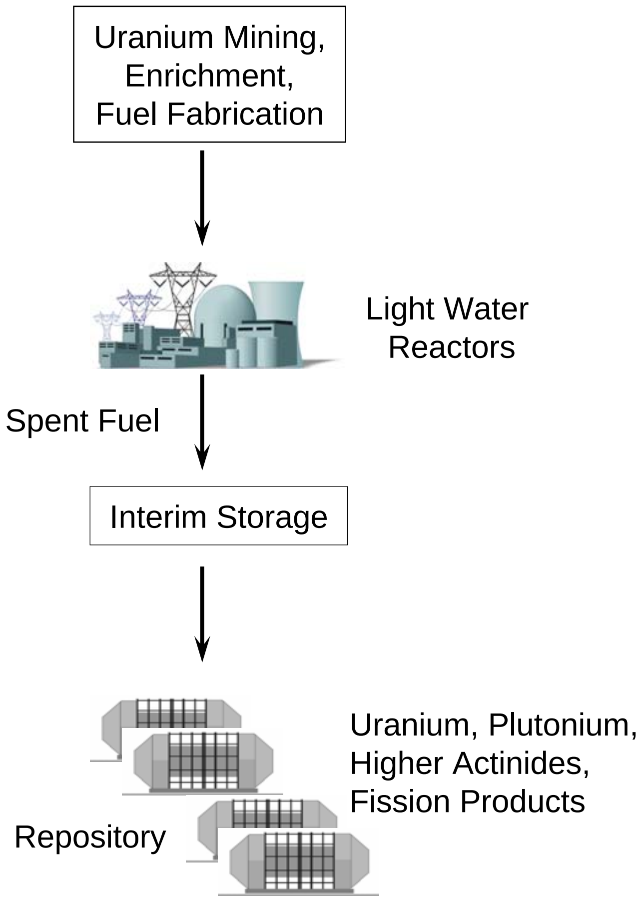
Global Nuclear Energy Partnership

Overview and Challenges

M. Cappiello

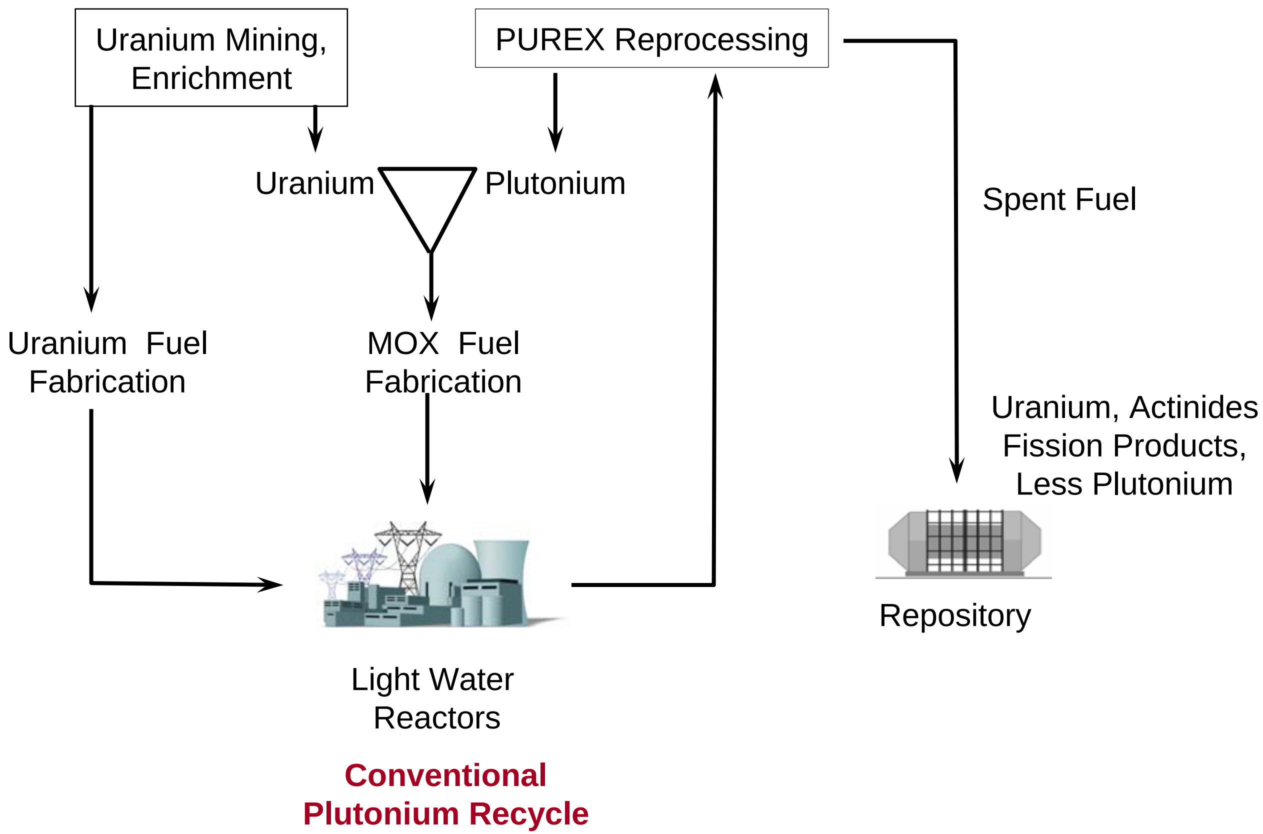
Once Thru Fuel Cycle: Current US Strategy



