

Development of TerraPower's Molten Chloride Fast Reactor (MCFR) to enable low-cost, economy-wide decarbonization

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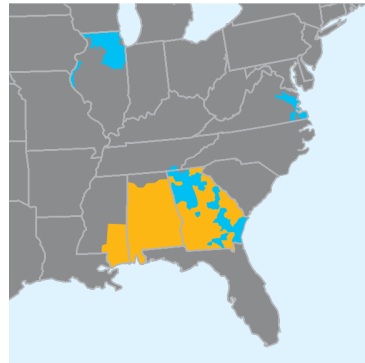
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Acronym List

- **DOE Awards**
 - ARC: Advanced Reactor Concepts
 - ARDP: Advanced Reactor Demonstration Program
- **Technology (general)**
 - MCFR: Molten Chloride Fast Reactor
 - SETs: Separate Effects Tests
- **Technology (specific)**
 - MCFR-CR: MCFR Commercial Reactor
 - MCFR-D: MCFR Demonstration Reactor
 - MCRE: Molten Chloride Reactor Experiment (critical)
 - IET: Integrated Effects Test (non-critical)
 - MaSTiF: Molten Salt Test Facility (non-critical)

Southern Company provides clean, safe, reliable, affordable energy and customized solutions.



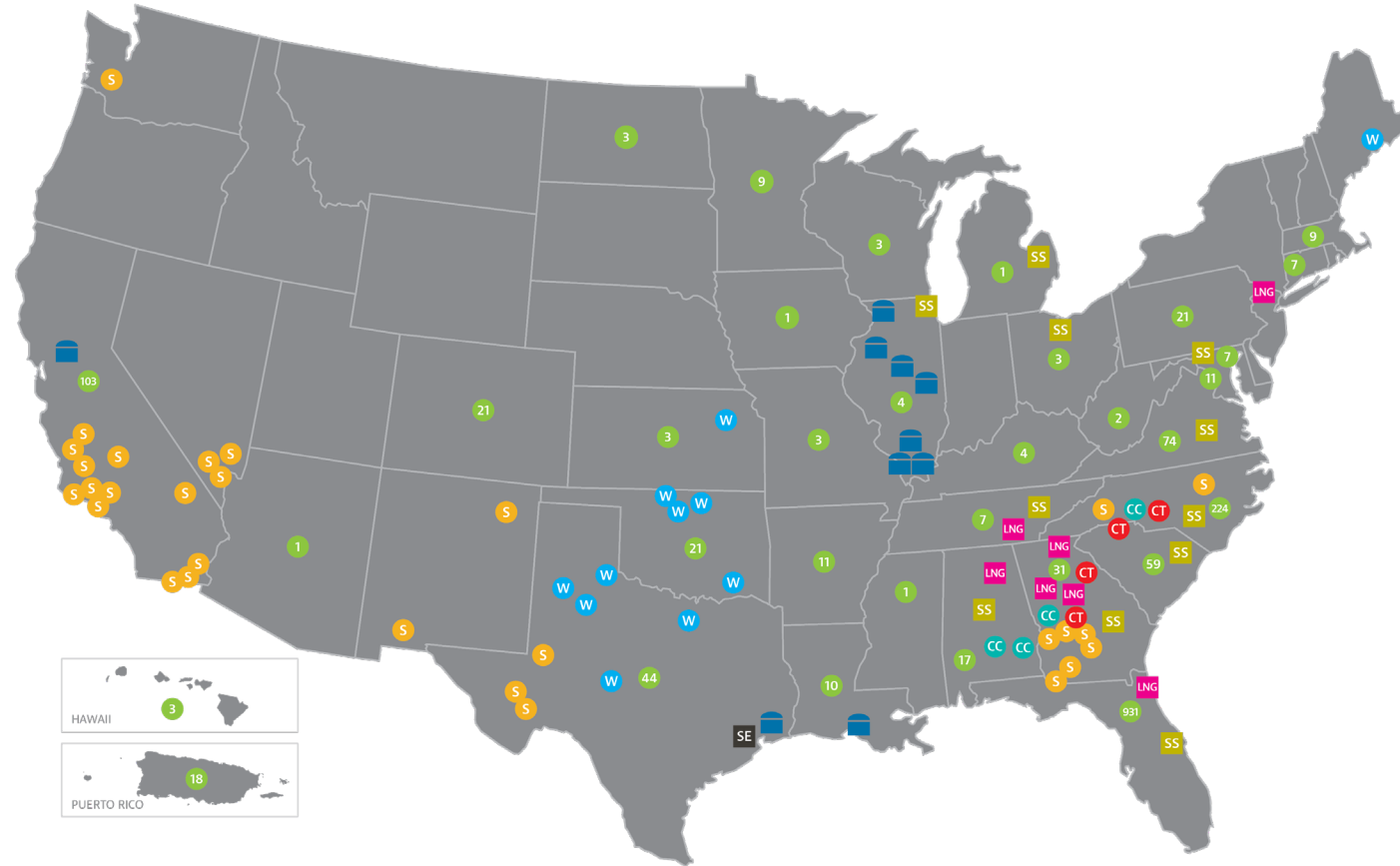
Service territories

- Electric
- Gas



Gas pipelines

- Southern Natural Gas
- Southern Company Gas
