitigating and preventive actions
  3. Parameters monitored
  4. Detection of the ageing effects
  5. Monitoring, trending, condition evaluation
  6. Acceptance criteria
  7. Corrective actions
  8. Confirmation process, increase of the CSAMP effectiveness
  9. Administrative controls – QA, coord., documentation
  10. Operating experience

II. Review

- Review of CSAMPs and other, operative AMPs
- Proposals for modification of CSAMPs, development of new CSAMPs
- Review of adequacy of applied programs (MEM, Preventive maintenance etc.) for „active" SSCs (including replaceable SSCs)

IV. Documentation

- Documentation of methodology of AMR (meeting the requirements for SLR Programme (SLRP) licensing)
- Documentation of AMR results (meeting the requirements for SLR Programme (SLRP) licensing)
- Proof of compliance with domestic nuclear requirements
- **Determination of additional tasks to be managed in the SLR Programme**

One-time inspection for Condition Assessment

I. Methodology	• Methodology & Criteria Document (MCD) development, basis: national and USA NRC requirements • Data scope definition (mechanical, E&IC and civil for each section above)
II. Implementation of condition assessment	• **Supplement to regular in-service inspections** • Considering results of reviewed TLAAs (e.g. RPV baffle-former bolts UT inspection) • Definition of „critical locations” (based on strength and fatigue calculations) • Based on the programme supplemented and approved by regulatory body (HAEA)

III. Documentation	• Documentation of methodology of CA (meeting the requirements for SLR Programme (SLRP) licensing)
	• Documentation of CA results (based on MCD), CA Review Reports for:
	  • Mechanical → SC1 for each main component
	  • Mechanical → CSAMP commodity groups
	  • Civil → buildings
	  • E&IC → CSAMP commodity groups
	• Proof of compliance with domestic nuclear requirements

Ageing management programmes

Main features:

