Plant layout arrangement and design of SMRs

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General NPP layout Design requirements and criteria

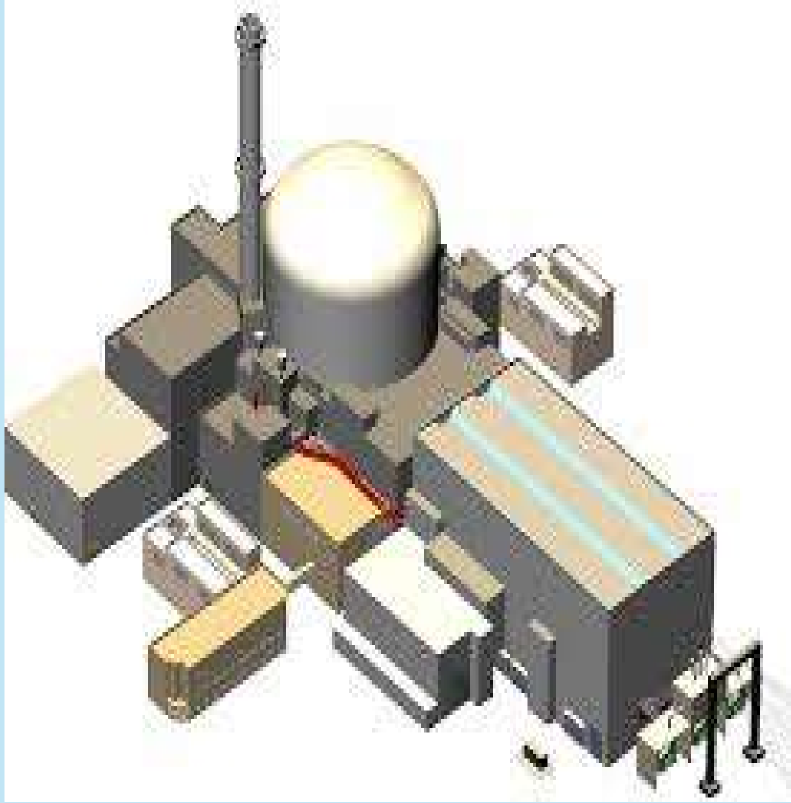
Safety functions: Safe shutdown, heat removal and confinement of radiation under normal, anticipated and accident conditions.

Constructability: integrate heavy-lift routes, work fronts, crane access, modular set points and commissioning boundaries

Operability: Support local operator actions, feedback, emergency response and clear equipment status.

Maintainability: leave space for inspection, surveillance, calibration, outages and temporary shielding.

Economics: avoid layout choices that drive excessive civil volume, long pipe/cable runs or repeated rework.

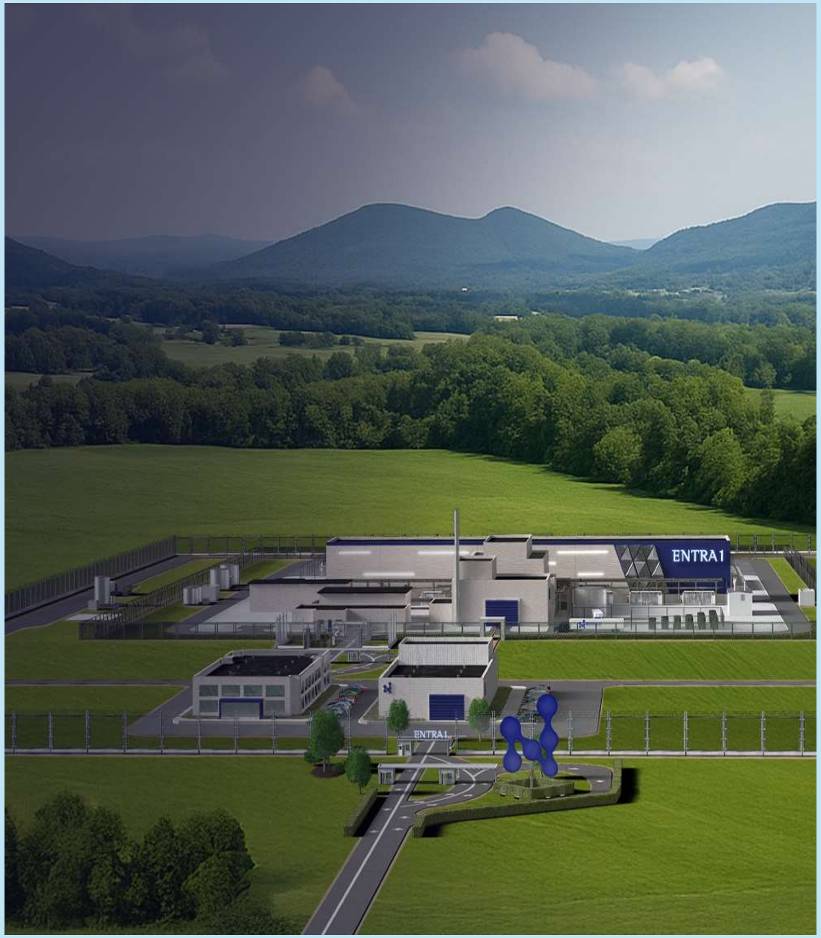


DESIGN LAYOUT DETAILED REQUIREMENTS

Requirement	Purpose
Defence in depth	Multiple protection layers
Separation and redundancy	No common cause failure
External hazard protection	Seismic, flood, wind, shock wave
Internal hazard protection	Fire, flood, pipe rupture
Safety functions	Control, confinement and heat removal
Containment arrangement	Radioactivity confinement
Radiation zoning	Shielding and ALARA
Access and security	Controlled and emergency access
Operability	Operators can operate, monitor access systems
Maintainability	Inspection and repair access
Fuel/waste logistics	Safe movement and storage
Electrical/I&C arrangement	Reliable independent systems
Constructability/decommissioning	Build, replace, dismantle

