

Molten Salt Reactors

Application of SCALE to Molten Salt Reactor Physics

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Why MSR's Are Challenging

Fuel is liquid and continuously circulating

Loop: core → pump → heat exchanger → return

Two coupled effects:

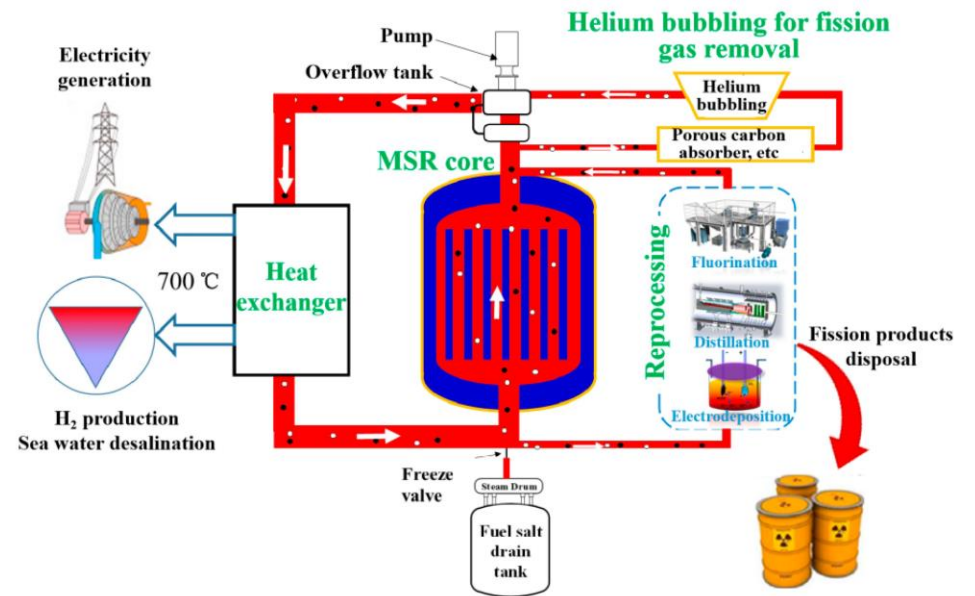
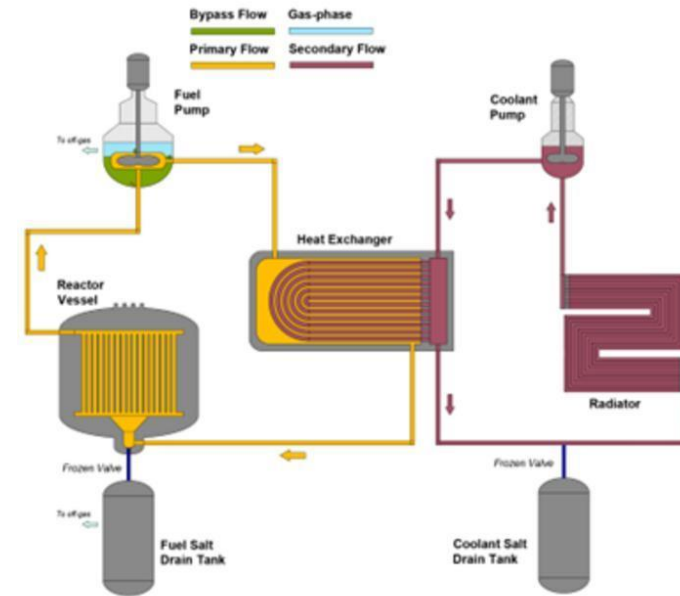
- Time evolution → burnup, decay (days–years)
- Spatial variation → fuel moves through system (seconds)

Example:

Loop time ≈ 25 seconds

Fuel partly outside core → no neutron flux

⇒ Conventional reactor methods are not directly applicable



What is SCALE?

