framatome

Improving Nuclear Economics: Towards LEU+ and High Burnup Fuel for Light Water Reactor Applications

Gwen Bolsée– Fuel BU

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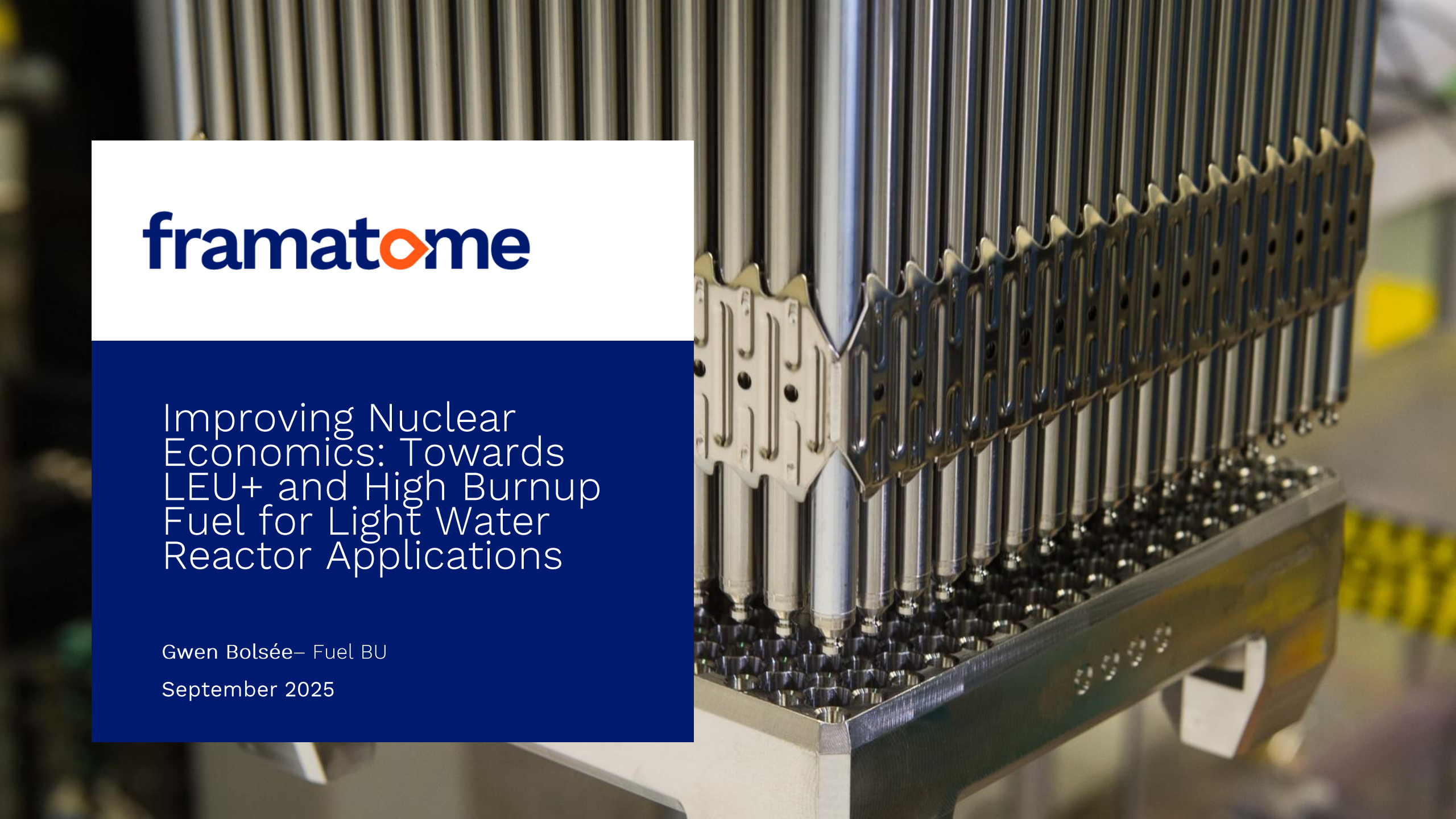


Improving Nuclear Economics: Towards LEU+ and High Burnup Fuel for Light Water Reactor Applications