- Pipeline projects



Southern Power

- CC Combined-cycle facility¹
- CT Peaking facility
- B Biomass facility
- S Solar facility
- W Wind facility

Southern Company Gas

- LNG LNG facilities
- SE Sequent Energy Management
- SS SouthStar
- Natural gas storage

PowerSecure

- # Owned and managed sites per state

¹In November 2018, Southern Power agreed to sell its combined-cycle facility in Mankato, Minnesota.

Capabilities in
50 States

7
Electric & Natural
Gas Utilities

9 Million
Customers

Approximately
29,000
Employees

Approximately
44,000 MW
of Generating Capacity

Develop and demonstrate high potential advanced nuclear options that can provide the best value to the company & customers

RIGHT TECHNOLOGY

- provide the backbone of a net zero economy – clean electricity, heat, hydrogen
- address safety & sustainability

RIGHT TIMELINE

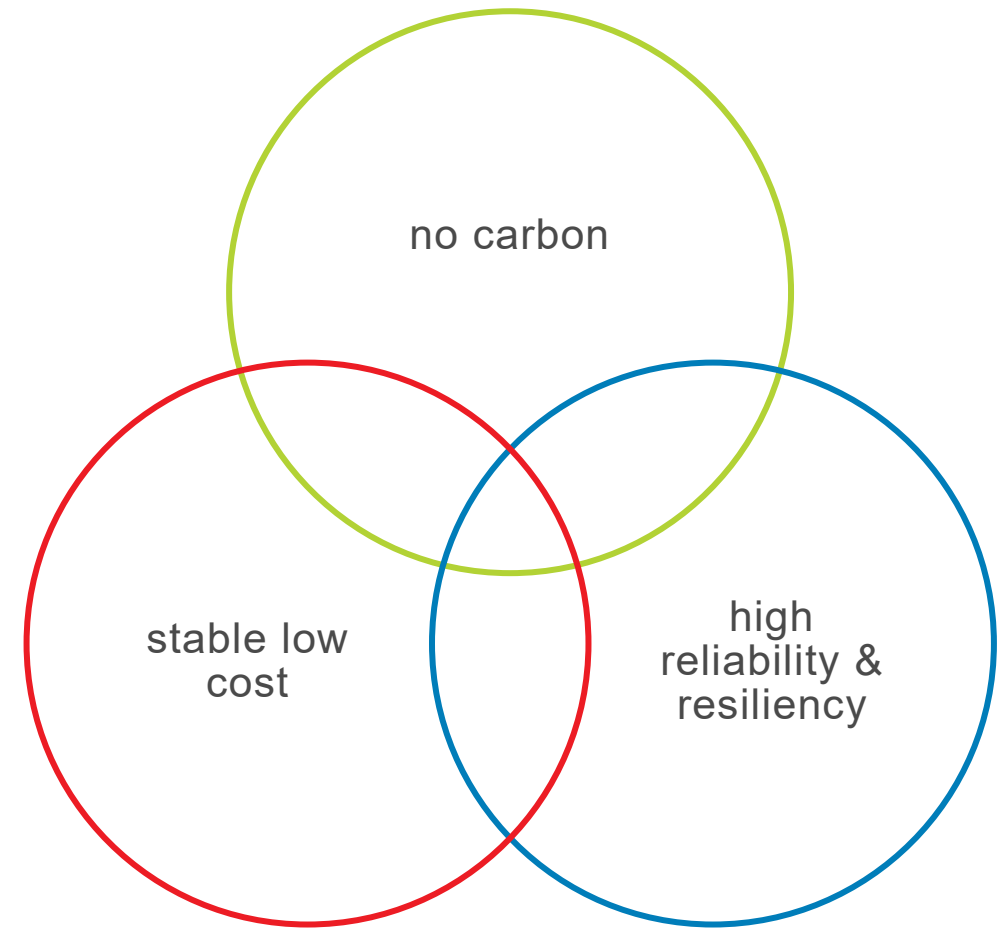
- support decarbonization commitments & demands
- replace potential retirements

