Nuclear Reactor Technology Subcommittee of NEAC

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The need for New Test/Demo Reactors

- At the December 2014 meeting, NRT report mentioned that at the March 2014 DOE "Big Idea Summit", a break-out group discussed the need for more rapid advanced technology deployment in nuclear power plants and more rapid commercialization of advanced nuclear power technology.

- That group outlined an approach that allows taking advantage of scientific advances for nuclear energy applications:
  - Develop and maintain small-scale state-of-the-art experimental facilities with easy access through an integrated user-facility approach;
  - Develop and maintain up-to-date computational frameworks for the development and use of modeling and simulations in practical but high fidelity applications;
  - Establish knowledge-based centers to support access to past and current experimental data and computational results;
  - Introduce engineering-scale capabilities to allow for final validation of new innovations under prototypical conditions.

- NRT found merit in the proposed approach in a meeting in September 2014, and particularly in pursuing a study of what test/demo reactors would serve best the experimental needs.

Motivation and Scope

- There are several concepts for new types of reactors and even for fuels of water cooled reactors that have been proposed by industry groups and DOE laboratories, that can make good use of new facilities.
- DOE had in recent years reviewed the capabilities of existing irradiation and other testing facilities both in the US and around the world. NRT was briefed on these capabilities at the September meeting and a subsequent meeting in December 2014.
- The current US test reactors are more than 40 years old and do not have the needed volume and neutron flux to accelerate the development of new fuels, whether for water-cooled reactors or fuel for reactors of other coolants.
- *Congress allocated in FY15: "$7,000,000 for an advanced test/demonstration reactor planning study by the national laboratories, industry, and other relevant stakeholders of such a reactor in the U.S. The study will evaluate advanced reactor technology options, capabilities, and requirements within the context of national needs and public policy to support innovation in nuclear energy."*

Broad Goals for Testing of Advanced nuclear technologies

- Accelerate development of improved nuclear options to secure long term energy in the US
  - Nuclear has a proven record in withstanding severe weather conditions, e.g. the polar wave.
- Explore and enhance economic and safety performance in nuclear reactors to enable a market ready base load source of carbon-free energy
- Maintain global leadership in "critical" energy and security technologies.
  - Witness the support Russia is providing to its nuclear energy exports to Turkey, Belaruse, Vietnam, and others
- Attract a new generation of experts in advanced nuclear energy technology.

Example of Specific Benefits from New Technology

- Enhancements to economy and safety, e.g.
  - in LWRs - including SMRs
    - Additives for higher fuel conductivity
    - New Cladding Materials to enable
    - Higher density fuels
  - In Other coolant technologies (liquid metal, gas, salt)
    - Higher power density cores
    - Longer fuel cycles (over 10 years)
    - Higher temperature to open new markets
- Environmental Benefits: Much Higher Power Cycle Efficiencies to reduce the need for water cooling and improve fuel utilization

The Reactor Type Options

- A demonstration reactor that would be able to evaluate several aspects of a selected advanced reactor technology, e.g., basic neutronic and thermal behavior, licensing process, safety case, operating characteristics
- A test reactor to obtain data to support more rapid RD&D of innovations in many reactor concepts via loops at the right conditions.
- NRT recommends the inclusion of advanced technology for light water reactors as well as other advanced reactors concepts in this study ;
- NRT recommends that international capabilities, both existing and planned, in test and/or demo reactors (France, China, Netherlands, and Russia) be considered so that collaborations where viable be taken into account.

Potential Capabilities of New Test/Demo Facilities to Accelerate Nuclear Technology Development

- High fast neutron flux to study neutron irradiation effects on materials, claddings and fuels
  - 10^{16} n/cm^2 s was recommended by two industry groups as a worthwhile, although a stretch from the capabilities anywhere)
- Large test volumes to allow for integrated component tests, e.g fuel
- Loops for a variety of coolants
- High temperature capability in loops
- Easy Accessibility of the test stations and of post irradiation examination facilities
- State-of-the-art instrumentation
- High availability, which means high reliability and dedicated facilities.

The study should consider the benefits and needed tradeoffs among these capabilities.

Non-technical Considerations

- Affordable build costs with sustained support over the construction period
- Sustained funding for operations and experimenter support
- Broad user community
- International collaborations
- Policy Constraints (e.g. < 20% U-235, export controls)

Process

- As a first step, establish desired goals/capabilities and evaluation criteria based on stakeholder input and develop project plan.
- Establish Steering Committee, with input from utility, reactor industry, labs, and think tank groups and universities.
- Establish working groups with lab, vendor, and university participation to provide technically accurate, and clear information to be used as evidence in evaluation process:
  - Evaluation of test reactors
  - Evaluation of demo options
  - Methodology
  - Siting and licensing options
  - Affordability of the test program (each facility) & sponsors
  - Economics of eventual resulting reactors
  - Independent review for technical correctness.
- Schedule (start March 2015, draft study report May 30, 2016, NEAC Review June 2016, Final August 31, 2016)
  - NEA- NRT will review progress every 3 months

Licensing

- Test and Demo facilities can be in principle either licensed by NRC or DOE.
- If a reactor is to be connected to a grid, then NRC is the right licensee. If there is more than 50% commercial output for a plant, then NRC is the right licenses.
- NRC can license test/demo reactors under a Section 104(c) or a Section 103 license. **The NRC could specify more requirements if a subsequent design were built and connected to the grid**).
- DOE doesn't have the staff with recent experience to make required startup reviews and authorize startup. Building up the DOE staff to complete such activities would be unnecessary duplication of effort.
- As an external authority, an NRC license may bring about a higher public confidence in the safety reviews.
- The realistic options are licensing under Section 104(c) by the NRC or the NRC acting as the TSO for the DOE approach.

Steps Taken Thus Far

- NRT held a meeting on December 11, 2014 to review.
  - the existing US reactor capability (ATR and HFIR) and the new and advanced capability in other countries
  - Gap analyses done by NE Laboratories.
  - NRC presentation on the 10CFR50 Class 104 process for regulation of test reactors.
- NRT held a meeting on January 15-16, 2015 to review stakeholders views of the needs for test/demo reactors; Meeting attended by about 50 people including
  - Industry (AREVA. GA, GE, WEC, NuScale, Terrapower, Transatomic and utility representatives EPRI, NEI, Southern)
  - NGOs (ANS, Nuclear Infrastructure Council, The Third Way, Clean Energy Taskforce and others)
  - Universities (MIT, Georgia Inst. Of Tech. , North Carolina State U., Texas A&M U.)
  - Investment community
- DOE held a meeting on April 24 to obtain stakeholder input on the Criteria and Metrics that will be used in evaluating the test and demo reactor concepts .
- A meeting of NRT was held on June 5 to review the status of development of the study including the criteria and metrics to judge the test or demo reactor with the best potential to lead to practical applications in the future.
  - A good start has been made, but further work is needed on the metrics
  - The process will start by screening of potential GEN IV and vendor concepts to provide a Technology Readiness Level (TRL), with a higher level TRL needed for the test reactor basic concept, and both a high and low limits for a demo reactor concepts.
  - Working groups will be formed to define point designs for the chosen concepts and dvelop them over a year.
  - Report that summarizes outcome to be ready in August 2016