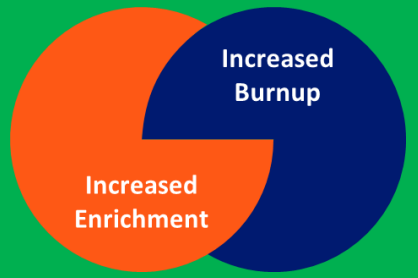
Increased Enrichment

Increased enrichment alone can be used to more efficiently distribute fissile material within and between fuel assemblies in a reload

Increased burnup alone can be used to avoid wasting fuel with moderate energy value by discharging it early or placing it in low power positions

Increased Burnup

Increased enrichment and increased burnup individually offer modest economic value...



but together enable significant economic value gains in a wide range of LWR applications

Driving Value

Improving Nuclear Economics: Leveraging LEU+ and high burnup to extend cycle length in high power density PWRs

Increase revenue per fuel cycle

- 24-month cycles are preferred by many US operators: Eliminates lack of production during outage once every six years vs. 18-month cycles

Decrease the amount of outages for the life of your plant

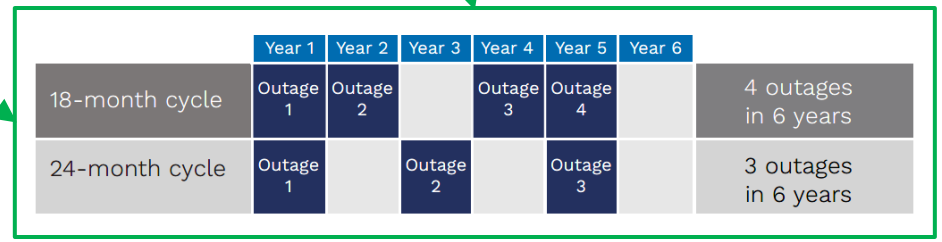
- Save on Operation and Maintenance (O&M) costs

Improve plant safety

- Decrease site personnel exposure to radiation

Reduce total number of used fuel

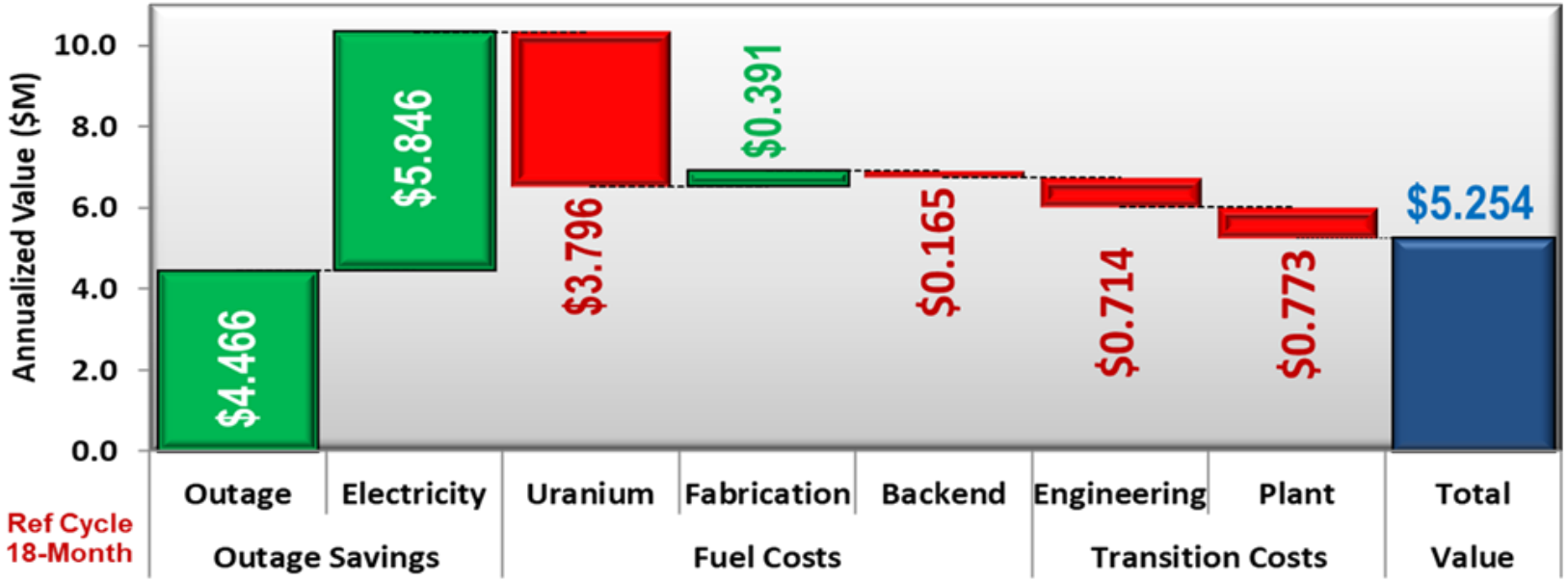
- Decrease fuel handling and need for storage capacity



