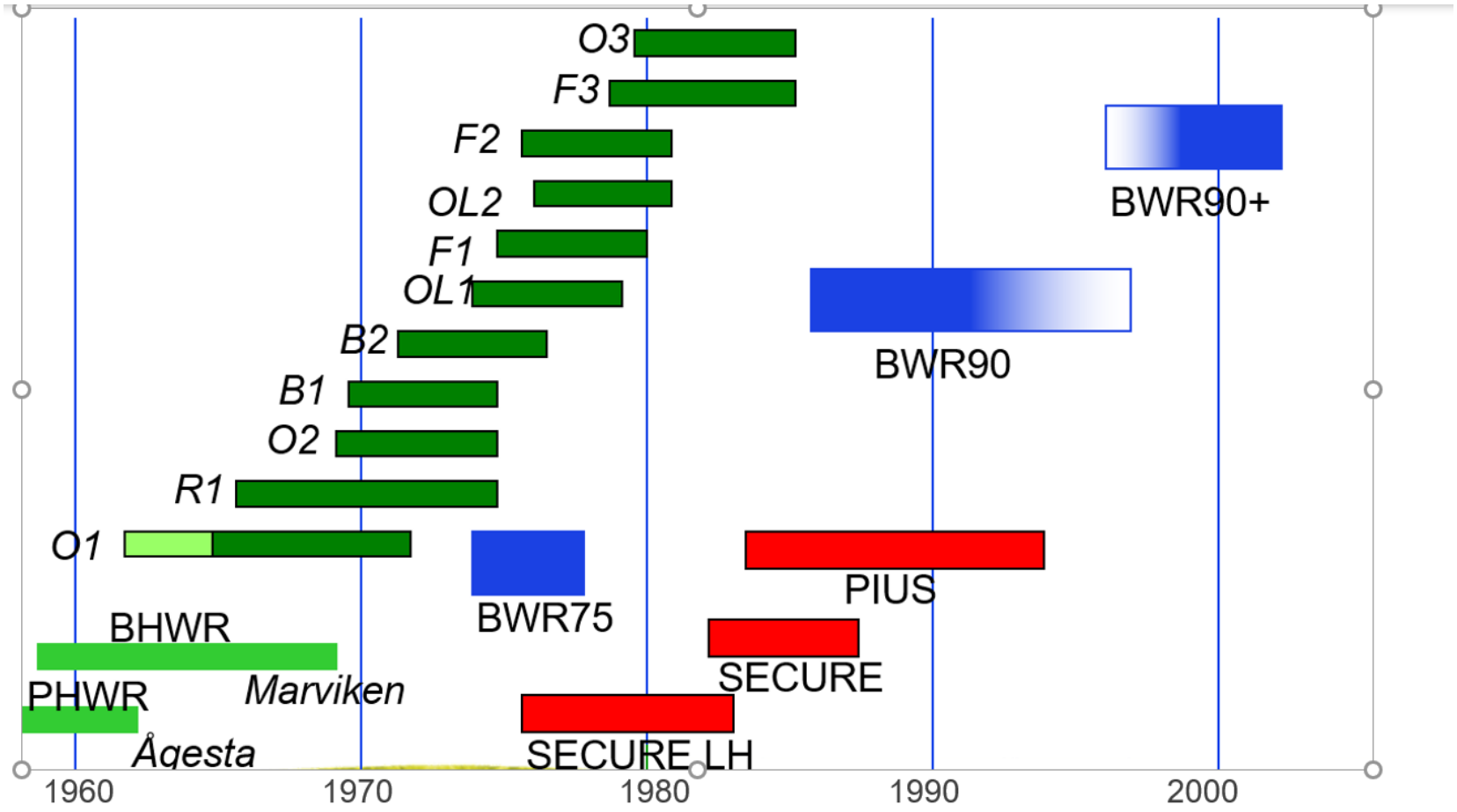
Dokument-ID: *Enligt PRIME*
Revision: *Enligt PRIME*

Passiva säkerhetsfunktioner-igår och idag

Tomas Öhlin Fellow Engineer

* Electronically approved records are documented in the Electronic Document Management System (PRIME).

