

## Fuel Lifetime Solutions

Safe, high performance, and forward-looking Fuel engineering services dedicated to support your Fuel-related projects

Framatome Fuel Engineering develops reliable solutions to your concerns arising during all stages of reactor life.

### Challenge

Stakeholders in the nuclear world are seeking solutions to various key challenges, be it through products, codes and methods or competency acquisition. Such challenges include extending fuel and core performance, increasing reactor operational flexibility during cycle operations and outages, or minimizing the costs associated with the End-of-Life & Back-End, all without reducing the safety of the plant.

### Solution

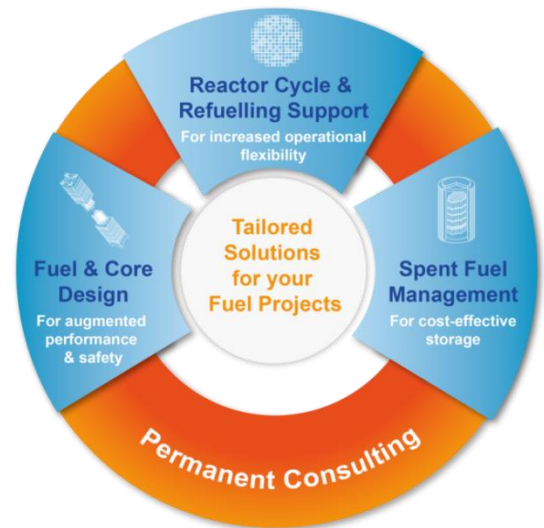
As an all-in-one service provider, Framatome Fuel Engineering brings a comprehensive range of competencies and solutions to your current and potential future challenges. This offering includes: the most advanced knowledge of the fuel assembly, extensive testing and manufacturing facilities, the largest experimental databases and the most innovative technologies applicable for OEM and non-OEM plants. Additionally, we also have long-standing experience with various international organizations and nuclear regulatory bodies worldwide that can support you during your licensing and implementation process. We bring over 60 years of world-wide experience on a wide range of commercial LWRs, SMRs, and research reactors, and we work to foresee and to be prepared for upcoming challenges in the nuclear world over the coming decades.

We offer a range of different models of consultancy tailored to suit your individual needs. If you are interested, simply contact us!

### Customer benefits

- Access to a comprehensive matrix of advanced engineering services thanks to Framatome's all-in-one portfolio accessible on multiple plant and fuel designs
- Profit from the most sophisticated and robust technologies proven by numerous Framatome worldwide reference projects, achieving customer needs for quality and fast turnaround time
- Experience the highest level of engineering expertise sustained by the most active, innovative, and internationally recognized R&D on the nuclear market
- Cash in on the highest Framatome flexibility using services on an as-needed basis, and with 7/24 worldwide resource presence
- Reduce costs by exploiting Framatome's effective resource management (manpower, equipment, IT)

**Your performance is our everyday commitment**



### Technical information

Cutting-edge fuel engineering competencies:

- Neutronics, criticality, and radiation
- Single- & two-phase thermal-hydraulics
- Core nuclear physics, design & safety
- Mechanical design, structure & dynamics, and fluid-structure-interaction
- Thermal-mechanical fuel rod expertise, pellet-cladding interaction, accidental behavior, and impact of water chemistry
- Material expertise and behavior under irradiation: Zr & Ni alloys, steel, ceramics, pelletizing, out- & in-pile characterization
- Prototyping, manufacturing, metallurgy technologies, measurement & testing
- Software development, code performance, safety architecture, and IT security

### Key figures

**550** passionate and professional engineers worldwide at your service

**125** of the 293 light water reactors in operation worldwide use Framatome Fuel technologies

**17%** of Framatome Fuel engineers are worldwide recognized experts by the international scientific community publishing in more than 100 journals and participating to the leading nuclear working groups, such as EPRI, WANO, IAEA, NEA

## Framatome Fuel Engineering offers various solutions, including products, codes & methods, and competencies, in the following areas:

### Fuel & Core Design

- Fuel prototyping, testing, manufacturing & licensing
- Fuel design (enrichment distribution, Gadolinium design, axial blankets), and fuel rod design (e.g., Pellet Cladding Interaction or PCI)
- Fuel economy with optimized fuel management (cycle length extension, stretch-in & stretch-out cycle phase, flexible operation such as load follow)
- Safety analysis methods for flexible core in normal & accidental conditions incl. advanced statistical and/or coupled methods for complex transients and seismic events

### Reactor Cycle and Refueling Support

- Core monitoring system ARGOS including continuous margin control for operational limits & maneuvering simulator
- Fuel performance optimization under flexible operation, for power uprate, or under demanding water chemistry
- PCI management tool XEDOR
- Fuel loading/unloading optimization tool COLOSS
- Risk assessment & optimization (e.g. for CRUD, core design and coolant chemistry optimization)
- Fuel failure root-cause analysis, management & remedies

- Fluence analysis, reliable and flexible solutions for plant lifetime extension, and power uprate
- Support during retrofitting of fresh & irradiated fuel assemblies from one plant to another (manufacturing, transport, licensing)
- Cost-effective plant phase-out strategy

### Spent Fuel Management

- Spent fuel pool manager – solutions to make the pool compacter
- End-Of-Life (EOL) fuel activity inventory, EOL state of fuel (such as structural integrity, decay heat evaluation) & fuel rod (such as inner pressure, oxide thickness, clad hydrogen concentration, fuel rod thermo-mechanical properties) for handling and transport activities
- Support for optimal cask loading
- Assessment of long-term cask inventory properties (such as clad degradation, structural integrity) for storage justification

### Permanent Consulting

- PWR & BWR knowhow maintenance, training and build-up programs
- Access to a comprehensive suite of software to support operation, incl. as code owner (such as ARCADIA core design suite)

## References

Some examples:

- Optimization of loading pattern (cycle lengths, batch sizes, stretch-in & stretch-out cycle phase, load follow operation and B-10 enrichment) and adaptation of fuel assembly design (ENU, ERU, MOX, enrichment distribution, Gadolinium design, axial blankets) for all US PWRs – Westinghouse, Babcock & Wilcox, Combustion Engineering, – as well as for all PWRs – Westinghouse, KWU, Framatome – and BWRs served by Framatome world-wide.
- Support on conversion to 24-month cycles for US Combustion Engineering, Babcock & Wilcox and Westinghouse plants as well as US BWRs.
- Assistance during reactor start-up & during reactor simulator tests on all US

Combustion Engineering, Babcock & Wilcox and Westinghouse and all KWU plants world-wide.

- Evaluation of Fuel performance under Flexible Operation on most of the KWU reactors.
- Core related studies for Extended Power Uprate (EPU) for PWR Swedish Westinghouse and US Babcock & Wilcox reactors.
- Identification of loads leading to PCI failures on US & European GE BWRs.
- CRUD management for US reactors.
- Agile modeling for Zn dosing and system identification for German KWU BWR reactor.

- Optimization of loading/unloading for French PWR Westinghouse and Framatome reactors, and German KWU reactors.
- Fuel integrity assessment and fuel failure remedy development on PWR & BWR reactors world-wide.
- Development of shielding concept for plant lifetime extension for Swedish PWR Westinghouse type reactors.
- Transport and insertion justification of irradiated fuel assembly in BWR Swedish reactors
- Plant phase-out strategy for German KWU PWR & BWR reactors
- Design and support for licensing of US SMR fuel design.

**Framatome is reinventing the meaning of service!**

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