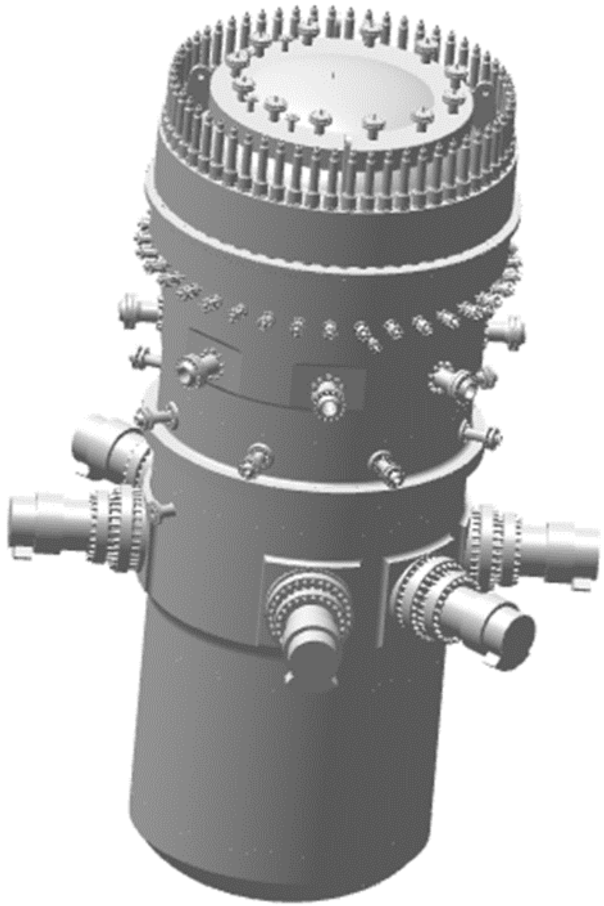

SMR / THE FRENCH APPROACH

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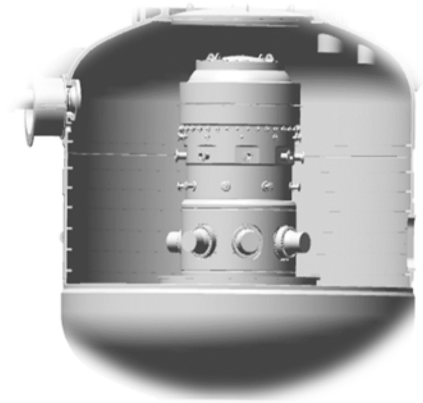
TECHNICATOME: MICHEL BRUN

IAEA SMR Technical working group meeting
Vienna July 8-11th 2019

SUMMARY

- SMR Interests and opportunities
- SMR Specific stakes for a new business model
- F-SMR Overview of the design
- F-SMR Status of current design and time schedule for design and deployment
- SMR : A real opportunity to meet market demands

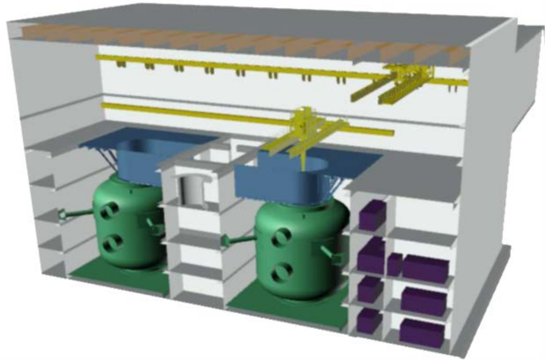
SMR Interests & Opportunities



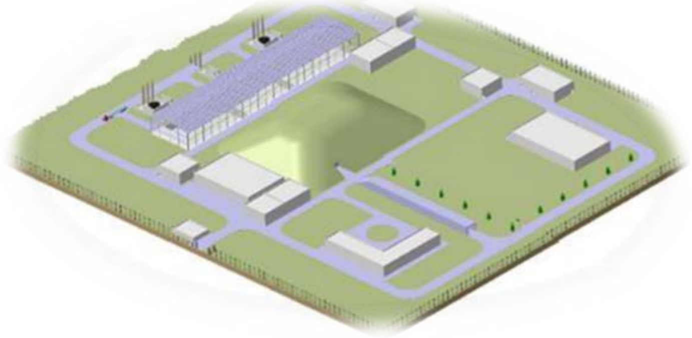
- **SMRs are complementary to medium and large reactors, for a wider nuclear offer**

