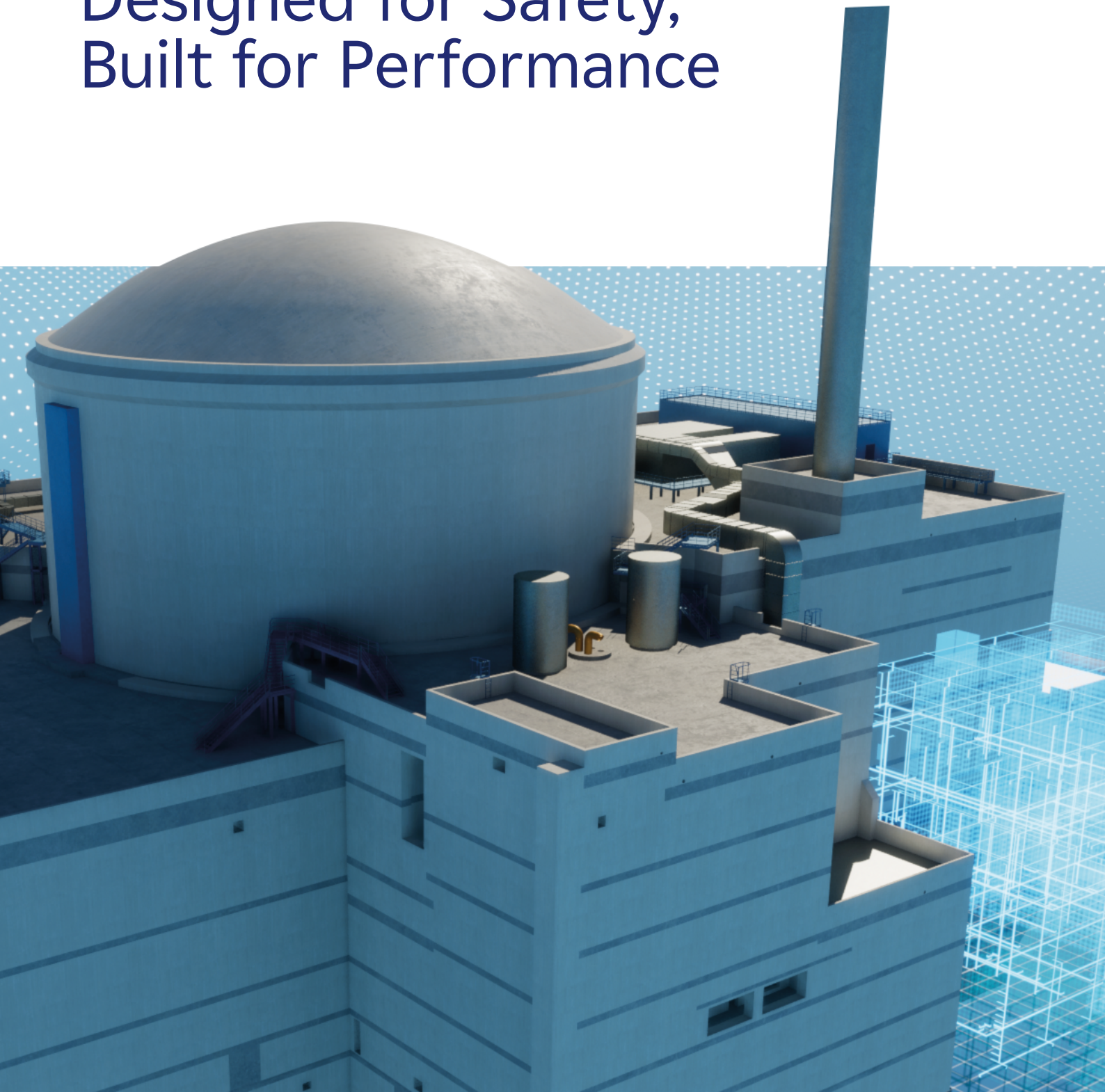
EPR1200

Designed for Safety, Built for Performance



Shaping the nuclear renaissance

The urgency of the climate crisis and the increasing share of intermittent renewable energy underscores nuclear power's role as a complementary solution in delivering baseload dispatchable and low-carbon energy. **As such, in full alignment with our company purpose, EDF is committed to delivering best-in-class technologies to meet our clients' expectations and their countries' vision in securing access to sustainable sources supporting energy security.**

At a time when the world faces the urgent need for decarbonisation, we believe there is no one-size-fits-all solution. Specific regional necessities, such as network restrictions and energy usage models, have prompted EDF to broaden its range of reactors, with nuclear technologies readily and reliably available to meet the global market's needs.

With our **EPR** (1650 MWe), **EPR1200** (1200 MWe) and **NUWARD SMR** (340 MWe) technology portfolio, EDF is unique in offering a full range of solutions to support legacy nuclear and newcomer countries in delivering their nuclear programmes. As the world's largest nuclear power plant owner-operator, EDF brings to market its track record, services and solutions covering the entire nuclear value chain, from design, construction, and commissioning to operation, maintenance, and decommissioning.

