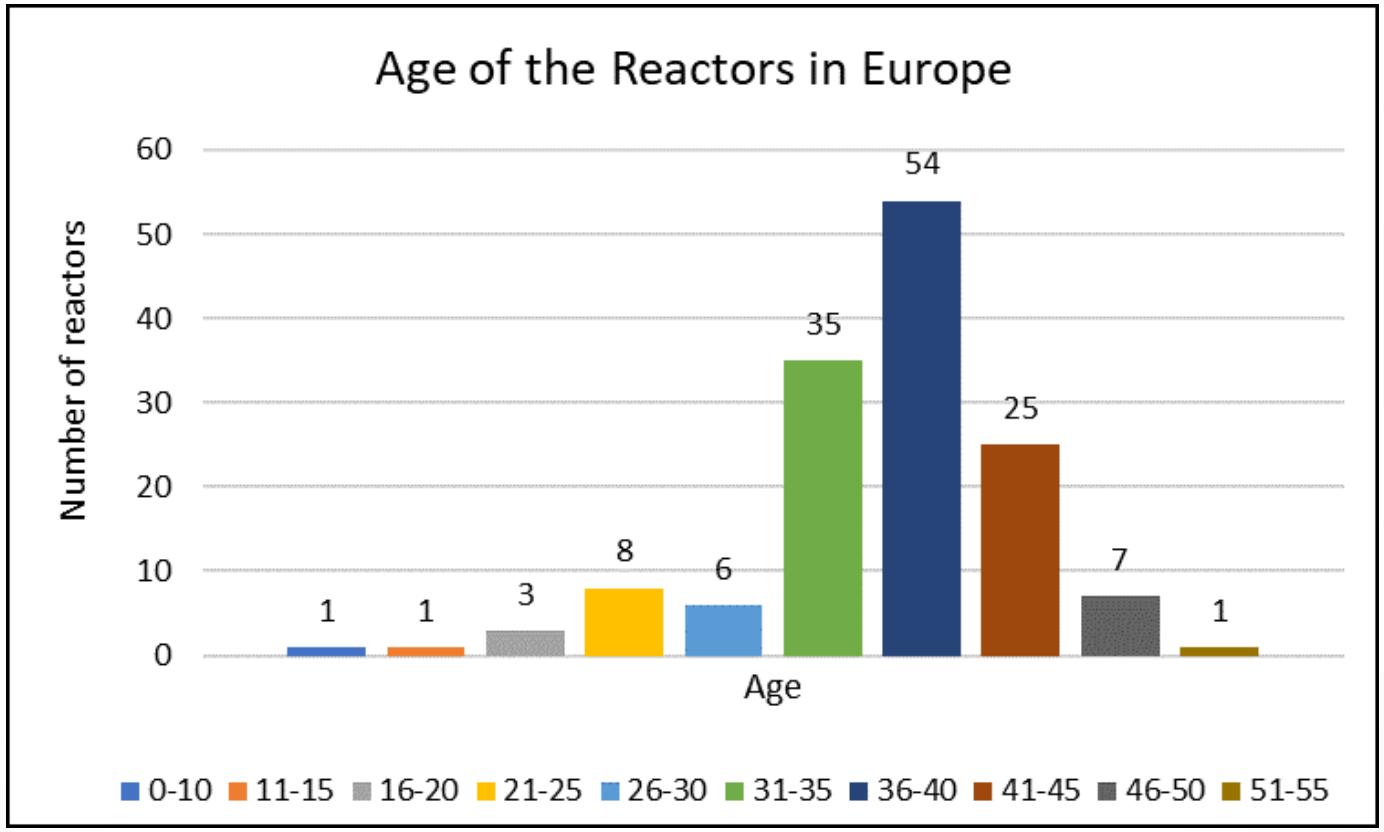
Introduction to the phenomenon of aging of nuclear power plants

Oda Becker
Independent Expert (Risk of Nuclear Facilities)

INRAG Study – “Risks of lifetime extensions of old nuclear power plants”, April 26, Online

Outline

- Age of Reactors in Europe and increased Risks
- Physical Aging and Aging Management Programmes
- Technical and Conceptual Obsolescence and Back-fittings
- Double Standards (EU Directive 2014/87/Euratom)
- Information on Risks and Lack of Transparency
- Conclusions



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Age of reactor fleet

Europe is looking at a fleet of aging reactors, currently planning to continue their operation for a long time

Age of Reactors Status 03/2021

Age in years	0-10	11-15	16-20	21-25	26-30	31-35	36-40	41-45	46-50	51-55	Total
Belarus	1										1
Belgium							4		3		7
Bulgarien					1	1					2
Czech Republic			1	1		2	2				6
Finland								4			4
Framce				4	3	14	21	14			56
Germany						4	2				6
Hungary						2	2				4
Netherland									1		1
Romania		1		1							2
Slovakia				2			2				4
Slovenia							1				1
Spain						2	5				7
Sweden							3	3			6
Switzerland							1	1	1	1	4
UK					1	4	6	2	2		15
Ukraine			2		1	6	5	1			15
Number	**1**	**1**	**3**	**8**	**6**	**35**	**54**	**25**	**7**	**1**	**141**

