



**Strål
säkerhets
myndigheten**

Swedish Radiation Safety Authority



Managing interdependencies and interfaces in the back-end of the nuclear fuel cycle – the Swedish experience

IAEA Nuclear Back End Webinar Series

Integrated View of the Spent Fuel Management Steps for Decision Making 10 February, 2021

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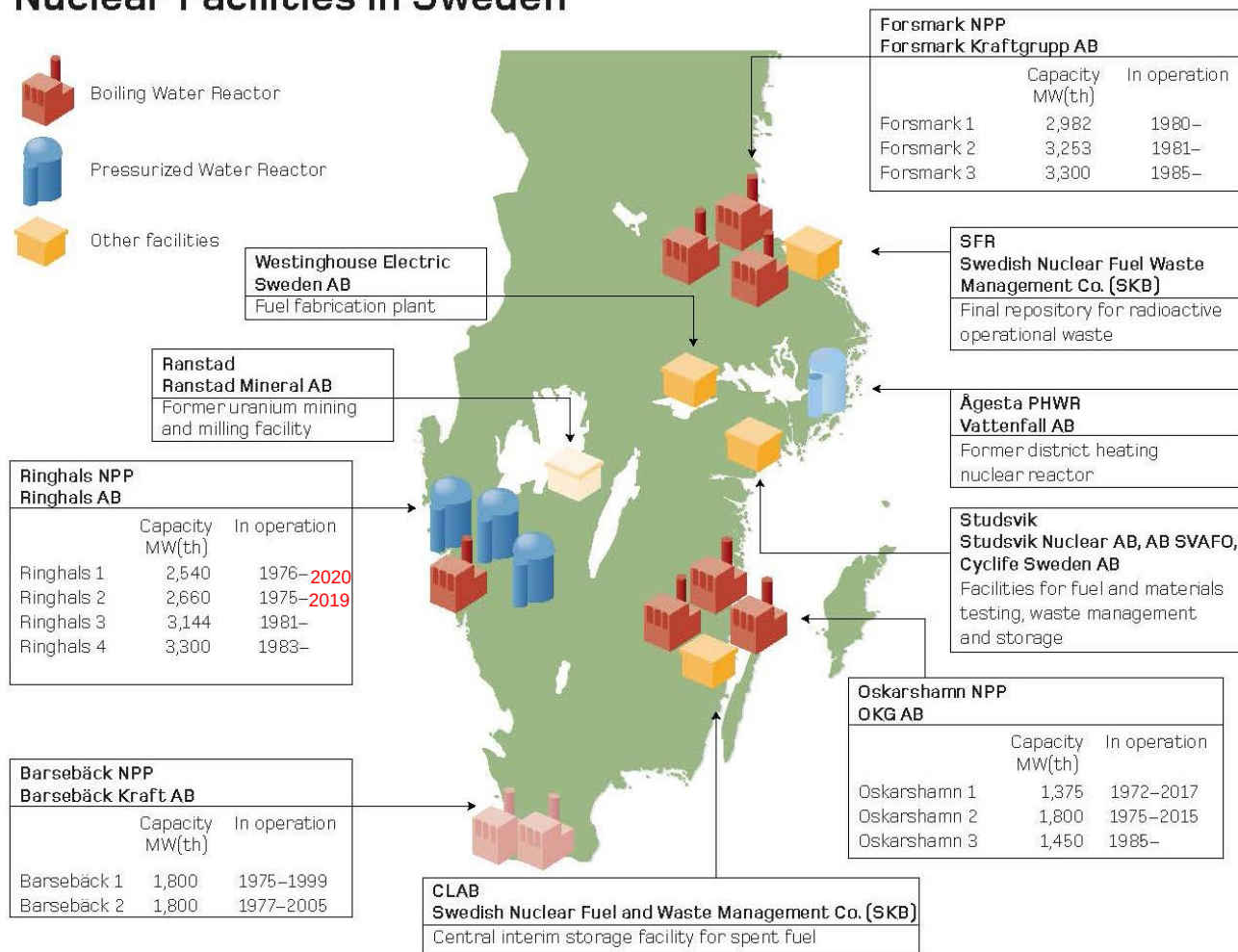
Swedish Radiation Safety Authority (SSM)



Setting the scene ...

Nuclear facilities in Sweden

Nuclear Facilities in Sweden



- Six reactors in operation (Forsmark, Ringhals, Oskarshamn)
- Two closed down reactors in Barsebäck
- Two closed down reactors in Oskarshamn
- Two closed down reactors in Ringhals
- Central storage facility for spent fuel (Clab)
- Central repository for short-lived LILW waste (SFR)
- Fuel factory (Västerås)
- Research facilities (Studsvik)
- Closed down uranium extraction facility



Setting the scene ... (cont'd)

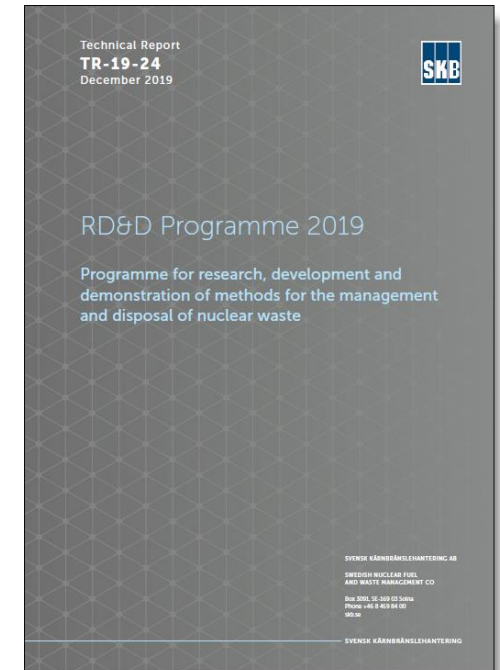
Basic prerequisites

A nuclear reactor licensee is by law required

- To manage spent nuclear fuel and nuclear waste from operation
- To decommission and dismantle the reactor and associated facilities and manage the decommissioning waste
- To perform necessary research and development
- **To, every 3 years, jointly with other reactor licensees, submit an updated program for necessary research and development**
- To pay for the costs for spent fuel and nuclear waste management

Nuclear reactor licensees cooperate through joint company SKB*)

- Centralised interim storage facility for spent nuclear fuel, Clab
- Centralised disposal facility or short-lived waste, SFR
- Transport arrangements including ship MS Sigrid
- Future encapsulation plant for spent nuclear fuel (Ink)
- Future centralised disposal facility for spent nuclear fuel
- Future centralised disposal facility for long-lived waste, SFL