SCALE (Standardized Computer Analyses for Licensing Evaluation)

Developed by Oak Ridge National Laboratory (ORNL)

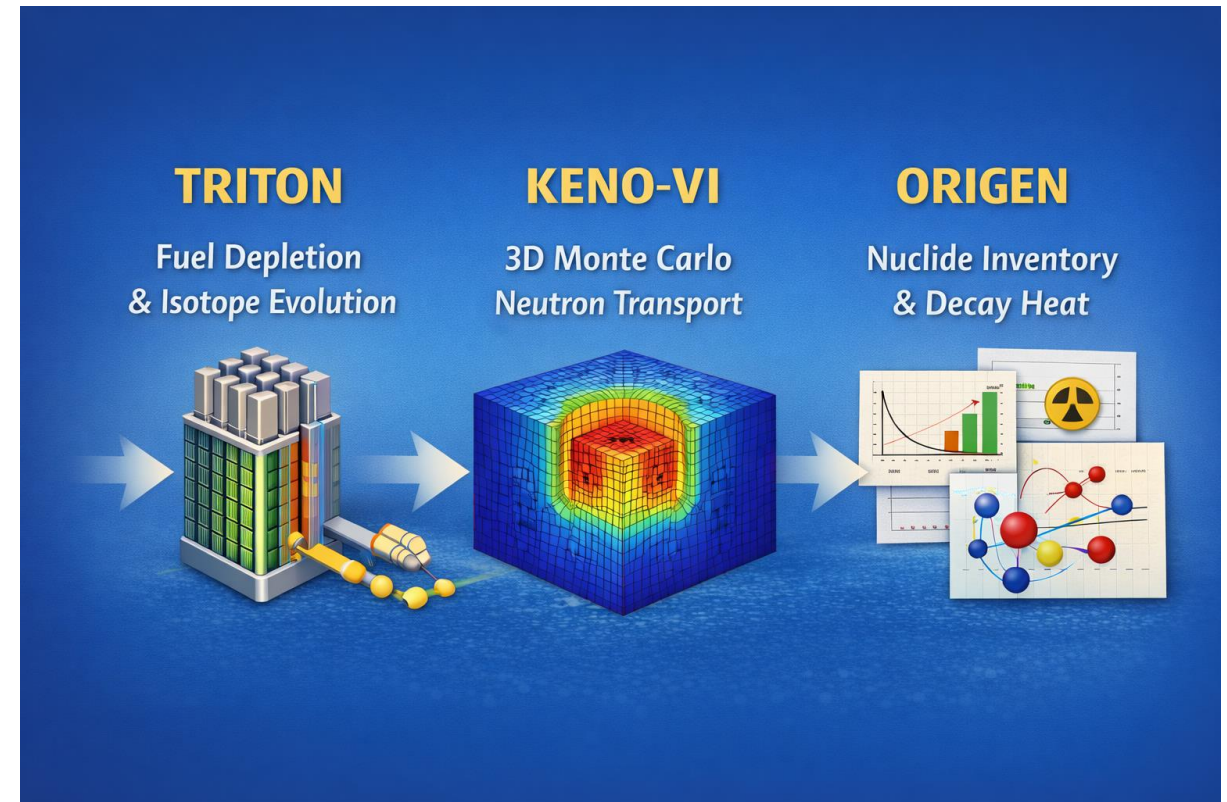
Comprehensive nuclear analysis suite for:

- Reactor physics
- Depletion and decay analysis
- Radiation transport

Key modules:

- TRITON – fuel depletion
- KENO-VI – Monte Carlo neutron transport
- ORIGEN – isotopic evolution and decay

Provides integrated capabilities for advanced reactor modeling, including MSRs



Modelling Approach

Multi-step SCALE methodology:

1. TRITON → Fuel depletion

Time-dependent composition Includes:

- fission products
- Decay Xe/Kr removal,
- metal deposition

2. KENO-VI → Core physics

3D Monte Carlo model

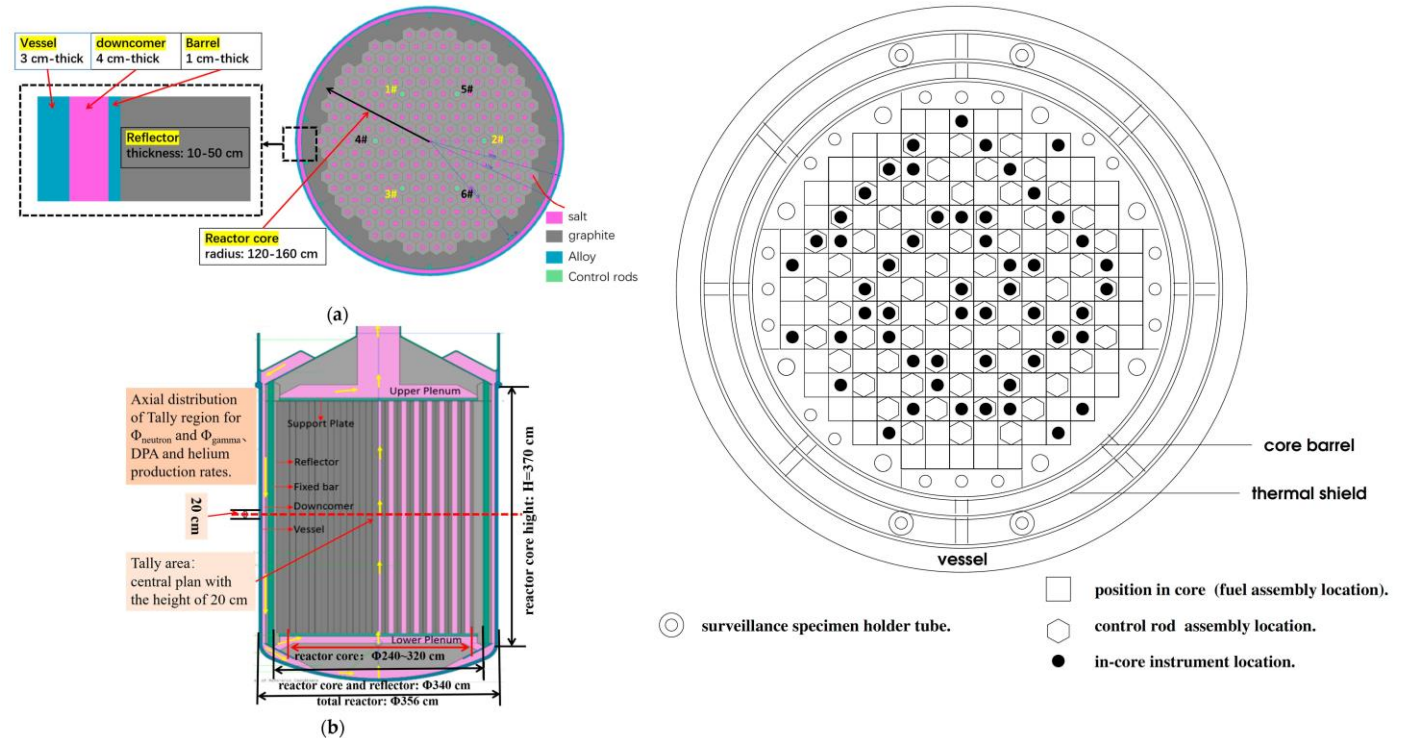
Calculates:

- neutron flux
- power distribution
- Reactivity

3. ORIGEN → Loop transport

- Tracks fuel through system
- Accounts for: irradiation in core decay/ outside core

Key idea: → Separate timescales, then couple results



Results & Safety Relevance

Model provides:

- system-wide and location-dependent inventory
- neutron flux and power distributions
- reactivity effects (incl. xenon poisoning)
- decay heat

Key findings:

- Fuel composition varies along the loop
- Short-lived isotopes strongly location-dependent
- Decay heat is distributed, not only in core

Importance:

- Enables realistic accident simulations
- Improves source term estimation
- Supports MSR safety analysis & licensing