ASEA-ATOM utveckling



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Aktiva säkerhetsfunktioner

Vissa säkerhetsfunktionerna i dagens reaktorer i Sverige baseras på passiva funktioner och vissa på aktiva funktioner

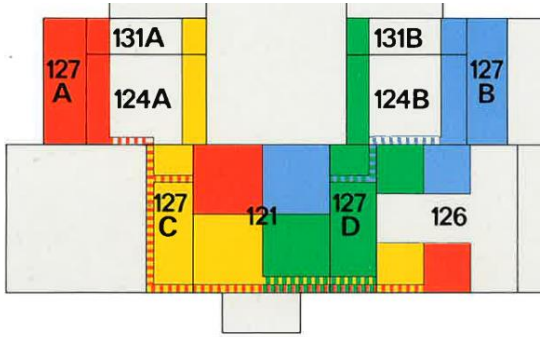
Exempel på en aktiv funktion

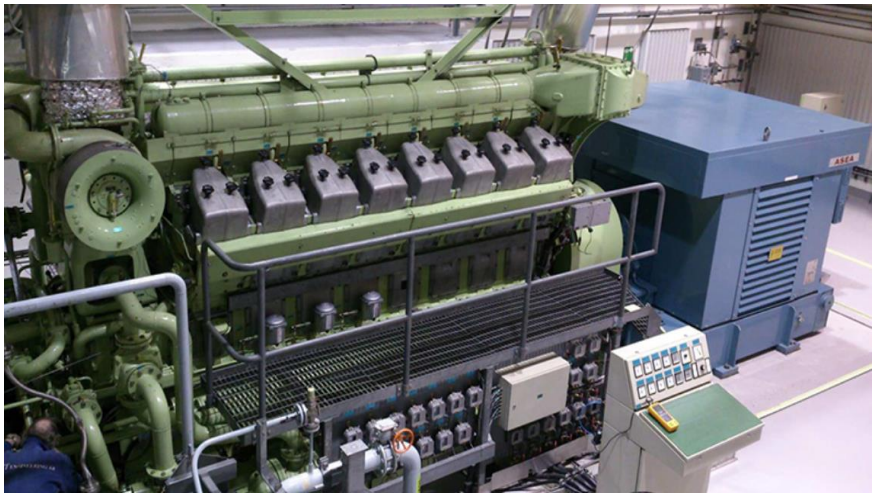
Pump → Aktiva signaler → Batterier

Pump → Kylning → Andra pumpar, fläktar

Pump → Kraftmatning → Dieselgeneratorer

Redundans, separation





SECURE/PIUS visioner

Säkerhetsfunktioner utan beroende av aktiv utrustning

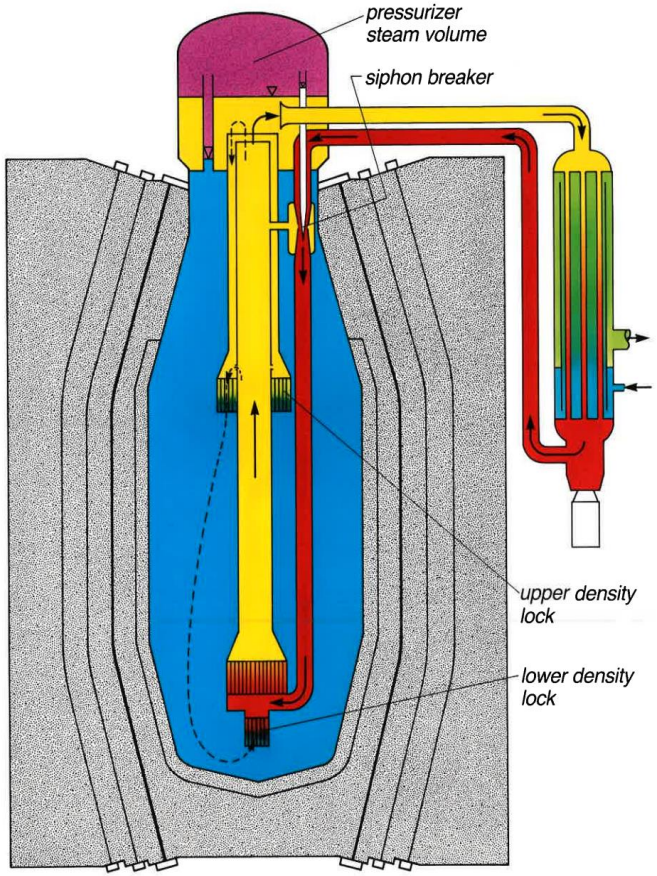
Lång tid innan aktiv utrustning eller operatörsinsatser behövs (en vecka)