Once Through Fuel Cycle

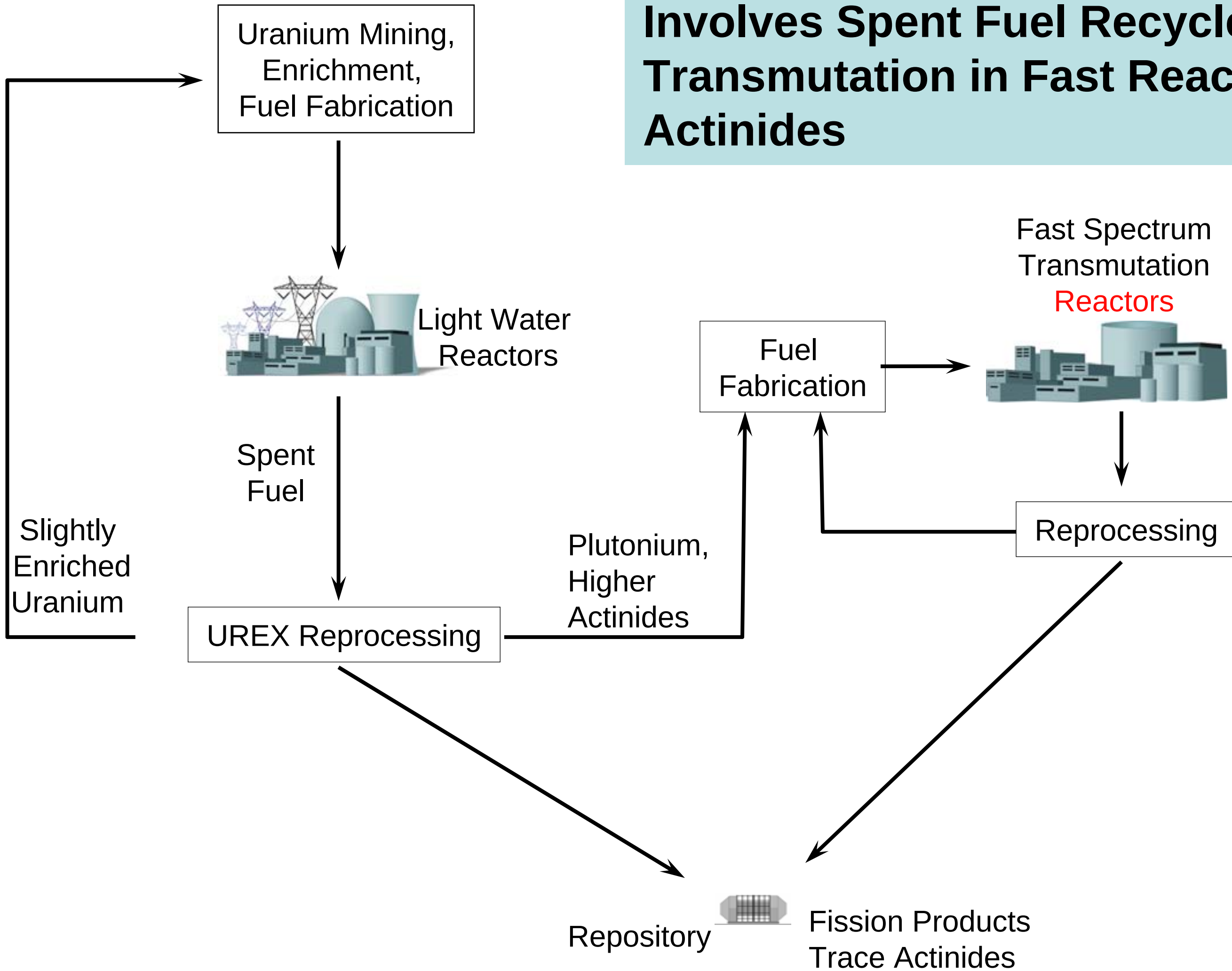
- Produces 20% of US electricity
- Approximately 2000 T of Spent Nuclear Fuel per year
- Yucca Mtn-sized repository needed every 30 y for continuation of nuclear power at current rate
- Long term heat load and radio-toxicity dominated by actinides

