

Meeting of the NEAC  
**Advanced Reactor Pipeline Subcommittee (ARPS)**  
**Nov. 7, 2018. 10-1 pm**  
Atoms for Peace Conference Room, DOE HQ

The primary objective of the Advanced Reactor Pipeline Subcommittee is to provide an independent and expert review of efforts within the Office of Nuclear Energy as directed towards the advanced reactor industry and to report its findings, recommendations, comments and guidance to NEAC and the Assistant Secretary for Nuclear Energy.

Subcommittee members attending were Ray Rothrock (co-chair), Brein Sheahan (co-chair), Jay Faison, and David Blee. Members attending by phone were Caroline Cochrane and Steve Kuczynski. Also attending by phone were ex-officio members Pete Lyons and Joy Rempe. Present from the DOE were Robert Rova, Brad Williams, and Chuck Wade. Rothrock chaired the meeting and kept notes.

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As this was the first meeting of this newly formed NEAC subcommittee, the subcommittee spent some time understanding and discussing its currently defined scope of review (topics to cover, technical vs. policy review or both.). This report describes activities of the meeting to address the objective, with the report of findings to date, recommendations, comments and guidance to come in a future report. We look forward to input from the NEAC at its next meeting and readout of this report.

The committee considered the following agenda.

1. Charter and charge from NEAC
2. Relationship with GAIN
3. Narrative for advanced reactors
4. Radiation Protection Standards
5. Certain issues brought forth by the Advanced Reactor community, e.g. IP protection, procurement
6. Assembled a list of key topics of interest for the Adv. Rx community, without priority, and subsequent discussion thereof

**Item 1. Charter**

The proposed charter to this committee from NEAC was reviewed. In the charge letter to Drs. Meserve and Rempe, NEAC Co-Chairs dated Sept 13, 2018 and signed by Ed McGinnis, DOE NE, there were four goals. The second goal states, “Establish an Advanced Reactor Pipeline to enable the deployment of innovative Nuclear Energy Systems.” The subcommittee conversation revolved around the word “Establish.” It did not seem relevant that the subcommittee’s charter, or the NEAC charter for that matter, was to “Establish” such a pipeline. Rather, NE, NEAC, and this subcommittee should address issues, policy and strategy that “Enable” a pipeline to develop from the private commercial advanced reactor industry in conjunction with and support of the DOE, NRC, and other relevant bodies.

**ACTION ITEM: Mr. Williams of DOE would take the comments and work with staff to revise the charter along the lines more about policy and strategy and less about technology.**

**Item 2. GAIN**

GAIN is a DOE program established in 2015 to assist innovative, emerging companies with access to DOE resources and, when possible, provide modest funding of selected projects. That program has grown nicely since its founding now assisting a good portion of the 70+ startups in the field. However, funding for GAIN is not a line-item, and therefore is zero sum against NE’s budget. The committee discussed that perhaps GAIN should be a line item budget going forward.

Second, in part GAIN is specifically addressing the financing options for the nuclear startups, on a tactical basis. The subcommittee discussed whether NEAC ARPS should jointly meet and discuss how to leverage the groups knowledge and position for the betterment of the startups. Nothing specific was proposed.

**ACTION ITEM: Member Rothrock, a member of the executive advisory of GAIN, will talk to the GAIN member leading this effort, Maria Korsnick, CEO**

**Item 3. Narrative for Advanced Reactors**

Advanced Reactors, by some measures, is just about any reactor not presently built but on the drawing boards. This is not a bad definition, it’s just not clear about how DOE NE is interpreting this term. That said, there is a swirl of views about what exactly an advanced reactor is, its purpose, and why it matters. It seemed appropriate to the subcommittee that DOE should develop a narrative for this term. This is not a prescriptive item or definitional, but rather an informational

item that has good technical credibility but yet exposes the reader to the range of reactors being developed, the range of use cases, and the general market layout – who, what, when, where, and why. This narrative could help create a unified vocabulary, a consistent story across the DOE and government in general, and something the general advanced reactor community could also use. How this would be implemented was deferred.