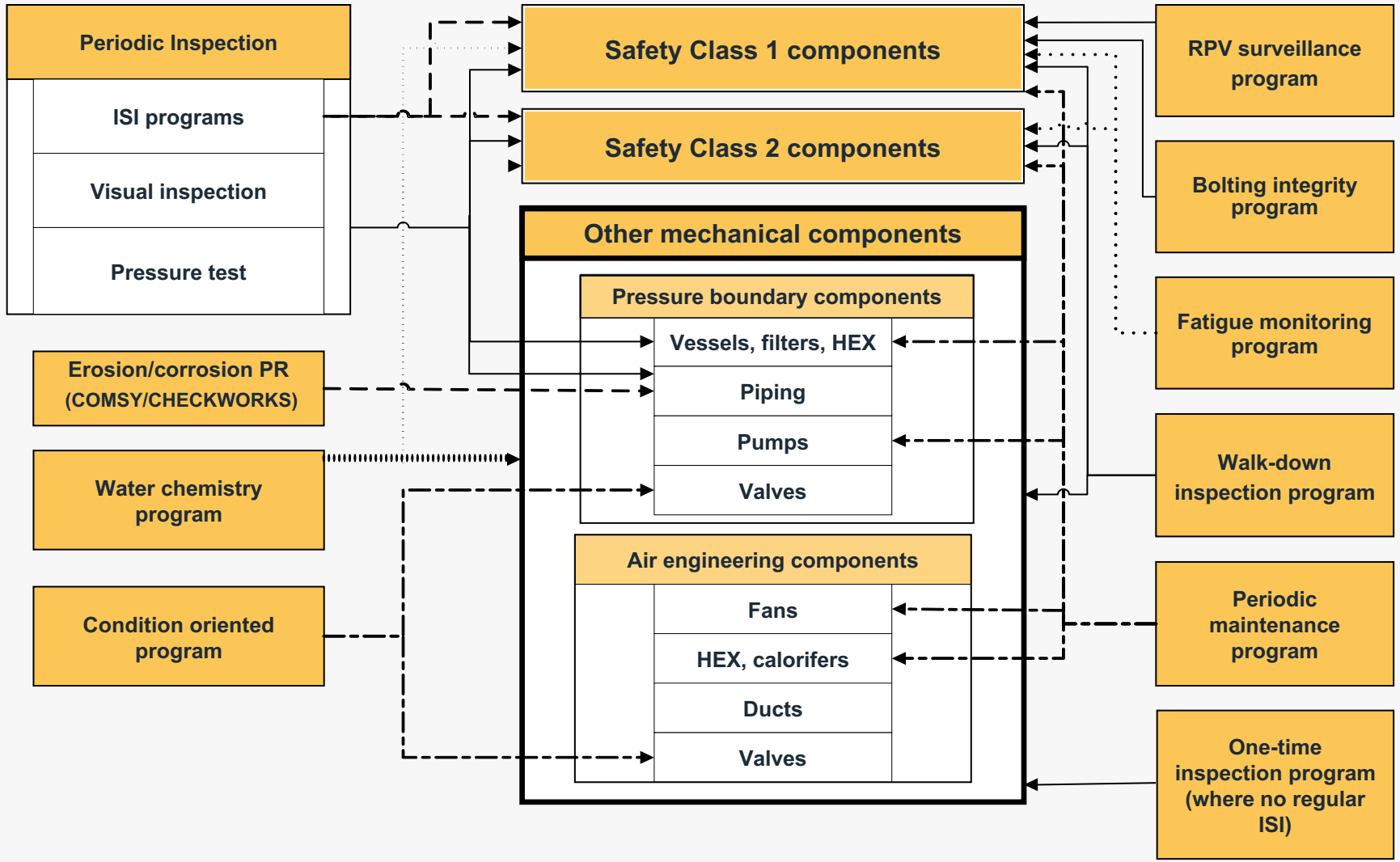
- **Based on the US NRC GALL (NUREG-1801), and updated by GALL-SLR (NUREG-2191) and IAEA IGALL AMPs**
- **~150 AMPs were developed for passive safety class components (component or commodity groups oriented)**
- **Active components are managed by the Maintenance Effectiveness Monitoring (*MEM)***
- **Very detailed programmes, 50 to 150 pages each**
- **Includes references to other operative AM programs (e.g. ISI, water chemistry, condition oriented programs, etc..)**
- **Living programmes (annually updated according to the new R&D results and OPEX (e.g. EPRI, EU NUGENIA) and WANO & IAEA failure databases)**

AMPs attributes

1. Scope of program (ageing eff./degradation mech. and critical locations)
2. Mitigation and preventive measures
3. Parameters to be monitored
4. Detection of ageing effects/degradation mechanism
5. Monitoring, trending, condition assessment
6. Acceptance criteria
7. Corrective actions
8. Feedback, efficiency and improvement of AMPs
9. Administrative control, quality assurance, coordination, documentation
10. Feedback from the OPEX and condition of the component

Attributes are in compliance with the HAEA SG 4.12 and with the U.S. (GALL & SLR-GALL) and with IAEA Safety Guide (SSG-48) as well.

Plant programmes for AMPs



Time Limited Ageing Analyses

- 30 + 1 new calculations was identified (RPV supports);
- New calculations performed (when necessary);
- State-of-the-art methods is applied:
  - most important (Class 1-3) **mechanical components:** design review is performed based on ASME BPVC III requirements;
  - all **building structures** are checked against the EUROCODE;
  - all safety related **I&C components** are subject to EQ (IEEE 323 or IEC 60780 & 60502) or replacement;

Grouping of TLAAs I.

I. Low-cycle fatigue	• TLAA1 Low cycle fatigue analyses of Class1-2 components (Review of „Load catalogue" started) • TLAA6 Thermal stratification analyses of Class 1-2 pipelines (procurement started for all group) • TLAA7 Extension of safety analyses corresponding to HELB • TLAA19 Analyses of corrosion allowances
II. EQ (E&IC)	• TLAA2 Environmental qualification E&IC components
III. Embrittlement	• TLAA3 PTS analysis of reactor pressure vessels (procurement started for all group) • TLAA4 Development of p-T limit curves of primary circuit
IV. Building settlement	• TLAA21 Settlement analyses of the main building complex (ongoing)
V. Building integrity	• TLAA18 Leak tightness tests of main building (procurement started)
VI. Fatigue analyses of civil structures	• TLAA11 Fatigue analyses of hermetic penetrations (procurement started for all group) • TLAA12 Fatigue analyses of liners and transient welding • TLAA15 Fatigue analyses of spent fuel pool liners • TLAA25 Fatigue analyses of spent fuel rack structure • TLAA27 Fatigue analyses of containment hermetic gates