Plutonium Re-Cycle: Used in Europe and Japan



- Strategy used in France, UK, Russia, Japan
- Fissile Pu depletion
- Reduced waste *volume*
- Geologic repository needed
- Long term heat load and radio-toxicity dominated by actinides

GNEP Approach to Spent Fuel Management Involves Spent Fuel Recycle and Transmutation in Fast Reactors to Eliminate Actinides



Closed Fuel Cycle

Global Partnership:

Provider States:

Provide total fuel service to the user states. Responsible for enrichment services, reprocessing and waste disposal.

User States:

Nuclear reactors for clean electricity production.

Receive fuel from and return spent fuel to the provider state(s)

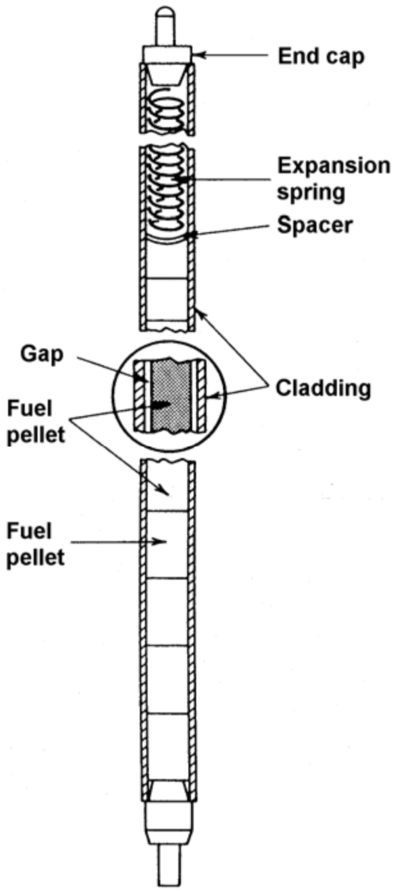
Major Facility Demonstrations

- **Engineering Scale Demonstration (ESD):**
  - Demonstrate UREX+1a separations process (group actinide separation)
  - Provide actinide feedstock for TRU fuel development
  - FY 2011 start, Jim Laidler NTD
- **Advanced Burner Test Reactor (ABTR):**
  - Sodium cooled, neutron fast spectrum
  - Demonstrate closure of the fuel cycle (Actinide transmutation)
  - TRU fuel testing
  - Support licensing of commercial Burner Reactors
  - Demonstrate advanced concepts
  - FY 2014 start, Phillip Finck NTD
- **Advanced Fuel Cycle Facility (AFCF):**
  - Advanced Fuel Fabrication (Fabricate TRU fuel for testing in ABTR)
  - Advanced Processing
  - Advanced Safeguards
  - FY 2016 start, Kemal Pasamehmetoglu, NTD

Approval of mission need (CD-0) for all three demonstration projects is expected by the Deputy Secretary of Energy (Clay Sell)

Qualification of Transmutation Fuel is a Major Challenge

- Fabrication Issues:
  - **Fabrication processes to provide adequate, density, uniformity, porosity, conductivity, dimensional stability etc.**
  - **Remote fuel fabrication processes to handle highly radioactive material**
  - **Americium volatility, Cm content effects, Feed material effects, Lanthanide contamination**
- Performance Issues:
  - **High burn up (30% fissile)**
  - **Clad integrity at high dose (>100 displacements per atom)**
  - **Fuel and fission product migration during irradiation**
  - **Fuel to clad interactions and fuel failure**
  - **Fission and capture rates of higher actinides (uncertainty due to sparse nuclear data)**
  - **Transient behavior**
  - **Reactivity feedback (temperature and expansion coefficients)**