RIGHT COST

- competitive with ngcc+pcc and solar+battery

BEST VALUE

- grow revenue in a rate neutral way
- be options positive – expand the market past electricity



SCS R&D performed a rigorous advanced reactor evaluation.



REACTOR TYPE →	GEN IV				
	aLWR	SFR	HTGR	FHR	MSR
high temperature	Red	Red	Green	Green	Green
low pressure	Red	Green	Red	Green	Green
online refueling	Red	Red	Green	Green	Green
potential for breeding	Red	Green	Red	Red	Green
compact size	Green	Green	Red	Green	Green
liquid fuel	Red	Red	Red	Red	Green
complete walkaway safety	Red	Green	Green	Green	Green

TerraPower's Molten Chloride Fast Reactor (MCFR) selected as a high potential option worth pursuing

OPPORTUNITIES

BROAD APPLICATION

- high-grade heat
- load following or 24/7
- flexible capacity

SUPERIOR OPERATION

- inherent & passive safety
- resilient

SUSTAINABILITY

- low used fuel yields
- high power density

GAPS

EXPERIENCE BASE

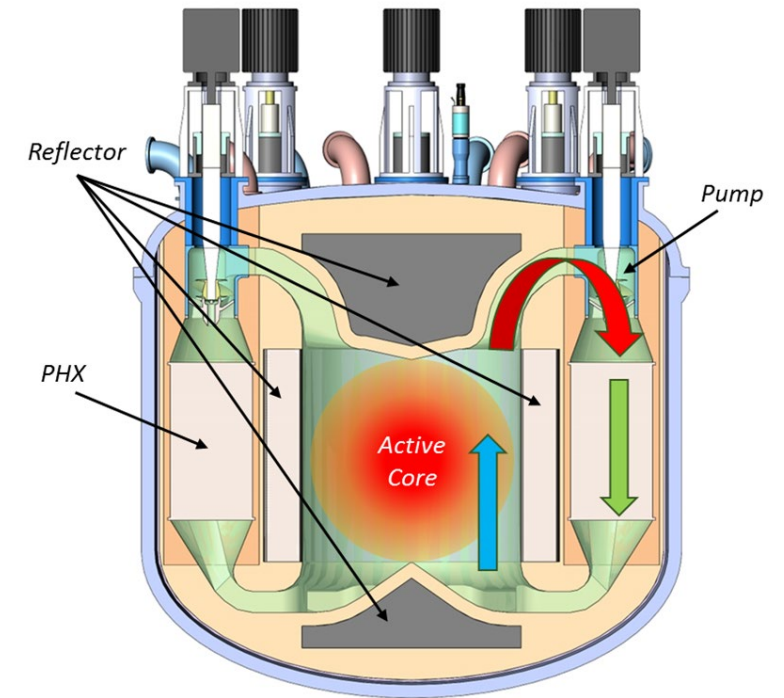
- MSRE built in 1960s
- rebuilding national infrastructure
- leveraging other industries

REGULATION

- prescriptive, LWR-centric
- leverage advanced reactor benefits

SUPPLY CHAIN

- FOAK components
- new fuel type



TerraPower was established by visionary investors and led by Bill Gates. All forms of energy were initially considered— carbon-free, scalability and energy density considerations led TerraPower to innovate in nuclear energy.

technology inclusive content of application

affirmative safety case
right-sized application

licensing modernization project

risk-informed, performance-based
recognize benefits of advanced reactors
endorsed by NRC