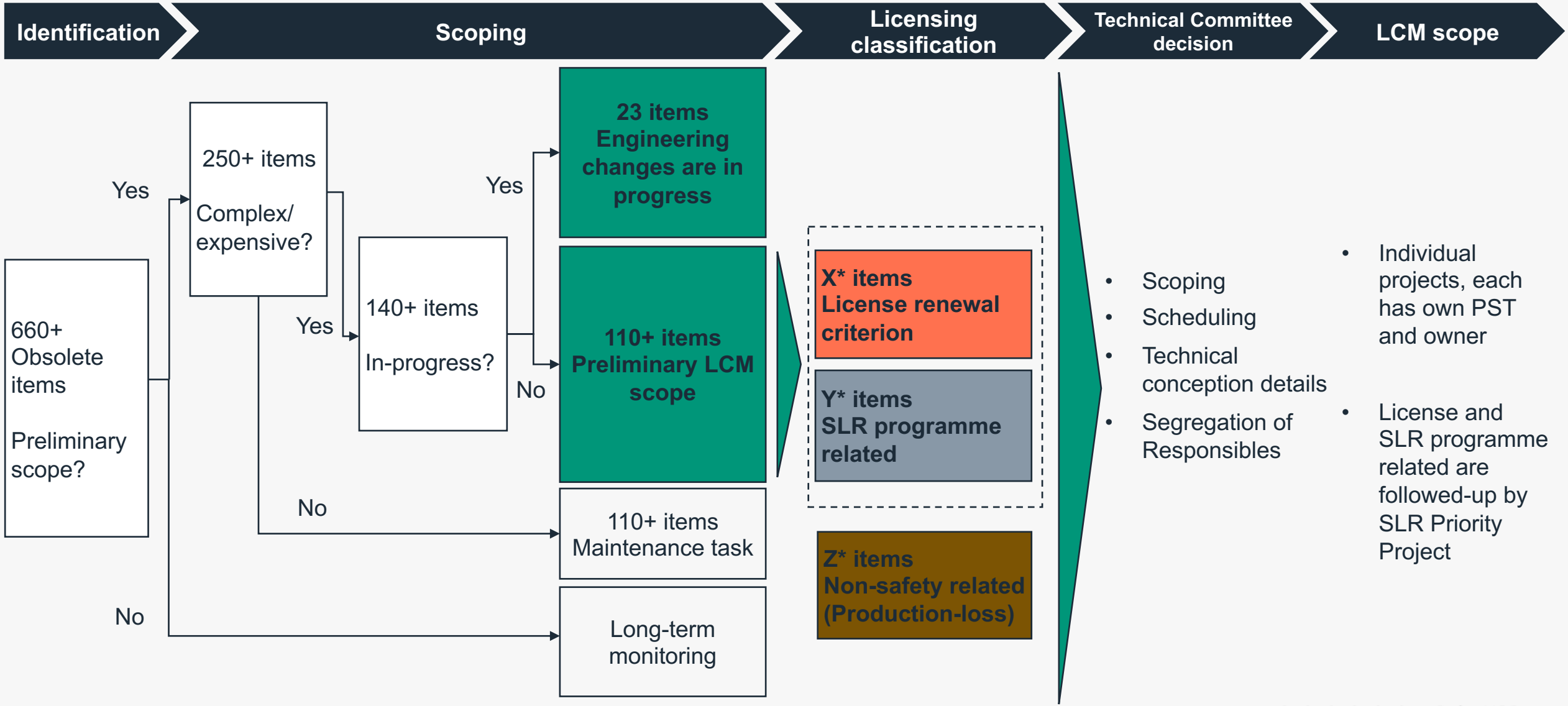
Grouping of TLAAs II.