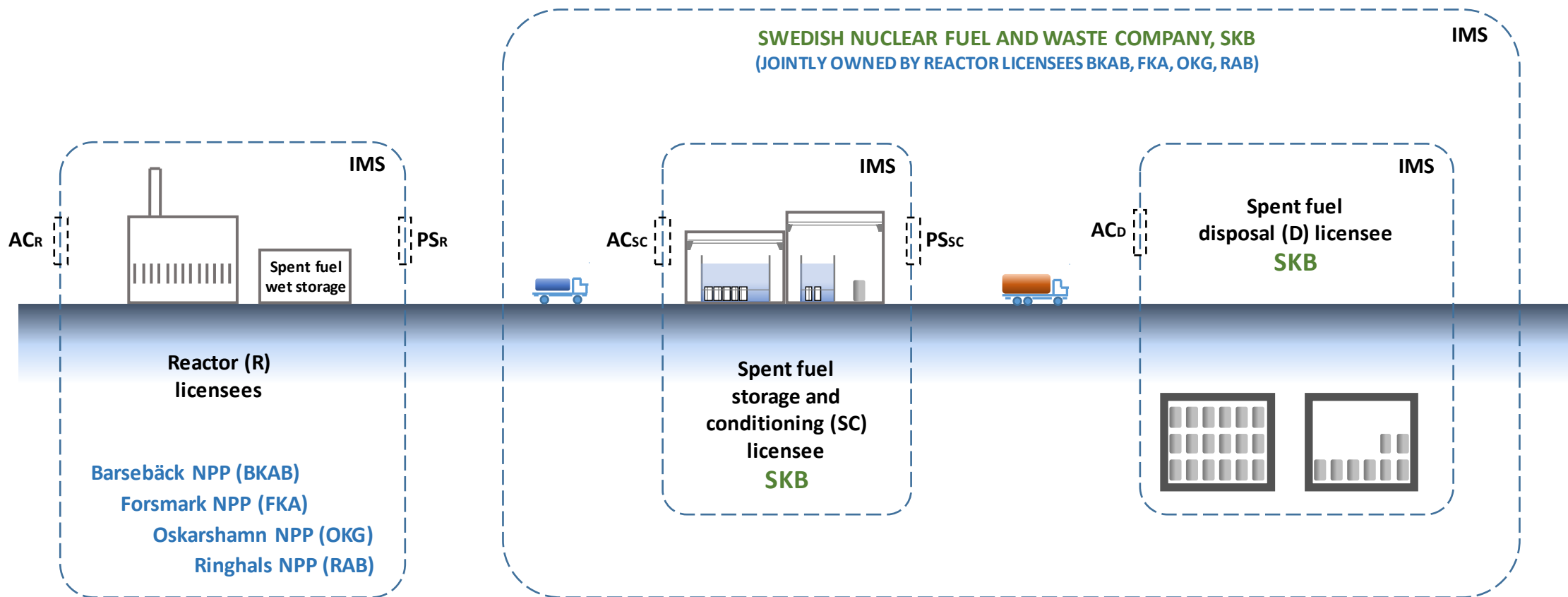


*) Swedish Nuclear Fuel and Waste Management Company



Setting the scene ... (cont'd)

Reactor licensees cooperation - 1



IMS = Integrated Management System integrates all activities including quality control

AC_x = Acceptance Criteria, licensee X

PS_x = Package Specification, licensee X

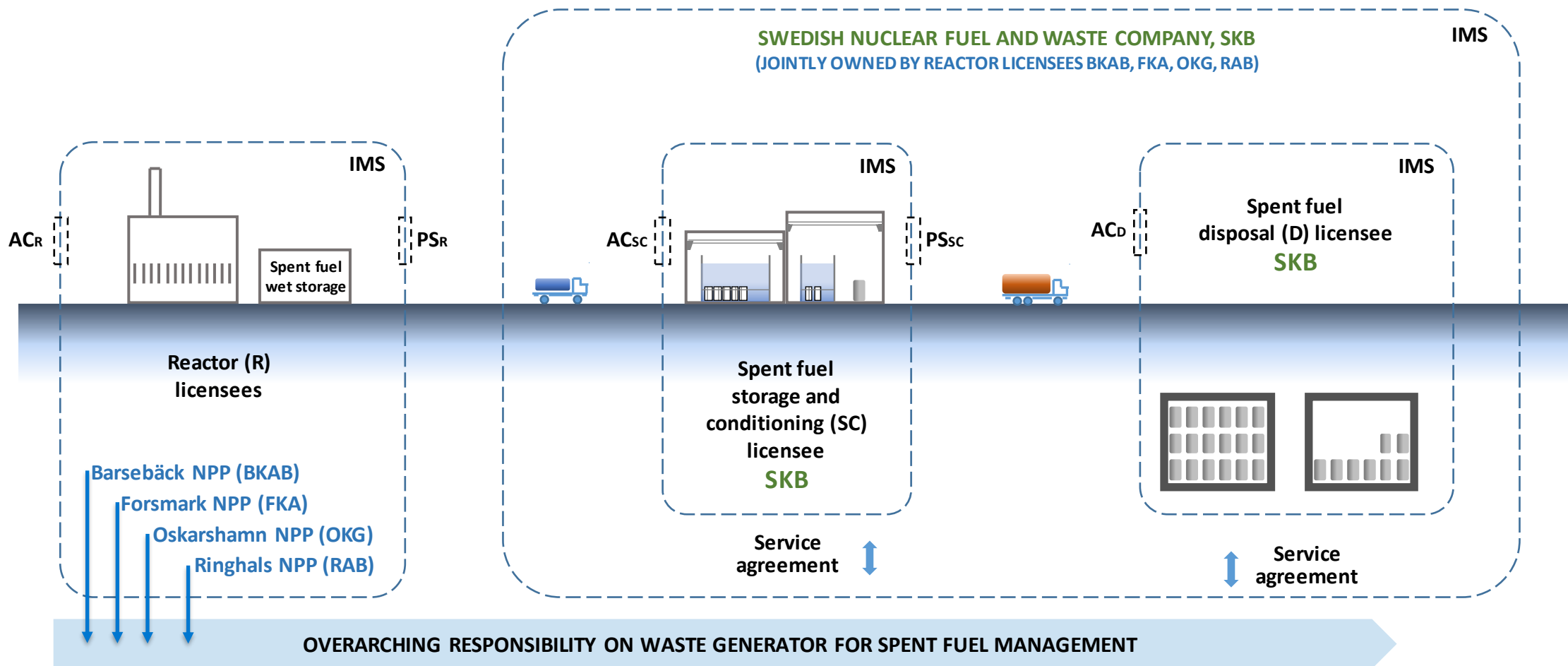


Symbolises upstream flow of information to ensure system compatibility



Setting the scene ... (cont'd)

Reactor licensees cooperation - 2



IMS = Integrated Management System integrates all activities including quality control

AC_x = Acceptance Criteria, licensee X

PS_x = Package Specification, licensee X

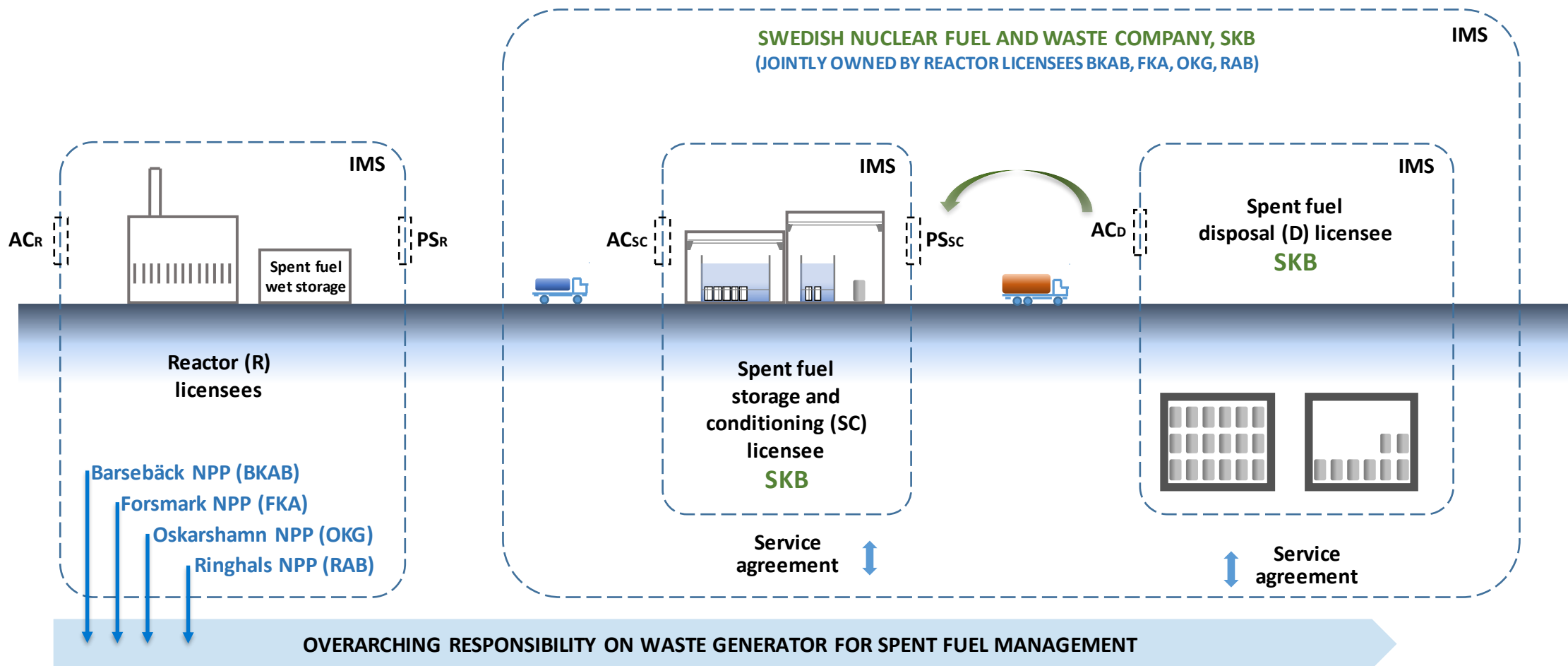


Symbolises upstream flow of information to ensure system compatibility



Setting the scene ... (cont'd)