In particular, the narrative must include and embrace the environmental movement in whatever channel it can. Having these groups in the tent of advanced nuclear is way better than outside the tent.

**ACTION ITEM: No action was recommended.**

**Item 4. Radiation Protection Standards**

Several participants brought up the need for the industry, perhaps through the ANS and with DOE or other health regulators (FDA?), to address the radiation protection standards. It is these standards on which all design and safety regulations take root. These standards are very old and are based on a theory called LNT – Linear No Threshold, meaning that any radiation is bad for a human. LNT had many unintended consequences. Intuitively and experientially, we know this is not the case, but we are living with the consequences. Over the many decades since this standard was put in place, much research has occurred as well as experience gathered – both good and bad. Updating this standard and modernizing it to what is known today is an urgent opportunity to readdress radiation protection standards.

The subcommittee discussed the need for continuing research at DOE to establish the appropriate replacement for LNT using the new law that now requires this action by DOE (and this legislation was successfully assisted by ANS). We also noted and agreed that both this subcommittee and the subcommittee on Existing Fleet would provide a policy recommendation to NEAC asking DOE to move on this action using the new law<sup>1</sup>. Dr. Lyons was on line for this discussion and strongly emphasized this point and support by Existing Fleet.

It was noted that in September there was held an ANS/HPS Joint Conference on

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<sup>1</sup> Under provisions of Public Law 115-246, the Department is encouraged to assure that the new Low Dose Radiation Research is staffed with outstanding leaders dedicated to resolving the uncertainties in health effects of low doses of radiation.

Low-Level Radiation where this question was discussed, and papers presented are available.

**ACTION ITEM: Member Rothrock will get the film and distribute to the ARPS/NEAC.**

Member Rothrock: The ANS/HPS Joint Conference on the Applicability of Radiation –Response Models to Low Dose Protection Standards, was held in Pasco, Washington on Sept. 3 – Oct. 3, 2018. It was chaired by Dr. Alan Waltar. A video of the conference proceedings in full is available at:

<http://www.lowdoserad.org>

**ACTION ITEM: Ex-officio member Lyons to report back the findings from the Existing Fleet subcommittee.**

Mr. Lyons reports that the Existing Fleet Committee in their report indicates the following (revised language here):

" The need for scientifically credible radiation dose standards underpins nuclear medicine, the nuclear navy, the commercial nuclear industry, our national laboratories involved in the weapons programs, and our environmental cleanup programs. An earlier DOE Low Dose Radiation Research program was terminated in the last Administration after their work suggested that the current model for radiation effects (the Linear No Threshold or LNT model) was not valid and is not based on sound science. The LNT model has been interpreted by some groups to mean that "all radiation is harmful," which inspires unfortunate public fears of any technology based on nuclear processes. After concluding that the LNT model was probably not valid, the goal of the Low Dose Radiation Effect program was to determine what standards should replace the LNT model, but that goal was not realized due to the early termination of the program. Many economic aspects of the current domestic fleet are influenced by the existing LNT-based radiation standards and any future uses of nuclear energy and technologies will continue to be tainted by the LNT model until a credible model is in place.

The Subcommittee applauds recent (September 2018) action by Congress and the Administration to pass H.R. 589 into Public Law 115-246. Section 306 of

H. R. 589 directs that “The Office [of Science] shall carry out a low-dose radiation research program to enhance the scientific knowledge of, and reduce uncertainties associated with, the effects of exposure to low-dose radiation to inform improved risk-management methods.”