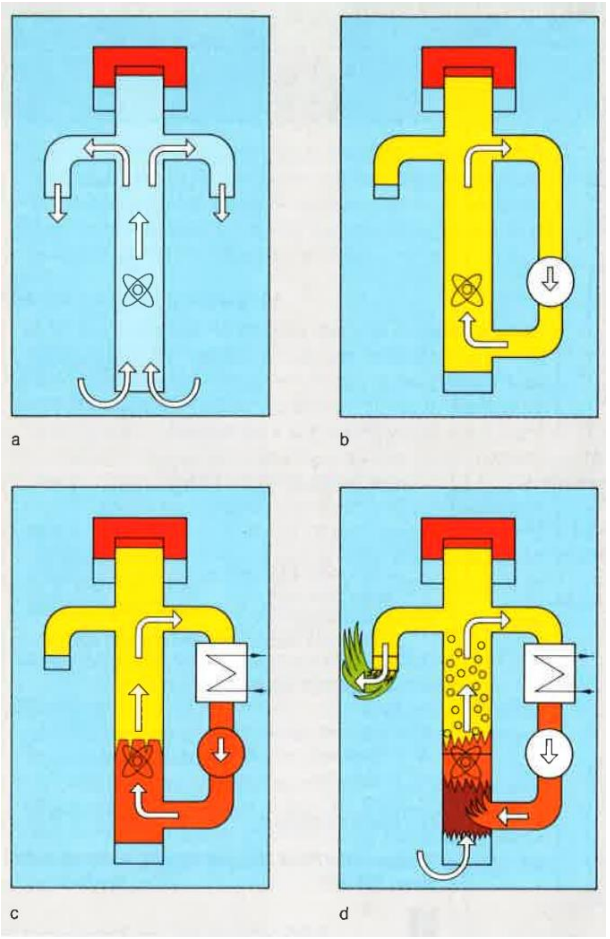
Högre säkerhet-förenklad tillståndsprocess

Minskad kostnad-inget behov av aktiv utrustning för säkerheten

Kärnkraft för fjärrvärme (400 MW)→PWR (600 MW_e)

SECURE/PIUS Princip





PIUS/SECURE Milestones

”Närförläggningsutredningen” 1970-74 Swedish public investigation on nuclear installations close to population centras

Bergförläggning Ågesta, Clab ”Nuclear Power in Rock” – Swedish State Power Board June 1977

Prestressed concrete reactor pressure vessel study 1975

Swedish-Finnish investigation SECURE-LH 1977

Bid 2x400 MW to IVO SECURE-LH Helsinki 1983

Licensability in Germany SECURE-H GRS 1987

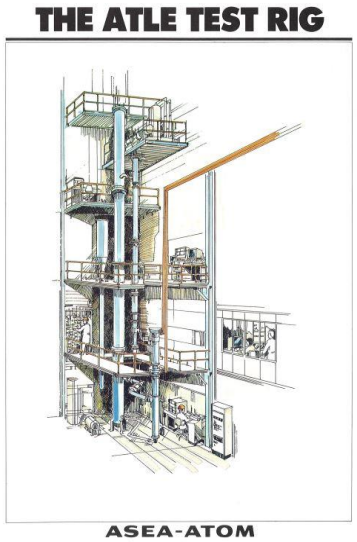
US DOE Bid for LWR with passive safety features PIUS 1989