Site and environmental consideration

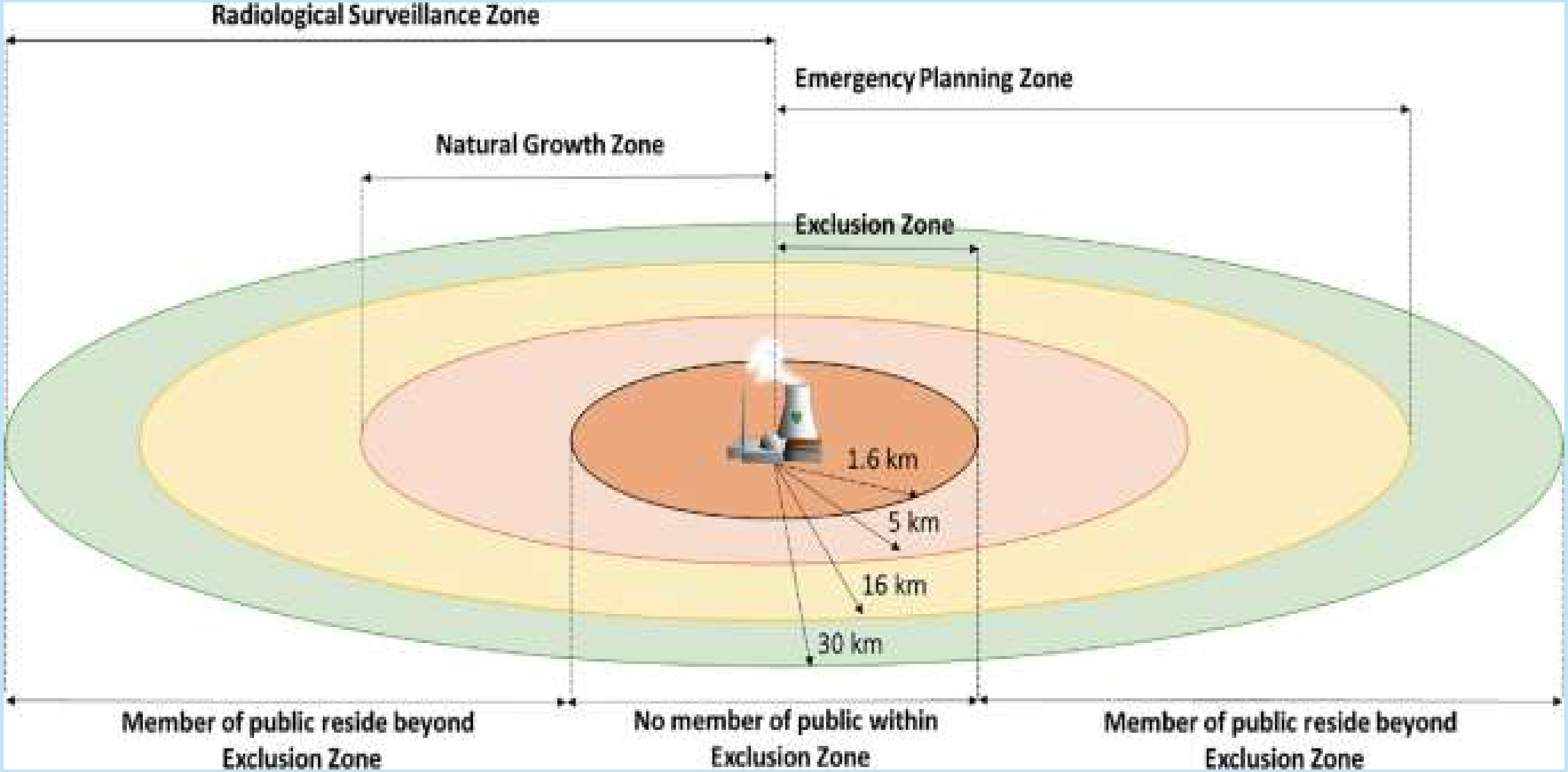
The site plan is where flood protection, seismic strategy, cooling-water design and external hazards are given due consideration.



Site Characterization and boundary conditions.

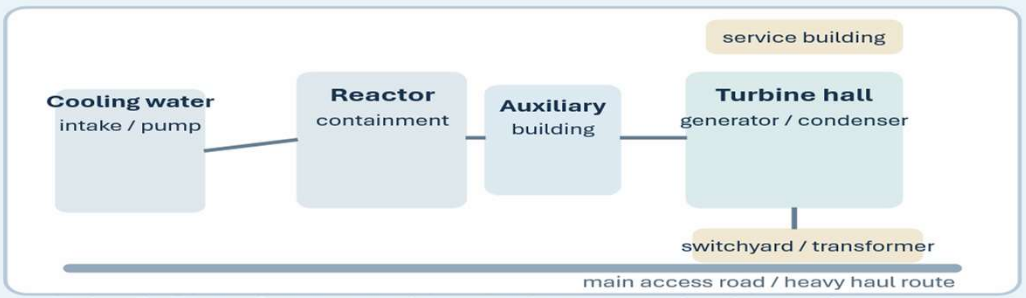
- **Geotechnical**: Bearing capacity for the massive Nuclear Island mat foundation.
- **Seismic (SSE/DBE):** Peak Ground Acceleration (PGA) and response spectra that dictate structural thickness.
- **Hydrology:** Flood protection (Fukushima lessons) and ultimate heat sink availability (river/ocean/air).
- **Demographics:** Exclusion Area Boundary (EAB) and population density requirements

With smaller source term, the exclusion zone in SMRS can be considerable smaller



Plant configuration and general arrangement (GA)

A good GA shows the station as an integrated campus: nuclear island, conventional island, support facilities, water systems and access routes.



