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Advanced Reactor Stakeholder Public Meeting

January 21, 2021

Microsoft Teams Meeting
Bridgeline: 301-576-2978
Conference ID: 644 910 374#

Time	Agenda	Speaker
10:00 - 10:15 am	Opening Remarks	NRC
10:15 – 10:30 am	Regulatory Priorities for New and Advanced Reactors – NRC Feedback on NEI Input	M. Shams, NRC
10:30 - 11:00 am	Pre-application Engagement White Paper – Incorporation of Feedback from November 5, 2020, Stakeholder Meeting	A. Muniz, NRC
11:00 – 11:30 am	Pre-application Engagement for Greater Enrichment of Fuels for Advanced Reactors	M. Diaz, NRC
11:30 am - 12:00 pm	Incorporation of HySplit Atmospheric Transport Dispersion (ATD) Model into MACCS to Advance ATD Capabilities	D. Clayton, Sandia National Laboratories
12:00 - 12:15 pm	Status of NRC's Endorsement Review of the Advanced Non-Light Water Reactor (ANLWR) Probabilistic Risk Assessment (PRA) Standard	M. Gonzalez, NRC
12:15 - 1:00 pm	BREAK	All
1:00 – 1:45 pm	U.S. Department of Energy (DOE) Gateway for Accelerated Innovation in Nuclear (GAIN) Initiatives	C. King, DOE/GAIN
1:45 - 2:15 pm	DOE Advanced Reactor Demonstration Program (ARDP) Update	T. Beville, DOE-NE
2:15 - 2:45 pm	ASME Section III, Division 5 – Discussion of Contractor Reports Supporting NRC Endorsement	J. Hoellman and J. Poehler, NRC
2:45 – 3:00 pm	Concluding Remarks and Future Meeting Planning	NRC/All

Advanced Reactor Integrated Schedule of Activities

Advanced Reactor - Summary of Integrated Schedule and Regulatory Activities

Summary of Integrated Schedule and Regulatory Activities (updated 11/02/2020)

Advanced Reactor Program - Summary of Integrated Schedule and Regulatory Activities*

Strategy 1	Knowledge, Skills, and Capability
Strategy 2	Computer Codes and Review Tools
Strategy 3	Flexible Review Processes
Strategy 4	Consensus Codes and Standards
Strategy 5	Policy and Key Technical Issues
Strategy 6	Communication

Legend

- Concurrence (Division/Interoffice)
- Federal Register Publication
- Public Comment Period
- Draft Issuance of Deliverable
- Final Issuance of Deliverable
- EDO Concurrence Period
- Commission Review Period**
- ACRS SC/FC (Scheduled or Planned)
- External Stakeholder Interactions
- Public Meeting (Scheduled or Planned)

Version 11/0/20

Present Day

Strategy	Regulatory Activity	Commission Papers	Guidance	Rulemaking	NEIMA	Complete	2020 Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	2021 Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1	Development of non-Light Water Reactor (LWR) Training for Advanced Reactors (Adv. Rxs) (NEIMA Section 103(a)(5))																													
	FAST Reactor Technology				x	x																								
	High Temperature Gas-cooled Reactor (HTGR) Technology				x	x																								
	Molten Salt Reactor (MSR) Technology				x	x																								
	Competency Modeling to ensure adequate workforce skillset					x																								
	Identification and Assessment of Available Codes					x																								
	Development of Non-LWR Computer Models and Analytical Tools																													
	Code Assessment Reports Volumes 1 (Systems Analysis)					x																								
	Reference plant model for Heat Pipe-Cooled Micro Reactor					x																								
	Reference plant model for Sodium-Cooled Fast Reactor					x																								
	Reference plant model for Fluoride-Salt-Cooled High-Temperature Reactor																													
	Reference plant model for Gas-Cooled Pebble Bed Reactor																													
	Reference plant model for Molten Salt Fueled Reactor																													
	Code Assessment Reports Volumes 2 (Fuel Perf. Anaylsis)					x																								
	FAST code assessment for metallic fuel																													
	FAST code assessment for TRISO fuel																													
	Code Assessment Reports Volumes 3 (Source Term Analysis)					x																								

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

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NRC feedback on NEI Input on Regulatory Priorities for New and Advanced Reactors

January 21, 2021

Mohamed Shams, Director
Division of Advanced Reactors and Non-Power Production and Utilization Facilities (DANU)