Reactor licensees cooperation - 3



IMS = Integrated Management System integrates all activities including quality control

AC_x = Acceptance Criteria, licensee X

PS_x = Package Specification, licensee X

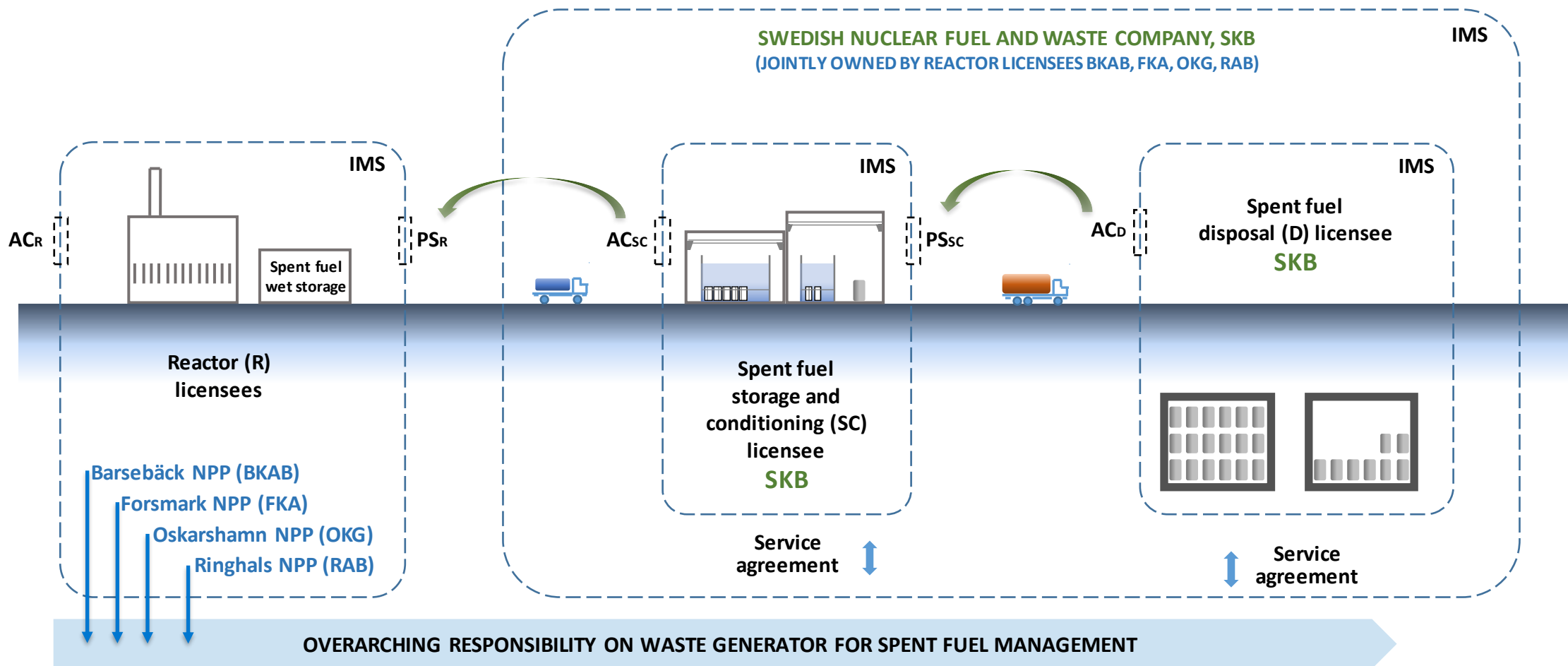


Symbolises upstream flow of information to ensure system compatibility



Setting the scene ... (cont'd)

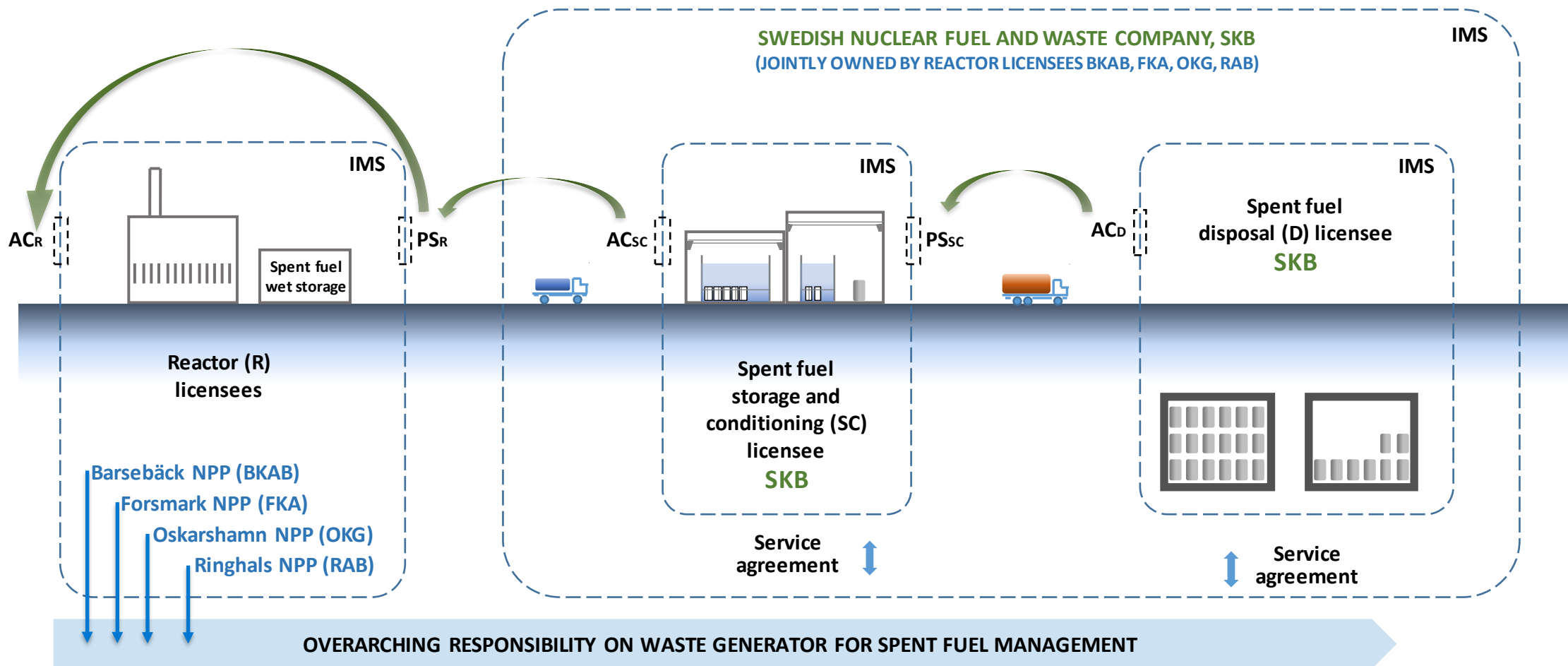
Reactor licensees cooperation - 4





Setting the scene ... (cont'd)

