# Development of Nuclear Energy Based on Small Modular Reactors – Molten Salt Reactors to Support the Clean Energy Transition in Indonesia

**PPMI FMIPA Skema Hibah Kompetititif**

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## Abstract

This study evaluates the neutronic performances and analysis of a Molten Salt Reactor (MSR) with a power output of 100 MWe, specifically adjusted for deployment in a low populated regions such as small island. The selection of a 100 MWe aims to meet the energy demands of these areas while reducing the infrastructural and environmental impacts. The comparative analysis was conducted on various molten salt types, including FLiBe (LiF-BeF2), FLiNaK (LiF-NaF-KF), and FNaBe (NaF-BeF2), to conduct the most efficient salt for reactor operations. The active core was also axially divided into multiple zones based on the temperature distribution to investigate the effect of the temperature gradient between the inlet and outlet core on the neutronic behavior. The results shows that FLiBe molten salt offers significant advantages in terms of neutron economy. These findings suggest that FLiBe is a superior choice for MSRs compared to both FliNaK and FNaBe. The change in fuel temperature from the inlet to the outlet has a significant neutronic impact compared to the average temperature. Using two radial regions, it was also found that the power peaking factor can be optimized below 2 with fuel volume fraction configurations for regions 1 and 2, namely 36% and 30%.

Keyword: MSR, Small Modular Reactor, Thorium

## Introduction

**Gen IV Nuclear for Indonesia's Net Zero 2060**

National power generation still leans heavily on coal. Small, passively safe, modular advanced reactors open a path to low-emission baseload power for a nation of more than 17,000 islands.



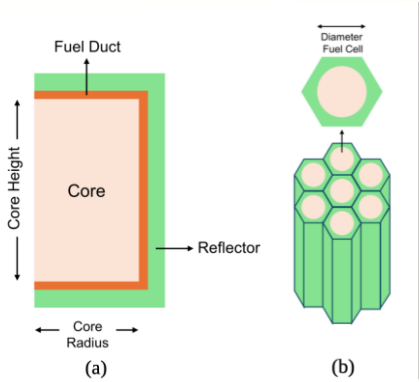

| ~67% | 500 MW | 35–44 |
|---|---|---|
| coal share of power (2024) | first NPP 2032–2034 | GW nuclear target by 2060 |

**Molten Salt Reactor (MSR)**

**Gen IV · liquid fluoride salt fuel**

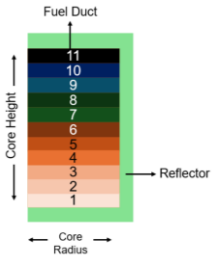
- Atmospheric pressure: no steam explosion
- Passive: freeze plug & automatic drain tank
- Thorium cycle — Bangka Belitung monazite
- ~700 °C output: power, hydrogen, industry

## Research Method

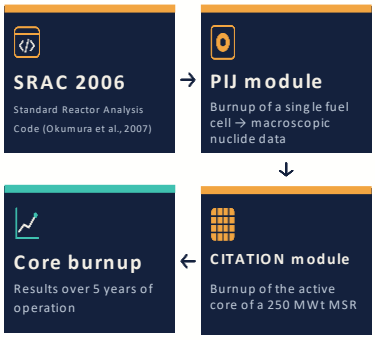



(a) Active core and (b) fuel cell

| Specification | Value |
|---|---|
| Height of the core | 2.33 m |
| Radius of the core | 1.18 m |
| Fuel volume fraction of core | 36 vol% |
| Width of fuel duct | 0.04 m |
| Fuel volume fraction of fuel duct | 90 vol% |
| Thickness of reflector | 0.30 m |
| Fuel volume fraction of reflector | 1 vol% |
| Diameter of fuel cell | 0.12 m |
| Temperature of fuel salt (in/out) | 833 K/ 973 K |




Axial discretization of the core into eleven temperature-dependent regions




| 250 | 5 yr | 2D R-Z | 65 × 32 |
|---|---|---|---|
| MWt thermal power | operation time | core geometry model | radial × axial meshes |

## Conclusion

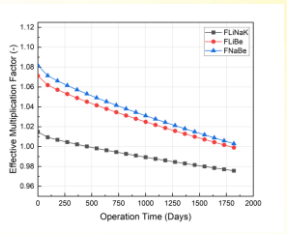
Molten Salt: FLiBe maximizes neutron economy and conversion ratio, whereas FLiNaK suits fast-spectrum reactors.

Thermal Modeling: Axial temperature modeling improves neutronic accuracy and keeps peak power factor below 2.

Core Zoning: A 36%–30% fuel fraction in 2-region cores optimizes radial power and reactor performance.

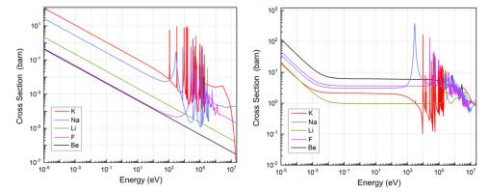
## Discussion & Result

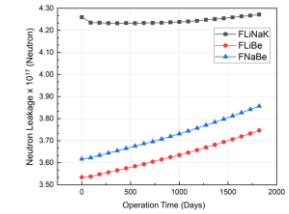
The keff values for different fuel salt vs operation time

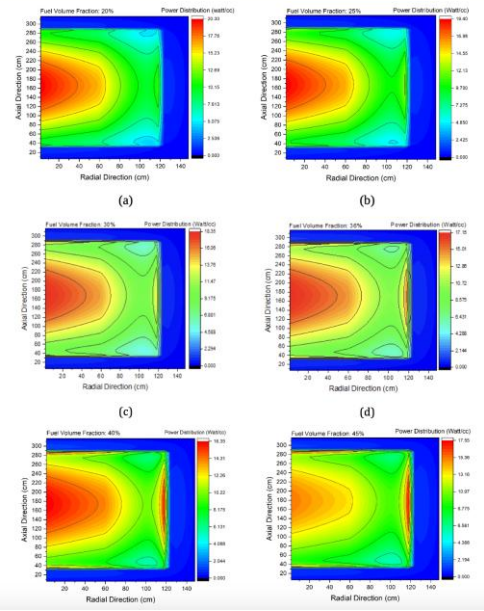



FLiNaK salt: the neutron population is reduced due to the significant neutron absorption by K and Na nuclides

The neutron captures cross section and the neutron scattering cross section for K, Na, Li, F and Be.




Neutronic results for 2 region core