Typical site GA must integrate heat sink, nuclear island, conventional island, switchyard and access cor

What the GA should communicate

- Relative position of containment, auxiliary building, turbine building, radwaste, switchyard and cooling-water structures.
- Radiation zoning and design of ventilation Philosophy
- Building spacing needed for fire protection, seismic gaps, blast considerations, maintenance laydown and equipment removal.
- Elevation strategy: finished floor levels, drainage direction, water barriers, buried structures and interfaces with below-grade rooms.
- . Personnel routes, heavy-component delivery path, crane reach logic and future expansion philosophy for additional units

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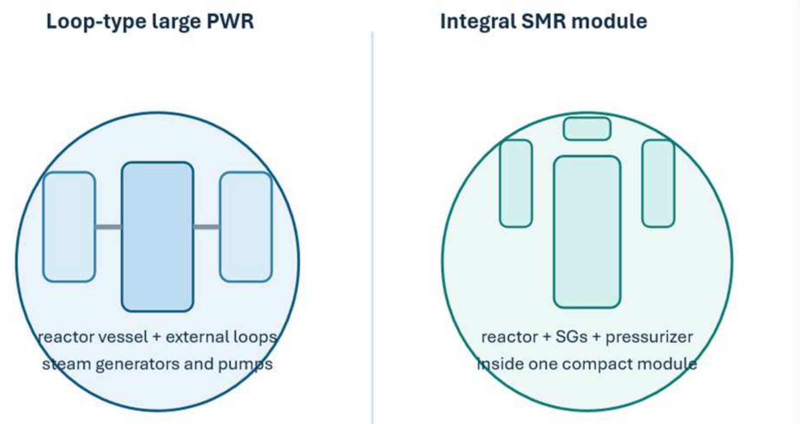
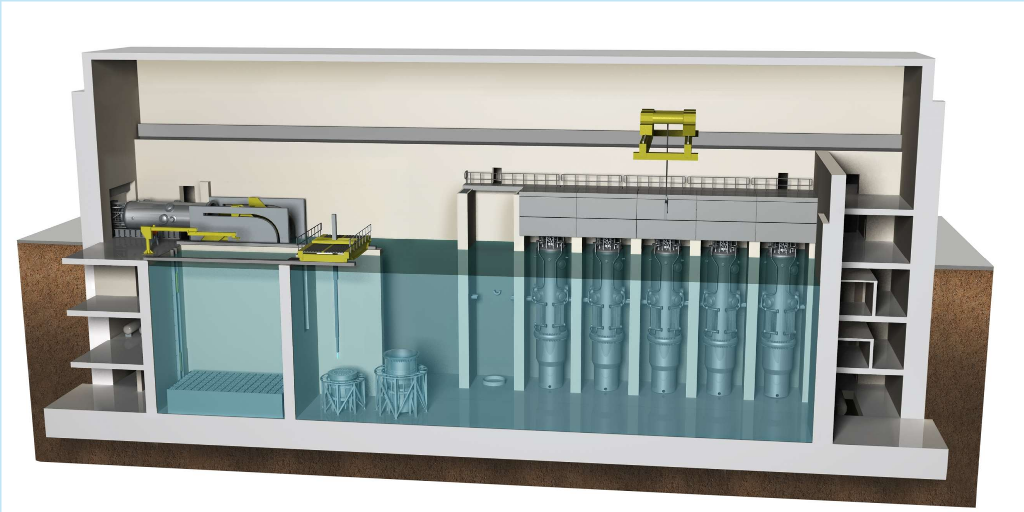
Reactor building and Primary coolant circuit

This is where nuclear safety, building geometry, penetrations, shielding and refuelling strategy become one arrangement problem.



Layout consequence: integralization shortens primary boundaries, but access, shielding, drainage and

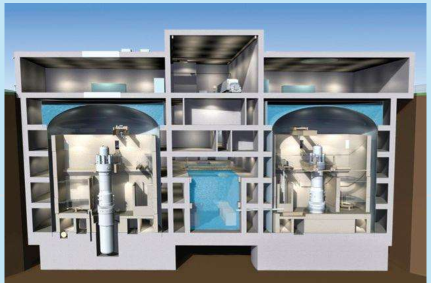


Large-plant perspective

- Loop-type layouts must coordinate vessel, steam generators, pumps, piping runs, equipment hatch, polar crane and refuelling cavity.
- Containment design drives dose fields, maintenance staging and outage logic as much as it drives accident analysis.