Reactor licensees cooperation - 5



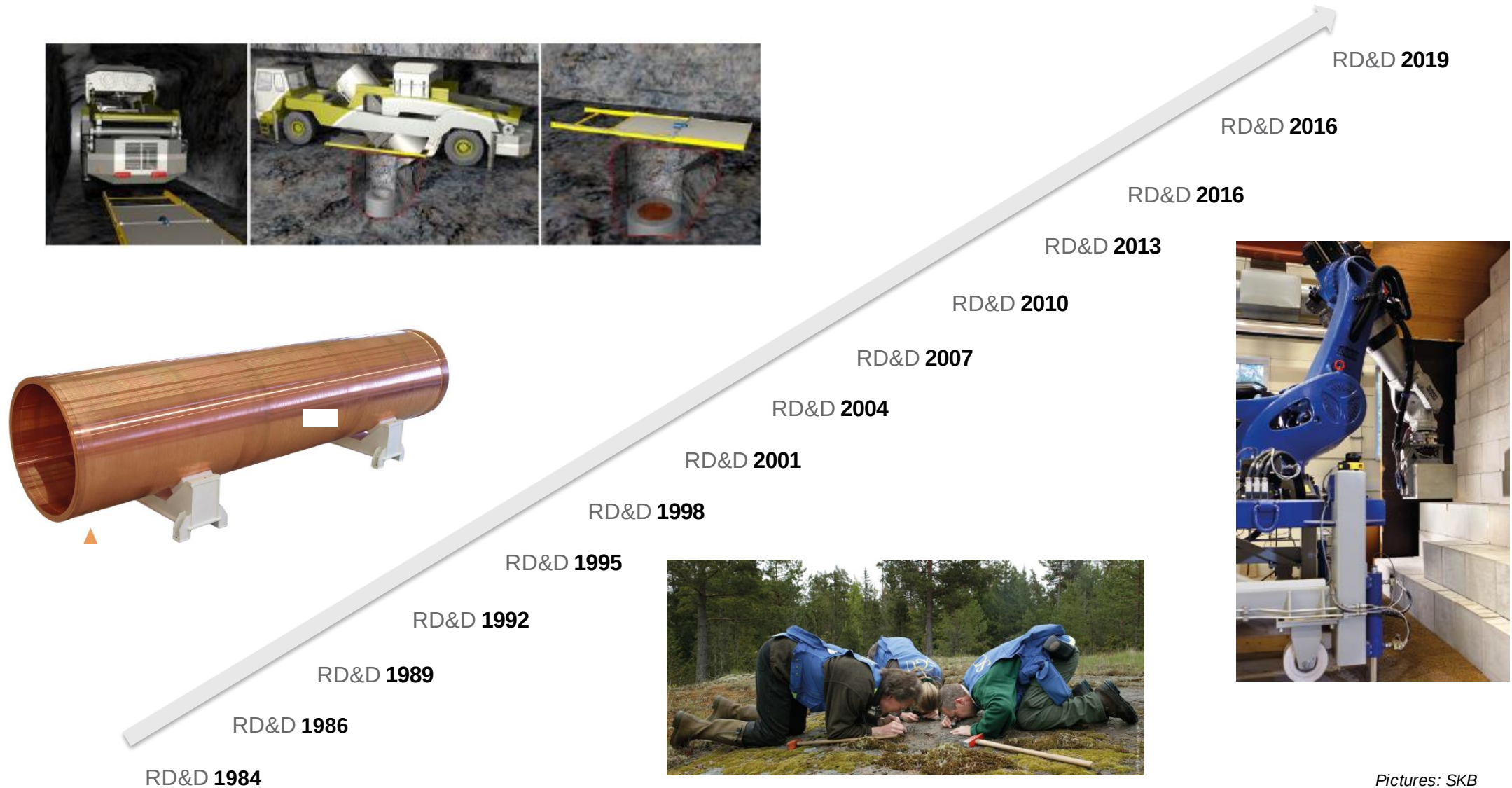
IMS = Integrated Management System integrates all activities including quality control
AC_x = Acceptance Criteria, licensee X PS_x = Package Specification, licensee X

 Symbolises upstream flow of information to ensure system compatibility



Review of RD&D-program every 3 years

Driver for the development



Pictures: SKB



The R&D and Financing

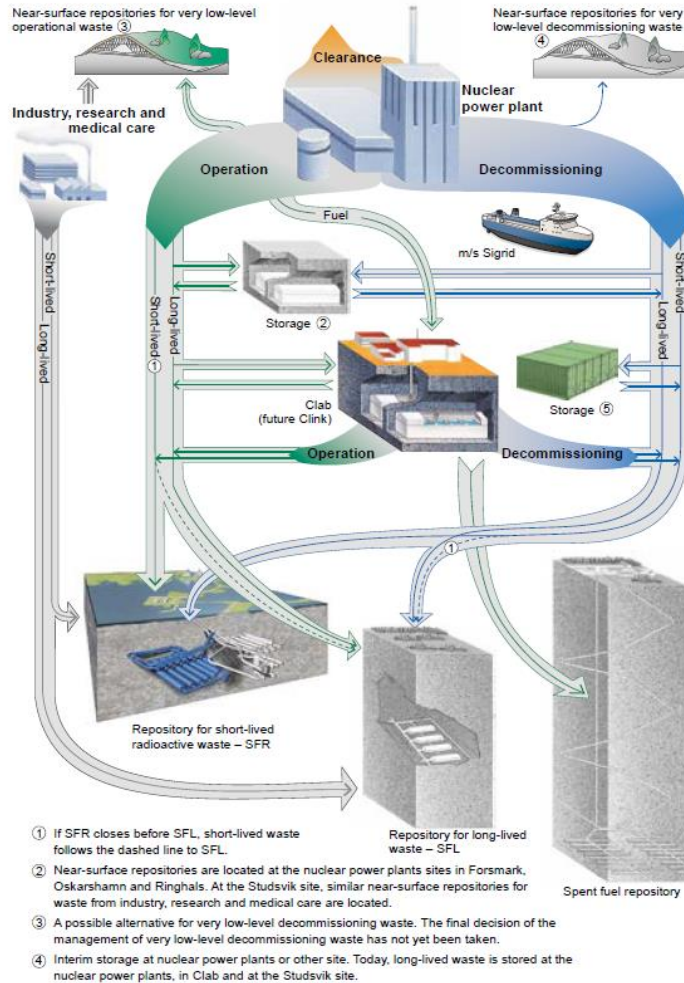


Figure 2-1. The system for management and disposal of Sweden's radioactive waste and spent nuclear fuel. Solid lines represent transport flows to existing or planned facilities. Dashed lines represent alternative routes of management.