VII. Fatigue of lifting equipment	• TLAA14 Fatigue analyses of safety-related cranes (procurement started for all group) • TLAA26 Fatigue analyses of refuelling machine
VIII. Crack-propagation analyses and high cycle fatigue	• TLAA5 Crack propagation analyses of the mechanical comp (procurement started for all group) • TLAA8 Flow induced fatigue analyses of RPV internals (vibration) • TLAA9 Flow induced fatigue analyses of SG tubes (vibration) • TLAA20 Fatigue analyses of the flywheel of main circulation pump • TLAA23 Analyses of the cladding of RPV due to interface cracking • TLAA28 Fatigue analyses of emergency diesel generators; TLAA29 Fatigue analyses of MCP impeller and head
IX. Changes in material properties (mechanical)	• TLAA10 Analyses of RPV internals due to changes in material properties (ongoing for all group) • TLAA13 Thermal embrittlement analyses of mechanical components (22K) • TLAA16 Analyses of SG tubing due to changes in material properties
X. Changes in material prop. (civil)	• TLAA17 Analyses of heavy concrete structures due to changes in material properties (technical task defined) • TLAA30 Lifetime analysis of the RPV shaft thermal insulating structure
Other	• TLAA22 Evaluation of B^{10} depletion in spent fuel pool rack (later) (ongoing) • TLAA24 Analyses of changing in material properties of ceramic thermal insulation of the reactor upper unit • New TLAA: **TLAA31 Irradiation of Reactor Vessel Steel Supports (IGALL TLAA125)** • Documentation of results of TLAA review (meeting the requirements for SLR Programme (SLRP) licensing) • Definition of additional tasks to be managed in the SLR Programme (e.g. modifications)

Independent reviews

IAEA support	• Extra budgetary programme (contracted) • Safety Aspects of Long Term Operation (SALTO) according to SRS No.106 - on-site SALTO missions - on-site SALTO follow-up mission
Independent reviews	• EPRI (USA) – agreed technical offer from EPRI • Other organizations – commercial basis (scope, some TLAAs contracted)
Expert Panels	• Civil engineering (established) • Mechanical engineering (established) • Environmental Protection (established)
Independent technical experts	• 5/2022. (IV. 29.) HAEA decree about the independent technical expert acting in the field of the application of nuclear energy