Increased NPP energy generation possible with Framatome's best-in-class technologies: manufacturing assets, GAIA product and advanced C&M

Improving Nuclear Economics: Towards LEU+ and High Burnup Fuel
The business case for shifting to 24-month cycles is strong

Annualized Net value for a PWR using > 5% enrichment and higher burnup for economically viable cycles: US case study



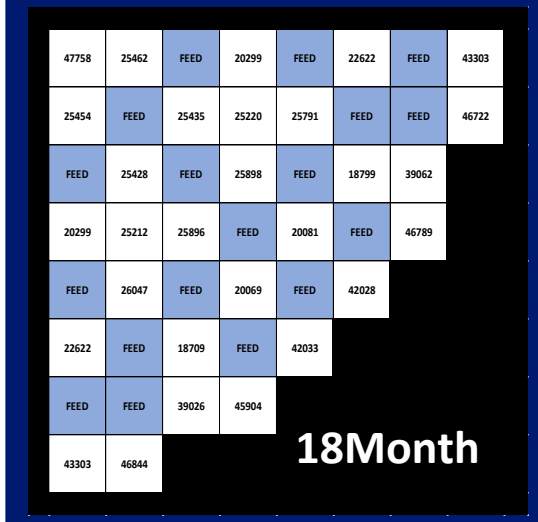
Value elements:

- **Outage:** 1/6 the cost of an outage (~$30M/outage)
- **Electricity:** 3-5 more full power days per year
- **Uranium:** Fuel needed for 3-5 more generating days
- **Transition:** Costs for end user readiness to receive and operate LEU+ fuel, as amortized over 6 years

Benefits of longer cycles outweigh the inherent adverse impact on fuel efficiency: about 5 M US$ annualized value

Securing the value through economical core design: keep reload batches size near or below half core

PWR 17x17: 18M to 24M cycle comparison



- Batch size remains <50% of core to burn all fuel for at least two cycles
- Fresh fuel is kept out of peripheral row

- Use of enrichment above 5% in U235 to keep batch sizes below half core (eg: 76/77 feed)
- Maximum burn-up beyond current licensed limit on US market (62 GWd/tU Fuel Rod average)

Significant analytical and capital investment is required by suppliers and end users

Cycle Design and Licensing

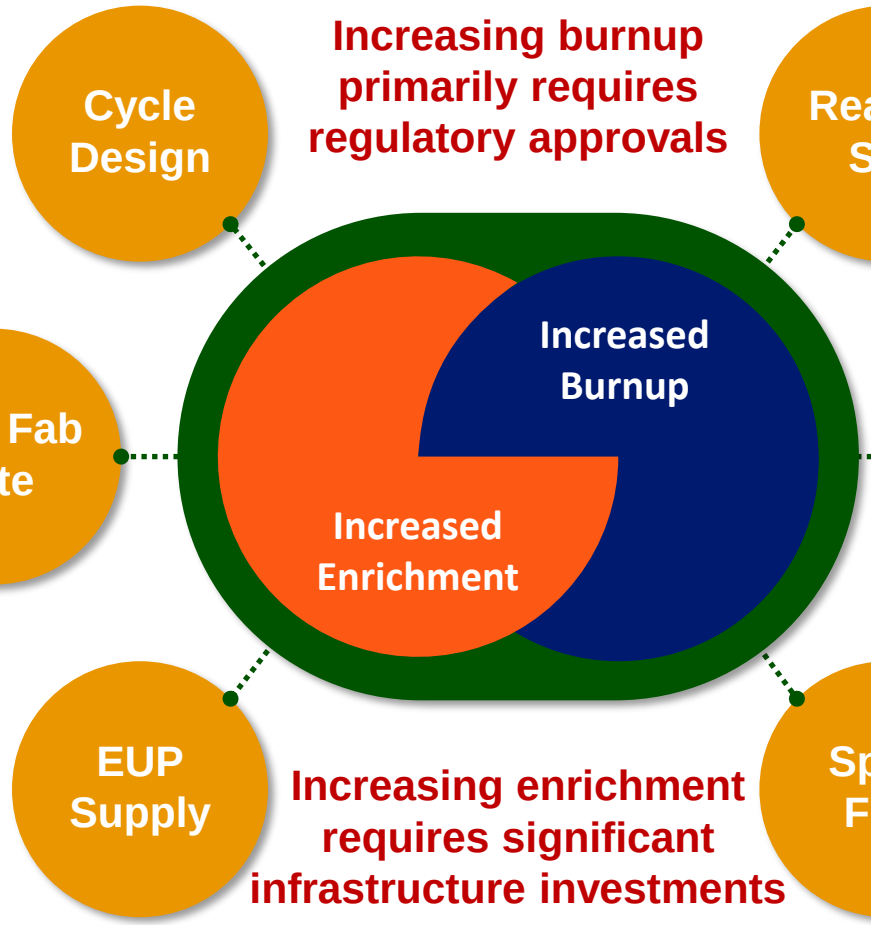
Reduced batch size designs
High burnup Licensing

