



Requirements for Break Preclusion in the Finnish EPR plant

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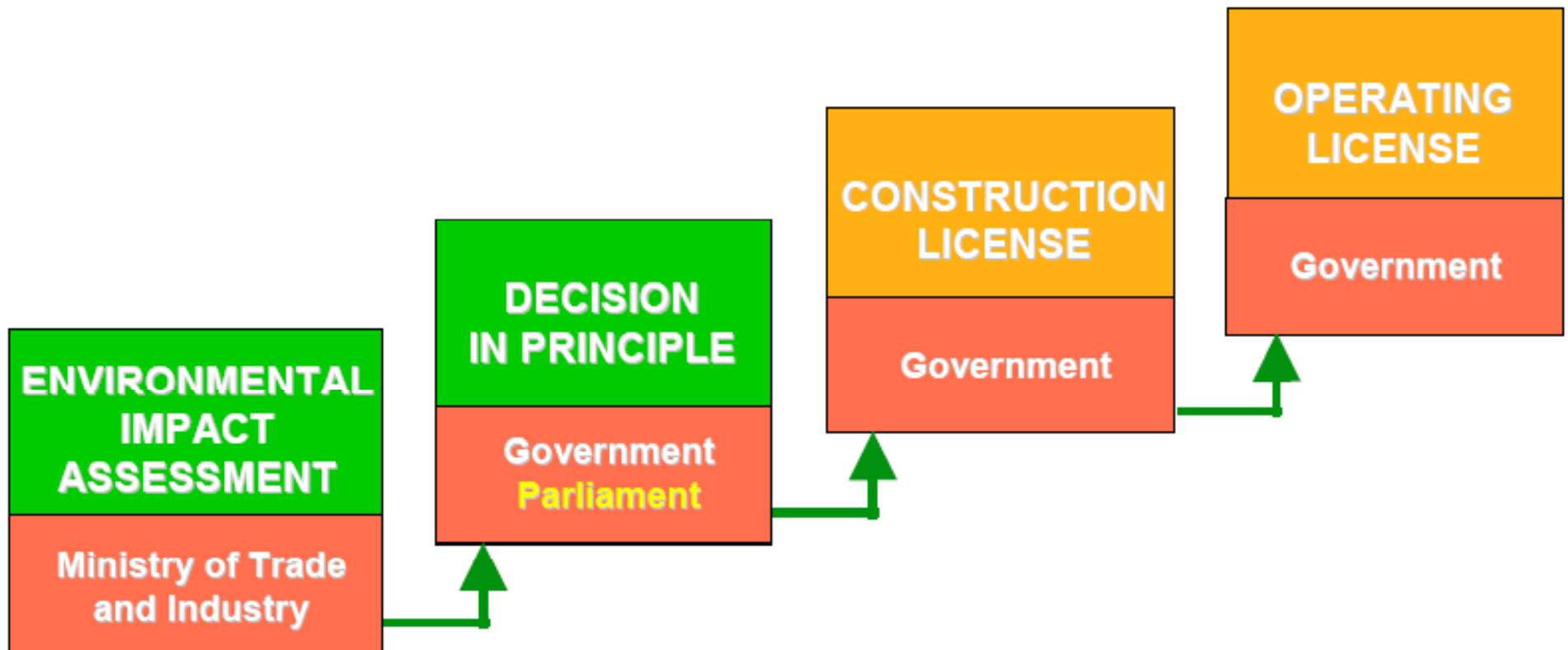
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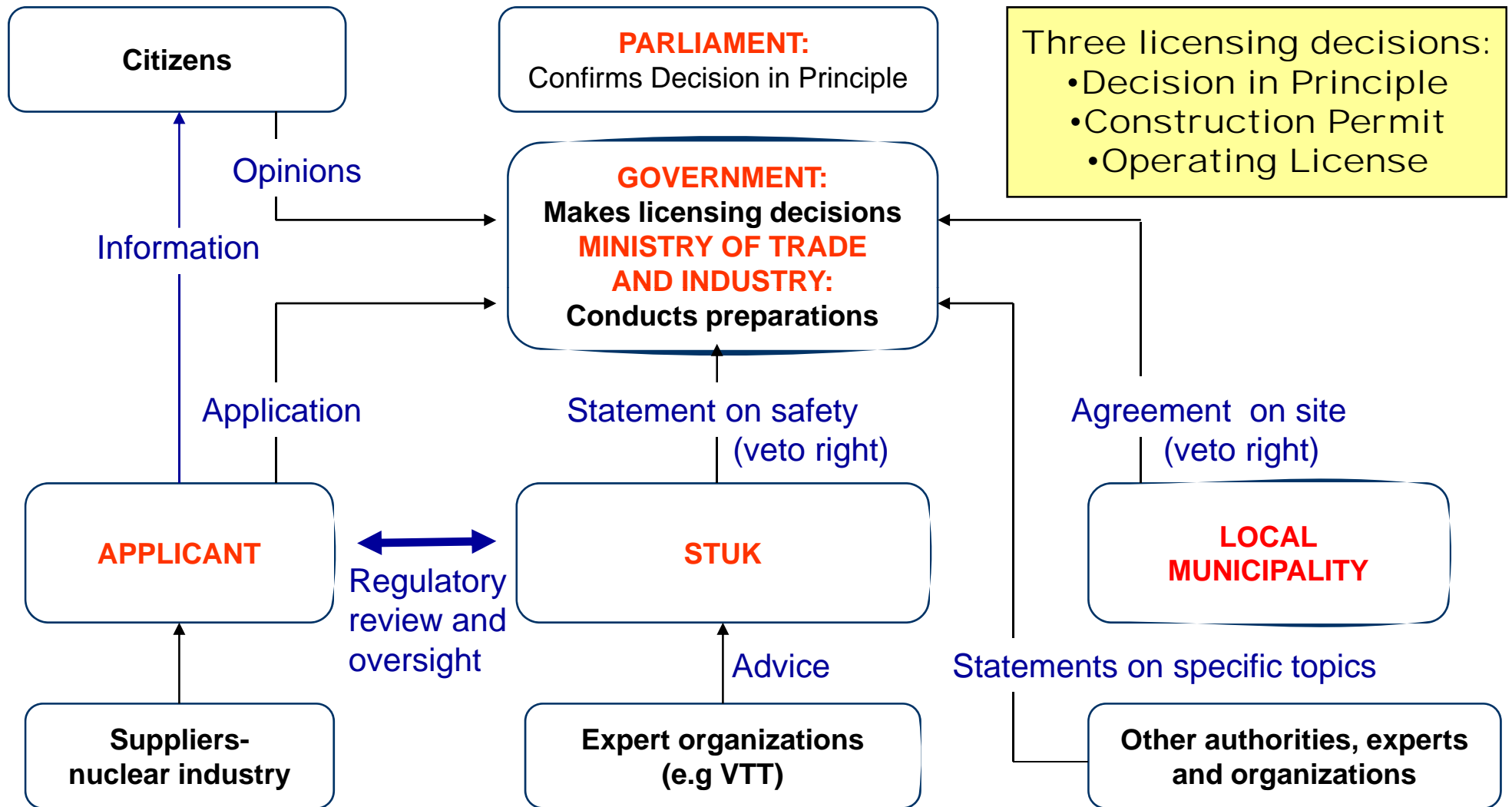
Topics