The EPR1200 fully leverages a complete and comprehensive suite of practices, tools, and design options built on EPR's proven adaptability to a variety of environmental, regulatory and industrial contexts. Additionally, thanks to EDF's experience in licensing, building, commissioning and operating EPR-based technologies in China, France, and the United Kingdom, the EPR1200 integrates all the latest advancements in the areas of nuclear and environmental safety, modularised construction as well as technical and economic performance.

EDF's unwavering commitment to delivering the best low-carbon solutions, exemplified by the EPR1200, embodies our strategic alignment with the world's urgent needs, encapsulating a future where nuclear power is not just an option but an essential path to a sustainable and secure energy landscape.

Drawing on our heritage and dedication, EDF builds on trust and partnership to realise your nuclear power vision. We look forward to forging a brighter, cleaner future together.

Vakisasai Ramany
EDF, Senior Vice President for New Nuclear Development

"EDF's unwavering commitment to delivering the best low-carbon solutions, exemplified by the EPR1200, embodies our strategic alignment with the world's urgent needs."

Learn more about EDF Groupe and our *raison d'être*, here.

Building on Experience

EPR1200 utilises EDF's vast experience in the design, construction, and operation of the world's largest nuclear fleet. Thanks to a comprehensive lessons-learned approach, the EPR1200 is the result of optimisations and adaptations based on proven and efficient design options and construction techniques.

CORE EPR TECHNOLOGY

EPR1200 is a Generation 3+ nuclear reactor with a net electrical power output of 1200 MWe. Adapted from proven EPR reactor technology already in service, EPR1200 shares most of its equipment, components and design options with EPR, in addition to benefitting from construction and operation feedback from ongoing EPR projects, including:

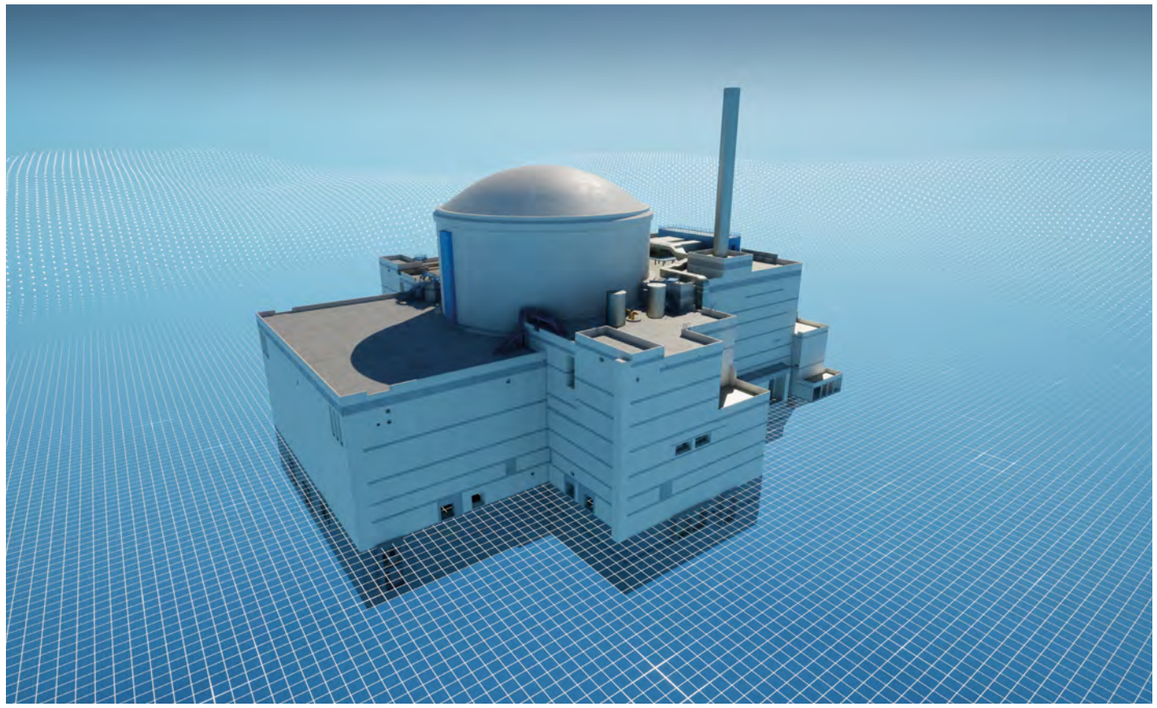
- Reactor systems design;
- Safety design options and architecture;
- Standardised components and equipment;
- Compliance to identical design and construction codes and standards.