Background

- NEI letter dated December 18, 2020 (ML20353A393)
- NEI recommended establishing the following key regulatory objectives to inform NRC priorities:
  1. Streamlining of regulatory processes needed to support the timely and efficient review and oversight of new and advanced reactors.
  2. Resolution of key generic technical or policy topics needed to support the review and approval of new and advanced reactor applications.
  3. Changes to the regulations that are needed to achieve a more modern and efficient regulatory framework.
- Specific recommendations provided in an enclosure

Overview

- The staff appreciates NEI's input.
- The recommended "key regulatory objectives" are consistent with the NRC's vision and strategy for advanced reactor readiness.
- Our ongoing activities align with the NEI's specific recommendations
  - Some differences in schedules

Several rulemakings are underway to modernize the regulatory framework

Ongoing:

- 10 CFR Part 53
- Alternative Physical Security Requirements for Advanced Reactors (PR 4Q2021, FR 2Q2023)
- Advanced Nuclear Reactor Generic Environmental Impact Statement (GEIS)
- Emergency Preparedness Requirements for Small Modular Reactors and Other New Technologies (FR 4Q2021)
- Alignment of Licensing Processes and Lessons Learned from New Reactor Licensing (10 CFR Part 50 and 52)

Planned:

- Annual Fee Rule for Non-LWRs (FY2022)
- Part 51

PR = Proposed Rule
FR = Final Rule

NRC is taking action to optimize the environmental reviews

NEI Letter	NRC Activities
NRC generic environmental impact statements (GEISs) that minimizes the scope of site-specific environmental reviews	GEIS rulemaking underway.
NRC guidance on the broader use of environmental assessments (EAs) and categorical exclusions	Rulemaking for categorical exclusion is underway and staff will consider EAs for microreactors under rulemaking.
NRC allows existing environmental analyses to be incorporated into a project's EA or EIS	NRC NEPA regulation already allows for environmental analyses to be incorporated into EAs and or EISs.
NRC clarity on an approach to use the applicant's environmental report (ER) as the draft EA or EIS	Not a planned activity
NRC elimination of unnecessary burden in alternative site analysis	ISG-029 provides guidance to the staff on focusing its review of the alternative site analysis.
NRC implementation of changes that increases efficiency of environmental reviews	Ongoing activities: Issued ISG-029, developing a GEIS, and participates in FAST-41 and EO-13807 (one Federal Decision).
NRC elimination of duplicative adjudicatory hearings for NRC environmental reviews	Not a planned activity: This requires Commission decision and possible rulemaking.

Ongoing guidance development facilitates safety-focused reviews

- ISG for Construction Permit Applications
- Technology Inclusive Content of Applications Guidance (TICAP) (2021)
- Advanced Reactor Content of Applications Guidance (ARCAP) (ISGs in 2021)
- Fuel Qualification
- Endorsement Non-LWR PRA standard
- Environmental ISG (Issued)

NRC's actions and initiatives continue to improve review timeliness

- The staff has published generic licensing review schedules in accordance with Section 102(c) of NEIMA https://www.nrc.gov/about-nrc/generic-schedules.html.
- The staff has developed a preapplication white paper to encourage robust preapplication interactions to facilitate shorter review schedules.
- The staff has implemented strategies such as core review teams and the use of audits to facilitate timely and efficient reviews.
- The staff is working on guidance to focus the level of detail in applications and to focus the staff's review on safety and risk significant areas.
- The staff completed the NuScale DC, Clinch River ESP, and APR1400 DC reviews on or ahead of schedule.
- In all cases, adequate time will be taken to provide reasonable assurance of adequate protection to the health and safety of the public.

Staff is working to timely resolve technical and policy topics

- Siting – awaiting Commission SRM
- Advanced Manufacturing Technologies (AMT)
  - AMT Action plan was published in July 2020 (ML19333B980)
  - Public workshop was held in December 2020
  - Initial AMT application and review guidelines framework document (Subtask 2C in the Action Plan) published July 2020 (ML20203M254) (Revision under development).
- Applicability of Regulations to Non-LWRs
  - Staff response to NEI input planned in early 2021
  - Revision to staff white paper planned in 2021

Conclusion

- Staff will continue to seek input from stakeholders on ongoing and planned activities
- Staff priorities are focused on ongoing license application reviews, preapplication engagement reviews, NEIMA required activities, Commission directed rulemakings, and activities to prepare for new applications.