  SMRs offer additional and relevant nuclear solutions to cope with :
  - Carbon free, predictable and flexible generation, complementary to renewable energy strategies
  - Affordable and progressive investment, with limited capital costs
  - A range of relative small power outputs (from 150 to 400 MWe)

    and other opportunities that cannot be properly fit by large reactors, due to site constraints, network capacity or access to the heat sink



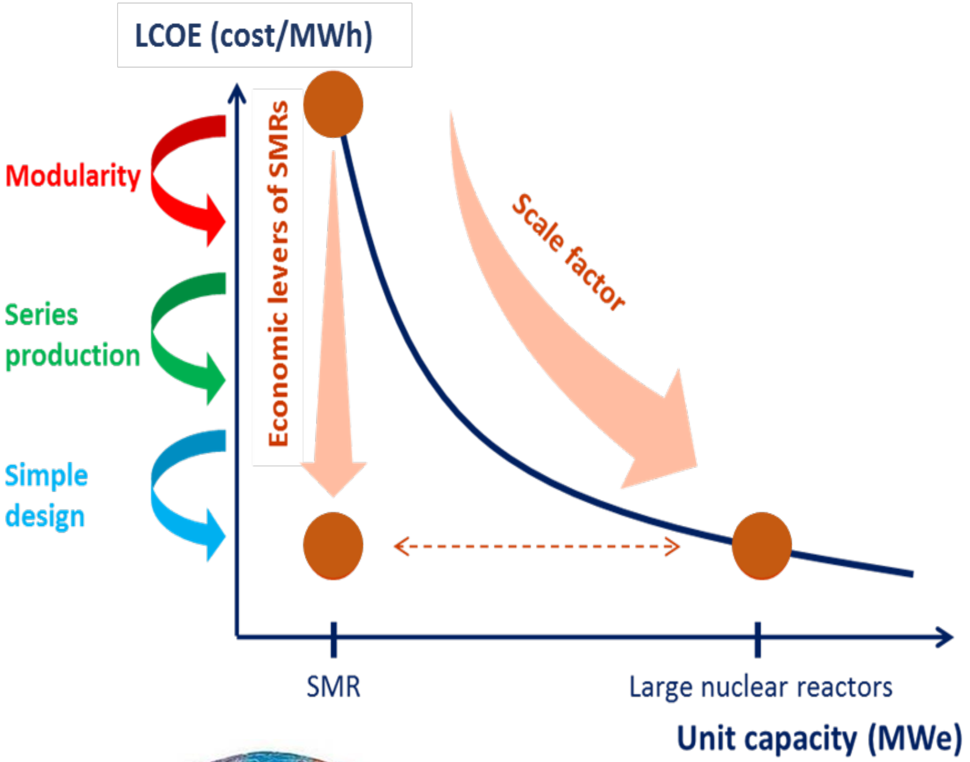
- **Small power, Simple and Safe**
  - Simplified and compact architecture with high safety
  - Robust to accident scenarios, protected by passive safety systems



- **Modular and Multiple**
  - Limited number of modules, manufactured and tested in factories
  - Reduction of the risks and the duration of the construction on site
  - Multi-reactors facilities for flexible solution

SMR Specific stakes for a new business model

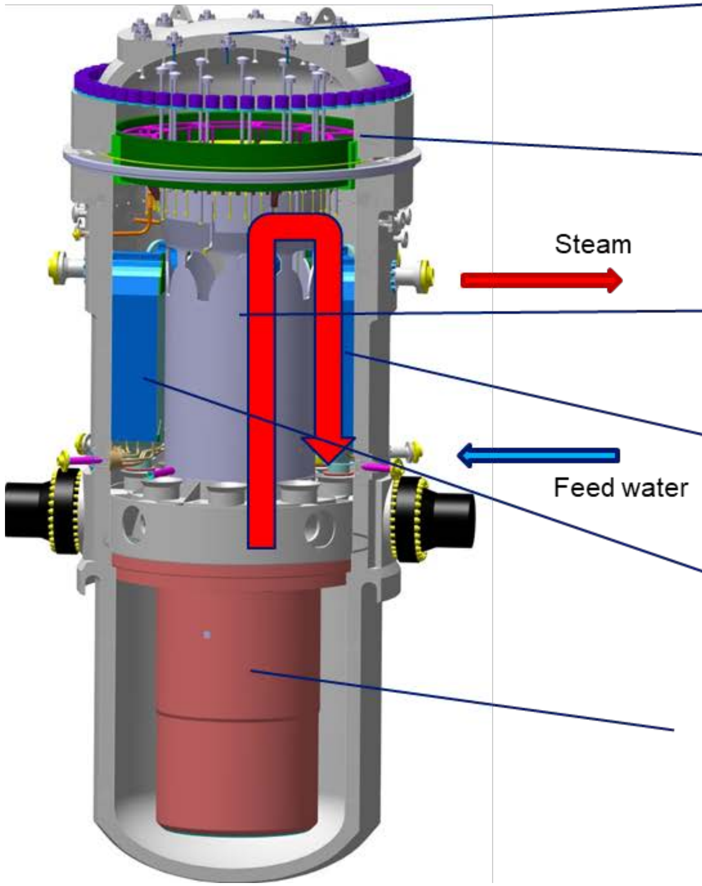
- Economic levers vs Scale effect
  - Modular design and manufacturing (construction cost decrease, shortened construction duration)
  - Series effect (In series production of components, standardisation...)
  - Simplification of design (architecture, components, regular civil structure, easy and quick to build)



