

OAPS System

Real time predictive system for flexible operation

Agile, real-time plant operator aid to facilitate safe, flexible operation of nuclear power plants

Challenge

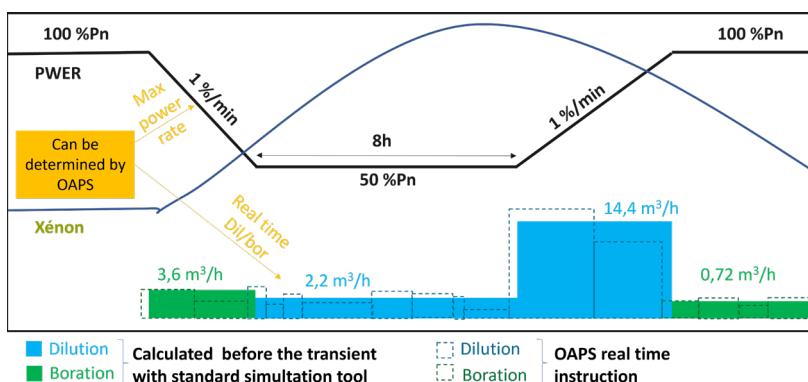
Increased variable renewable energy production and market regulations that favor renewable energy, along with aggressive carbon neutrality goals challenge nuclear plant operators to employ flexible operations of the plants in their fleets. Currently, fossil plants are the first choice to provide flexible generation, costing more and putting owners at the mercy of volatile fossil fuel costs and potential low/negative electricity pricing. Flexible nuclear plant operation requires complex calculations and planning that are burdensome and risky. Relying on their fossil plants also puts owners at risk of not meeting their carbon reduction goals.

Nuclear power plants must become more flexible, even those designed for baseload production.

Solution

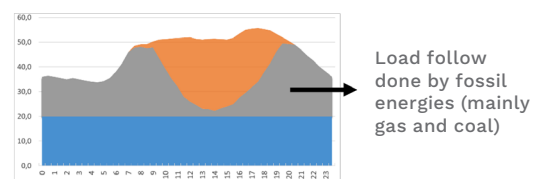
Framatome OAPS real time predictive system for flexible operation is an operator aid that supports operators with real-time guidance for safe, flexible operation of their nuclear plants. The system acts like a "GPS" for reactor core control to eliminate operator burden during transients with no core control modification. It allows the increase in renewable penetration while maintaining grid stability and reducing carbon emissions, and makes nuclear the profitable, preferred alternative to gas for load follow.

Current standard load follow in mode A (AO ≈ AOfref strategy)

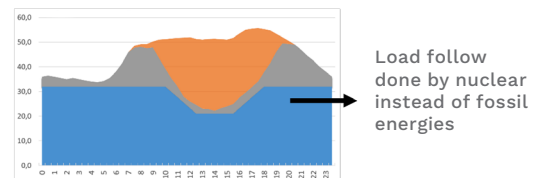


Despite accuracy of standard simulation tools (even with 3D neutronic model), operator must adjust dilution/boration during the transient which is tricky due to dilution/boration delay (> 15 min).