“part 53”

new licensing pathway
flexible, predictable framework

advanced reactor fuel

domestic HALEU production

thermal energy storage

bulk storage
high-grade heat

small-scale electric

90-360 mw_{th} applications

maritime transportation

enables efficient manufacturing

efficient hydrogen

thermally-driven and enhanced processes

cost-effective, carbon-free energy

360-720 mw_{th} applications
enables up to 1800 mw_{th}

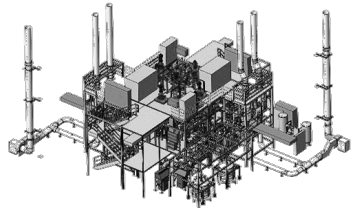
2015

2020

2025

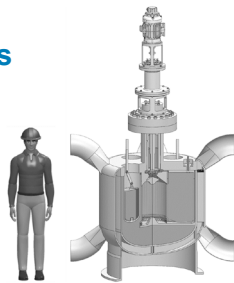
2030

2035



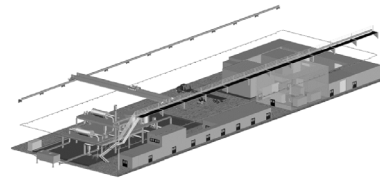
separate & integrated effects tests

hardware focus
salts + materials management
integrated systems



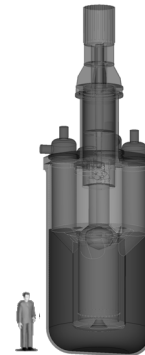
critical experiments

first fast salt criticality in the world
nuclear data needs
leverage lab infrastructure



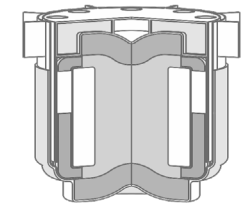
at-scale component operation

demo reactor scale components
remote maintenance equipment
end-user operations



demonstration reactor

modular approach
NRC licensed
180 mw_{th} full power operation



commercial reactor

full commercial operations

Advanced Reactor Concepts (ARC) Award – SETs & IET



Rebuilding lost infrastructure for high potential technology

→ \$76M total project, 60/40 cost share

SEPARATE EFFECTS TESTS

→ microloops for salts and materials compatibility including uranium chloride salt

→ isothermal loop – *world's largest pumped chloride salt system*

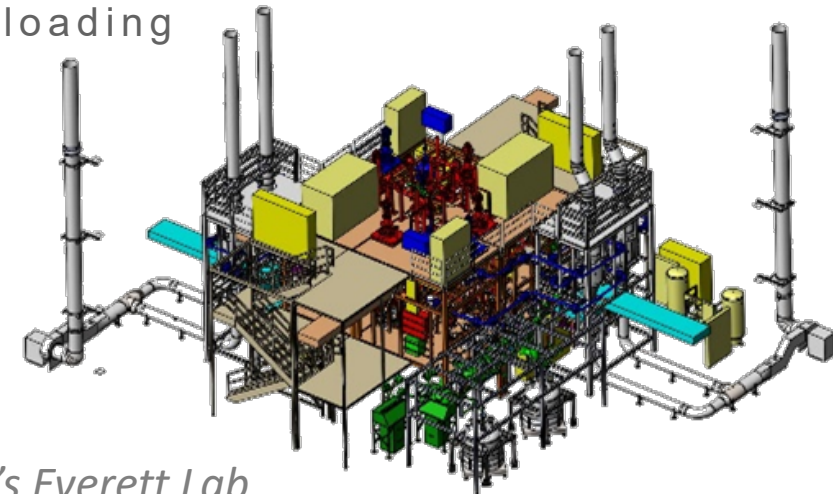
INTEGRATED EFFECTS TEST

→ <1 mw electrically heated, multi-loop system

→ salt handling including salt production, loading, and unloading

→ new salt pump development

→ freeze valve design, development, and testing



IET in TerraPower's Everett Lab

Advanced Reactor Demonstration Program (ARDP) – Molten Chloride Reactor Experiment (MCRE)