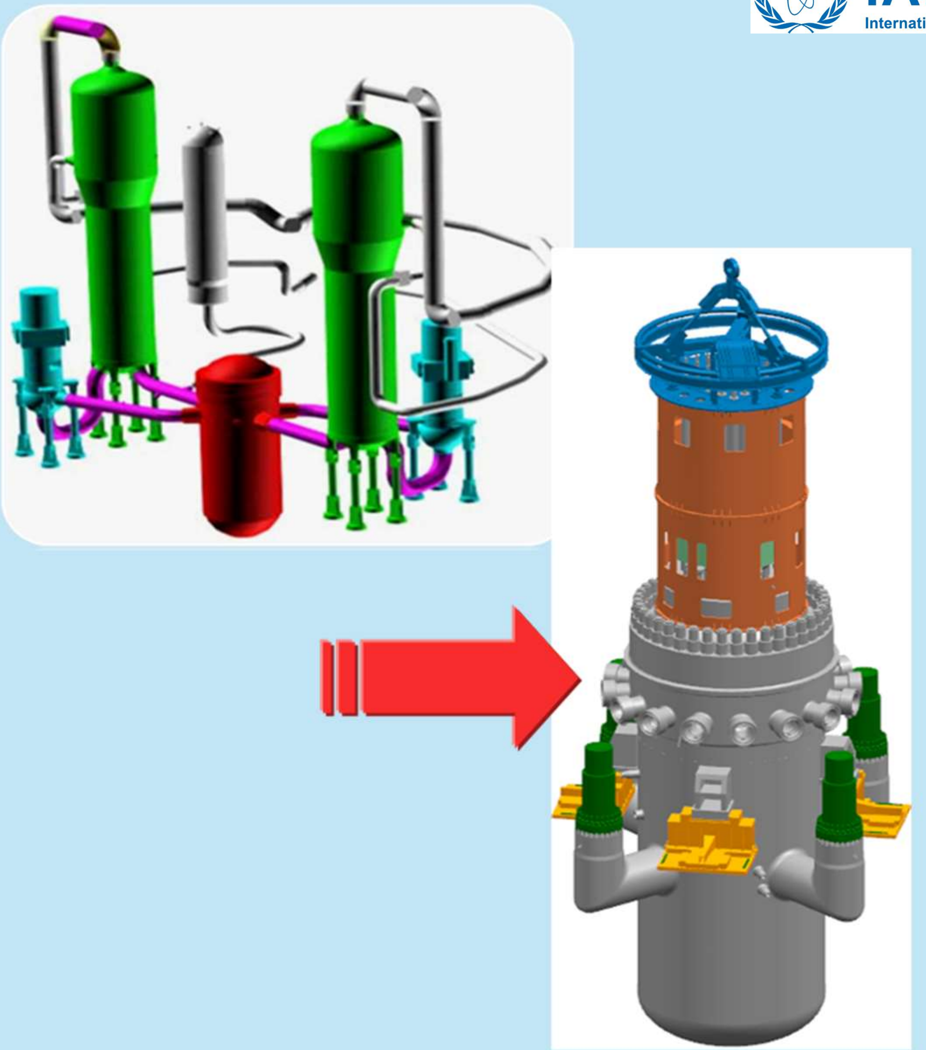
SMR perspective

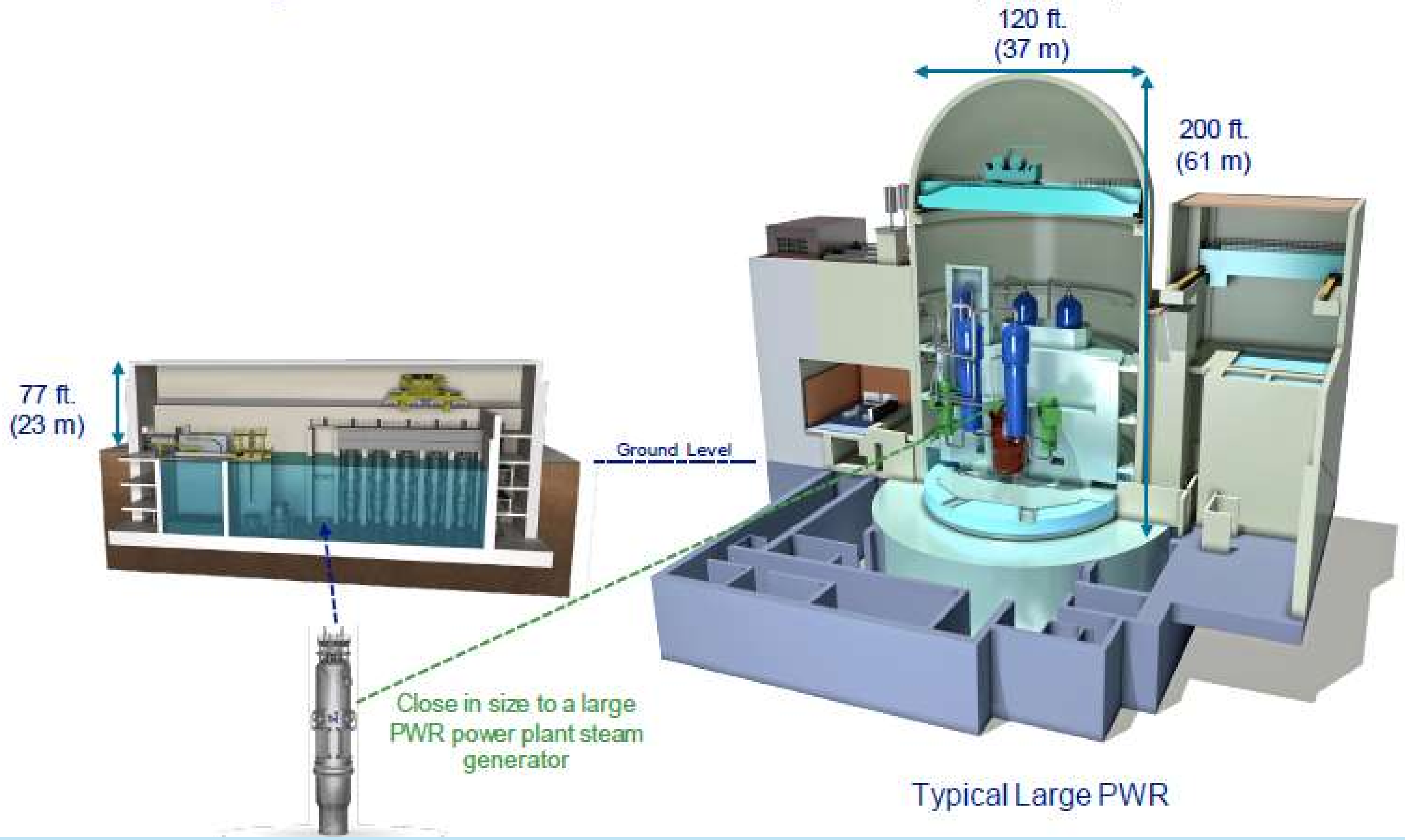
- Integral modules compress the primary system, often enabling below-grade pools or compact nuclear islands.
- The layout proof is still the same: shielding, drainage, access, replacement routes and confinement interfaces must remain credible.



Integral NSS

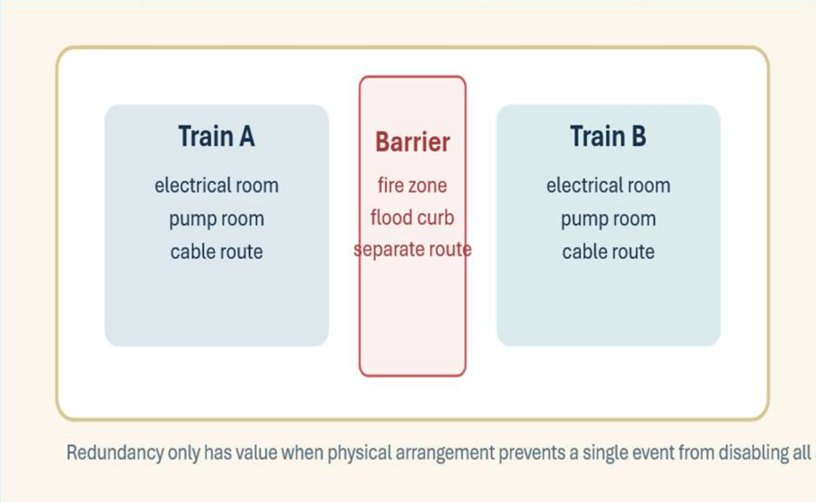
In SMRs primary system can be collapsed into the reactor vessel or a compact reactor island, changing the geometry of containment, shielding, piping runs, and maintenance access.