PROVEN, RELIABLE, ADAPTABLE

EPR1200 is designed to meet the most stringent requirements in terms of operational performance and licensing.
EPR technology is already endorsed by four leading safety authorities: France's ASN, United Kingdom's ONR, Finland's STUK and China's NNSA, demonstrating its inherent safety and adaptability.

The adapted EPR1200 design is compliant with the highest international standards such as:

- IAEA Safety Standards;
- WENRA guidance;
- European Utility Requirements (EUR);
- AFCEN – RCC.



EPR1200
The EPR1200 is an optimised version of the EPR adapted to deliver a maximum electric capacity of 1200 MWe.

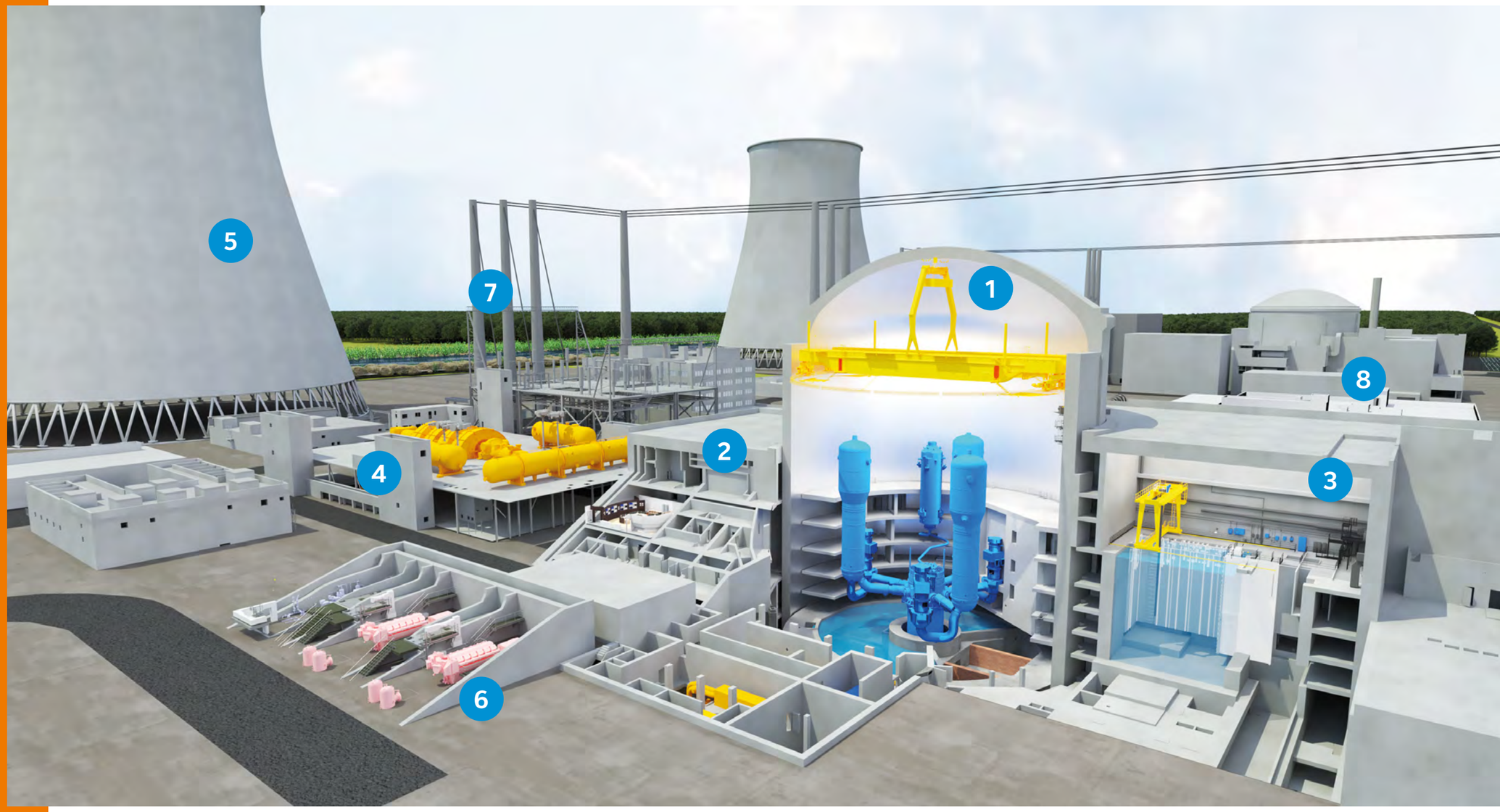
FLAMANVILLE 3
EPR Reference Plant
The EPR1200 refers to EPR2 as its standard design, and to the EPR Flamanville as its Reference Plant, meaning that EPR1200 takes into account design optimisations as well as construction and operation feedback from all current EPR projects.

