



**NRC Evaluation Model (EM) Development for the Next Generation Nuclear Plant (NGNP)**

**RIC 2011**

**Status of Research Activities in Preparation for Licensing of Advanced Reactors**

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USNRC Research  
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**NRC EM Development**

**• Objectives**

- Develop confirmatory safety analysis capability (i.e., an evaluation model) to:
  - Support NGNP licensing review
  - Provide technical basis for regulatory decisions

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**NRC EM Development**

**• Scope:**

- Radiological consequences (workers & public)
  - Fission product release from confinement/containment
    - Nuclear analysis
    - Thermo-fluids
    - Fuel performance
    - Fission product transport
    - Consequence analysis
- Applies to pebble-bed (PBR) and prismatic (PMR)
- Consists of three evaluation models
  - Normal operations (pre-break)
  - Initial fission product release (blowdown transient)
  - Delayed fission product release (heatup transient)

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## NGNP EM: Codes

- **PARCS** - Core Neutronics Simulator
  - 3-D, time-dependent core flux/power
    - Cylindrical (PBR) and Hexagonal (PMR)
    - Preliminary validation for PBR with OECD PBMR-400 Benchmark
  - Ongoing development tasks:
    - Triangle-Based Polynomial Expansion Method (TriPEN) for PMR
    - Improve cross-section generation capability for HTGRs
    - Update flux solver: anisotropy & coarse mesh acceleration
    - Higher order transport methods: SP-3
    - Computational efficiency: OpenMP
    - Microscopic depletion capability
    - Participate in development of OECD Benchmark for PMRs

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## NGNP EM: Codes

- **AGREE** - Advanced Gas REactor Evaluation
  - 3-D, two-temperature porous medium (PBR) approach based on the legacy THERMIX/DIREKT codes.
  - Coupled to PARCS to provide coupled time-dependent neutronics and thermo-fluid solution for gas reactors
    - Preliminary validation with SANA tests & PBMR-400 benchmark
    - Extended to model prismatic (PMR) core using r- $\phi$ -z geometry
  - Ongoing development tasks:
    - New PMR modeling capability: 3-D heat transfer & bypass flow
    - Improved numerics: increase implicit coupling between field equations and implement parallel processing

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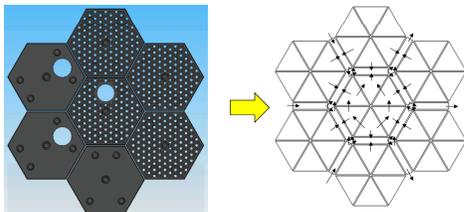
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## NGNP EM: Codes

- **AGREE** - PMR Bypass Flow Model
  - 3-D core represented by a series of cross-connected subchannels
  - Subchannel method is based on proven light water reactor core thermal-hydraulic analysis techniques (ie. COBRAVIPRE)



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## NGNP EM: Codes

- **SCALE/AMPX - Nuclear Analysis Code Suite**
  - AMPX processes ENDF nuclear data into code usable libraries
  - SCALE provides lattice physics and depletion capabilities to generate few-group cross-sections, decay heat and fission product inventory
    - Double Heterogeneity Model implemented
      - Uses layered continuous energy CENTRM calculations for self shielding
    - Work in progress:
      - Benchmarking vs. HTTR, HTR-10 and PROTEUS
      - Detailed models of NGNP for sensitivity & parametric studies
      - Improve & validate interface to PARCS
      - Interface for fission product release calculations
      - Participate in IAEA CRP on uncertainty analysis for coupled reactor physics and thermo-fluid analysis of HTGRs

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## NGNP EM: Codes

- **SNAP - Symbolic Nuclear Analysis Program**
  - Graphical user interface (GUI) toolkit for NRC codes
    - GUI for both pre- and post-processing
      - MELCOR
      - PARCS/AGREE
    - Plug-in capability, for example:
      - Driver code for steady-state normal operation
        - » Equilibrium core for PBR
        - » Fuel shuffling methodology for PMR
    - Auto validation tool
    - Uncertainty analysis tool

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## NRC EM Development

- **Summary**
  - Code and model development tasks are underway
  - Preliminary code assessment vs. existing database will begin in 2011
  - Independent confirmatory analysis capability to be ready in 2013

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## Acronym List

- AGREE: Advanced Gas Reactor Evaluator
- EM: Evaluation Model
- ENDF: Evaluated Nuclear Data File
- GUI: Graphical User Interface
- HTGR: High Temperature Gas Reactor
- HTR-10: High Temperature Reactor (10 MW)
- HTTR: High Temperature engineering Test Reactor
- NGNP: Next Generation Nuclear Plant
- PARCS: Program for Advanced Reactor Core Simulation
- PIRT: Phenomena Identification and Ranking Table
- PBMR: Pebble-Bed Modular Reactor
- PBR: Pebble-Bed Reactor
- SNAP: Symbolic Nuclear Analysis Program
- Tri-PEN: Triangle-based Polynomial Expansion method

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