[END]

### **Item 5. Advanced Reactor Community Requests, Issues, and Concerns**

The ARPS discussed a range of topics that some members of the advanced reactor community brought forth to the group. These included the protection of IP when working at a national lab, and CRADAs versus NDAs for the control of information. A startup doesn't know everything when it starts down a path of a design. This is generally true with all startups, not just nuclear related ones. As such, things will be learned during development, things will fail during development, and even in some cases success is not always as clearly defined in the beginning because the metric of success changes too. The lab culture, at least in some cases presented to the subcommittee, doesn't fully understand these matters of startup life. Nothing specific was proposed as a solution or even if this was a serious concern that needed resolution. It was requested to be included in this report. Certainly, a separate conversation among the startups and lab directors may be warranted to tightened up understandings or eliminate misunderstandings, improve whatever processes are in place now, and enhance an already robust partnership culture that clearly exists.

### **Item 6. List of Key Topics of Interest to the Advanced Reactor Community**

The ARPS conducted a lengthy roundtable identifying main categories that an advanced reactor company might care about. This is certainly not an exhaustive list. And it is not in any particular order, but some have commentary trying to capture rationale:

1. **Fuel.** Most advanced reactors will require HALEU fuel. So where will it come from, who will it be transported, etc. What's the long-term plan to solve this issue?

Subsequent to the subcommittee meeting submitted by Member Faison submits: [Advanced Fuels – Looming Crisis in Fueling Advanced and Innovative Nuclear Reactor Technologies](#)

This white paper, coauthored by the Nuclear Industry Council, outlines a

series of recommendations on next steps for HALEU fuel. From an NE perspective the top recommendation is to begin work to provide an interim supply of HALEU fuel (this is also authorized in the Nuclear Energy Leadership Act in the Senate and the Advanced Nuclear Fuel Availability Act in the House). Nearly as important is for NE to work with canister suppliers and the NRC to develop risk-informed regulations and infrastructure as quickly as possible. If initial reactors are prototyped at Idaho National lab the transportation concerns are slightly less pressing than the fuel availability itself, but this will remain a large issue.

2. **Data.** There is a treasure trove of data pertaining to many advanced reactor types resulting from work done at the national labs in decades past. The current activities should leverage this as best it can and not recreate the wheel. These data cover more than neutronics, including materials science, durability testing, and general components and controls for the systems envisioned then. The people who performed this work are senior in years and retired – no longer available to the labs. While there are many papers, libraries full of thesis and research work, and on and on, often the work of all these pioneers is not connected except in their relationships with each other. This is often referred to as tribal knowledge. Tribal knowledge is very valuable, and the ARPS would like to see a program to collect this data, organize it and make it available – OPEN SOURCE it. Those few startups that have walked the halls verify that this perishable asset for the community is there and does exist.

**POSSIBLE ACTION: The subcommittee submits that this is a very good short-term project for DOE (we won't say an easy win but a win for sure) that would be tremendously invaluable in the near term compared to others on this list which may take a long time.**

3. **Test Reactor.** The previous NEAC recommended to DOE to begin work on a new test reactor. That work is budgeted and has begun.

**Action Item: It would be a good outcome for the estimates on workplan, budget and schedule to be updated to reflect the choice of the PRISM design as the basis for the VTR and report this back to NEAC for understanding.**

4. **Financial.** The thinking here was how to access the DOE Loan program.

Could it be redirected? Also, GAIN funding falls under this topic, too.

5. **Materials science.** This is a critical area for all reactors, existing and future. In recent years when the DOE would gather outside groups to discuss issues pertaining to the emerging reactors, this topic came up. In particular, coordinating and managing the regulatory side of this problem, perhaps with the ASME and other bodies. A more coordinated materials science program that sets out ambitious development and qualification strategies for materials that could greatly lower the cost of reactors should be developed. Current funding towards materials technology and design is not coordinated.
6. **Government enhanced deployment.** Many times, the topic of government as a customer has been discussed in many circles. Given the stage of industry development, this should be seriously addressed in conjunction with power and heat needs at national labs, a natural place to locate a FOAK advanced reactor. There well could be a need within a handful of years.
7. **Licensing.** Regulatory processes are being addressed through initiatives by the DOE, industry, and the NRC itself. For the last several years congress has appropriated \$10 million in off-fee funding for advanced reactor regulatory modernization. This has largely focused on the safety characteristics of the reactor itself, and much less time has been spent on updating security, environmental, and fuel issues related to advanced reactors.