PIUS PRA with ENEL (Italy) 1992-93

PIUS Preapplication US NRC 1991-93 (not finished, request from ABB Atom)

PIUS/SECURE

- Density lock tests
- ATLE tests-Verification of PIUS/RIGEL code
- Core design methods
- Containment design concept was not fully resolved 1993



AP-1000 History

The vision

Passive safety functions

Increased safety

Passive ”Walk-away safety” (72 h)

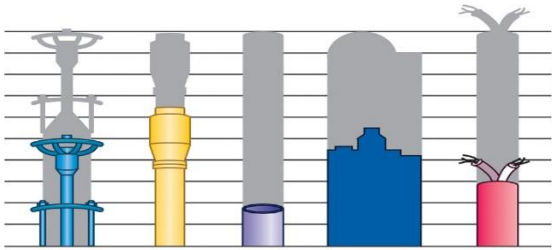
Valve-one stroke

DOE EPRI

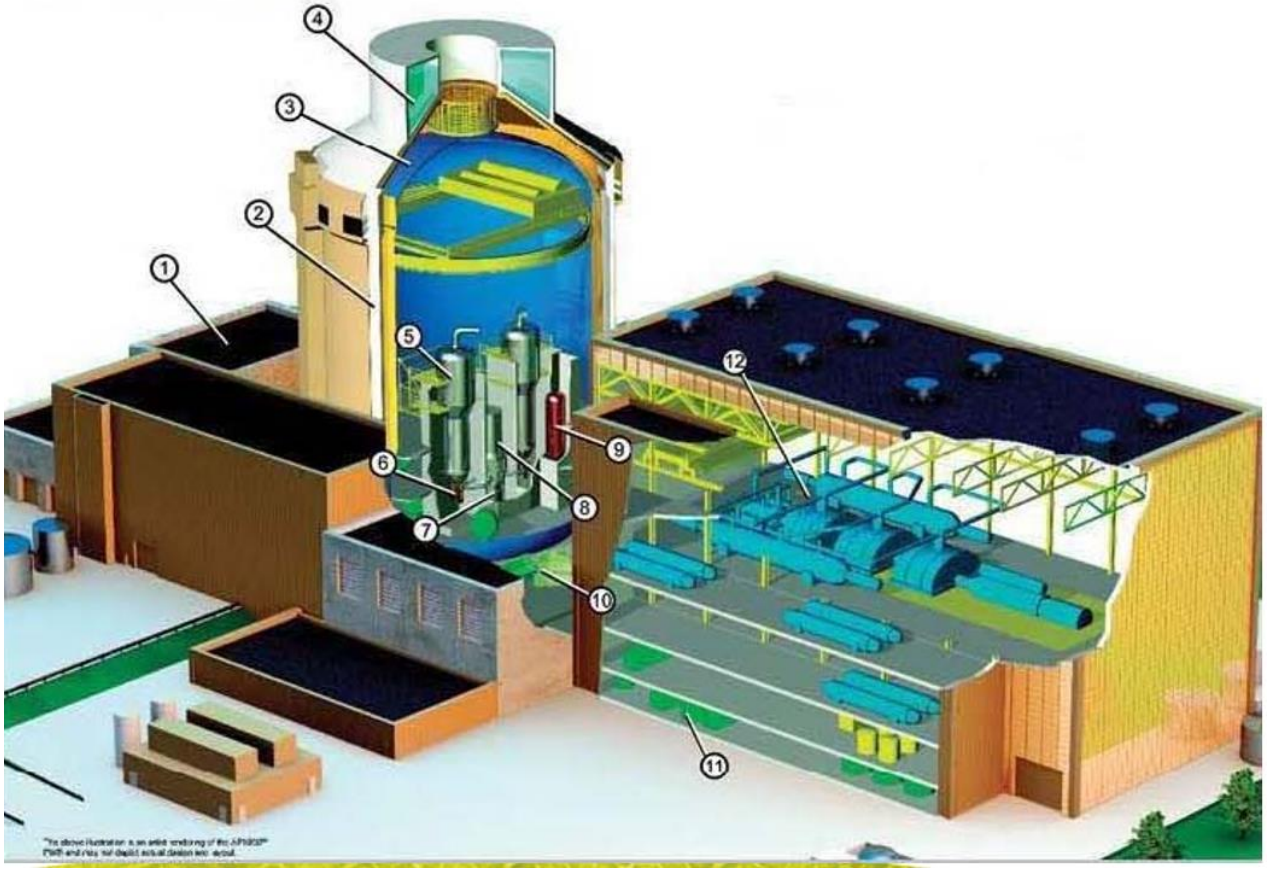
AP-600

AP-1000