- ❑ Finnish licensing concept
(decision in principle, construction & operation licences)
- ❑ Safety requirements in Finland - defence-in-depth -approach
 - ❑ Loss of coolant accidents
- ❑ Break Preclusion
 - ❑ Requirement on provision against pipe breaks
- ❑ Break Preclusion Implementation

Licensing Approach in Finland



Licensing approach in Finland



Safety requirements in Finland

Defence-in-depth approach: loss of coolant accidents

- Postulated loss-of-coolant accidents are important for defining the design targets for
 - fuel,
 - reactor core,
 - mechanical structures, and
 - safety systems,as well as for setting respective operational limits for them.
- They also give a basis for assessing the consequences and acceptability of design modifications

Safety requirements in Finland

Defence-in-depth approach: loss of coolant accidents

- ❑ Design basis requirements based on postulated LOCA's take into account
 - ❑ experience from the safety systems at the existing plants: do not remove the protective features that are proven to be feasible (e.g., fuel and core design limits, ECCS, containment)
 - ❑ development of technology: make safety improvements that are reasonably achievable
 - ❑ need to provide protection against unforeseen events or events left outside the design basis

Safety requirements in Finland

Defence-in-depth approach: loss of coolant accidents

- ❑ Eliminate the possibility of sudden large breaks of the reactor coolant circuit by applying Break Preclusion (BP) principle
- ❑ Postulate a sudden guillotine break of the largest pipeline, but limit the physically possible maximum break flow areas (and consequent fluid transients in the reactor coolant circuit) by means of pipe whip restraints
 - ❑ use the maximum estimated break flow as the design basis for specific mechanical structures
- ❑ Postulate a loss of coolant accident that is equal to a free flow from both ends of the broken pipe
 - ❑ use the large break LOCA as the design basis for safety systems, thus providing protection also for unforeseen events
 - ❑ study the actual strength of mechanical structures under influence of dynamic forces, by using best estimate assumptions for physical phenomena

Safety requirements in Finland

Defence-in-depth approach: loss of coolant accidents

- ❑ Break Preclusion (BP) principle used to eliminate the possibility of sudden large breaks of the reactor coolant circuit must involve:
 - ❑ qualified construction (materials, fabrication, QA), operation (loadings, chemistry), and surveillance to prevent major cracking throughout plant life
 - ❑ strength analysis to demonstrate adequate safety margins in all design-basis load conditions
 - ❑ effective in-service inspections of welds and other stressed areas
 - ❑ effective leak detection and verification of the leak-before-break principle

Safety requirements in Finland

Defence-in-depth approach: loss of coolant accidents

- Limitation of the break flow area after a potential guillotine break by restricting the pipe motion is required in order to limit dynamic forces on mechanical structures. Vital structures that need to preserve their integrity after a sudden (1 msec) limited break with adequate margin are among others
 - support and anchoring structures of the main components
 - reactor pressure vessel internals, including fuel (mechanical strength) and control rod drive systems
 - steam generator tubes and other internals
 - main coolant pump flywheels
 - reactor containment internals

Safety requirements in Finland

Defence-in-depth approach: loss of coolant accidents

- Requirement to use double ended leak as the design basis ensures that safety margins remain at the level achieved in the current PWR's. Large break LOCA must be taken into account as the design basis for
 - nuclear fuel (thermal and hydraulic design)
 - reactor core (thermal and hydraulic design)
 - emergency core cooling systems
 - containment, including penetrations
 - environmental qualification of equipment inside the containment

Safety requirements in Finland

Defence-in-depth approach: loss of coolant accidents

- Beyond design studies are made to assess the actual mechanical strength under the influence of dynamic forces that would result from the maximum free leak from both ends of the broken main coolant pipe
 - best estimate assumptions can be used for physical phenomena such as break opening time
 - items to be looked at are the fuel, reactor vessel internals, steam generator tube bundle and its supports, steam generator primary side manhole and main coolant pump flywheel

Break Preclusion

YVL Guide 3.5 Requirements on Provision against Pipe Breaks

All safety implications of 2A breaks shall be considered, also in the secondary circuit:

- rise of ambient pressure, temperature & humidity
- reaction forces on components, supports & internals
- leaks, flooding & impurities

Local dynamic effects of pipe whip, missiles and jets shall be limited by

- physical separation
- whip restraints (WR) as per SRP 3.6.2 - primarily

MCL construction without WRs possible

- high quality renders large cracks unlikely
- efficiently detected with ISI and leak monitoring
- no unpredictable/detectable failure mechanisms like water hammer or corrosion

No WR alternative for other systems presented

- case-by-case safety assessment

Break Preclusion implementation

Preventive measures

- Design, materials and manufacturing: minimized welds and stress concentrations, forged main parts, integrally forged nozzles, weldability
- Operation condition assessment: thermal transients, vibrations, water chemistry, external loads
- Failure modes and degradation: fast fracture, thermal ageing, erosion, corrosion, IGSCC

Leak before break

- Life-cycle growth and stability of reasonable initial defect
- Multiple life-cycle through-wall growth and final configuration
- LBB margin demonstration on stability and leak detection as per SRP 3.6.3

Surveillance

- Transient book-keeping and comparison with design transients
- Water chemistry monitoring during operation and shutdowns
- Diverse and independent leak detection systems
- In-service inspections

Thank You!