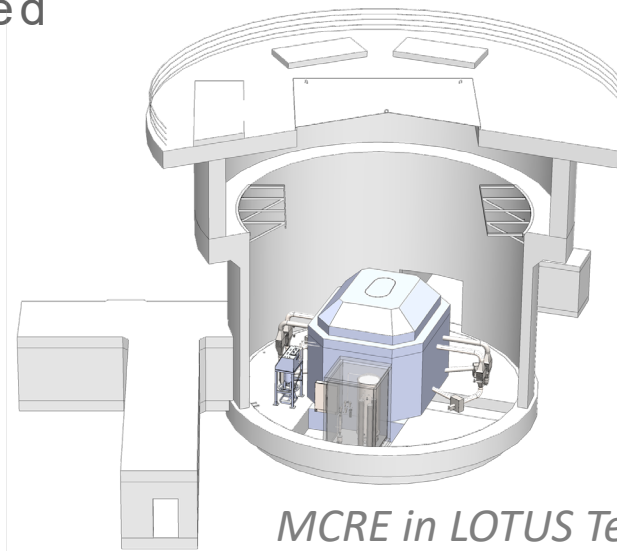


Gathering reactor physics data with the world's first fast chloride salt reactor

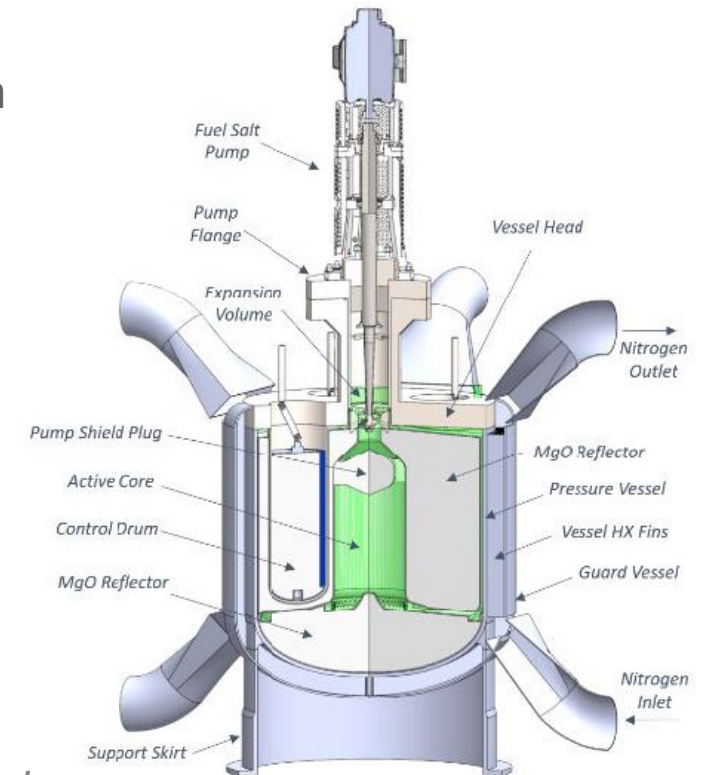
- \$113M total project, 80/20 cost share
- HEU-fueled critical experiment, low power operation
- year 5 operation
- INL sited & DOE authorized