Decreased cost



AP1000 Overview



1. Fuel handling area
2. Concrete shield building
3. Steel containment
4. Passive containment cooling water tank
5. Steam Generators
6. Reactor Coolant Pumps
7. Reactor vessel
8. Integrated head package
9. Pressurizer
10. Main control room
11. Feedwater pumps
12. Turbine generator

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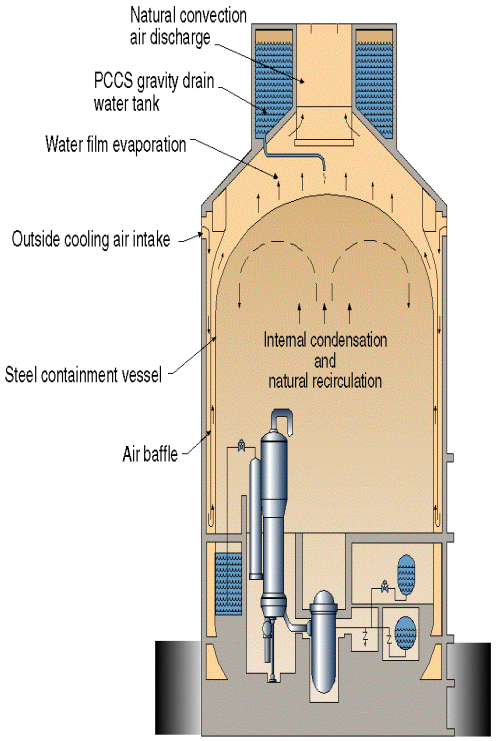
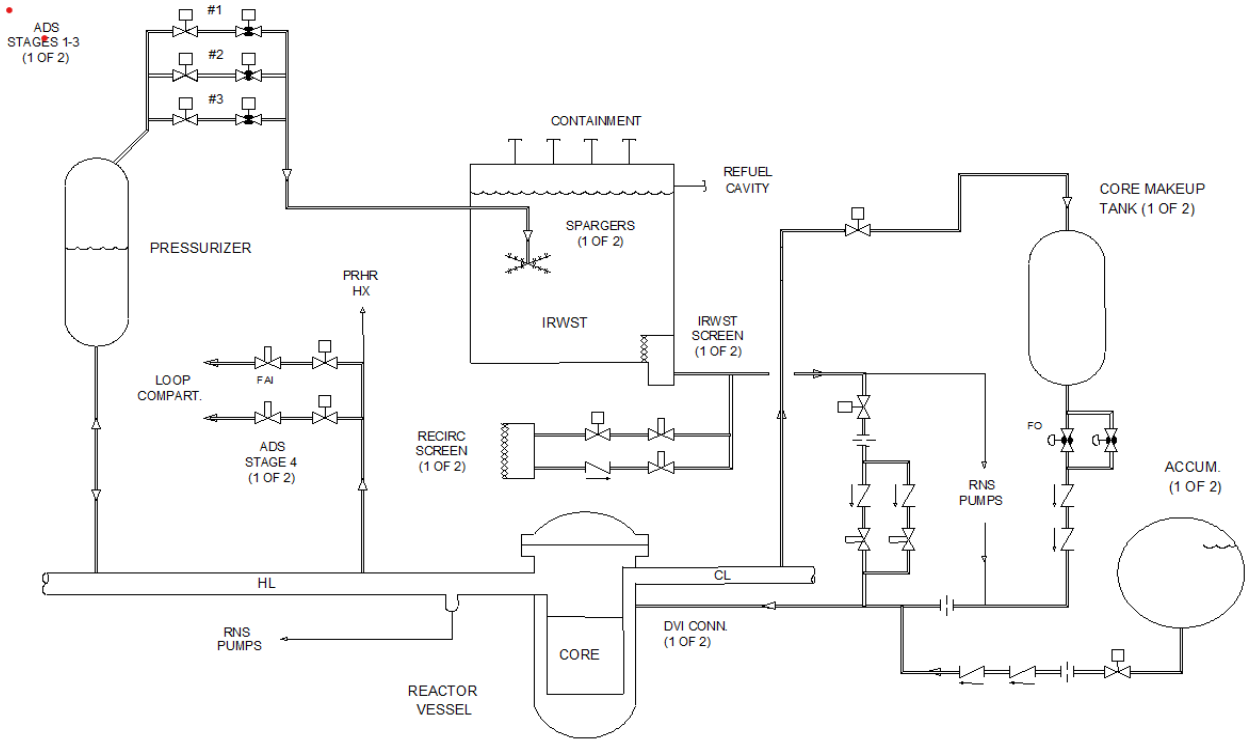
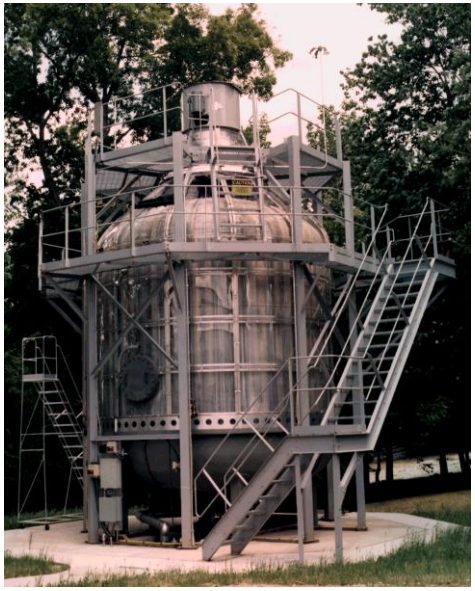
Passive safety functions