Graphics: SKB

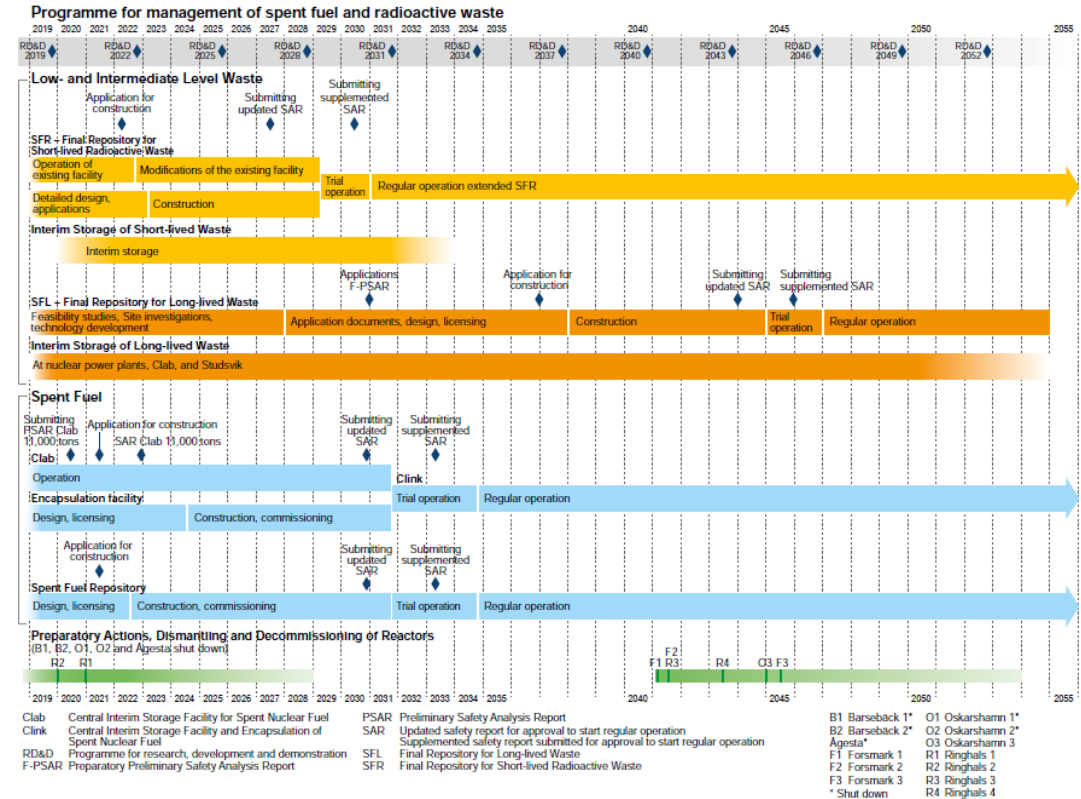


Figure 3-1. General timeplan for SKB's Programme for management of spent fuel and radioactive waste and decommissioning plans for the nuclear power reactors.

Graphics: SKB



Where we are today ...

Ongoing licensing processes

- **Management of spent nuclear fuel (KBS-3-system)**

- **Spent fuel repository, Östhammar Municipality** 1

- **Encapsulation plant (Ink)** Oskarshamn Municipality, adjacent to existing centralised facility for interim storage of spent fuel (Clab), to become an integrated facility (Clink) operating under on license 2

- **Extension of existing repository SFR**

- Licensed for short-lived operational waste 3
- License application to allow for also disposal of decommissioning waste 3

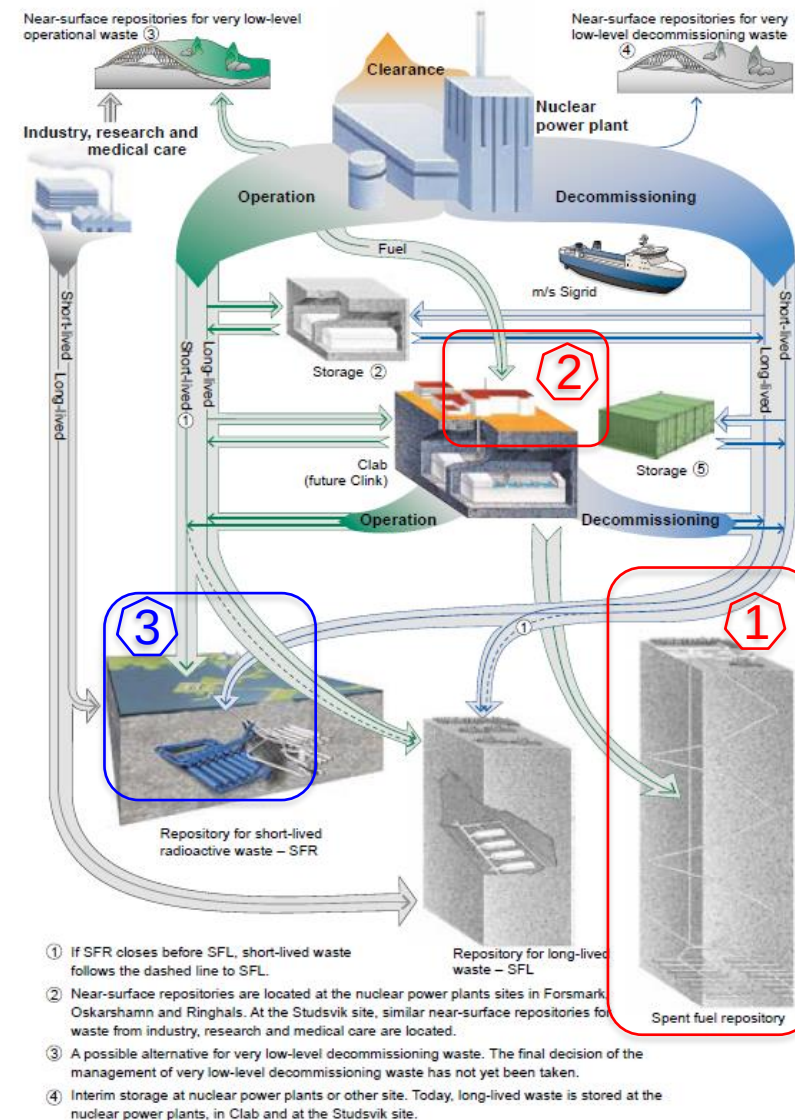
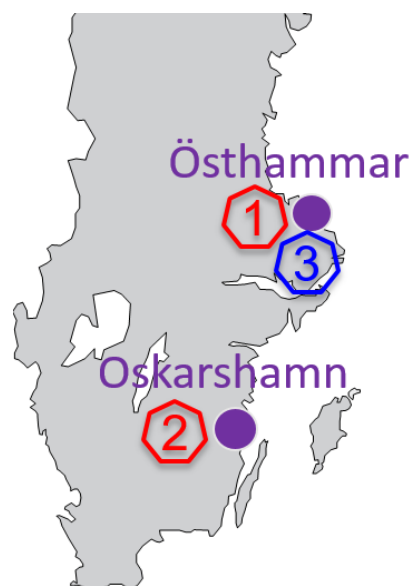


Figure 2-1. The system for management and disposal of Sweden's radioactive waste and spent nuclear fuel. Solid lines represent transport flows to existing or planned facilities. Dashed lines represent alternative routes of management.