Adapting to the challenges of the 21st century

Ensuring that the environmental impact of a nuclear unit remains minimal requires both foresight and adaptability. Designed to operate and at least 60 years, EPR1200 takes into account, from its initial design stage, climate change projections at the end of the 21st century.
Thanks to innovative solutions such as optimised water management procedures, increased storage in effluent reservoirs, advanced cooling tower designs, and enhanced thermodynamic efficiency, EPR1200 minimises water consumption and limits the ecological impact on local fauna and flora, in both its riverbank and seaside configurations.

EPR1200 layout

EPR1200 technology can accommodate a variety of site conditions with limited and controlled adaptations, whether it be rocky seashores, sandy beaches, estuaries and riverbanks with open or closed cooling solutions. Thanks to EDF's experience in managing EPR engineering and construction projects across the globe, the EPR1200 layout is optimised for constructability whilst providing unique resistance to external hazards.



Typical EPR1200 riverbank layout
Designed for limited environmental impact, the EPR1200 layout is optimised for safety and performance.

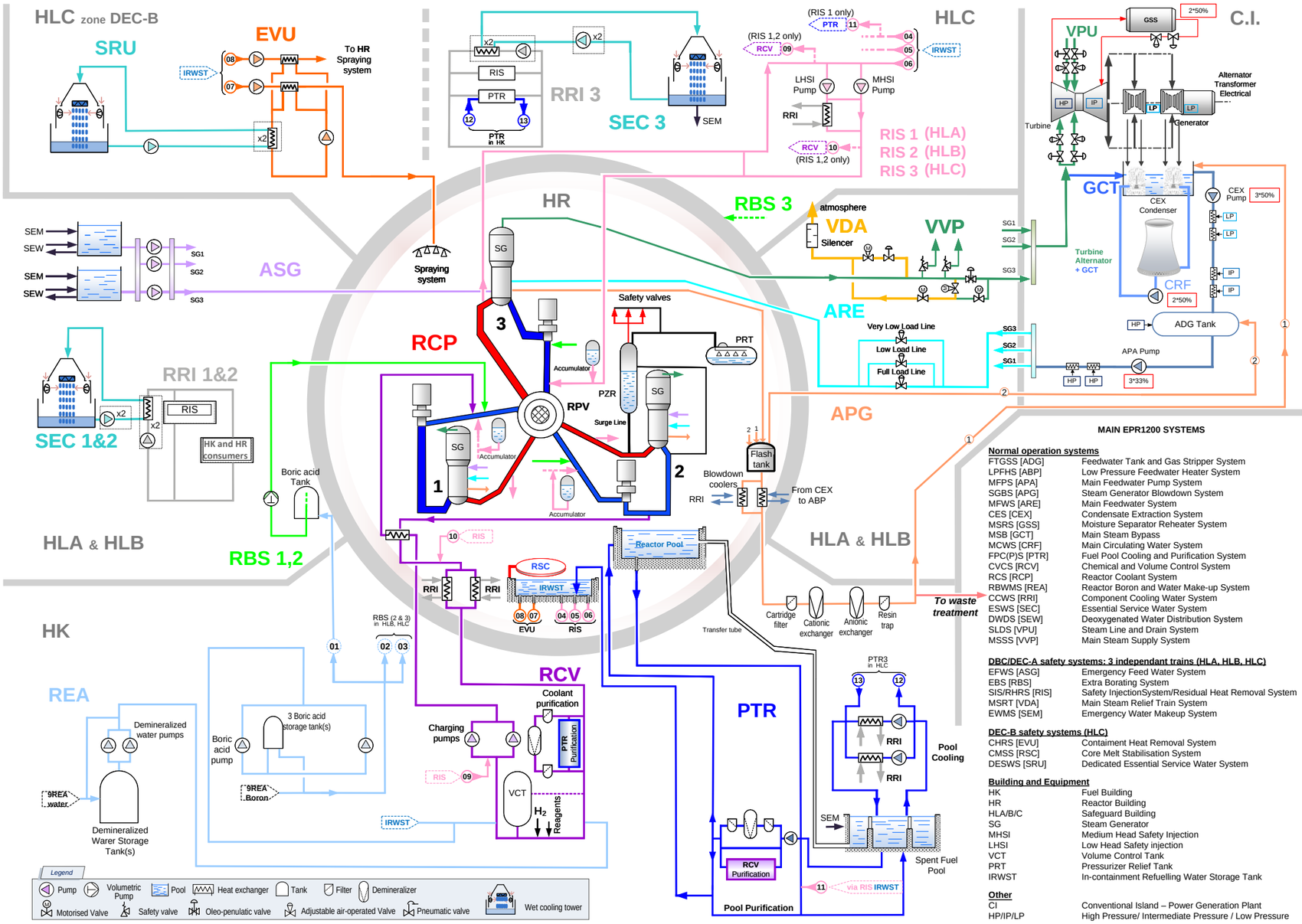
1. *Reactor Building: houses and protects the reactor core, the area where nuclear fission reactions take place, facilitating the controlled release of energy in a secure environment.*
2. *Safeguard Building: houses the main safety systems and emergency backup equipment, ensuring that in the event of anomalies or malfunctions, the plant can be safely shut down or operated in a safe state.*
3. *Fuel Building: the dedicated space for the storage, management, and preparation of nuclear fuel assemblies before and after they are introduced into the reactor for energy production.*
4. *Turbine Hall: houses the nuclear steam turbine and generator, used for converting the produced steam's mechanical energy into electricity before condensing it back into liquid water.*
5. *Cooling Tower: dissipates heat waste by transferring it from the reactor's cooling system to the atmosphere.*
6. *Diesel Buildings: houses the emergency diesel generators, used to supply power to the plant's emergency systems in the case of loss of the plant's connection to the electricity grid.*
7. *Transformers: steps up the voltage of the produced electricity to 400,000 V, in order to reduce energy loss over long transmission distances.*
8. *Effluent Treatment Building: processes liquid and gaseous wastes, utilising advanced filtration and monitoring systems to ensure adherence to environmental safety and strict regulatory standards before release.*