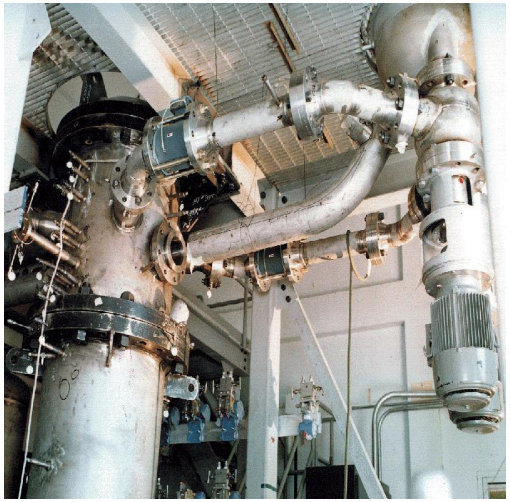


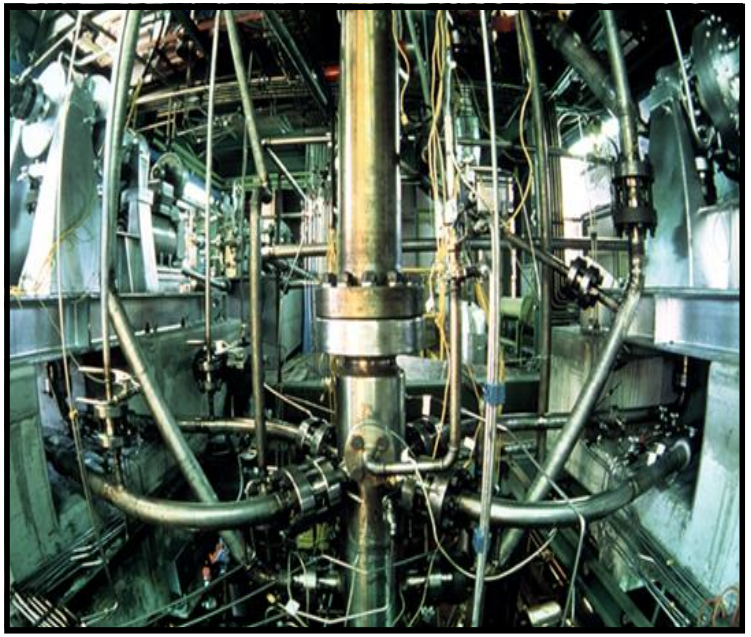


AP1000 Tests to validate passive safety functions

PCS Heat transfer LOCA entrainm. Natural circulation







Licensing

USA

AP600 Design certification 1998

AP1000 Design certification 2006

AP1000 Rev 19 DCD (Malevolent airplane crash) 2011


The United States Nuclear Regulatory Commission certifies the amended

AP1000 Standard Design