- Standardization and international deployment
  - Standard design, licensable in several countries
  - Safety case based on extensive use of passive systems
  - Qualification of modular fabrication and construction
  - International initiatives for adaptation and convergence of national nuclear regulations for SMRs (IAEA, WENRA, …)
  - Opportunities for international cooperation for development and operation

Overview of the F-SMR Design

Integrated reactor block : everything inside the vessel



No CRDM penetration on the vessel-head

Integrated pressurizer (no external pipe)

Internal CRDM (no rod ejection – compactness)

6 CSG (once through)
associated to 6 canned primary pumps

2 independent S-CSG passive heat removal

69 or 76 standard FA core

Boron-free control (one absorber per FA)

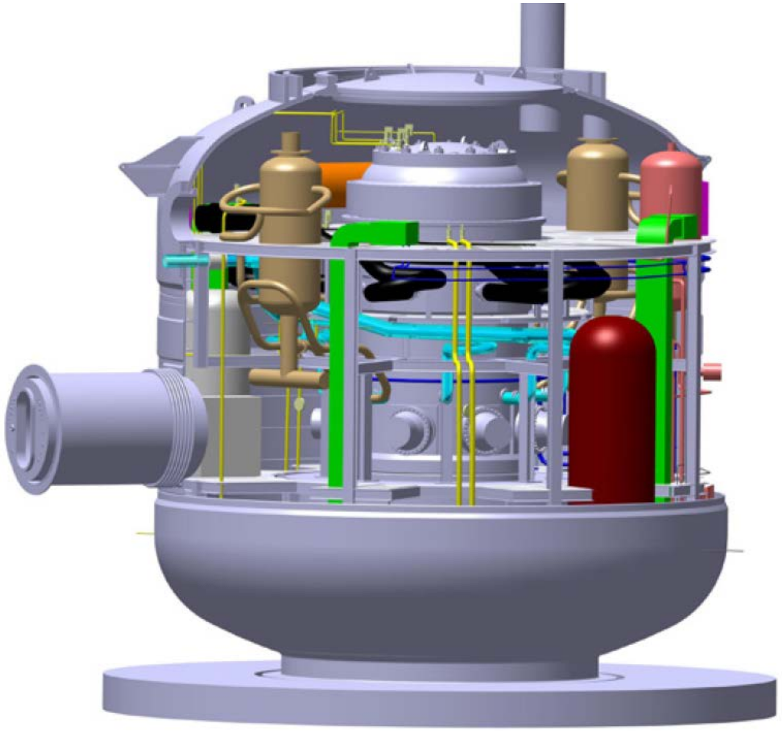
Integrated reactor architecture is innovative

It offers a very compact design and a high resistance to accident scenarios :