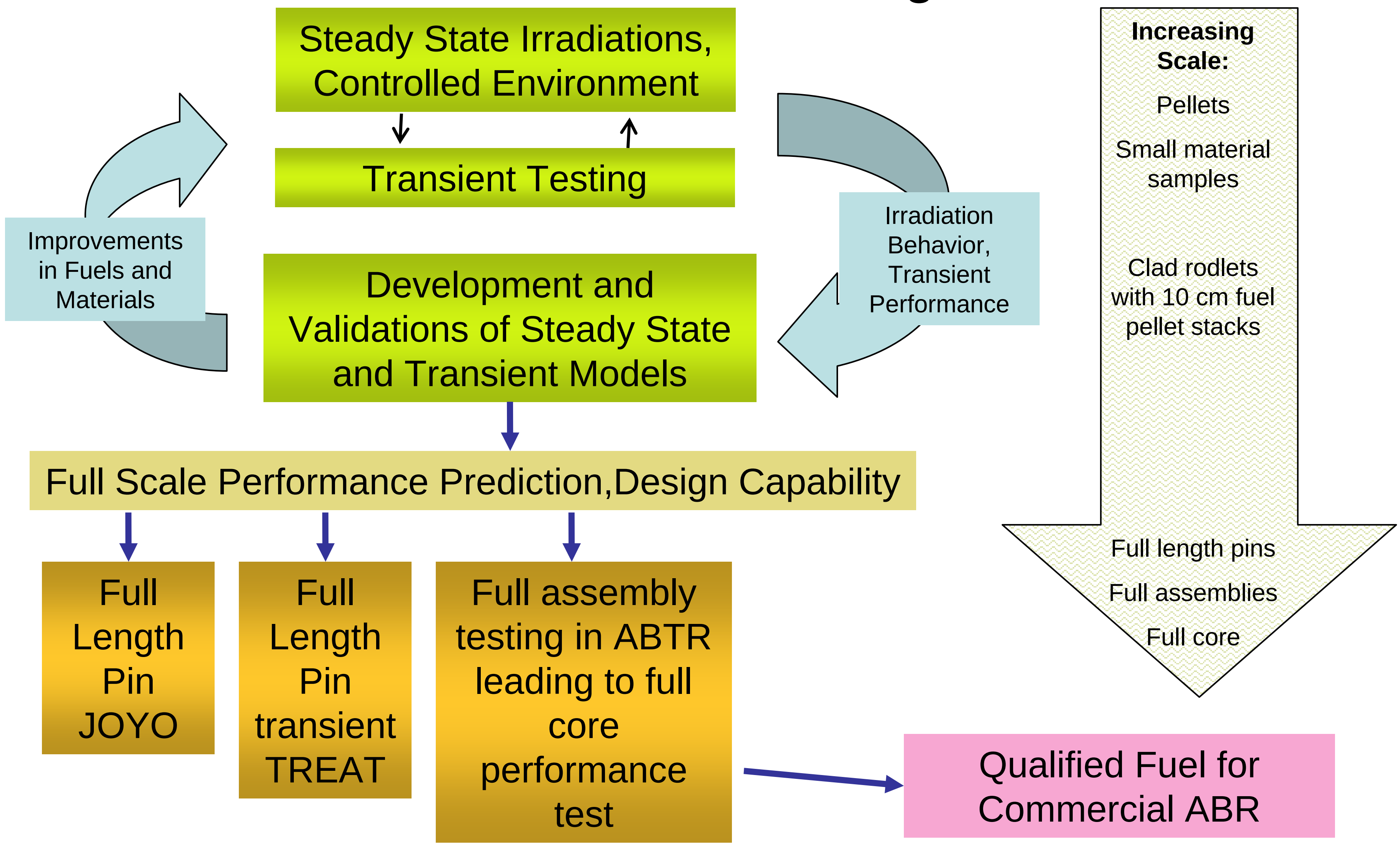
<u>Features:</u>

- **Typical fuel pellets are small (5 mm diameter).**
- **Clad in stainless steel tubes**
- **Sodium or helium bond**
- **Contains Pu, Np, Am, Cm, La, balance U**

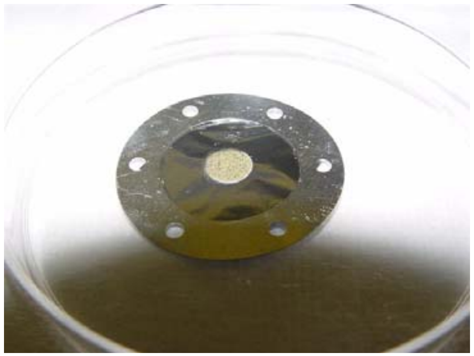
TRU Fuels are in the Early Stage of Development

