NEA and MIT Systems Code Benchmarks

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Background

- **Systems codes are complex and difficult to verify**
- **Benchmarking provides a means for code validation**
- **VISION has now been benchmarked in two separate studies**
  - NEA benchmark
    - *3 scenarios in a progressive series*
    - *5 codes (COSI, FAMILY, DESAE, EVOLCODE, VISION)*
  - MIT benchmark
    - *5 scenarios varying in growth rate and fuel cycle*
    - *4 codes (CAFCA, COSI, DANESS, VISION)*

NEA Benchmark Series

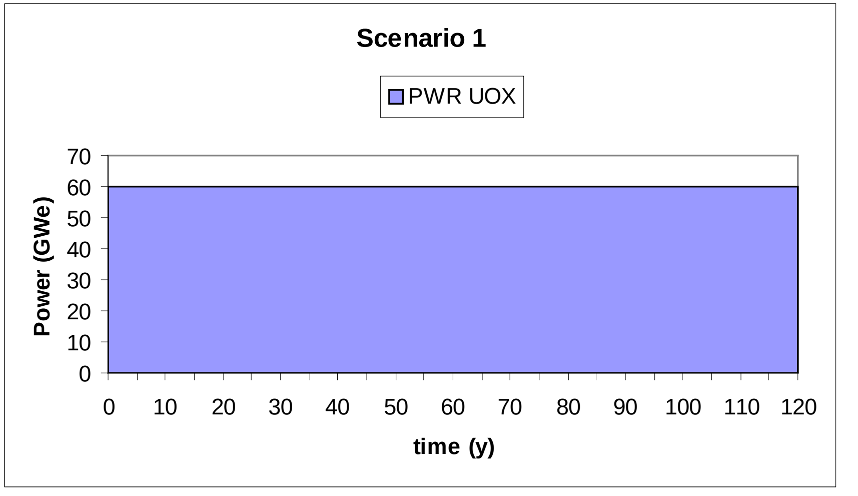
- **Three benchmarks based on a constant level of nuclear energy**
  - Open cycle
  - Monorecycling of the Plutonium in the PWRs.
  - Monorecycling of the Plutonium in the PWRs and then deployment of the Gen IV fast reactors recycling Plutonium and minor actinides.
- **Benchmark specification includes numerous parameters defining the scenarios**
  - Reactor properties
  - Core properties
  - Fuel properties and isotopic contents
  - Reprocessing schedules, capacities, priorities, efficiencies
  - Electricity output by reactor type by year

NEA Benchmark Series

- **Specified outputs in a spreadsheet format, to include:**
  - Natural Uranium consumption,
  - SWU needs,
  - Fuel fabrication flows
  - Interim storage inventories
    - *spent fuel*
    - *depleted Uranium*
    - *Plutonium*
    - *Etc.*
  - Processed spent fuel
  - Pu and MA mass flows
  - Plutonium and minor actinides losses from reprocessing

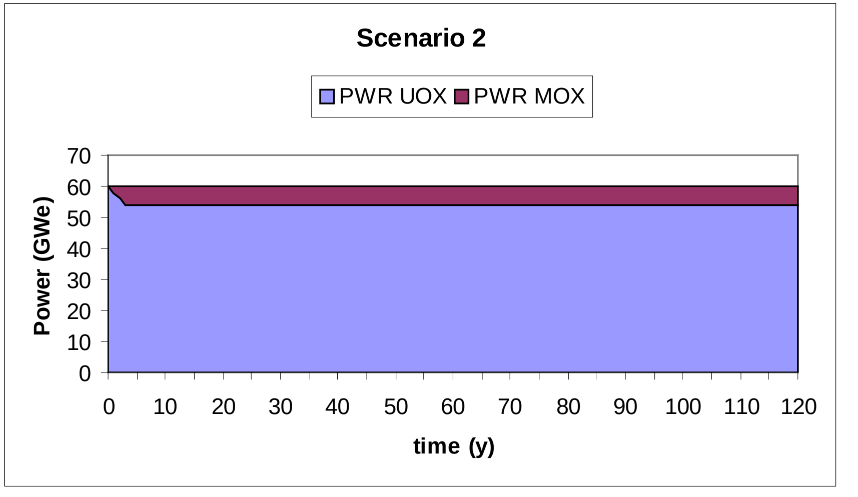
NEA Benchmark #1 – Open Cycle

- **A constant energy level with a single reactor type**
  - Confirms initial conditions modeled consistently
  - Confirms fuel cycle front-end flows
  - Simple case easily verified



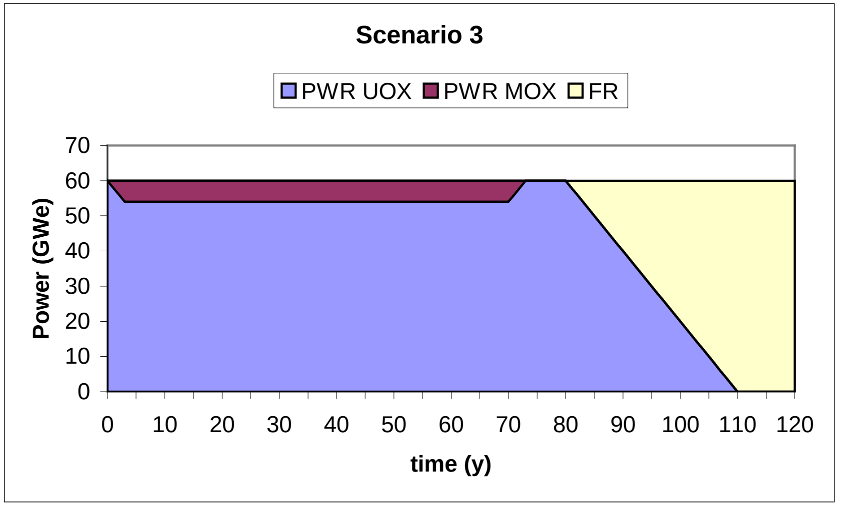
NEA Benchmark #2 – Adds MOX

- **Designed for equilibrium behavior**
  - Confirms separations initialization
  - Confirms fleet fuel mix transition
    - *Rate of introduction*
    - *Level sustained*
  - Storage inventory decay impacts results



NEA Benchmark #3 – Adds FR Transition

- **Much more complex**
  - Adds two more transitions
    - *Ending MOX*
    - *Starting FRs (convertors)*
  - Augments separations strategy
    - *UOX, MOX, FR core, FR blanket all specified separately*
  - Adds reactor retirement



- **Tests TRU mass management**
  - TRU for FR startup schedule barely sufficient

Discussion

- **Benchmarking is hard to do**
  – Even a simple case requires specifying pages of input
  – Differences in interpretation require iteration of the specification
- **In general, all the codes demonstrated similar behavior**
  – Especially true for general trends, which is purpose of these codes
  – Specific differences usually traceable back to how each code modeled features (more stages/details gives more time step delays, etc.)
- **Benchmarks generally did not test advanced features of codes**
  – Many intelligent capabilities were overridden (code dumbed down) to get best match with other cases
  – Many advanced extensions appear only in a single code