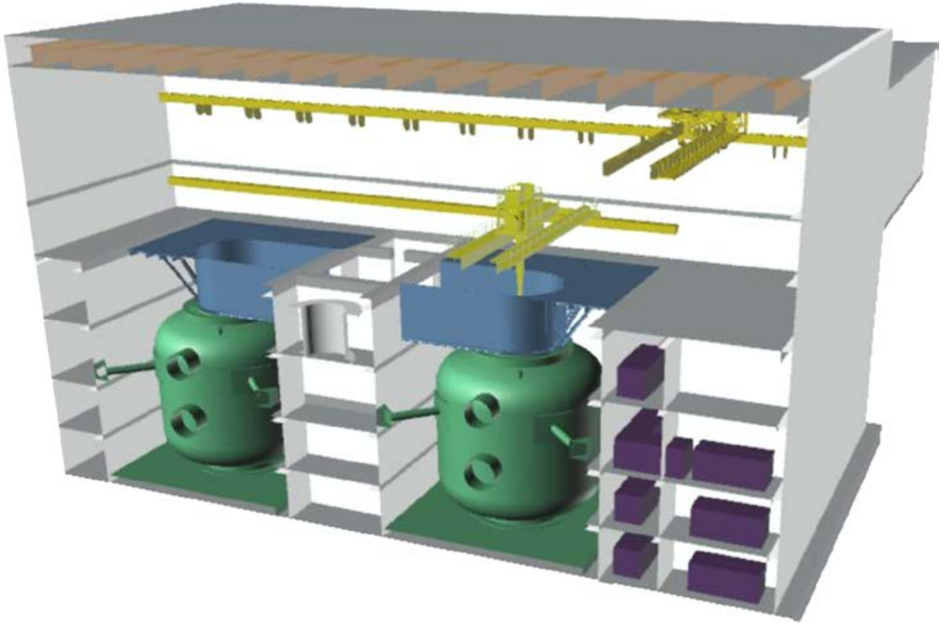
- No large bore pipes *(no large break LOCA)*
- No external CRDM *(no rod ejection)*
- Boron free operation *(no spurious boron dilution accident)*

Overview of the F-SMR Design

NPP designed for targeted market 2 x 170MWe (The Design allows 4 and 6 reactors NPP)



Integrated reactor located in a metallic containment shell (H 16m),
Containment immerged in a water basin



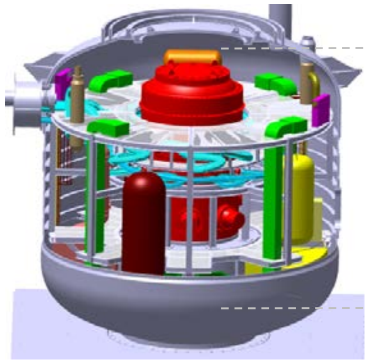
Typical 2 reactors (2 X 170MWe) facility