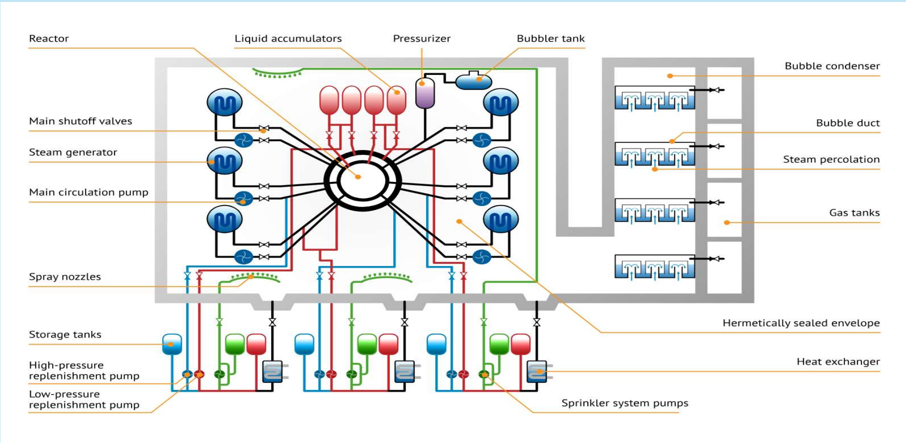



120 ft.
(37 m)
200 ft.
(61 m)
77 ft.
(23 m)
Ground Level
Close in size to a large PWR power plant steam generator
Typical Large PWR

Safety layout and separation principles

Redundancy only becomes real when the physical arrangement prevents one event from defeating all available lines of defence.