- **Both oxide and metal fuels containing TRU for fast spectrum transmutation are at the early stages of the proof-of-principle phase in the technology readiness level (TRL) scale.**
- **Limited data exist over a narrow range of fuel compositions. Fuels with Cm have never been fabricated.**
- **Considerable additional development is needed to complete the proof-of-principle and proof of performance phases.**

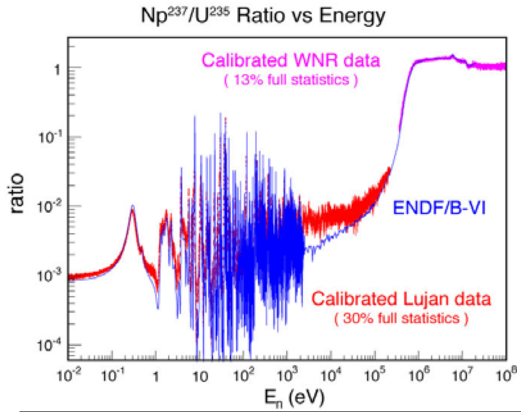
Development Strategy: Accelerate Development with Multi-Scale Modeling and Simulation. Validate with Small Scale Testing



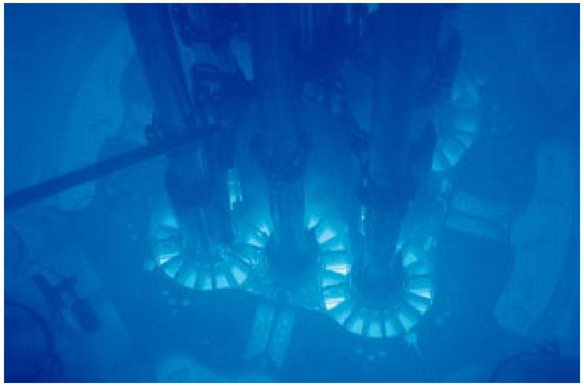
Modeling, simulation and some validation activities is underway under AFCI, supports GNEP



242Pu cross section measurement target fabricated at INL

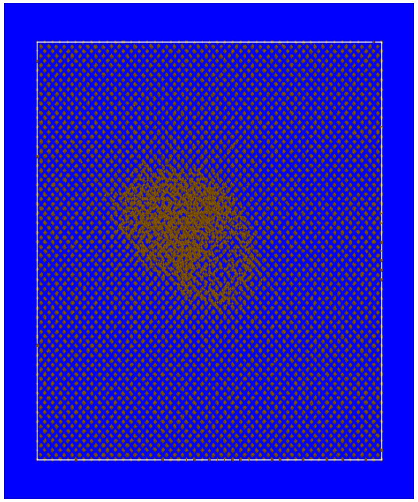


237Np cross section measurement data taken at LANSCE/WNR and Lujan



Thermal Neutron Irradiations in ATR at INL

Post Irradiation Examination at LANL

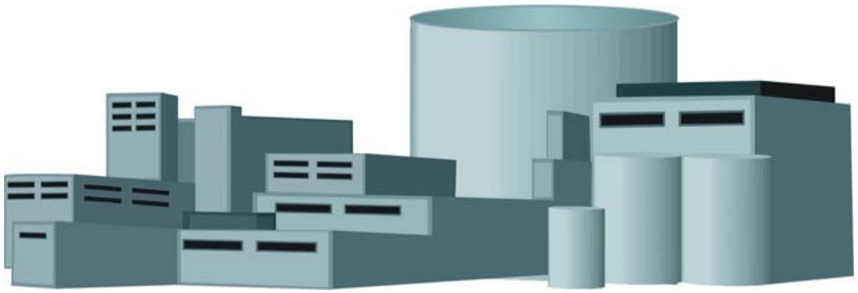


Multi-scale modeling of irradiation performance of fuels and materials

Transmutation and Safety Performance of the ABRs is a Major Cost Driver

Transmutation Reactors

- Fast Neutron Spectrum for efficient actinide fission (high fission to capture)
- High burn up fuels
- High dose to cladding and structures
- Low Conversion Ratio
- TRans-Uranic fuel (U, Pu, Am, Np, Cm)
- Metal, Oxide or Nitride
- Liquid Metal Coolant (Sodium)



Performance has a major impact on cost

• dictates the Uranium content

• determines the minimum conversion ratio and therefore the number of systems required

Conclusion

- AFCI program has evolved into GNEP
- Focus is redirected towards major demonstrations
- Major challenges exist for the fabrication and performance of the fuel
- And for the performance of the reactors