NRIC LOTUS
Laboratory for Operation and
Testing in the United States



MCRE in LOTUS Test Bed

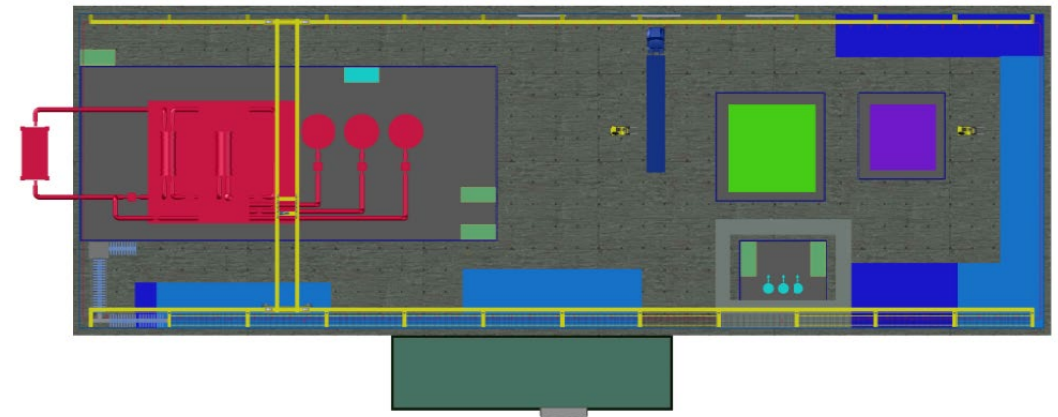
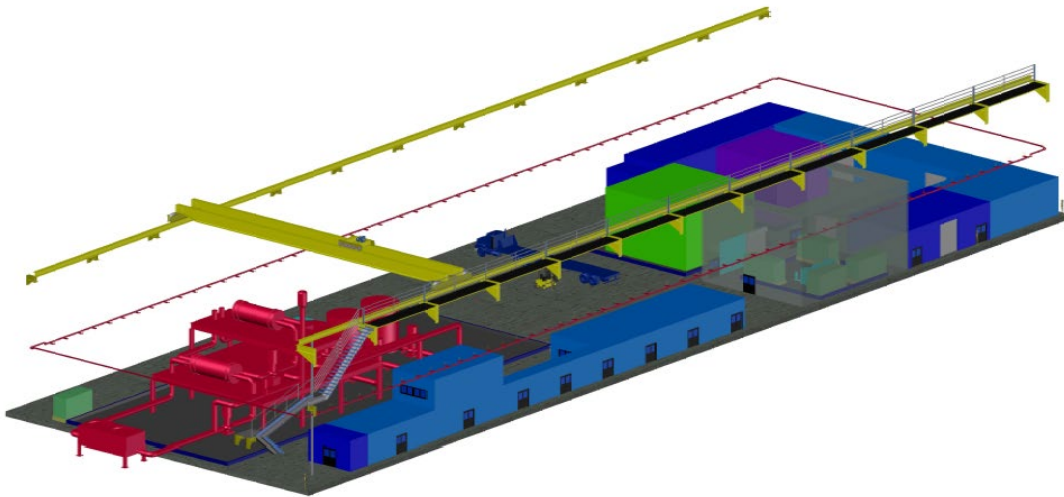


Molten Salt Test Facility (MaSTiF)