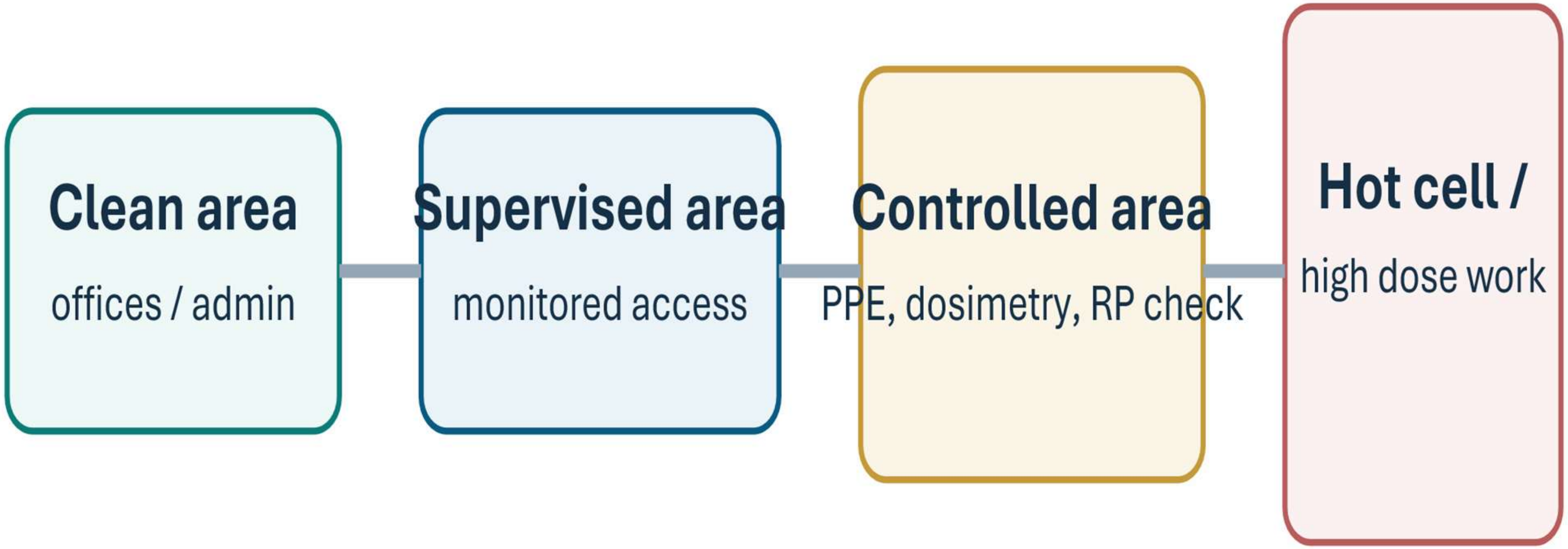




What separation, redundancy and independence means in layout terms

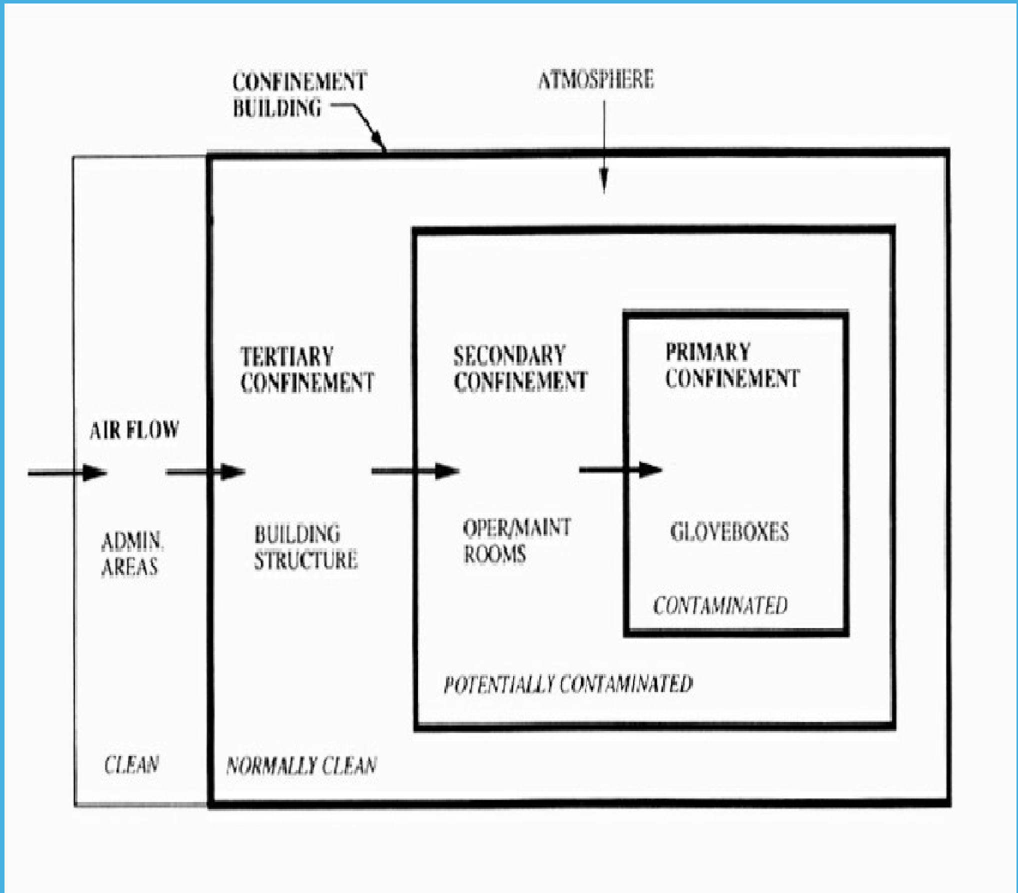
- Physically separate redundant trains, cable routes, emergency power supplies and cooling chains so that fire, flood or internal missile does not cause total loss of function.
- Show barriers explicitly: fire zones, flood curbs, room segregation, seismic gaps, route diversity and protected ventilation boundaries.
- Make passive safety features visible in the layout rather than discussing them only in system descriptions; the audience should see where natural circulation, gravity or inventory margins are protected.
- For SMRs, shared systems and close module spacing mean whole-site interactions matter more than unit-by-unit reasoning alone.
- Module-to-module separation in multi-module plants, so an event in one reactor unit does not disable the safety functions of another
- Independence means, independent actuation logic, sensing and instrumentation channels,
- For SMRs, these all are achieved through **compartmentation, passive features, protected I&C and power architecture, and careful control of shared systems in multi-module sites**.

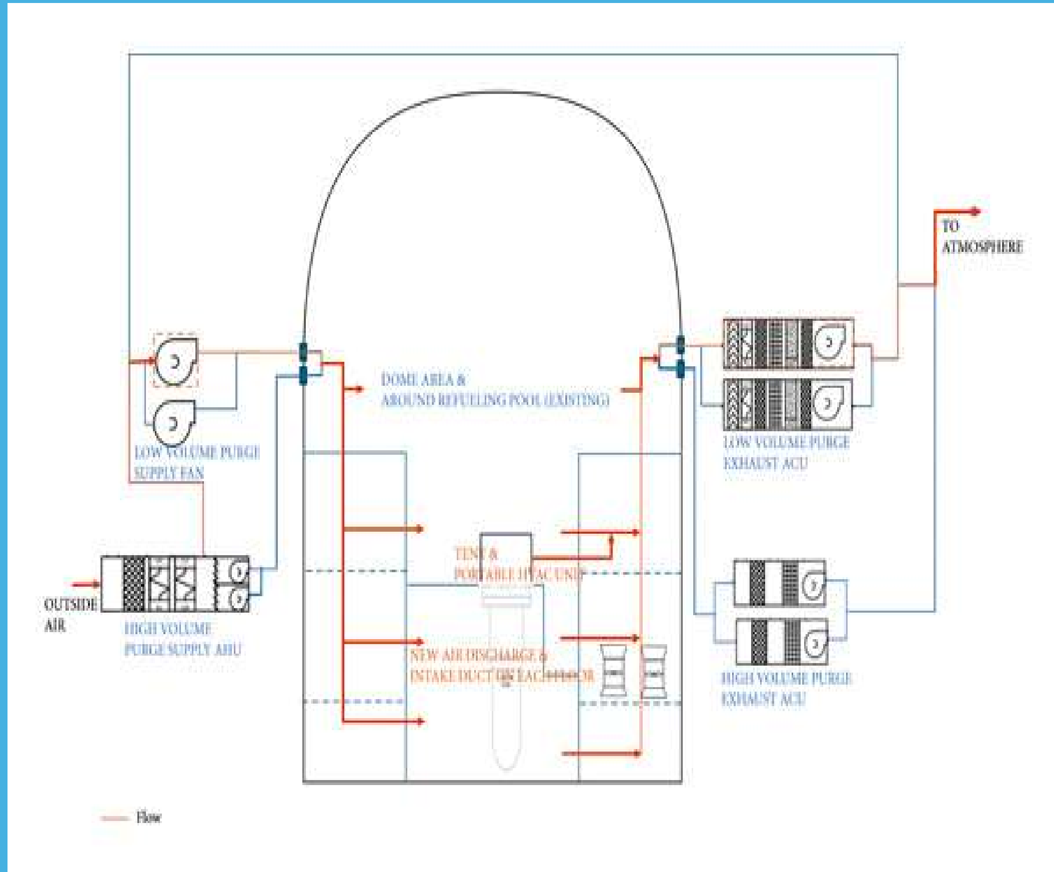
Representative radiation zoning logic



Plant layout In SMRs must consider Ventilation zone design

Contamination confinement is achieved by maintaining pressure differential between various radiation zones





Systems integration and balance of plant (BOP)