Finalization of Draft White Paper - Preapplication Engagement to Optimize Application Reviews

Adrian Muñiz, Project Manager
Advanced Reactor Licensing Branch
January 21, 2021

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Background

- Draft White Paper was discussed during the 11/05/2020 advanced reactor meeting
- Stakeholders provided feedback for staff's consideration
- NRC staff considered the comments and is revising the document, as appropriate
  - See ADAMS Accession No. ML21014A267 for current version

Summary of Key Changes

- Probabilistic Risk Assessment (PRA)
  - Clarified the need for pre-application engagement to support efficient application reviews. Key areas include:
    - Preliminary PRA and/or peer review results for audit
    - PRA acceptability for its use in the application
    - Deviations from endorsed standards and staff guidance
    - Early availability of risk insights
    - Level of detail and degree of realism of PRAs for different licensing applications including construction permit
- Regulatory Exemptions
  - Regulatory gap analysis should be informed by staff's draft white paper titled "Analysis of Applicability of NRC Regulations for Non-LWRs"
- Environmental Sections
  - Updated the list of guidance documents that should be considered in developing an environmental report in preparation for pre-application interactions
  - Revised and clarified examples of issues that have been challenging for previous combined license and early site permit application reviews
  - Clarified the timeframe to begin pre-application interactions

NEXT STEPS

- Review and concurrence of Revised Draft White Paper for final issuance
- Final White Paper will be posted on NRC's advanced reactor's website

Questions?

NMSS/DFM Pre-application Engagement for Advanced Reactor Fuels

Fuel Cycle Facilities, Transportation & Storage

January 21, 2021

Marilyn Diaz

Office of Nuclear Material Safety and Safeguards (NMSS)

Division of Fuel Management (DFM)

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NMSS/DFM Advanced Reactor Fuel Activities

Support NRR Advanced Reactor (AR) program.

Readiness to license and certify fuel facilities, transportation packages, and spent fuel storage installations.

- Enrichment (10 CFR Part 70),
- Fuel fabrication (10 CFR Part 70),
- Transportation package certification (10 CFR Part 71),
- Spent fuel storage installations (10 CFR Part 72),
- Material Control & Accounting (MC&A) (10 CFR Part 74)

Readiness Activities – Fuel Cycle Facilities

Regulations (10 CFR Part 70) are adequate for the review of fuel enrichment and fabrication for technologies being developed at higher enrichments.

We continue to assess our regulatory framework to identify any challenges and/or data needs.

We are conducting technical evaluations to assess necessary updates for the guidance to account for AR designs

- Finalized report on possible material control and accounting approaches for a pebble bed reactor (ML20112F355).
- Updating NRC guidance for material control and accounting for Category II fuel cycle facilities.

Readiness Activities – Storage, Transportation & Disposal

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We have experience in the approval of transportation packages and storage systems for TRISO and metallic fuels.

We are completing technical evaluations on transport and storage activities of ARF designs to identify potential information needs and determine whether additional updates to safety review guidance may be warranted.

- Review of Operating Experience for Transportation of Fresh (Unirradiated) Advanced Reactor Fuel Types
- Potential Challenges with Transportation of Fresh (Unirradiated) Advanced Reactor Fuel Types
- Storage Experience with Spent (Irradiated) Advanced Reactor Fuel Types
- Potential Challenges with Storage of Spent (Irradiated) Advanced Reactor Fuel Types
- Transportation Experience and Potential Challenges with Transportation of Spent (Irradiated) Advanced Reactor Fuel Types
- Disposal Options and Potential Challenges to Waste Packages and Waste Forms in Disposal of Spent (Irradiated) Advanced Reactor Fuel Types

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How are we preparing?

Meetings between AR vendors will help staff gain knowledge on specific designs and technologies.

Training sessions will provide staff with insights into significant safety features of specific designs and technologies.

Technical reports addressing potential challenges will help staff risk inform their reviews.

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Pre- Application Engagements

We encourage pre-application engagements to support an efficient review of new applications and amendments.

- NMSS/DFM Letters to Advanced Reactors Stakeholders to encourage potential applicants to engage in early communication and interactions.

Pre-application engagements provide benefits for NRC staff and applicants.

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Conclusions

NMSS/DFM is proactively identifying potential technical challenges and information needs associated with the safe use of AR fuels in the areas of enrichment, fabrication, transport and storage.

NRC expects some of the efforts related to accident tolerant fuel to benefit the licensing and certification of ARFs.

Applicants are encouraged to engage early to ensure a common understanding of the regulatory issues associated with new AR fuel technologies.

We have experience with advanced technologies with regards to fuel cycle and transportation licensing, and we have the regulatory infrastructure in place. We continue to gather information to ensure our readiness.