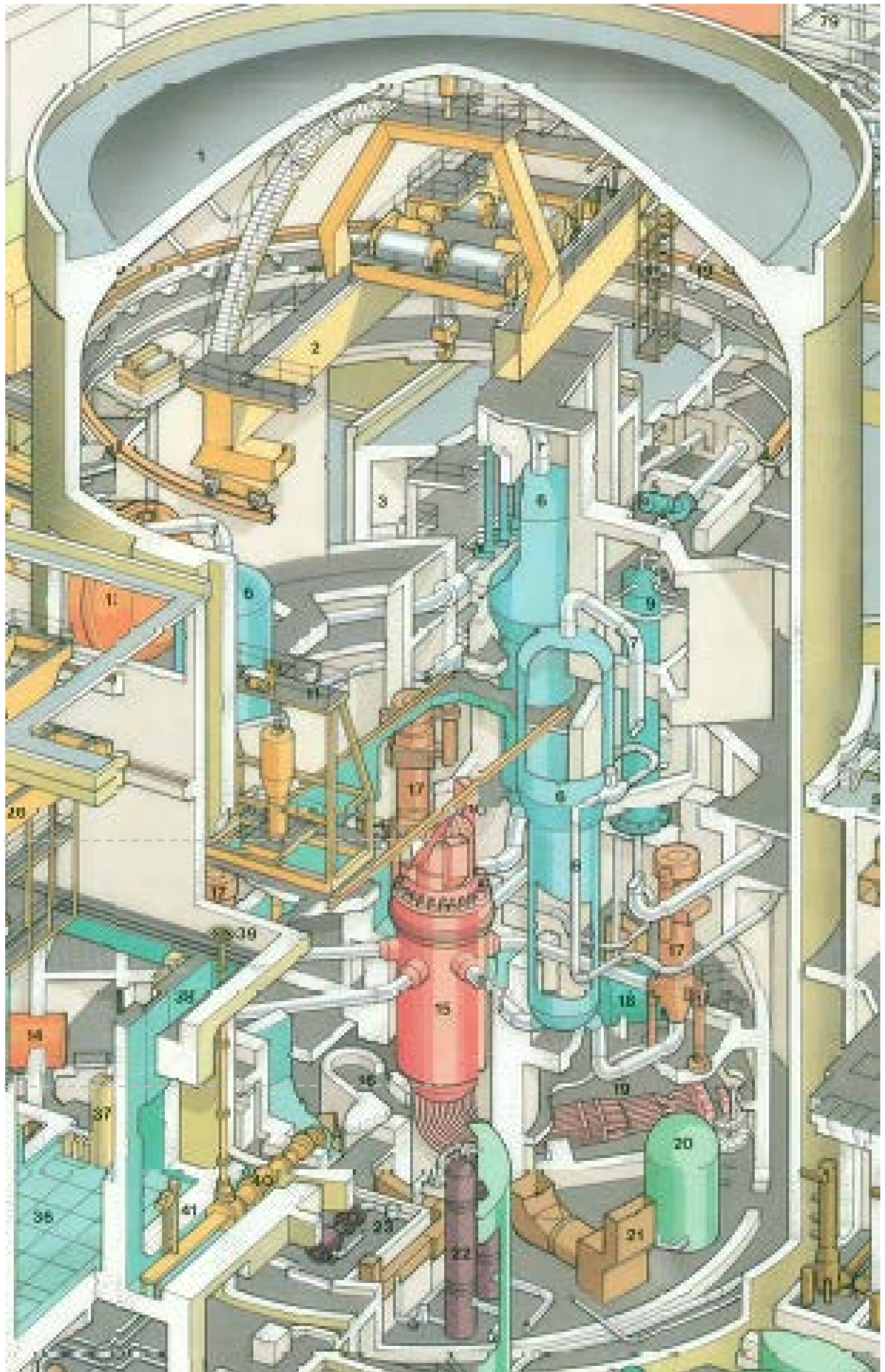
Overview of the F-SMR Design

Metallic and compact containment

PWR 900 Containment :
Φint 37 m – h: 58m

SMR reactor:
Φint 15m - h:16m

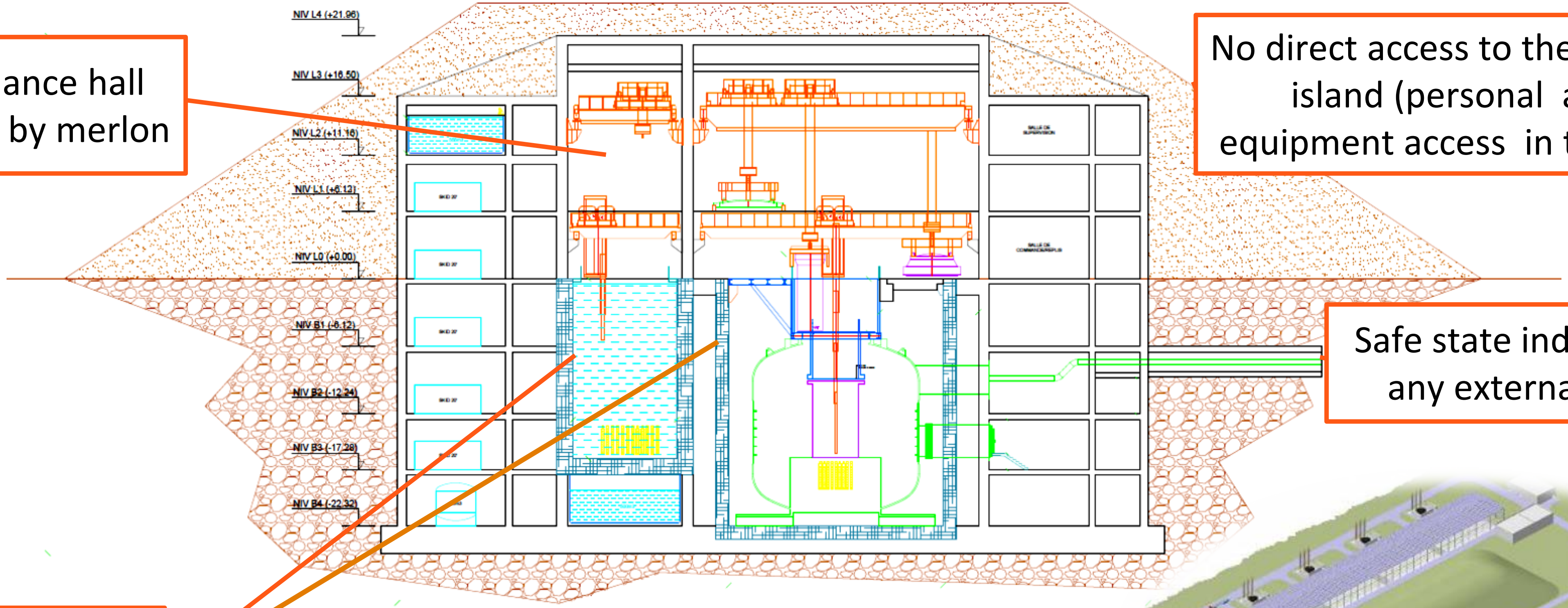




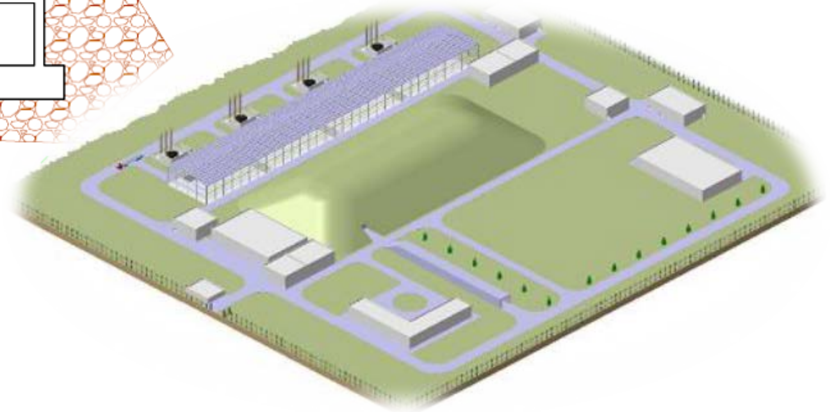
Overview of the design