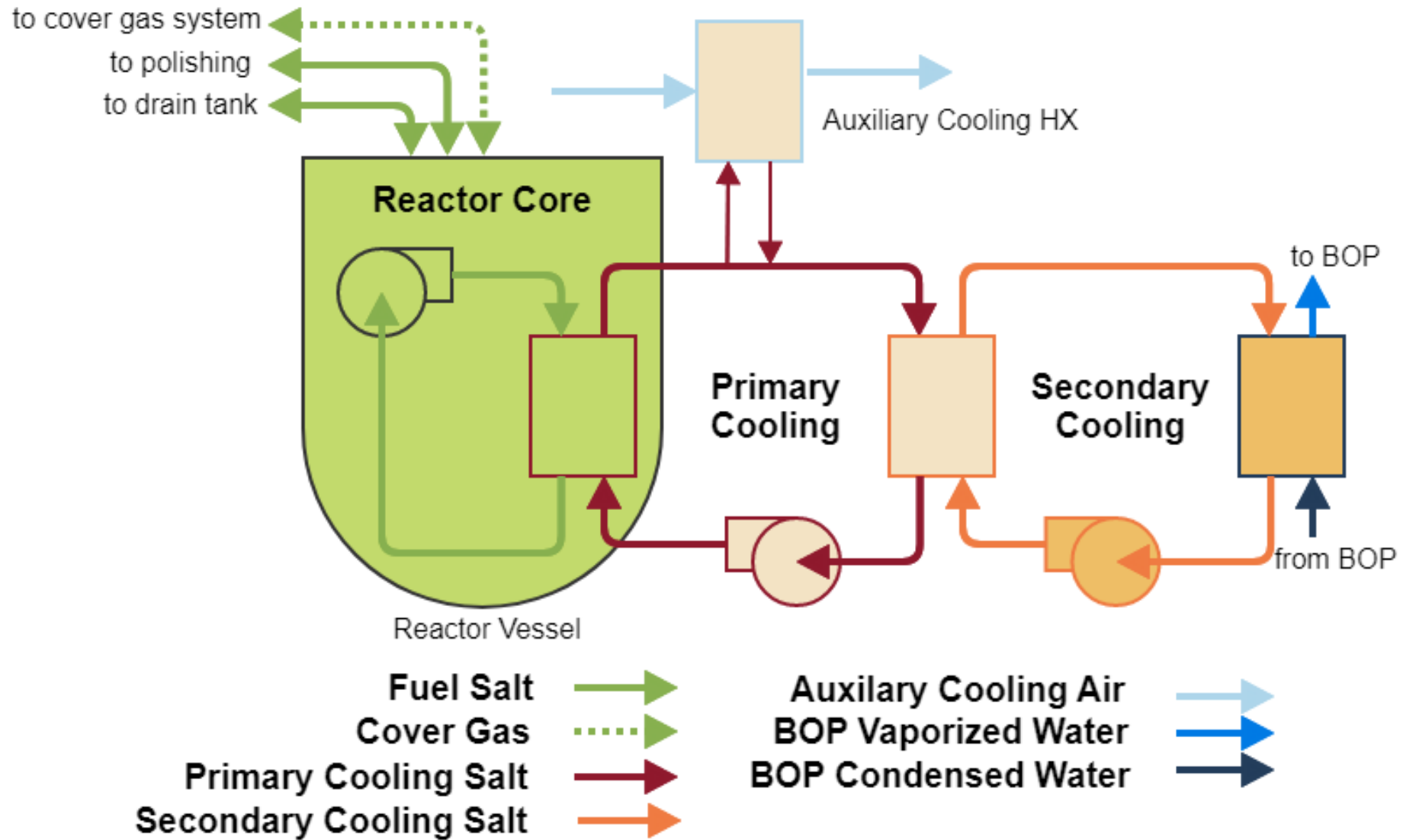


Product-scale component operation and integrated remote maintenance

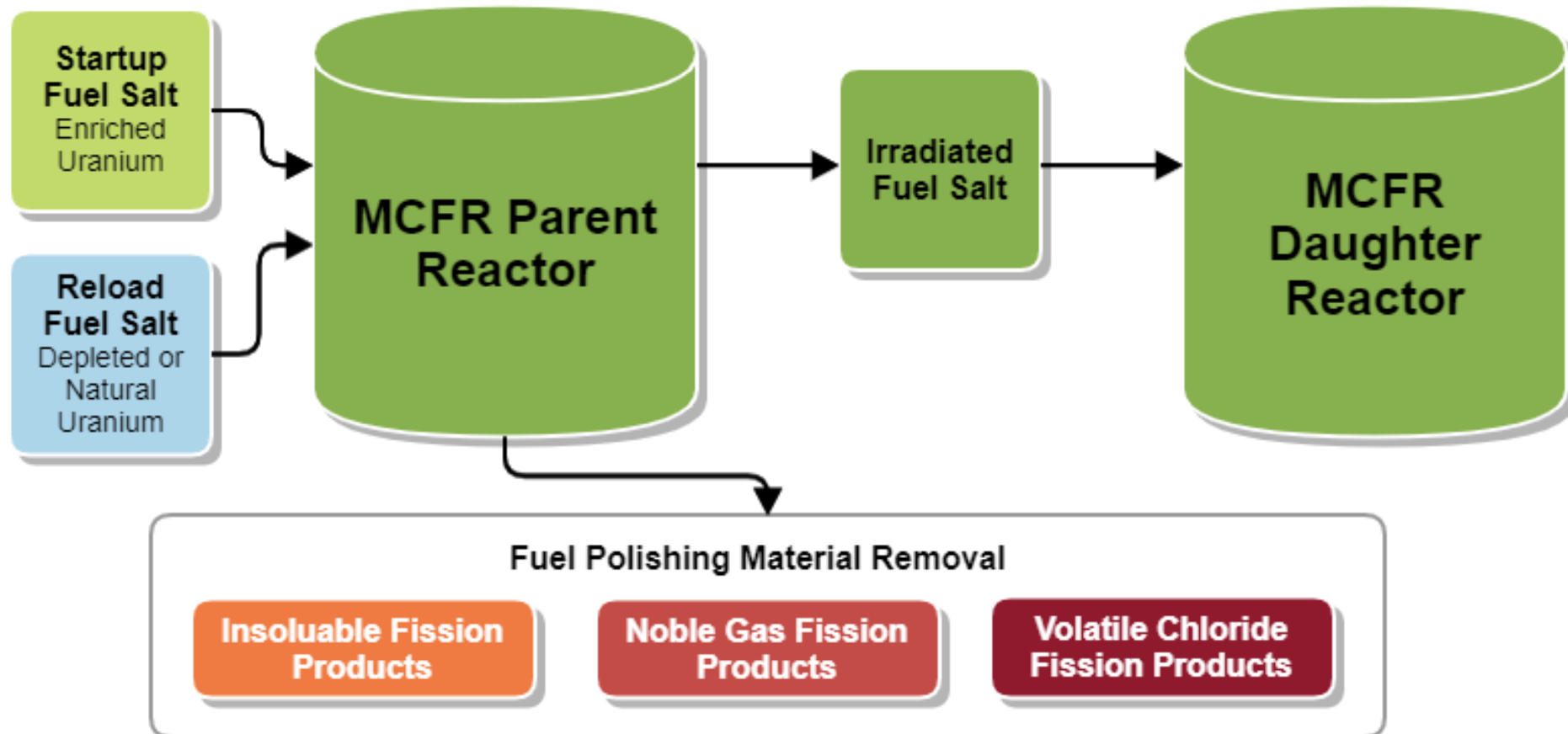
- thermal hydraulics & component reliability data/confirmation
- demo reactor component scales
- remote handling and maintenance
- hands-on end-user operations experience



