# GAIN-EPRI-NEI-US NIC Micro-reactor workshop

*R&D opportunities and recommendations*

# R&D Opportunities (I)

- HALEU infrastructure:
  - *HALEU supply, shipping infrastructure, fabrication infrastructure*
  - *Good steps taken, but more needed*
  - *We cannot afford to underfund this cross-cutting work to fund specific reactor design work*
  - *Let's avoid the situation of having licensed reactors but no fuel for them*
- Legacy data on fuels, alloys, plant operations, and reliability data
  - *Thank you to GAIN for leading on this*
  - *This data is a real national asset, so let's keep building on work to date, such as tying data together with subject matter expert reviews*

# R&D Opportunities (II)

- Higher temperature alloys
- Advanced cladding materials for higher temperature and longer duration operation
- FCCI barrier advancement
  - *Zr, Cr, V, or inclusions*
- Alternative bonds, e.g. lead, fuel-material compatibility, and associated fission product retention
- Advanced heat exchanger design and fabrication for compact geometries
- Low-flow liquid metal flow meters
- Advanced PCS scouting and development
  - *Nitrogen brayton, AMTEC, large Stirling, advanced S-CO2, others*
- Moderate to high temperature moderators
  - *Updated evaluation of thermal scattering data for ZrH materials following recent updates to YH materials*
- Advanced passive control systems, e.g. lithium expansion modules

# I&C Opportunities

- Temperature sensors that can operate efficiently and effectively in the active core: high-flux, high-temp conditions
  - Fiber optics, thermocouples, or new designs
- Also interested in total ex-core monitoring capabilities
- Smaller/new mechanism flux sensors
  - Potentially including gamma heating sensors that can operate without a cold sink, but also simply entirely new designs
  - Adaptive flux sensors that can operate over the entire flux range
- Wireless communications for sensors
  - Even better if wireless for the advanced in-core flux and temperature sensors mentioned above
  - May be able to piggyback on development from other industries here
  - If possible, wireless sensor-to-sensor communication testing at high-temp/high-flux
- Live radiation damage trackers on sensors
  - Monitor the dpa seen by the sensors to evaluate sensor health
- Smart controllers/tags for sensors
  - Report operating time, last maintenance, anomalous operating conditions experienced, dpa (mentioned above)
  - Find sensors about to fail before they fail
  - This may be already in development for other industries
- Next generation UI/UX monitoring interfaces
  - Both display and interactivity advancements - how do we see the system's conditions, and manipulate that information to go deeper if desired?
  - Also for monitoring the autonomous control system - can we tell what it's 'thinking' and what information it's basing those decisions on?
- Micro-speed motors or gearing for fine motor control
  - Process for sensing micro movements with high fidelity, and little signal error
- Software testbed for evaluating potential sensor configurations or system controllers
  - Particularly secondary side and “beyond the transformer”

# M&S Opportunities

- Clear need for a MOOSE "animal" (Sage Grouse?) for reduced order modeling at a systems level that can capture the three major modes of heat transfer with robust transient capabilities
- Design development approach often involves rapid iteration, which does not work well with high fidelity, small scope codes
- We can still use higher fidelity models of a component, system, or location in the core
- In that case there should be a means of increasing or decreasing the fidelity of different aspects of the code (e.g. higher fidelity thermal hydraulics or fuel performance by plugging in existing MOOSE tools such as BISON)
- It would also be helpful for MOOSE packages to be distributed via a container (docker image)