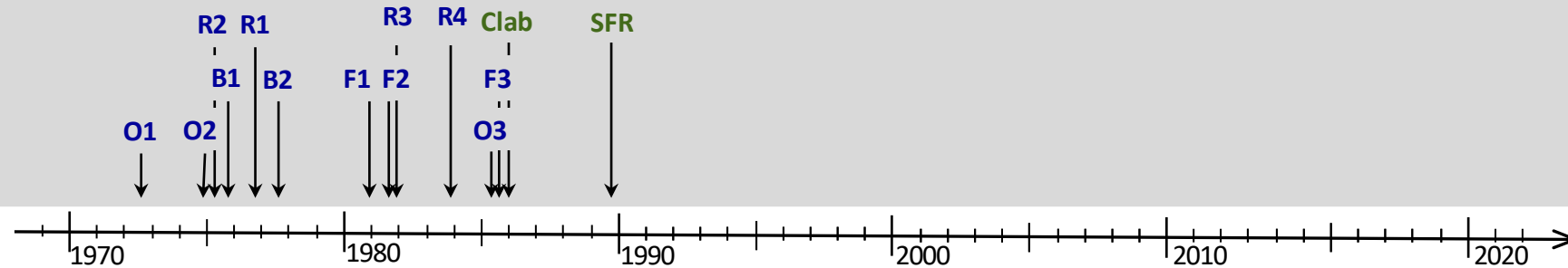
Graphics: SKB



Planning under Uncertainty and Risk

External factors influence - 1

START OF OPERATION NUCLEAR FACILITIES



1968: Atomic Accountability Act

- No provisions for management of spent fuel and nuclear waste

Legend

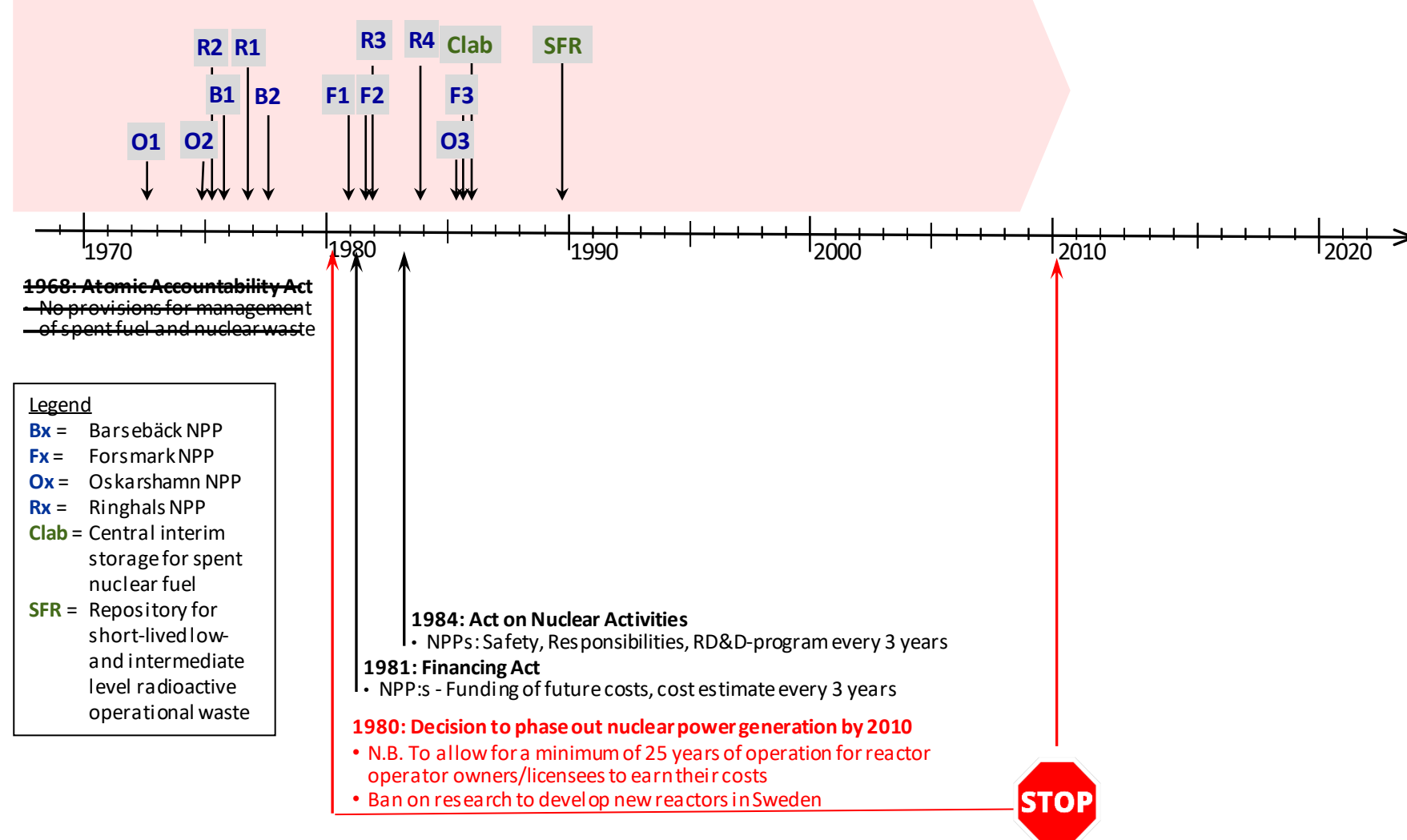
- Bx** = Barsebäck NPP
- Fx** = Forsmark NPP
- Ox** = Oskarshamn NPP
- Rx** = Ringhals NPP
- Clab** = Central interim storage for spent nuclear fuel
- SFR** = Repository for short-lived low- and intermediate level radioactive operational waste