as set forth in Appendix D of 10 CFR Part 52

Dated the 30th day of December, 2011

China

PSAR 2009/FSAR 2018

UK

Generic Design Assessment concluded with issuance of Design Acceptance Certificate (2017)

Canada

Pre-project Design Review Phase 2 concluded no fundamental barriers to licensing AP1000 plant design in Canada (2013)

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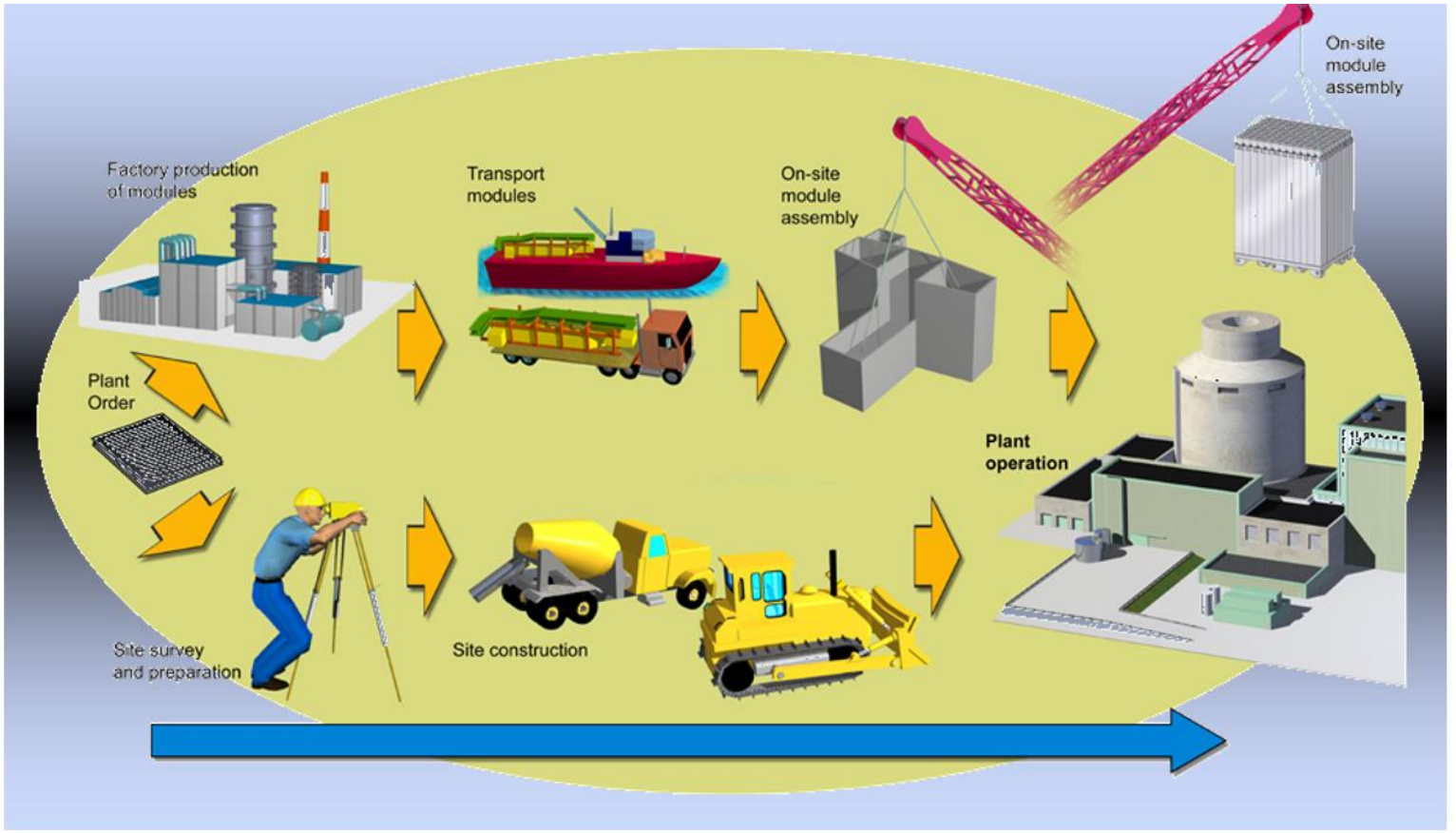
Passive safety functions