Fuel Fabrication

Licensing for >5%
Criticality protection upgrades
Shipping container relicensing

Enriched Uranium Product

New centrifuge cascades
New or relicensed UF_6 cylinders
New or relicensed overpacks



Increasing burnup primarily requires regulatory approvals

Increasing enrichment requires significant infrastructure investments

Fuel Receipt at Reactor

Licensing for LEU+ receipt
Criticality protection upgrades
Fuel pool rack management

Reactor Operations

Fuel shuffling constraints
Boron/SLC upgrades
Alternate Source Term changes

SLC = Standby Liquid Control [BWR boron injection system]

Spent Fuel Management

Increased decay heat burden
Dry cask relicensing
Capacity for 24M cycle reloads

Impact

Significant analytical and capital investment is required by suppliers and end users

Cycle Design and Licensing

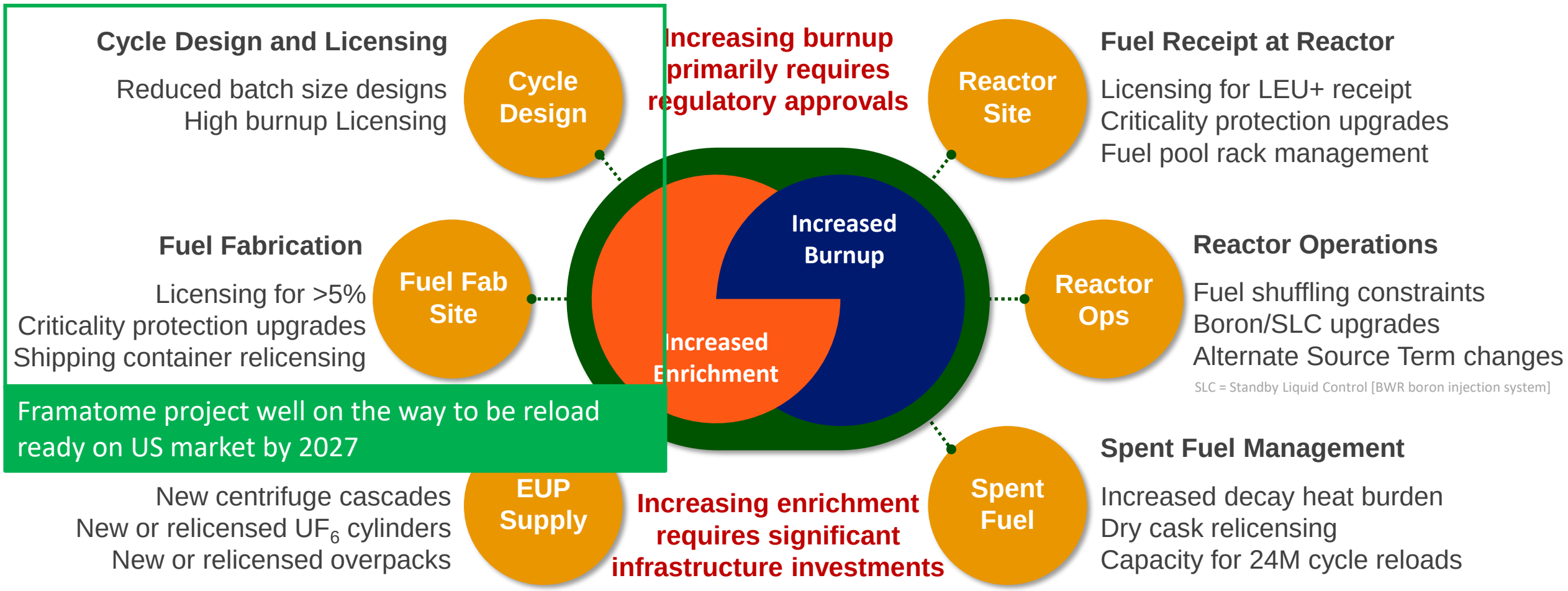
Reduced batch size designs
High burnup Licensing