2,200 reactor.years of experience, in one design

EPR1200 architecture employs proven reactor system design options, ensuring consistency in its core EPR technology, facilitated licensability in a variety of regulatory environments and reliable long term performance.

By adhering to the principles of Defence-in-depth, Safety Design, Diversification and Redundancy, and Severe Accident Management, EPR1200 has reached unparalleled levels of safety in core damage frequency and severe accident consequences.
This entails reinforced protection against various internal and external threats, extending even to the operator's response time.
Bridging the foundational safety concepts with their practical applications, let's delve deeper into the specific systems and components that embody these principles in the EPR1200 design:

- **The Reactor Coolant System (RCP)** contains the reactor core and three cooling loops composed of a steam generator and main coolant pump. The produced steam is sent to the turbine hall through the **Main Steam Lines (VVP)**, where it will drive the turbine to generate up to 1200 MW of electricity;
- The RCP is supported by auxiliary systems that contribute to three main safety functions: controlling the chain reaction, cooling the nuclear fuel, and containing radioactivity. Two crucial support systems are the reactor's **Chemical and Volume Control System (RCV)**, responsible for adjusting the water mass, chemical composition and water quality in the primary circuit, and the **Component Cooling Water System (RRI)**, which evacuates residual heat by diverting excess energy to the heat sink through the **Essential Service Water System (SEC)**;
- Additionally, emergency backup circuits, including the **Safety Injection System (RIS)** stops the nuclear reaction and supplies the reactor with a constant source of water during a coolant loss accident, the **Containment Spray System (EVU)** decreases pressure and traps radioactive elements in the Reactor Building (HR) in the event of significant pressure increase, and the **Emergency Feed Water System (ASG)** supplies cooling water to the steam generators in case the normal feedwater system becomes unavailable.



MAIN EPR1200 SYSTEMS

Normal operation systems

FTGSS [ADG]	Feedwater Tank and Gas Stripper System
LPFHS [ABP]	Low Pressure Feedwater Heater System
MFPS [APA]	Main Feedwater Pump System
SGBS [APG]	Steam Generator Blowdown System
MFWS [ARE]	Main Feedwater System
CES [CEX]	Condensate Extraction System
MSRS [GSS]	Moisture Separator Reheater System
MSB [GCT]	Main Steam Bypass
MCWS [CRF]	Main Circulating Water System
FPC(P)S [PTR]	Fuel Pool Cooling and Purification System
CVCS [RCV]	Chemical and Volume Control System
RCS [RCP]	Reactor Coolant System
RBWMS [REA]	Reactor Boron and Water Make-up System
CCWS [RRI]	Component Cooling Water System
ESWS [SEC]	Essential Service Water System
DWDS [SEW]	Deoxygenated Water Distribution System
SLDS [VPU]	Steam Line and Drain System
MSSS [VVP]	Main Steam Supply System

DBC/DEC-A safety systems: 3 independant trains (HLA, HLB, HLC)

EFWS [ASG]	Emergency Feed Water System
EBS [RBS]	Extra Borating System
SIS/RHRS [RIS]	Safety InjectionSystem/Residual Heat Removal System
MSRT [VDA]	Main Steam Relief Train System
EWMS [SEM]	Emergency Water Makeup System

DEC-B safety systems (HLC)

CHRS [EVU]	Containment Heat Removal System
CMSS [RSC]	Core Melt Stabilisation System
DESWS [SRU]	Dedicated Essential Service Water System