Ex-officio member Rempe provided the following additional comments to this section:

From <https://www.nrc.gov/reactors/new-reactors/advanced.html>

“Initial activities are focused on ensuring a flexible regulatory review process and addressing technology-inclusive policy issues. Actions have been taken by the staff to address ‘policy’ issues such as non-LWR Design Criteria (to replace the existing LWR-centric General Design Criteria), providing a pathway for reactors with a “functional containment” rather than the typical containment building found in PWRs and BWRs, a risk-informed performance based (RIPB) regulatory

framework ( increased reliance of PRA for selection of licensing basis events (including the use of a ‘cut-off’ frequency for events that must be considered with appropriate consideration of ‘defense-in-depth’), and methods for emergency preparedness requirements for SMRs and advanced reactors.

“Additionally: Member Faison provided the following from ClearPath. ClearPath developed a useful document with comments to CEQ on the need to modernize NEPA as it relates to advanced reactors. Options for reforming NEPA as it relates to advanced reactors should be seriously considered as current processes are becoming longer duration and potentially impacting length of development and adoption.

[END]

- 8. **Public private partnerships.** This picks up the innovative nature of the private sector with the large, well-financed, knowledge and capabilities of DOE. It was noted that many of these issues have been or are being addressed by the GAIN technology working groups. Many reports have already been written and the issues surfaced.

**ACTION ITEM: As there seemed to be a lack of awareness by the subcommittee of this body of knowledge and relevant work, member Kuczynski agreed to collect the technology working group reports and provide them to the subcommittee.**

Member Kuczynski submits the following:

Cross-Cutting Needs	Reference
<b>Generic- Access to applied technology (AT) documents.</b> DOE is reviewing options to facilitate access by U.S. commercial organizations to AT documents on advanced reactor and fuel technologies	GAIN Technology Workshop, Updated 3/2017
<b>Generic – Managing and reducing construction costs;</b> includes developing advanced construction technologies (e.g., concrete technologies) and practices (e.g., modularization techniques).	MIT report “The Future of Nuclear Energy in a Carbon-Constrained World,” September 2018; Section 2.5
<b>Generic- Modeling and simulation code development and validation for design and licensing.</b> A common	

<p>paradigm is targeted for providing general design capabilities, establishing consensus standards, and fulfilling the NRC’s validation requirements for confirmatory codes.</p>	<p>Ongoing discussions within nuclear energy development community.</p>
<p><b>Generic- Advanced reactors licensing framework.</b> Accelerate the joint work with NRC for establishing the advanced reactor licensing framework, with a focus on remaining open topics that are restraining deployment.</p>	<p>NEI white paper entitled <i>“Addressing the Challenges Associated with Establishing the Infrastructure for the Front-End of the Fuel Cycle for Advanced Reactors,”</i> released in January 2018</p>
<p><b>Generic – ongoing determination of resources, capabilities and infrastructure</b> to support nuclear energy research and development; primarily directed toward national laboratory complex.</p>	
<p><b>Generic- Capability to employ fixed fuels with uranium enriched to greater than 5% (up to 20%).</b> This is a need for multiple advanced reactor designs, including most of the designs considered during the workshop.</p>	
<p><b>Generic – Alternative fuel cycle development</b> (e.g., molten core; Thorium)</p>	
<p><b>Molten Salt Reactors technologies-</b> The MSR community identified a set of needs for the fundamental data and multiple small-scale test loops as discussed in the GAIN report. The recommendations were 1) Perform a feasibility assessment for a megawatt scale, molten-salt fueled critical system to be tested at a DOE site and 2) Identify alternatives to critical-system demonstration for meeting all the identified data-needs using different and simpler options.</p>	
<p><b>Fast Spectrum Reactors technologies-</b> The specific RD&amp;D needs are different in the fast reactor community depending on the coolant (sodium, lead, molten salts or gas). Access to fast spectrum testing capabilities is a common, high-priority need.</p>	
<p><b>High Temperature Gas Cooled Reactors technologies-</b> The high-temperature gas reactor community identified the completion of the TRISO fuel and</p>	

