TRACTEBEL Engineering
GDF SUEZ

# INNOVATIONS IN GEN III DESIGNS & MODERNISATION OF EXISTING NPP – AN OPERATOR'S POINT OF VIEW

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CHOOSE EXPERTS, FIND PARTNERS

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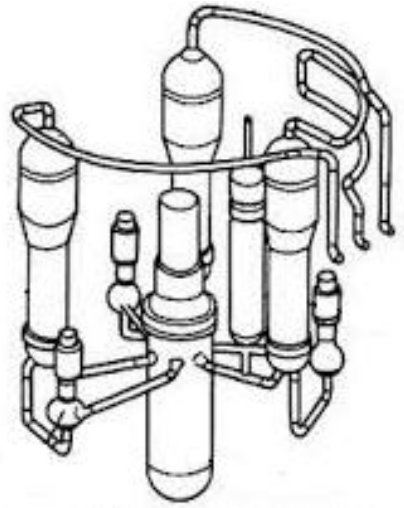
# GENERATION III/III+

## Origin

- Europe - Technical guidelines for the next generation - Groupe Permanent chargé des réacteurs nucléaires
  - Significant Safety Improvement → Early & Large Releases practically eliminated
  - Design basis considers Multiple Failure & Severe Accident
  - Probabilistic Safety Assessment analysis used for PIE definition
  - Evolutionary designs
- WENRA safety objectives for new NPP designs
  - Design Extension Conditions
  - Defense in Depth
  - Waste Management: reduce as far as reasonably achievable
- IAEA Specific Safety Requirements – 2/1

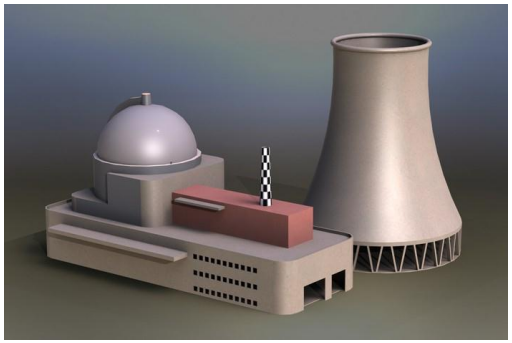
# GENERATION III/III+

## Origin



- USA - Single Combined Construction and Operating License (COL)
  - Improve Licensing Process Efficiency, Predictability
  - Reduces Financial Risk
  - COL Granted Prior To Beginning Of Construction
  - Cf. Generic Design Assessment process in UK

  → **Standardization: NSSS → Nuclear Island or complete plant**
- EUR - European Utility Requirements (US URD)
  - Focus on Safety, Competitivity and Operational aspects



# GENERATION III/III+

## Origin

**Reactors with Active Safeguards** | **Reactors with Passive Safeguards**


| | | | |
|---|---|---|---|
| System 80+ | VVER AES92 | AP1000 | PWR |
| EPR | APWR | | |
| ABWR | | ESBWR | BWR |
| SWR1000 | | | |

# GENERATION III/III+

## Operator needs

- No distinct difference between passive and active designs
  - Hybrid plant designs
  - Not the main concern of the future operator
- Nor evolutionnary design nor passive design present a dominating advantage in Safety Case discussions and permitting
  - E.g: UK Generic Design Assessment of EPR and AP1000
  - Safety Case is not the only concern of the future operator
  - Operational comfort and economical margin

# GENERATION III/III+

## Operator needs

- Return of experience of new plant design missing at this moment
  - Less uncertainty in evolutionary designs
  - Revolutionary designs offer opportunity to simplify operations: decrease (classified) equipment
  - Revolutionary designs need to confirm
    - Impact of simplification on operational comfort
    - Reduced maintenance efforts
    - Robustness/flexibility of active safeguards

# GENERATION II

## Plant Improvement

# GENERATION II SAFETY IMPROVEMENTS

## Processes

- Periodic Safety Review
  - WENRA Reference Level as a guideline
  - Continuous process
- Safety Improvements in the Life Time Extension framework
  - Large and/or small scale projects
  - Important investment budgets justified by improved cost/benefit balance
  - License renewal used by authorities as a lever to impose new regulation or solve long lasting discussions
- Non-planned additional Safety Review
  - Stress tests

# GENERATION II SAFETY IMPROVEMENTS

## Changing regulatory framework

- Generic developments
  - WENRA, IAEA: guides
  - New Built guides -> existing plants through Periodic Safety Review or directly imposed.
- Local rulemaking details, provides interpretation, might go further
  - Belgium
    - WENRA Reference Levels endorsed in Royal Decree in 2011
    - New legislation with new absolute release requirements will be issued beginning February 2015
  - Sweden
    - SKIFS 2004:2 / SSMFS 2008:17: New rulemaking for the design and construction
    - Independent Core Cooling Systems requirements 2014: need for new DiD level with fixed systems
  - France
    - DUR, SAM efforts
  - Slovenia
    - New bunker necessary

# GENERATION II SAFETY IMPROVEMENTS

## NPP commissioned in the 70ies

- Main challenges
  - PIE extension from LBLOCA to current Design Basis Conditions
  - Physical separation
  - Qualification / classification of supporting functions
  - Extension of hazard probability ranges
- Non standardised plants
  - NSSS + Large BOP scope
  - Limited number of Nuclear Codes, Standards and Guidelines
  - Local Engineering Companies

→ Non standardised Plant Improvements

# GENERATION II SAFETY IMPROVEMENTS

## NPP commissioned in the 70ies

- Additional bunker/annex buildings
  - Doel 1/2, Tihange 1, Borssele, Beznau, Ringhals 1
  - Building not on critical path - Continuous operation to be guaranteed
  - Increased robustness
  - I&C integration during prolonged outage
  - Complexity added by layout constraints
- Modifications in existing buildings
  - Use of common equipment between DiD levels
  - Important layout constraints
  - Margin assessment of robustness

# GENERATION II SAFETY IMPROVEMENTS

## Limits of Safety Improvements

- Layout limits of reactor building and auxiliary building
  - Physical separation safeguard trains
  - Reactor cavity: Ex-vessel corium coolability in case of limited spreading area
- Changing state of the art
  - E.g. Filtered Containment Venting System
- Safeguard systems
  - Number of Electrical and hydraulic trains
  - Common header systems
- Generation II plants commissioned in ’70 <-> ’80

# GENERATION II SAFETY IMPROVEMENTS

## Reasonably practical safety improvements

- Considerable efforts done
  - PIE GENIII → GENII
    - LOCA -> DBC -> DEC
    - Severe accidents: large and early releases avoided
  - Acceptance Case by Case
- Return on investment not always possible
- Technical limits: Generation III is a target, not an acceptance criterion