Building and Equipment

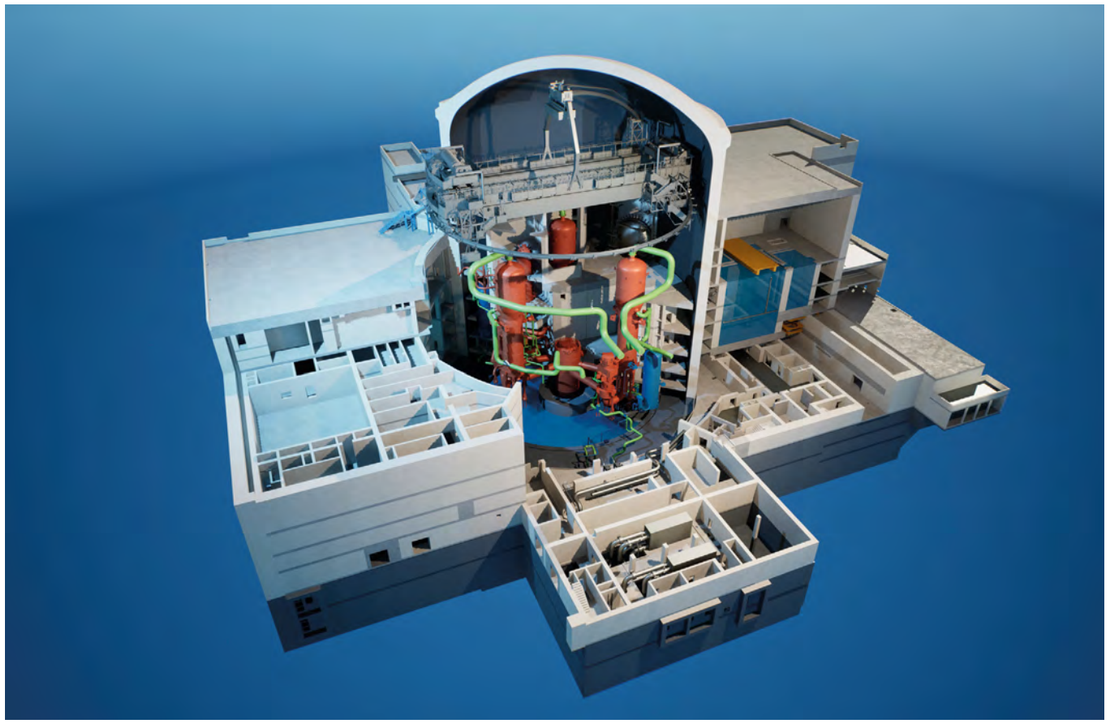
HK	Fuel Building
HR	Reactor Building
HLA/B/C	Safeguard Building
SG	Steam Generator
MHSI	Medium Head Safety Injection
LHSI	Low Head Safety injection
VCT	Volume Control Tank
PRT	Pressurizer Relief Tank
IRWST	In-containment Refuelling Water Storage Tank

Other

CI	Conventional Island – Power Generation Plant
HP/IP/LP	High Pressure/ Intermediate Pressure / Low Pressure

EPR1200 in a nutshell

EPR1200 is a GENERATION 3+ three-loop adaptation of EDF's flagship EPR technology for a power output in the range of 1200 MWe, and ideally suited to meet the power production requirements of a vast variety of sites across Europe and around the globe.



A NEW GENERATION OF NUCLEAR TECHNOLOGY

EPR1200 benefits from major optimisations and lessons learned in designing, building and operating EPRs across the globe. Key factors contributing to EPR1200's reliability in terms of construction delivery and adaptability to different licensing scenarios include:

- Simplified architecture and civil structures;
- Standardised off-the-shelf components;
- Reuse of proven equipment designs on existing EPRs;
- Modular construction techniques;
- Integrated digital design and construction planification tools;
- Best-in-class codes and standards for electrical, mechanical and nuclear systems design and fabrication.

ADAPTABILITY IN LICENSING

EPR1200 has been specifically designed with, in mind, the need to address the 1000-1200 MWe power production needs for the European and global market. **The technology has passed a review by France's Nuclear Safety Authority (ASN), confirming alignment with the EPR's recognised safety standards and acknowledging the robustness of the EPR1200's enhanced safety margins.** ASN gave a positive assessment on the safety objectives, safety baseline and design options of EPR1200 which, by reusing EPR components and design options, will reinforce the EPR1200's overall performance. This review confirms EPR1200 as a reliable and sustainable energy solution for a broad market in Europe and around the globe.

Data-centric EPR1200

EPR1200's technical configuration is designed and maintained in EDF's modern digital Plant Lifecycle Management platform (PLM). Thanks to this detailed digital twin strategy, EPR1200 not only benefits from the most modern and sophisticated system engineering processes but also offers unparalleled accuracy in managing the vast amounts of data involved in its design, construction and ultimately its operation and maintenance. This lifecycle approach greatly improves requirements traceability and configuration management of the design and allows for adaptive and controlled change management during the execution phase of the project: coordinating millions of data points, ensuring robust data integrity, integration of supplier data systems, and facilitating the handover of the engineering and design data to the owner-operator of the plant once the project is completed.