Semi-buried NI building - protected against hazards and threats

Maintenance hall protected by merlon

No direct access to the nuclear island (personal and equipment access in tunnels)



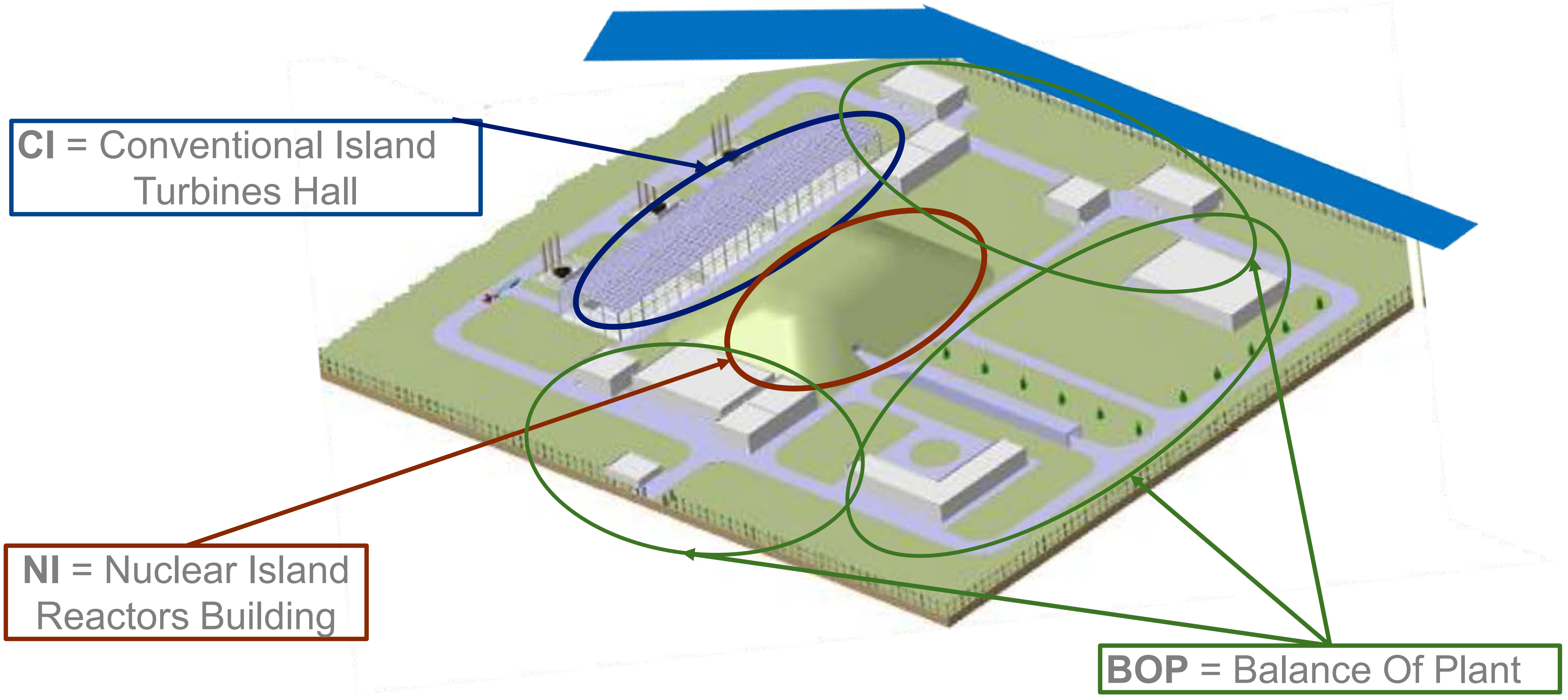
Safe state independent of any external situation