Life-Cycle Management programme



* Discussion with the HAEA is in progress

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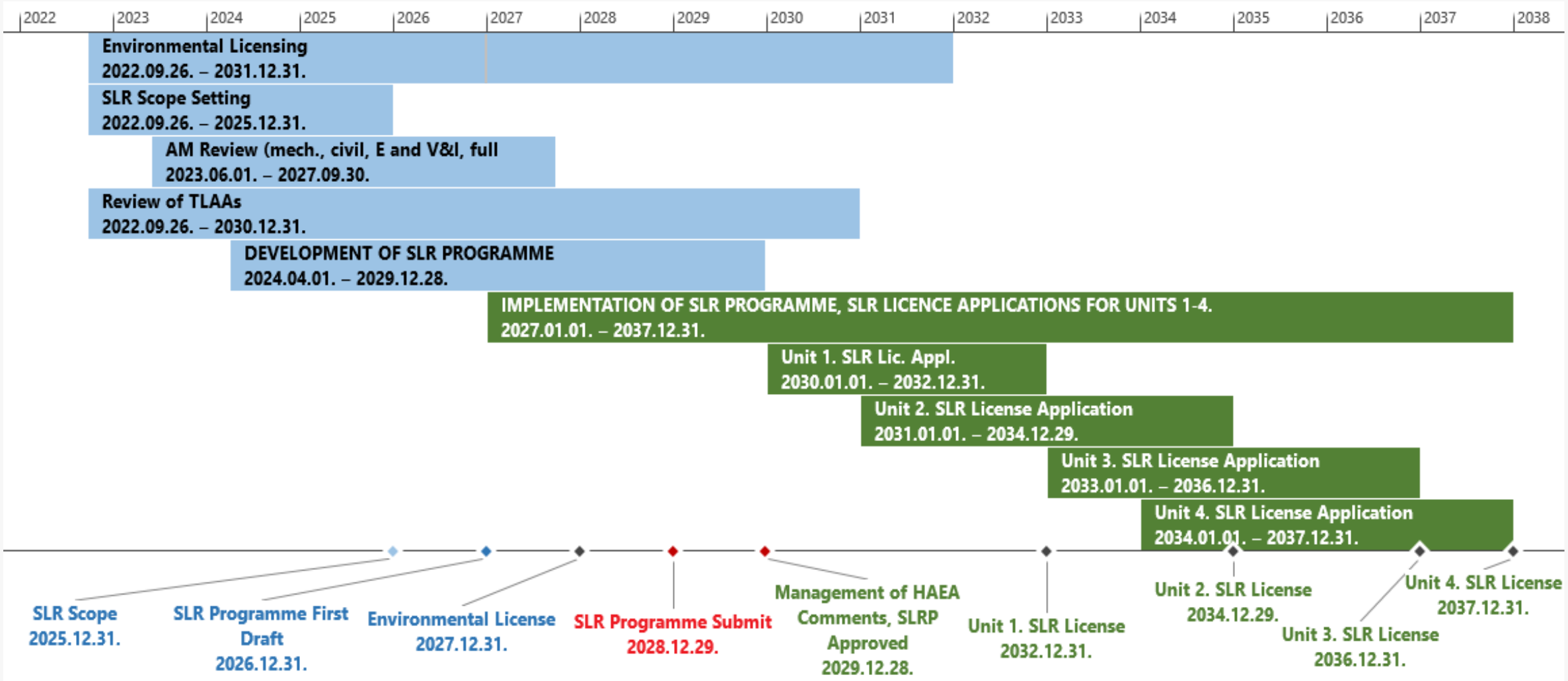
LCM programme – main replacement items

- Inspections of the core barrel baffle bolting in units 1-4; replacement/repair if necessary;
- Reconstruction of fuel handling pool liner and the underlying carbon steel and concrete components;
- Reconstruction of spent fuel pool liner and the underlying carbon steel and concrete components;
- Replacement of cables not complying with the equipment's environmental qualification;
- Full or partial replacement of diesel generators for units 1 and 2;
- Supply units, limit switch and signal transducer instruments replacement;
- Replacement of obsolete pressure and pressure difference gauge transmitters;
- 0,4kV RTZO and 06F model distribution equipment control, interlock, and automation circuit technological overhaul;
- Main Control Room and Emergency Control Room, Auxiliary Building of the Plant control room panel and board devices, equipment;
- Control and Protection System control rod drive replacement;
- Reactor protection systems radiation detectors, amplifiers, interface modules replacement;
- Reactor protection systems hardware overhaul.

Paks NPP Units 1-4 SLR challenges

- Paks 2 EU agreement;
- Tough timing to gain licenses;
- Regulatory requirements for SLR still not defined;
- Paks 2 construction impact for Paks NPP safe operation;
- Environmental licensing + public hearings (Espoo treaty);
- Financing of the technical tasks for environmental and nuclear licensing and replacement/reconstruction;
- Huge reconstruction tasks needed (involving extra human resources);
- Potential increase in outage for implementing reconstructions (e.g. spent fuel pond or cables);

Roadmap for SLR Licensing



Conclusion

- SLR project is launched at the Paks NPP to achieve the government goal **to assure the safe and long term energy supply** in Hungary;
- SLR main technical tasks comply with U.S. NRC 10CFR54 and 10CFR50.65;
- Technical basis of LTO is established by:
  - Environmental impact assessment and licensing
  - Nuclear licensing incudes:
    - Integrated Plant Assessment (Scoping & Screening, AMR, One-time inspection, etc.);
    - Time Limited Aging Analyses (TLAAs)
    - Development of SLR AR;
- Main SLR Project tasks have already started (scoping, AMR and TLAAs revalidation)
- SLR is not just a repetition („copy”) of LR