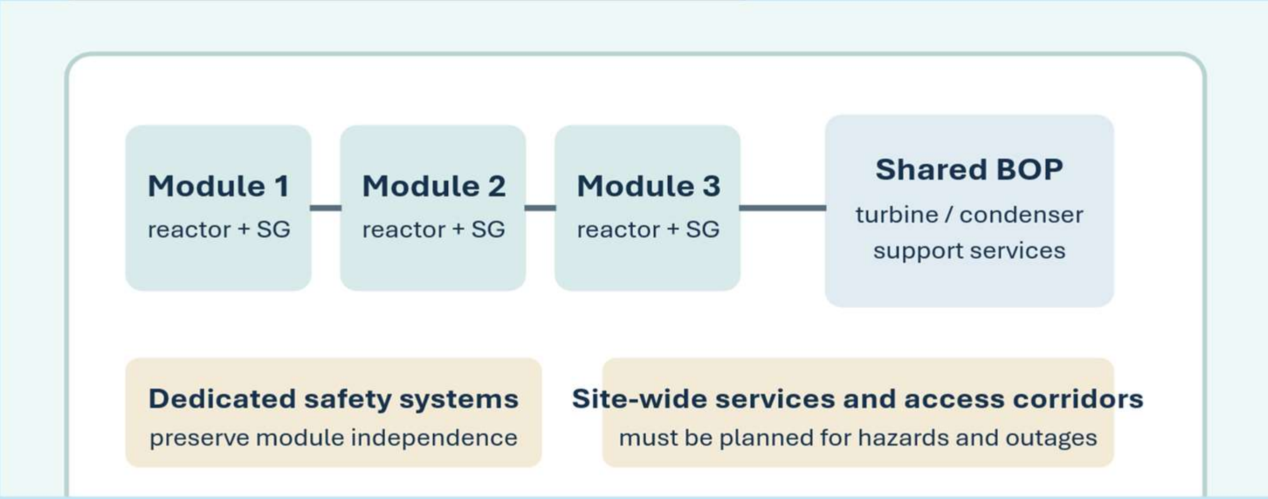
A nuclear plant is not only a reactor building. The layout succeeds only when the nuclear island, turbine island and support services are coherently integrated.

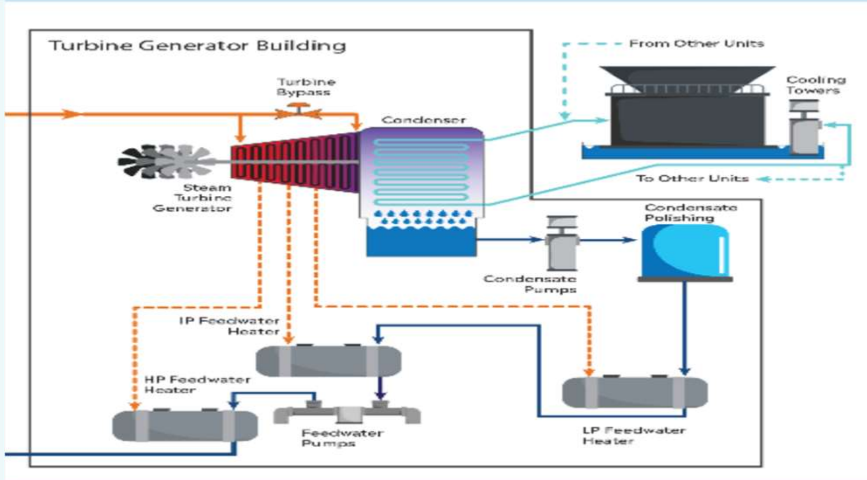
BOP in all NPPs

- Turbine-generator, condenser, feedwater and heat rejection systems dominate the conventional island footprint.
- Auxiliary systems such as service water, HVAC, chemistry, compressed air and electrical support create critical building interfaces.
- Good layout makes safety-class to non-safety-class boundaries obvious and manageable.

SMR integration issue

- Economics often encourage shared BOP systems across modules.
- Every shared service must be checked for hidden common-cause, outage and staffing implications.
- Industrial heat, hydrogen or desalination applications widen the interface problem beyond a normal turbine island.





Modularization and construction sequence

In SMRs especially, layout cannot be separated from how the plant is fabricated, transported, erected and commissioned.

Constructability logic for any NPP

- Reserve heavy-haul access, crane standing areas and erection envelopes before detailed piping and civil congestion appear.
- Keep civil sequence, equipment installation windows and commissioning boundaries aligned so that trade congestion does not destroy schedule performance.
- Provide temporary laydown, test boundaries, temporary power and access routes because construction is a physical process, not only a schedule chart.
- A constructable layout lowers rework, supports quality control and reduces interference between civil, mechanical, electrical and I&C activities.

What modularization adds

- Modularization changes the construction sequence , shifts large part of the work from site to the factory.
- Challenges can appear during interface between modules.
- A good modular design strategy can reduce the number of workers and work fronts in congested areas.
  That improves:
  - Safety
  - Access
  - Quality and Schedule control

Construction-led layout: design the plant around transport, lifts, and sequence

SMR layout quality is strongly correlated with how early modular fabrication and site assembly are frozen into the design baseline.

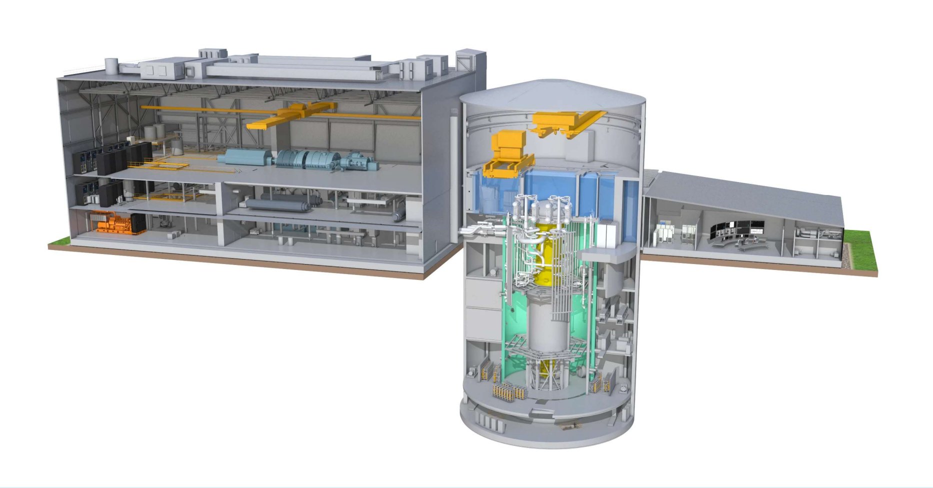
Factory packaging — Split SSCs into transportable modules with stable interfaces and test boundaries.