Generic MCFR Flow Diagram

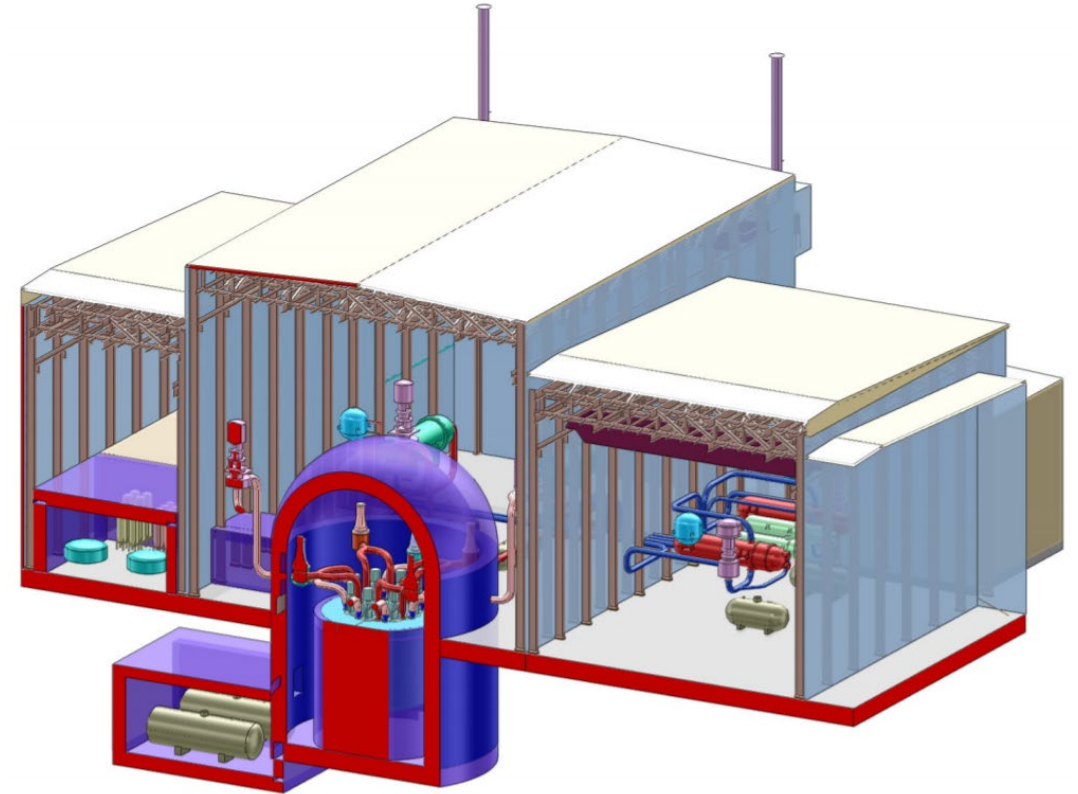


MCFR Fuel Cycle



MCFR-CR Plant High Level Summary

Parameter Name	MCFR Commercial
Power Output	800 MWe
Net Efficiency	44%
Power Cycle	Super-critical Steam
Reactor Vessel Structural Material	SS316
In-vessel Parallel Legs	8
Primary Cooling System Loops	4
Primary Cooling Fluid	NaCl-MgCl ₂
Secondary Cooling System Loops	4
Secondary Cooling Fluid	Solar / Nitrate Salt





Southern
Company