Fuel and reactor pools below ground level

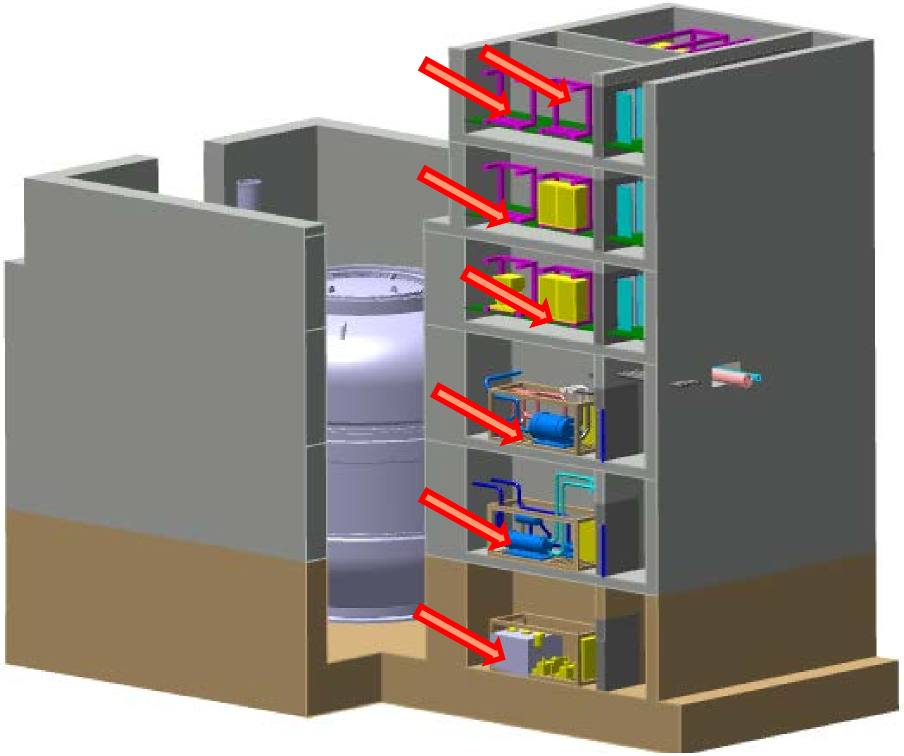
NI building includes all passive features for stand-alone management for several days, with no external support