Transport envelope — Road, rail, or barge constraints cap dimensions, weight, and route geometry.

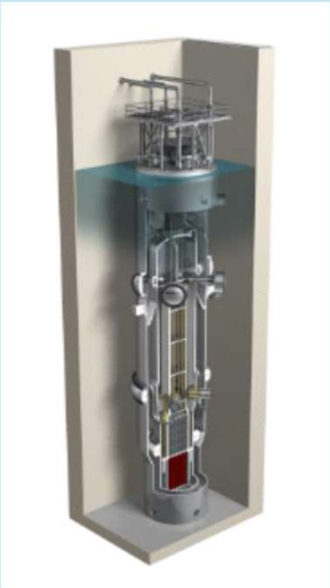
On-site laydown — Need clean receiving area, protected storage, and QC/inspection access.

Heavy lift & set — Crane radius, hook height, and weather windows drive building spacing and sequence.

Closure & commissioning — Once modules are set, access routes disappear; confirm maintainability before closure.



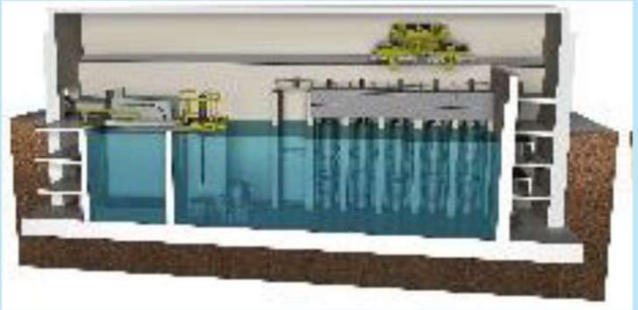
1. Factory Fabrication



2. NuScale Module including containment and reactor vessel

3. Shipped by truck rail or barage

4. To the plant site



5.Installed in RB as various modules

Maintenance ,Inspection and Surveillance.

Plant layout must ensure maintainability, accessibility and adequate provision for material handling

Inspection (In-Service Inspection - ISI)
The layout must provide physical access for non-destructive examination (NDE).

Surveillance (Online Monitoring)
Increased use of online monitoring (OLM) and embedded sensors

Reactor pressure vessel material
The layout must facilitate the validation of design margins through actual site data.
Coupon Sampling: Dedicated "material capsules" placed in the reactor's beltline region. The layout must allow for the periodic removal of these capsules to analyze neutron embrittlement of the vessel steel.

Environmental Sampling Points: Chemical analysis

Repair & Replacement (R&R)
The layout must treat major components as replaceable assets, not permanent fixtures.

Modular Replacement: In SMRs, if a Steam Generator fails, the layout allows you to swap the entire module rather than performing a 6-month in-vessel weld repair. Hence modular replacement is preferred over repair

OPERATION OF SMALL MODULAR REACTORS

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Modularization and cogeneration may present operational challenges

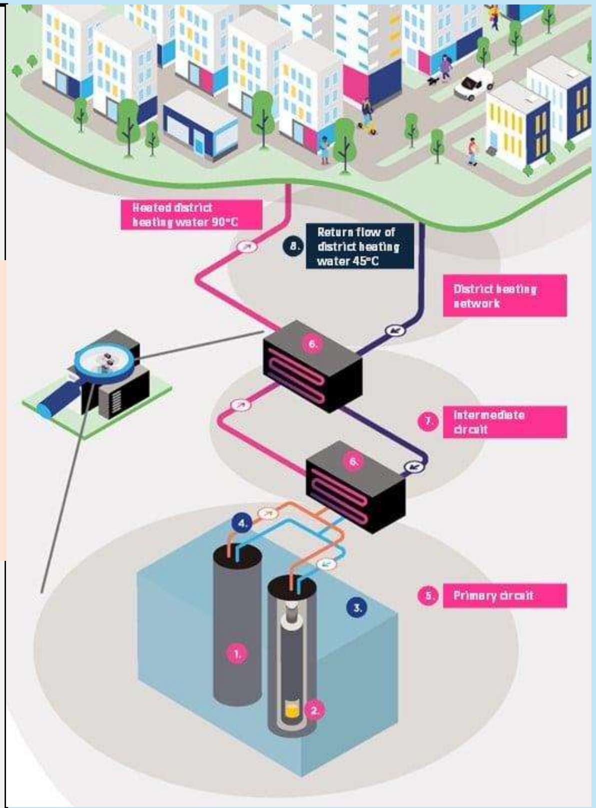
- SMRs can be deployed for cogeneration which may include and because of small exclusion zone can be located closer to city centers.

SMRs simplify construction through modularisation, but shift operational complexity toward system integration, multi-unit coordination, and energy coupling.

Besides electricity

they may be used for

- For desalination
- Process heating
- Chlorine production
- Hydrogen production and
- District heating



Key take away of SMR layout

In SMRs, compact modular design provide some design advantages as well as challenges.

1

Integral NSSS

More of the primary system can be collapsed into the reactor vessel or a compact reactor island, changing the geometry of containment, shielding, piping runs, and maintenance access.

2

Passive safety

Pools, natural circulation, gravity-driven inventories, and longer coping times shift the layout emphasis from active-system separation to protected passive inventories and reliable heat rejection paths.

3

Multi-module Design

The plant may share control room, heat sink, confinement, electrical systems, or balance-of-plant; layout must explicitly manage coupling and common-cause vulnerabilities.

4

Factory-built modules

Transport envelopes, lift strategy, factory breakpoints, and assembly sequence become layout constraints as real as seismic or radiation zoning.

5

Flexible siting

Reduced footprint and potentially smaller **EPZ**s can enable co-location with industrial loads, but the site plan must still satisfy security, access control, emergency response, and safeguardability.

Thank you