EPR1200 KEY CHARACTERISTICS

Electrical net output	Up to 1200 MWe
Operation cycle	18 to 24 months
Availability factor	91%
Design plant life	At least 60 years
Fuel	UO_2 enriched up to 4.2% Possibility for up to 30% MOX
Fuel assemblies	177 assemblies
Grid connection	Compliant with EU Requirements for Generators
Primary coolant system	3-loop configuration
Load follow flexibility	25% to 100% nominal power in 30min

Designed for Safety, Built for Performance

EPR1200 is ushering in a new nuclear renaissance, driven by the imperative to meet a level of safety, reliability and operability performance that is up to the challenges of large energy infrastructure projects of the 21st century.

OPTIMISED FOR CONSTRUCTABILITY

The design and construction of EPR1200 involves a combination of innovative engineering techniques and optimisation strategies. These encompass the use of factory pre-fabrication methods for quality and efficiency, the optimisation of civil engineering for easier construction, and the use of proven components.

- Factory pre-fabrication is used to its full potential. 30% fewer welds will be performed on the construction site, and some buildings will be entirely modularised.
- The number of unique references for valves, pipes, pumps has been significantly reduced, by retaining references that already exist in the suppliers' catalogs.

MASTERING POWER MANOEUVRABILITY

EPR1200 adopts EDF's unrivalled technological breakthroughs in power load-following and frequency control adjustments and manoeuvrability. **Thanks to its network monitoring capabilities, EPR1200 is capable of quickly adjusting its power output to compensate for rapidly changing grid requirements, being able to ramp up power from 25% to 100% in only 30 minutes.**
This makes EPR1200 a uniquely ideal high-power load following solution for electrical grids, particularly those with a significant portion of power sources such as wind and solar.

DESIGNED FOR LIMITED IMPACT

EPR1200 complies with stringent European regulations concerning environmental impact during construction and operation.

- With its strategic placement and quantity control of cobalt-containing materials, EPR1200 minimises the creation of radioactive effluents.
- Thanks to a meticulously planned layout of equipment and systems and optimised use of radiation shielding, worker exposure to radiation is limited to a strict minimum.
- The remarkable efficiency of its core design and management systems lead to savings of up to 15% on natural uranium per produced MWh, setting EPR1200 apart from older reactor designs.
- During its operation phase, precise processing, testing, and monitoring of liquid chemical waste and gaseous emissions guarantee adherence to local regulations. To limit its environmental impact, EPR1200 includes modern design solutions for filtering, control, and monitoring of gaseous and radioactive waste.

By combining technological advancement with a conscious approach to the environment, EPR1200 presents a remarkably sustainable electricity production solution.

One EPR1200 unit can produce

9.5 TWh

of very low carbon electricity per year

Up to

15%

uranium consumption savings per produced MWh as compared to older reactors

91%

availability factor

Nuclear Steam Supply System

The beating heart of the EPR1200 is its Nuclear Steam Supply System, designed and built by EDF's strategic historical partner Framatome.

ARABELLE™ steam turbine platform

The ARABELLE™ steam turbine technology equipped on EPR1200 is implemented in French nuclear plants in operation as well as EPRs in France, China and the UK.

ENERGY PERFORMANCE

EPR1200 is characterised by its excellent thermal efficiency of 37%, achieved in part thanks to its Steam Supply System design that facilitates fuel management optimisations and accommodates fuel cycle lengths of up to 24 months. The innovative axial economiser found in EPR1200 steam generators provides a higher outlet steam pressure compared to traditional steam generator models, improving overall plant efficiency. Further contributing to its performance is its core heavy neutron reflector, which not only improves fuel usage but also preserves the reactor vessel's long-term mechanical properties.

Built for power

EPR1200's electrical performances and reliability is boosted thanks to its highly efficient Arabelle nuclear steam turbine: a modern, half-speed solution featuring a fully adaptable steam path to accommodate any site backpressure conditions and grid frequency (50/60 Hz). The turbine's welded rotors and half-speed 1,500 rpm technology offer the best resistance to stress corrosion cracking. With these features, along with its fewer components, the EPR1200 boasts reduced maintenance duration and costs. Thanks to its unique architecture, featuring a combined High & Intermediate Pressure module and two Low Pressure modules, Arabelle is also suitable for co-generation applications such as district heating or desalination.

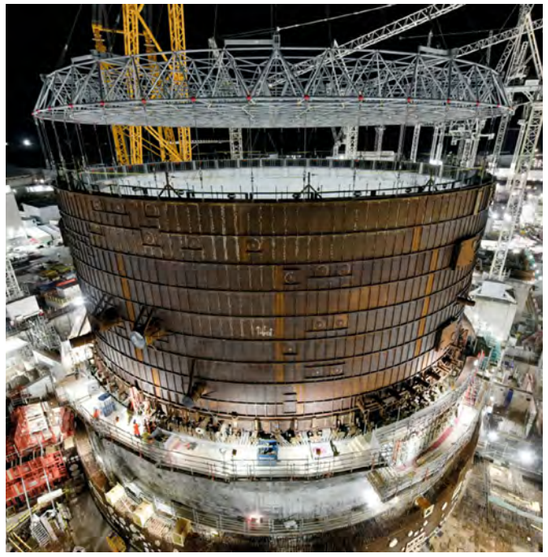
Leveraging EPR's proven technology

Thanks to our EPR technology framework, EPR1200 fully benefits from innovative and proven design choices, standardised equipment and industrial practices deployed on EPR's around the world.