Overview of the Design
Site schematic layout



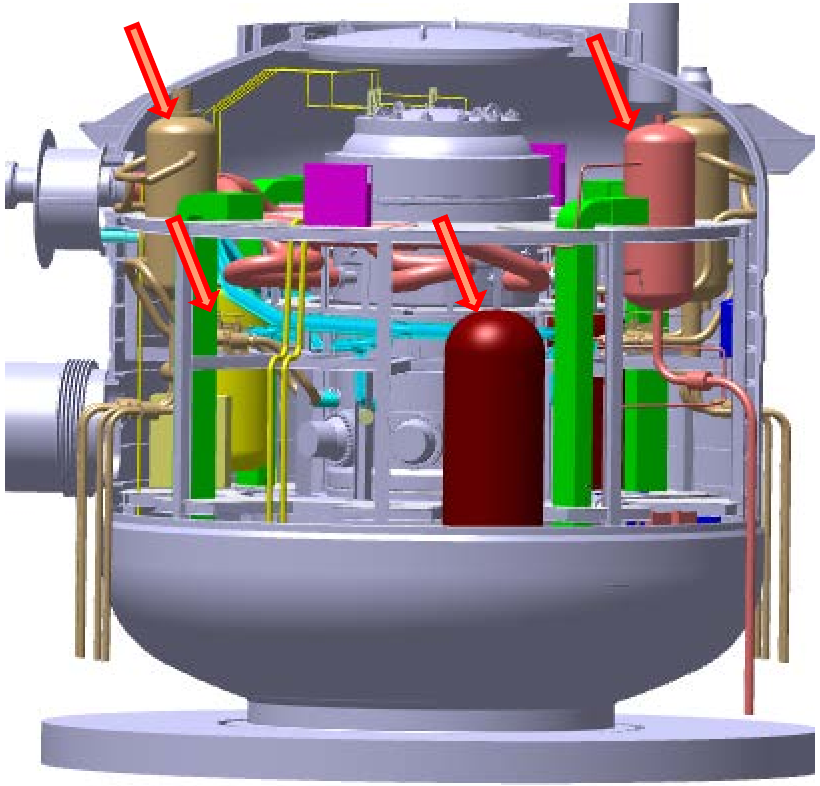
Overview of the Design

Modular design and construction



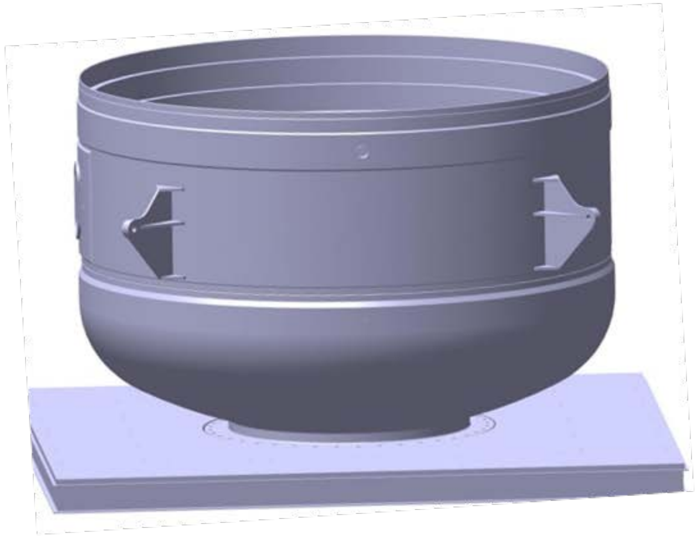
Few circuits/I&C/electrical skids thanks to the integrated architecture

Integration of all circuits on prefabricated skids inside building and inside containment

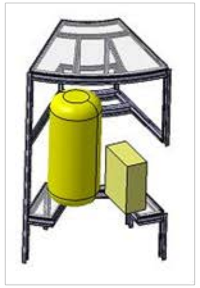


Overview of the Design
Manufacturing and construction

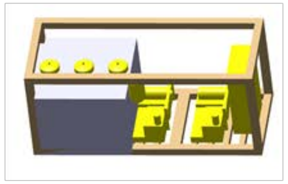
Reactor vessel



Half containment



In-containment pre-tested skid
class 2 transport



Out-containement pre-tested skid
Standard 20' format

Development phases for F-SMR

Concept Description. 2012 - 2015

Conceptual design. 2017-2022

Where we are

Basic Design. 2022-2025

Detailed design and construction.
Early 2030s

SMR : A real opportunity to meet market demands

A proper response to high expectation

- A relevant and affordable solution for carbon free electricity
  - New comers in nuclear, carbon free alternative to existing fossil
  - Remote sites, isolated network
  - Electricity generation, heat, steam and desalination

- Compatible with renewables and complementary with existing large nuclear
  - Base load generation

  or
  - Mid merit (flexible) operation, complementary to large base nuclear and intermittent renewable

As world leaders in nuclear technology and operation, we are engaged to develop a valuable and competitive SMR solution

ADDITIONAL SLIDES

Combining skills of Partners for SMR development

Atomic Energy and Alternative Energies Commission (CEA)

- French public research institution in low-carbon energies (nuclear and renewable energies), defense and global security, information and health technologies
- A key player in research and innovation with 16,000 scientists, engineers, and support staff in 10 research centers

•Core designer

•Involved in the reactor design

•Thermohydraulic codes, expertise and test facilities

EDF Group

- Designs, builds and operates nuclear plants in France and abroad
- Architect Engineer for new build projects
- The World's largest nuclear operator
- Produces around 22% of the European Union's electricity, primarily from nuclear power

•NPP Architect Engineer

•Safety demonstration

•Operation & maintenance

Combining skills of Partners for SMR development

NAVAL GROUP

An European leader in naval defence and a major player in marine renewable energies:

- designs, builds and supports submarines and surface ships.
- supplies services to shipyards and naval bases
- offers a wide range of marine renewable energy solutions.

•Steam conversion system

•Modular concept

•Steel containment

TechnicAtome

- Specialized in the design, construction, operation and maintenance of compact nuclear reactors
- For more than 45 years, offering nuclear engineering expertise on reactors, fuel and related facilities
- Proposes solutions and products that meet the highest safety and availability standards
- About 1,500 people and operates for naval propulsion, research, nuclear medicine and energy.

•SMR reactor designer

•New technologies developer

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