Typical day without nuclear flexibility



Typical day with nuclear flexibility



Customer benefits

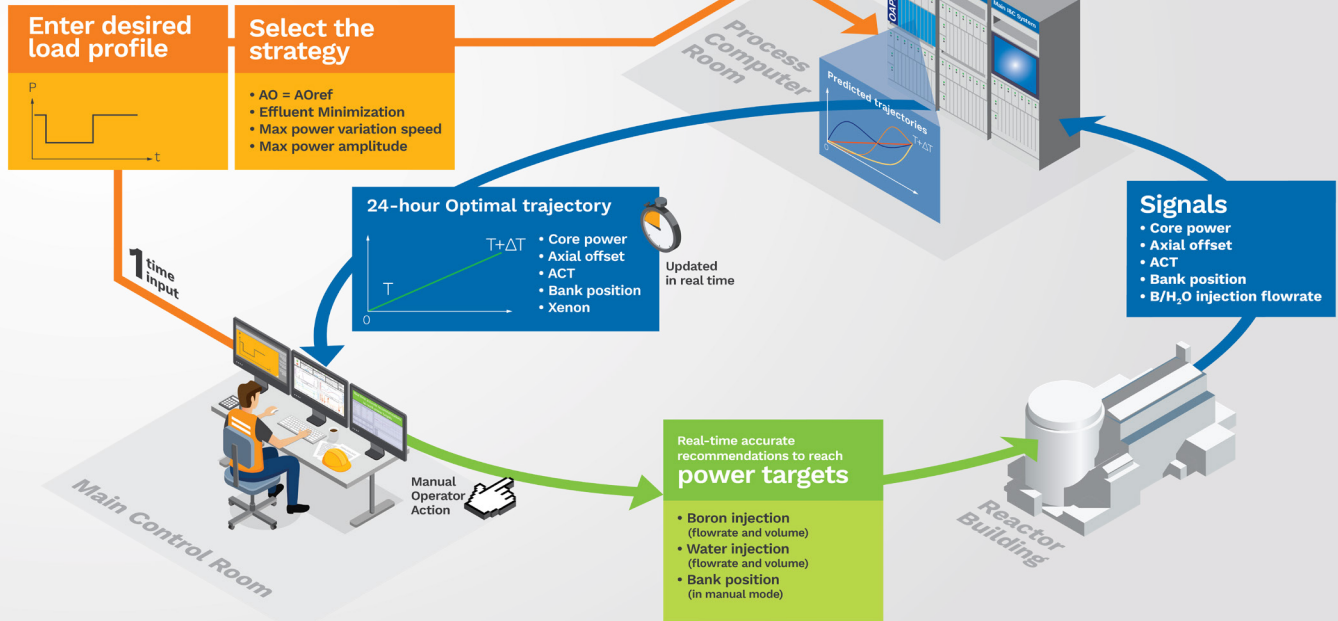
Maximize nuclear power plant operations

- Maximizes fleet ROI by making nuclear the preferred alternative to gas for load follow
- Improves profitability due to less power production during low or negative pricing scenarios
- Optimizes renewables and nuclear generation to help reduce carbon emissions
- The OAPS solution is adaptable to any specific need in any reactor type or size

Ensure safe operation

- Minimizes boron consumption and effluent production with strictly necessary dose calculation resulting in additional savings
- Provides guidance during transients and baseload operation, reducing operator burden and reaction time
- Reduces risks of exceeding operating limits by keeping core characteristics within safe operating domain, and providing predictions of the evolution of key parameters (axial offset, Xenon) 24 hours in advance

OAPS System



Technical information

No core control modifications required.

Two main features as a GPS:

- Optimal trajectory:
 - An evolved optimization solver proposing the best strategy based on your needs and constraints: effluent minimization, maximum power variation, being as close as possible to the Axial Offset reference
 - 24 hours in advance predictions of core key parameters: Axial Offset, Xenon, bank position, temperature, chemical condition
- Real time commands:
 - A rapid calculation time allows for continuous recommendation and prediction even in the event of unexpected occurrences such as urgent grid requests or reactor contingencies
 - Accurate boron/water injection or control rod insertion recommendation with a stability of the command allowed by the Model Predictive Control system developed

Examples of usages where the OAPS system provides substantial added value include:

- Optimization of effluents
- Flexible operations and load follow
- Extended low power operation (ELPO)

OAPS system provides:

- The ability to react to any unexpected events to keep Axial Offset (AO) within a tight band during transients and baseload operations
- Optimized, accurate boration, dilution and other parameters to reach power targets while minimizing effluents production
- Enhanced maneuvering with real-time guidance to reduce operator burden and risk

Key Figures

2,400 I&C professionals at **21** sites in **10** countries.

Framatome has more than **30** years experience helping customers achieve flexible operations of their nuclear plants.

References

I&C flexible operation solutions already installed on the following PWRs:

- Germany (4)
- Switzerland (1)
- Spain (1)

Can be installed on any PWR:

- Without core control modification (for manual mode)
- With core control modification (for automatic mode)

Contact: IC@framatome.com
www.framatome.com

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Your performance
 is **our** everyday **commitment**