Fuel Fabrication

Licensing for >5%
Criticality protection upgrades
Shipping container relicensing

Framatome project well on the way to be reload ready on US market by 2027

New centrifuge cascades
New or relicensed UF_6 cylinders
New or relicensed overpacks



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Status

Ongoing Licensing activities to support increased burn-up

GAIA as Fuel product vehicle to Advanced Fuel Management

> 5% Umbrella Topical report: approved by US NRC in March 2023

High Burn-up Major elements already approved

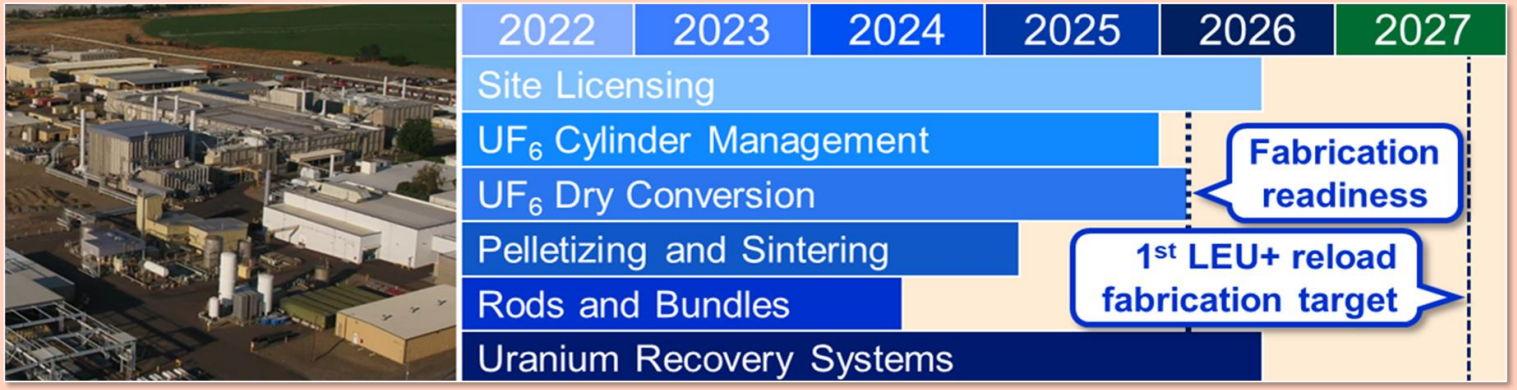
High Burn-up Topical Report (TR) : Under NRC review (approval expected in 2025)

- Highest standard in Fuel performance and dimensional stability at high burn-up
- PROtect (E-ATF) rods as an option
- License extension granted for use of full Framatome Codes & Methods suite above 5%: Fuel Rod Rod (Galileo), Safety Analysis LOCA & non LOCA, Mechanical , Core design, neutronics,…
- Major elements are already approved: $M5_{Framatome}$ as cladding material, Fuel rod performance code, Neutronic codes (ARCADIA, AREA) up-to 75MWd/tU (FR average)
- Addresses all remaining aspects of increased burn-up: Fuel mechanics, seismic, SB/LB LOCA, Non LOCA transients, DNB correlation

Leveraging Framatome’s best-in-class technologies to unlock value through increased Licensing space

Activity is well underway to support Fabrication & Shipment of increased enrichment Fuel

Framatome AFM Reload Readiness Timeline



Procurement phase is largely complete, and upgrade installation is proceeding to plan

New >5% rated equipment is already in reload service (LEU) in all fabrication areas

Significant investment project ongoing as planned at Framatome Richland (USA) manufacturing for reload fabrication in 2027

Take Away

- High enrichment (>5%) and High Burnup Fuel brings significant value proposition: ≈5M USD / year by transitioning a PWR 17X17 reactor from 18 month to 24 months cycle
- Leveraging Framatome's best-in-class technologies (eg: GAIA product, Codes & Methods) to unlock value in the Licensing space
- Significant investment project ongoing as planned at Framatome Richland (USA) manufacturing facility for first reload fabrication in 2027

Thank You

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