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Increased Risk

- Life-time extension (LTE) of the aging fleet of nuclear reactors increases the risk for significant radiological releases in Europe.
- Severe accidents can happen in all currently operating European reactors.
- Aging of the reactors increases the risk of severe accidents
- Partial back fitting cannot change the situation significantly

Physical aging (1)

- Physical aging: degradation of structures, systems and components (SSCs) due to variation in temperature, stress, ionizing radiation, chemical processes during operation
- Examples are aging of reactor pressure vessel, primary system components, valves, pumps, concrete structures, electrical systems
- Aging management program (AMP) consists in identifying, monitoring and timely replacement of aging structures

Physical aging (2)

- Aging management only works well with known aging mechanisms and accessible and replaceable SSCs, but
  - Some components cannot be replaced (example: RPV), aging effects reduce the safety margin
  - Some components are hard to access (example: piping in concrete or cable in earth) and monitor
  - Not all aging effects are known
- **Result: Unexpected aging failure**

Technical and conceptual obsolescence

- The plant is out of date compared to current knowledge, standards and technology
- Huge steps forward in technology/standards occurred mostly after major accidents (e. g. Fukushima)
- Changes are often be such that full backfitting is impossible

Limits of Back-fittings

- Back-fittings are impossible, because the plants is built
  - e. g. Protection against airplane crash
- Back-fittings do not meet the required safety level
  - e.g. higher requirements in redundancy (n+2 concept instead of n+1)
  - e.g. higher requirements in diversity
  - e.g. Requirements of physical separation of safety systems
  - e.g. Requirements of safety related systems able to manage a core melt (core catcher, in-vessel retention)
- Back-fittings are postponed for decades
- Back-fittings causes failures

Double Standards

- The design of current reactors (for most of them from 1970/1980) is out of age and would not be accepted today

- Most European countries accept different standards for existing and “new” reactors (Council Directive 2014/87/Euratom has different provisions for reactors with construction license before and after 4 August 2014)

- In many cases, existing reactor designs would not receive a construction license, would the operator apply today. To nowadays standards, their risk is not acceptable.

EU Directive 2014/87/Euratom

The revised Directive Council Directive 2014/87/Euratom defines in Article 8a “Nuclear safety objective for nuclear installations”:

- 1.Member States shall ensure that the national nuclear safety framework requires that nuclear installations are designed, sited, constructed, commissioned, operated and decommissioned with the objective of preventing accidents and, should an accident occur, mitigating its consequences and avoiding:
  - (a**) early radioactive releases** that would require off-site emergency measures but with insufficient time to implement them;
  - (b) **large radioactive** releases that would require protective measures that could not be limited in area or time.

More specific with regard to existing nuclear power plants the Directive states:

- 2.Member States shall ensure that the national framework requires that the objective set out in paragraph 1:
  - (a) applies to nuclear installations for which a construction licence is granted for the first time after 14 August 2014
  - (b) is used as a reference for the timely implementation **of reasonably practicable** safety improvements to existing nuclear installations, including in the framework of the periodic safety reviews as defined in Article 8c(b).

Information on risks

- Operation of nuclear power plants means accepting a residual risk of catastrophic accidents
- To decide whether or not the risk is acceptable, it should be known and transparently communicated to the public
- However, the risk cannot be fully known, since not all processes, state of materials, state of safety systems is fully known
- Even if the risk is known, it is not transparently communicated. Instead, the assessment of the risk is up to the regulatory authority, which then communicates that the plant is “safe”, which means, it adheres to safety regulations.

Lack of Transparency

- Operation of nuclear power plants and the decision on life-time extension (LTE) is within national authority
- However, the risk of operation of nuclear power plants is affecting also citizens across national borders
- There are currently no European regulations on high level requirements for LTE of nuclear power plants
- European countries provide the possibility for public participation for new builds of nuclear power plants
- Life-time extensions, even if of greater impact considering the risk, do not necessarily require public consultation process

Conclusions

- Nuclear power plants are very complex plants, and aging is a multifaceted process, complex on its own, requiring multiple disciplines for understanding
- In principle, physical ageing can be counteracted with age management program (monitoring and timely replacement), but this is not always possible or is avoided for economic reasons..
- Obsolescence is a fact, back-fitting is usually not possible for technical reasons or is avoided for economic reasons.
- Combination of physical ageing and obsolescence leads to a significantly increased risk that would be present in Europe for a long time when considering current plans.
- Transparent information about risks and the participation of the population in decisions are necessary.