A BALANCED AND PROVEN APPROACH TO PASSIVE AND ACTIVE SAFETY FEATURES

EPR1200 utilises a proven combination of passive and active systems licensed and implemented on all EPR designs. These systems are diversified to prevent a single failure cause from concurrently affecting several of the systems providing the same safety function.

As a result, EPR1200 benefits from an extremely low probability of a severe accident, with a core meltdown rate of less than a factor of 10-5.



Assembly of the inner containment steel liner of the reactor building.

INCREASED RELIABILITY AND OPERATOR RESPONSE TIME

In the event of an incident, EPR1200's automated control functions take immediate protective actions, requiring no immediate operator intervention. Advancements in digital instrumentation & control, combined with feedback from EDF's N4 reactor designs, equip the EPR1200 with an enhanced Man-Machine Interface.

This interface offers real-time, accurate summaries of the reactor and plant status, which in turn increases the reliability of operator responses and reactivity.

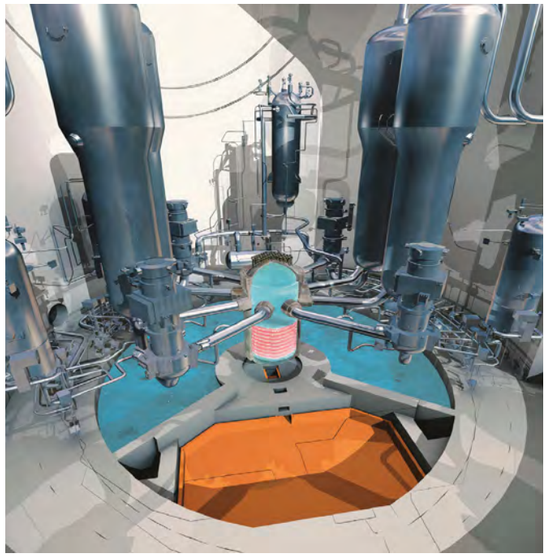
SOME OF EPR1200'S INNOVATIVE SAFETY FEATURES

- Three independent safety trains ensure safe shutdown and cooling of the core during safety incidents.
- The reactor building and auxiliary structures are safeguarded by a reinforced concrete wall that can withstand airplane crashes, both commercial and military.
- The reactor's coolant system equipment (pressure vessel, steam generators, pressuriser, coolant pipes) are forged out of high-performance materials, under stringent and tested metalurgic fabrication codes and norms.
- Specific safetey mesures allow to safely manage plausible accumulations between design basis hasards and extreme natural hasards as well as malevolent acts, including cyber.

DESIGN LIMITING THE OCCURENCE AND CONSEQUENCES OF A SEVERE ACCIDENT

The occurrence of a core meltdown is significantly reduced by a methodical management of single failure events and common cause failure events. Even in the extremely unlikely case of a core meltdown penetrating the reactor pressure vessel, the melted materials and radioactive products would remain confined inside the reactor building whose integrity and cooling would be ensured over time.
In such an event, EPR1200's generation 3+ design features would protect against a Fukushima-like event.

- **Core Catcher:** spreading area directly under the reactor vessel, designed to isolate, cool and solidify molten fuel assemblies in case of a core meltdown.
- **Catalytic Hydrogen Recombiners:** dedicated equipment that maintain hydrogen concentration below 10%, avoiding the risk of explosions within the reactor building.



A core catcher (in orange) allowing passive collection and retention of the molten core, in the highly unlikely event of a core meltdown.

EPR1200's beating heart

A CORE FULL OF TECH

The EPR1200 employs an "aeroball" system, using vanadium balls for precise 3D core power distribution mapping.
Its in-core instrumentation, featuring self-powered neutron detectors and thermocouples, measures neutron flux and temperature at the core outlet.
All instruments are introduced via the vessel head, ensuring the reactor pressure vessel's bottom remains free from any penetrations. This unique feature enhances vessel integrity, minimises leak paths, reduces maintenance, and decreases thermal stresses, bolstering the overall safety, reliability, and longevity of the reactor vessel.

ADAPTABLE FUEL STRATEGIES

EPR1200's nuclear fuel and core design ensure highly efficient fuel usage. Due in part to the very low nominal linear heat rate of its fuel, EPR1200 benefits from larger safety margins, reduced wear and tear and an overall increased fuel lifespan. It also offers great flexibility in power maneuvering and supports diverse fuel management strategies, including the usage of recycled MOX fuel assemblies.

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