Planning under Uncertainty and Risk

External factors influence - 2

START OF OPERATION NUCLEAR FACILITIES

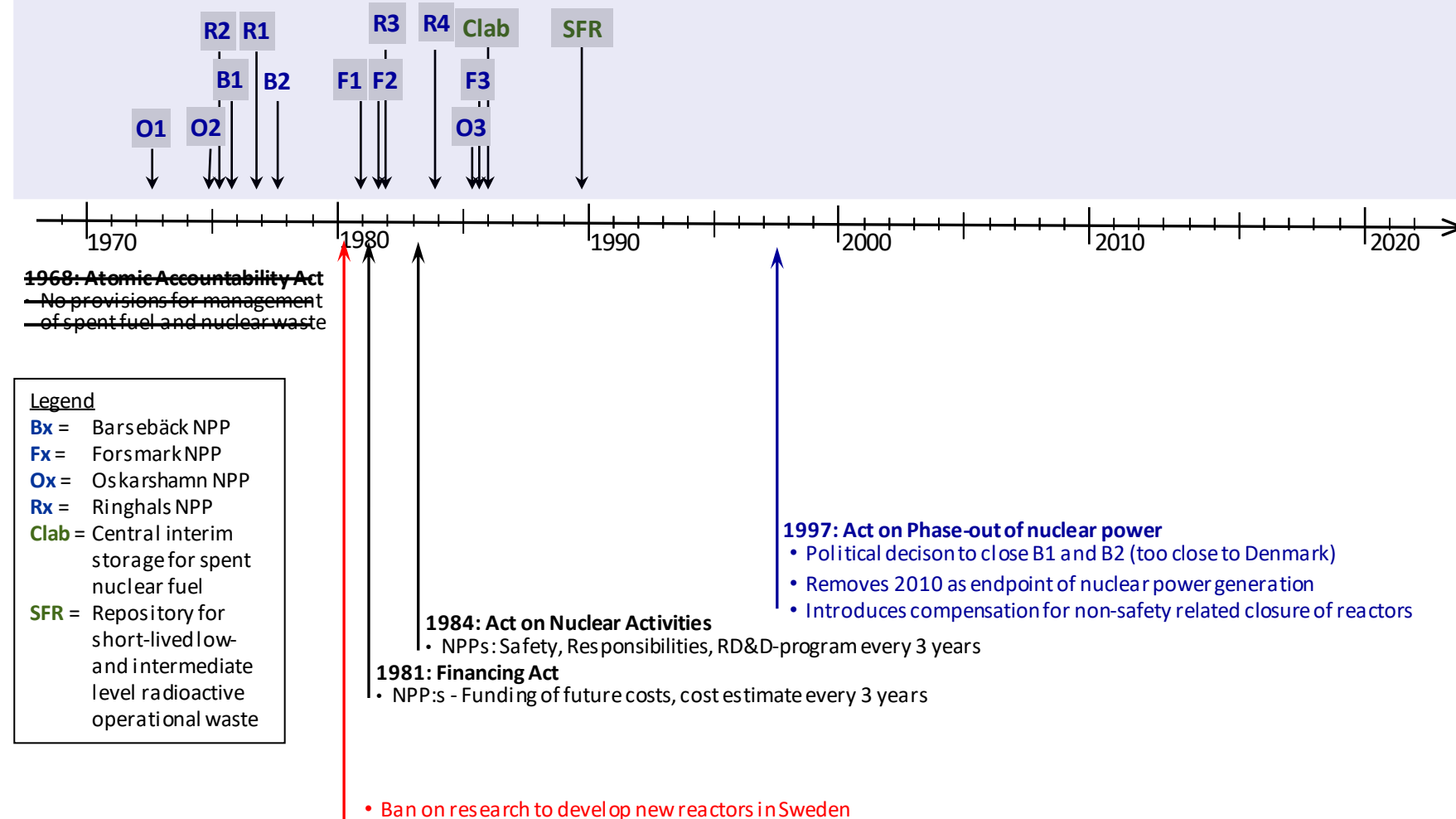




Planning under Uncertainty and Risk

External factors influence - 3

START OF OPERATION NUCLEAR FACILITIES

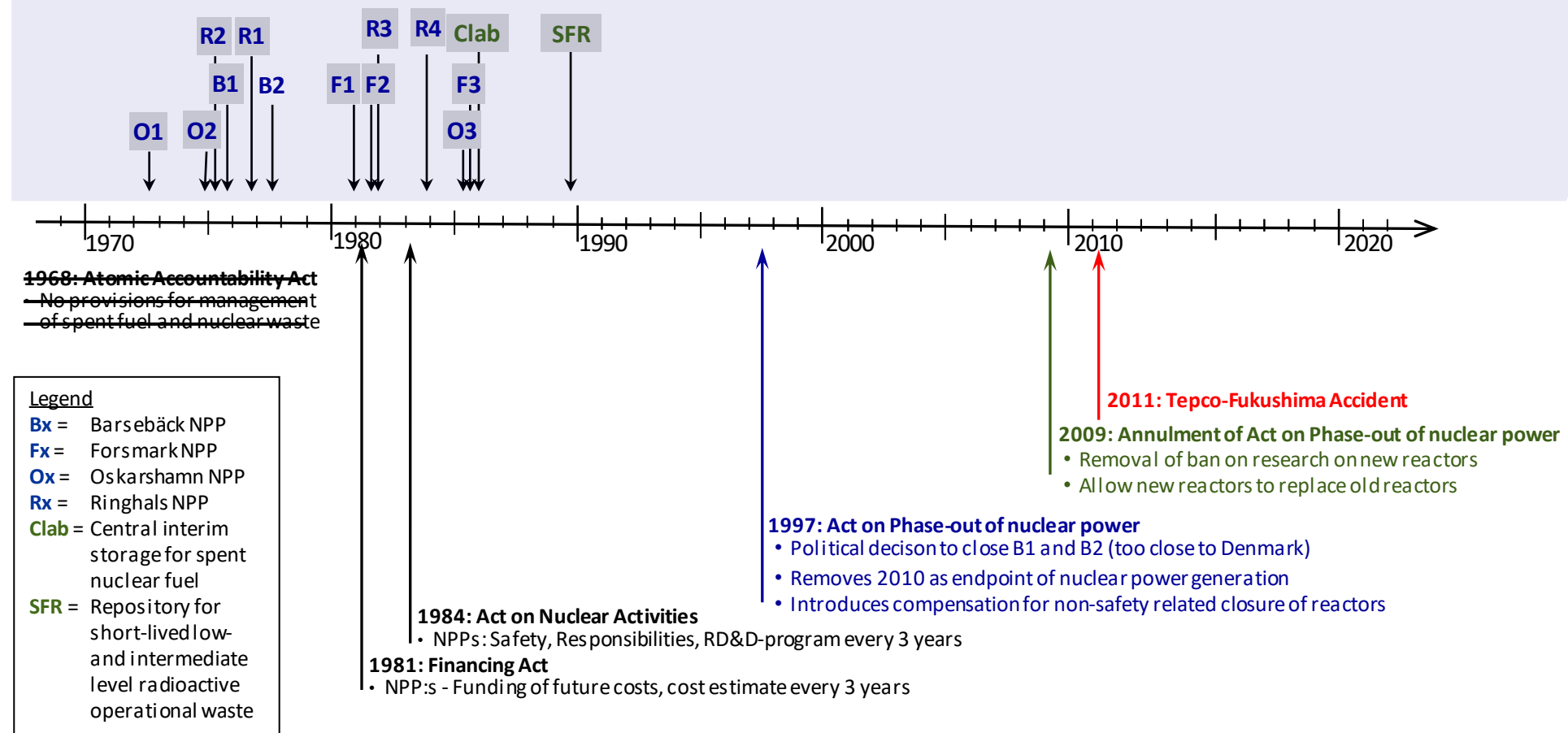




Planning under Uncertainty and Risk

External factors influence - 4

START OF OPERATION NUCLEAR FACILITIES

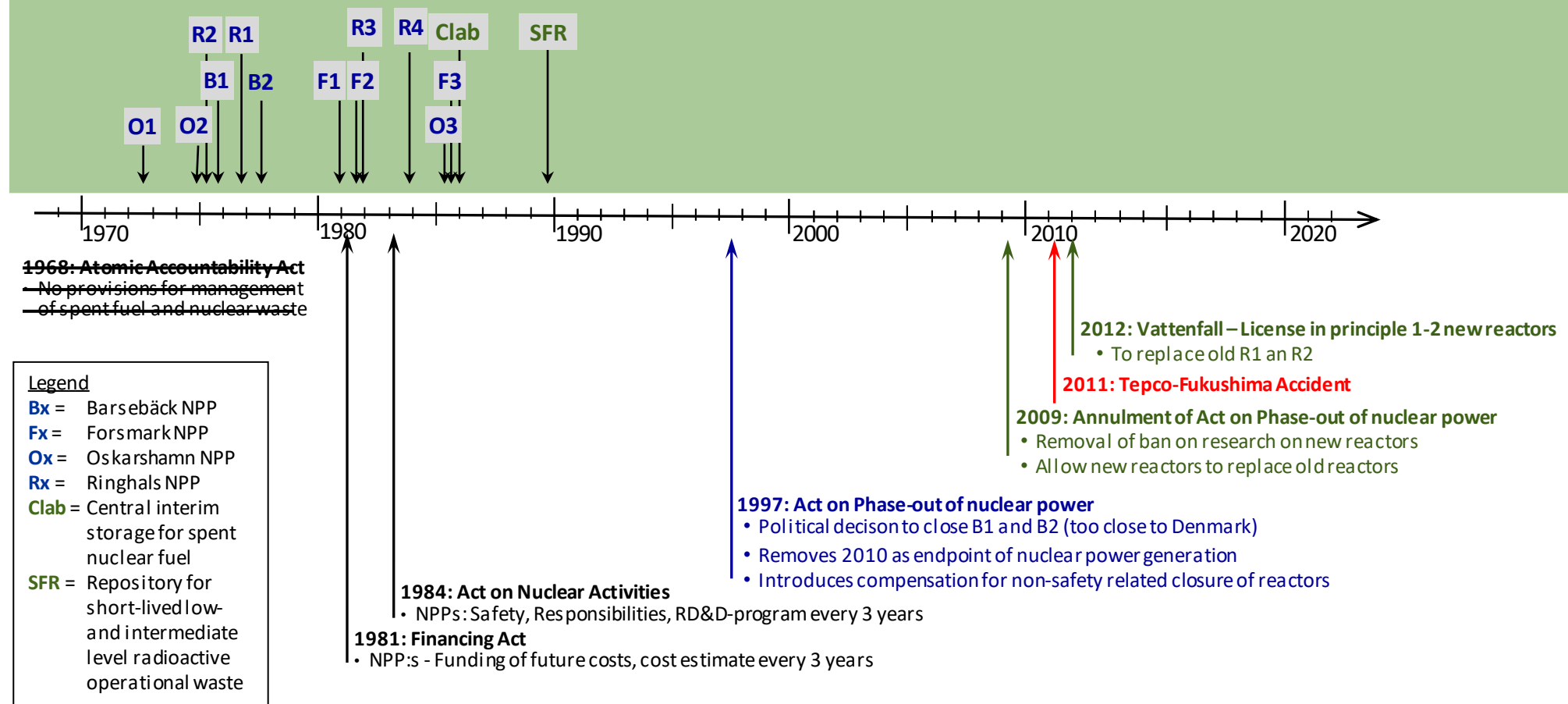




Planning under Uncertainty and Risk

External factors influence - 5

START OF OPERATION NUCLEAR FACILITIES

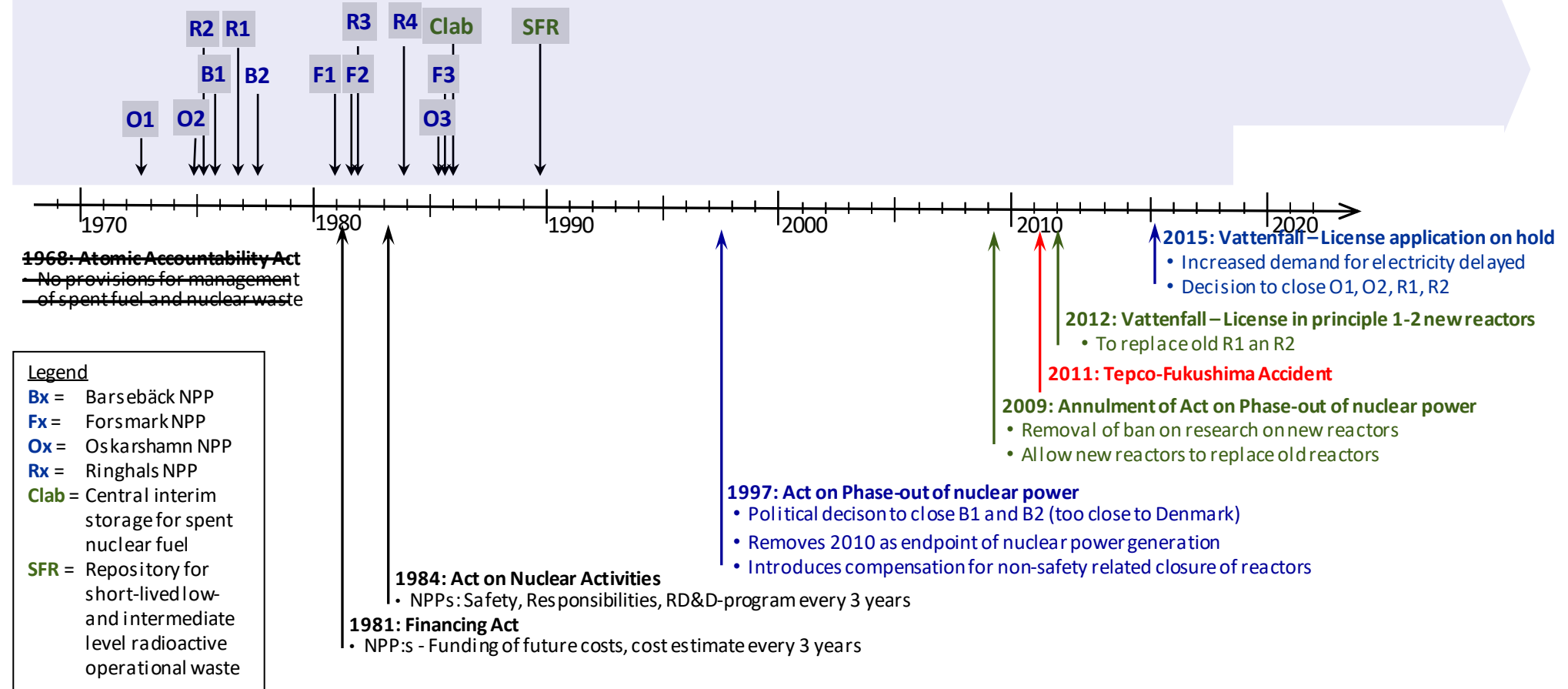




Planning under Uncertainty and Risk

External factors influence - 6

START OF OPERATION NUCLEAR FACILITIES





Spent fuel storage flexibility

Examples of Internal Factors

YEAR*)	CAPACITY	MEANS	COMMENT
1981	3 000 tHM	STANDARD CASSETTES ¹⁾	BUFFER STORAGE FOR RECYCLING
1989	5 000 tHM	COMPACT CASSETTES ²⁾	BUFFER STORAGE FOR DISPOSAL
1997	8 000 tHM	REUSE STANDARD CASSETTES	ENOUGH IF PHASE OUT BY 2010
2015	11 000 tHM	ONLY COMPACT CASSETTES	INCREASED CAPACITY NEEDED ³⁾

¹⁾ 16 BWR and 5 PWR elements respectively, criticality control by distance

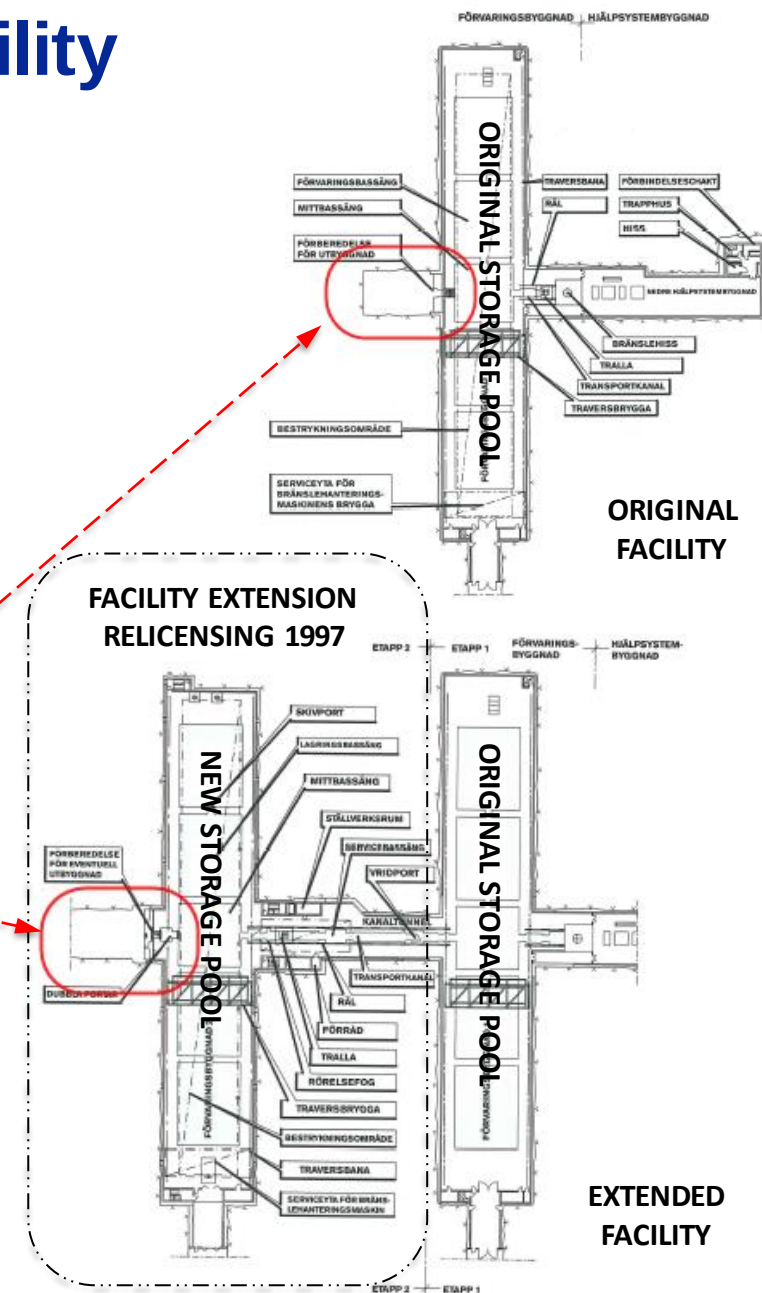
²⁾ 25 BWR and 9 PWR elements respectively, criticality control by boron steel

³⁾ Capacity to store all generated spent fuel from power reactors as per today's reference scenario

*) Indicate year for relicensing to accommodate changes



PREPARATORY
CONSTRUCTIONS TO
FACILITATE FACILITY
EXTENSION





Lessons Learned ...

Main trigger for development ...

- Is the political decision 1980 to phase out nuclear power generation by 2010, and providing for long-term commitment for back-end activities long after that

Main driver for development ...

- Is the setting-up of legal requirements on reactor operators to conduct a R&D-program and submit a report on progress for review and evaluation every 3 years
- The regulatory review and subsequent governmental decision on the program provides a structured process to adopt to external and internal factors influencing developments

Roles and responsibilities clearly defined in the legal framework

- Reactor owners are assigned responsibility for everything that is needed to ensure safe operation of facilities and post-closure safety of spent fuel disposal facilities
- The regulator develops regulations and reviews compliance with requirements



Lessons Learned ... (cont'd)

Management of Spent Fuel and Nuclear Waste addressed from early on

- Voluntary cooperation between all reactor licensees

Realistic planning prerequisites ...

- Necessary to plan future activities on an agreed reference scenario, but allow for enough flexibility to accommodate to potential external and internal factors

Nuclear reactor licensees are individually responsibility for

- Management of spent fuel and nuclear waste and building up funds

Cooperation between reactor licensees through SKB allows for

- optimized management by implementing centralized joint storage/disposal facilities
- facilitates management of interfaces and interdependencies
- optimizes use of resources and efficiency
- facilitates and optimizes financing arrangements



Thank you!