[…], as has been pointed out to me by Japanese colleagues as they reflect upon Fukushima, had the plant been operating AP1000 reactors, it is likely that the outcome would have been very different. The AP1000's passive safety systems provide the ability to maintain core cooling for at least 72 hours with little human intervention. 72 hours to make repairs, transport emergency equipment, and take other actions in response to the earthquake and tsunami that assaulted the Fukushima site would have made a very significant difference.

UR NRC Commissioner William D Magwood

AP1000 Modular construction



Decreases construction time and costs, and improves quality

Construction

Experiences

China wave 1

Sanmen 1&2 Haiyang 1&2 Construction permit 2009

Commercial operation 2018

Average Lifetime Operation Availability Factor 85,7%

Vogtle 3

Combined operation license 2012 `Commercial operation 2022(?)

- **Procurement/FOAK equipment**
  - FOAK manufacturing issues (e.g. reactor coolant pumps, reactor coolant loop piping, reactor vessel internals, modules)
  - Best suppliers (from a quality & experience) selection process
- **Critical timing of Engineering Completion**
  - Percent engineering complete at time of contract signing.
- **First time regulatory challenges**

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SMR

”Small Modular Reactors” <300 MW_e
”Heterogen skara”

Lättvattenreaktorer Andra SMR

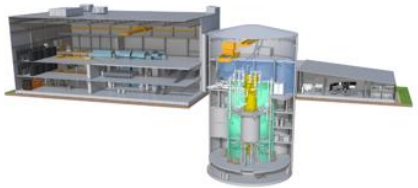
Dagens säkerhetskrav Behov av nya säkerhetskrav?

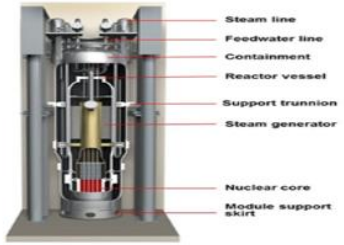
Samma tidsplan som Generation IV?
”At least two or three decades”

SMR fördelar:
Kan användas till annat än elkraftproduktion
Kort byggtid lägre kostnad

Lättvatten-SMR Några exempel

Generellt små BWR/PWR med passiva säkerhetsfunktioner





EDF Nuward™	General Electric BWRX-300™	Nuscale	Rolls-Royce SMR
PWR 2x170 MWe	BWR 300 MWe	Modulär PWR 50 MWe	PWR 470 MWe
Europeiska myndigheter samgranskning Börjat 2022	NRC pre-application börjat 2019	NRC DC 2020 (start 2008)	ONR GDA börjat 2022

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