graphite qualification program as the high-priority need.	
<p><b>Generic and Technology Specific- Mechanistic Source Term Estimation-</b> The realistic evaluation of radionuclide release and transport to the environment during potential accident scenarios is a vital feature of future advanced reactor licensing efforts. However, questions remain regarding specific regulatory criteria and technical issues associated with mechanistic source term development. This work can be used to support regulatory modernization initiatives such as the <b>technology inclusive fuel qualification methodology</b> (see below) and <b>consequence-based physical security consideration</b> as well as/in combination with the Licensing Modernization Project's (LMP) products.</p>	<p>Assessment of recent SECYs (e.g., Physical Security and Functional Containment Approach) NEI's ARRTF priority list and the bipartisan <b>Nuclear Energy Innovation and Modernization Act (NEIMA)</b> direction.</p>
<p><b>Technology-Inclusive Component Testing Facility-</b> The component testing facility specialized in <b>non-nuclear</b> testing of components which were designed to be used in AR designs such as components used to transfer heat from a nuclear reactor using liquid metals, gases or salts to the energy conversion plant (e.g., for power generation or process heat utilization). This would be analogous in concept to the <b>Energy Technology Engineering Center (ETEC)</b>, a government-owned, contractor-operated complex of industrial facilities located within the 2,850-acre (11.5 km<sup>2</sup>) <a href="#">Santa Susana Field Laboratory (SSFL)</a>, <a href="#">Ventura County, California</a>.</p>	<p>Discussion with developers</p>
<p><b>Technology-Inclusive Content of Application Project (TICAP)-</b> This project, conducted using the same model as the LMP, will collaborate with the NRC to develop robust and technology-inclusive content of application guidance that facilitates efficient design development and application review while enabling NRC to meet its principles of good regulation.</p>	<p>Discussions with the NRC staff and industry representatives</p>

<p><b>Updating Regulatory Requirements for Aircraft Impact Assessment.</b> Aircraft impact assessment compliance determines the mass of reinforced concrete and steel for the various designs and hence represents a substantial percentage of the overall capital cost. Existing rules may not be appropriate for many advanced designs due to their small physical target size and greatly reduced radiological inventory.</p>	<p>Discussions with the NRC staff, ARRT list, and industry representatives</p>
<p><b>Establish a Consequence-Based Alternative for Regulatory Compliance with Security Staffing Requirements</b> – Security staffing is a key component of facility O&amp;M costs, and existing requirements may be overly prescriptive and unreasonable for some advanced reactor designs.</p>	<p>Discussions with the NRC staff and industry representatives</p>
<p><b>Technology inclusive fuel qualification methodology-</b> NRC currently considers fuel to be the first barrier to fission product release and requires extensive and lengthy fuel qualification program to ensure that fission product release is minimized for all conditions of operation (normal, Anticipated Operational Occurrences, and postulated accidents).</p>	<p>Discussions with the NRC staff and industry representatives</p>
<p><b>Technology Inclusive Licensing Framework for Test Reactors.</b> A number of developers are getting prepared to work on licensing a test reactor. The current definition of a test reactor as well as the NRC’s guidance for its licensing (NUREG-1537, “Guidelines for Preparing and Reviewing Applications for the Licensing of Non-Power Reactors.”) are inadequate for efficient and effective licensing of the variety of AR technologies.</p>	<p>NEI’s AR licensing list as well as discussion with developers such as TerraPower.</p>

[END]

There being no other business before the subcommittee we adjourned at 1 pm.

Submitted,

Ray A. Rothrock, Co-Chair

PS. I wish to thank all members of the subcommittee, the ex-officio members and DOE staff for their time and energy and contributions to this report. – RAR 3/12/19