CONTACT US

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Incorporation of HYSPLIT Atmospheric Transport and Dispersion (ATD) Model into MACCS to Advance ATD Capabilities

PRESENTED BY

Dan Clayton

Sandia National Laboratories

Presented at the Advanced Reactor Stakeholder Meeting, January 21, 2021

Sandia National Laboratories is a multimission laboratory managed and operated by National Technology & Engineering Solutions of Sandia, LLC, a wholly owned subsidiary of Honeywell International Inc., for the U.S. Department of Energy's National Nuclear Security Administration under contract DE-NA0003525.

SAND2021-0549 PE

Background

Purpose for MACCS

Created by Sandia to support NRC research and regulatory requirements

- Origins go back to the mid-1970s

Typically used for prospective analyses, e.g.,

- Probabilistic risk assessments (NUREG-1150 and Level 3 PRA)
- Probabilistic consequence assessments (SOARCA)
- Cost/benefit analyses (commonly used for environmental analyses in licensing)

Very versatile with a large set of user inputs

- Intended to run rapidly for PRA applications
- Large set of weather trials (hundreds or thousands)
- Significant set of release categories (ten or twenty)
  - A release category is a group of similar source terms that can be represented by one or a few source terms.
  - Each source term can be complex, multi-isotope, and time-dependent.

Challenges to Gaussian Plume Model

Use of Gaussian model questioned

- Adequacy at locations that experience lake or sea breezes
- Suitability for river valleys that strongly influence local winds
- Adequacy for areas with significant surface relief
- Distance to which a Gaussian plume model is reliable

Challenges motivated a detailed benchmark study (NUREG-6853, 2004)

- Four ATD models
  - Lagrangian model (LODI)
  - Two Gaussian puff models (RASCAL and RATCHET)
  - Gaussian plume segment model (MACCS)
- Oklahoma ARM site using weather station data (ADAPT)
- Showed differences in the annual average exposure and deposition results were nearly within a factor of two out to 100 miles
- Did not address sea breezes, river valleys, or other terrain variations

HYSPLIT Selection

Selection of Advanced ATD Model

Essential features

- Treats Lagrangian particles
- Executable can be distributed to users (either by Sandia or directly from developer)
- Source code available in case modifications are required for integration
- Code meets QA requirements
- Treats 3D wind field (gridded data)

Desirable features

- Can model both puffs and particles
- Supports a variety of gridded weather data formats
- Facilitates graphical post processing

Evaluation of Advanced ATD Model

	HYSPLIT	FLEXPART	LODI	CALPUFF	RASCAL	SCIPUFF
	Includes Essential Feature					
Distributable	Yes	Yes	No	Yes	Yes	Yes
Source Code	Yes	Yes	No	No	Yes	No
QA	Yes	Yes	Yes	Yes	Yes	Yes
Treats 3D Wind	Yes	Yes	Yes	Yes	No	Yes
Meets All Requirements	Yes	Yes	No	No	No	No
	Score on Desirable Feature					
Puffs & Particles	5	3	Not scored	Not scored	Not scored	Not scored
Weather Formats	5	4	Not scored	Not scored	Not scored	Not scored
Graphics	5	1	Not scored	Not scored	Not scored	Not scored
Supports Linux & PC	5	5	Not scored	Not scored	Not scored	Not scored
Total Score	20	13	Not scored	Not scored	Not scored	Not scored

Interface Requirements

Multiple aerosol diameters (typically 10) plus inert gases

Variable emission rates

Multiple release elevations

Transient air and ground concentrations (to work with evacuation model)

Option to choose particles or puffs

One year of weather data to support weather sampling

Mapping native concentration grid to MACCS grid

Implementation

MACCS Modules

ATMOS

- Source term definition
- Weather sampling algorithms
- Atmospheric transport, dispersion, and deposition
  - Option for either HYSPLIT or Gaussian model

EARLY (1 to 40 days)

- Doses as modified by emergency-phase countermeasures such as sheltering, evacuation, relocation, and KI ingestion
- Multiple population cohorts
- Acute and latent health effects from early acute exposure

CHRONC (1 week to >50 years)

- Doses as modified by intermediate and recovery-phase protective actions such as relocation, interdiction, decontamination, and condemnation
- Latent health effects from chronic exposure to deposited materal
- Economic impact from early and late phase protective actions

Implementation Choices

Unit releases without radioactive decay and ingrowth in HYSPLIT (MACCS treats these aspects) for each hour of a calendar year

MACCS then scales and sums unit releases to account for variable emission rates

Releases at several fixed elevations or buoyancy fluxes (MACCS determines which to use)

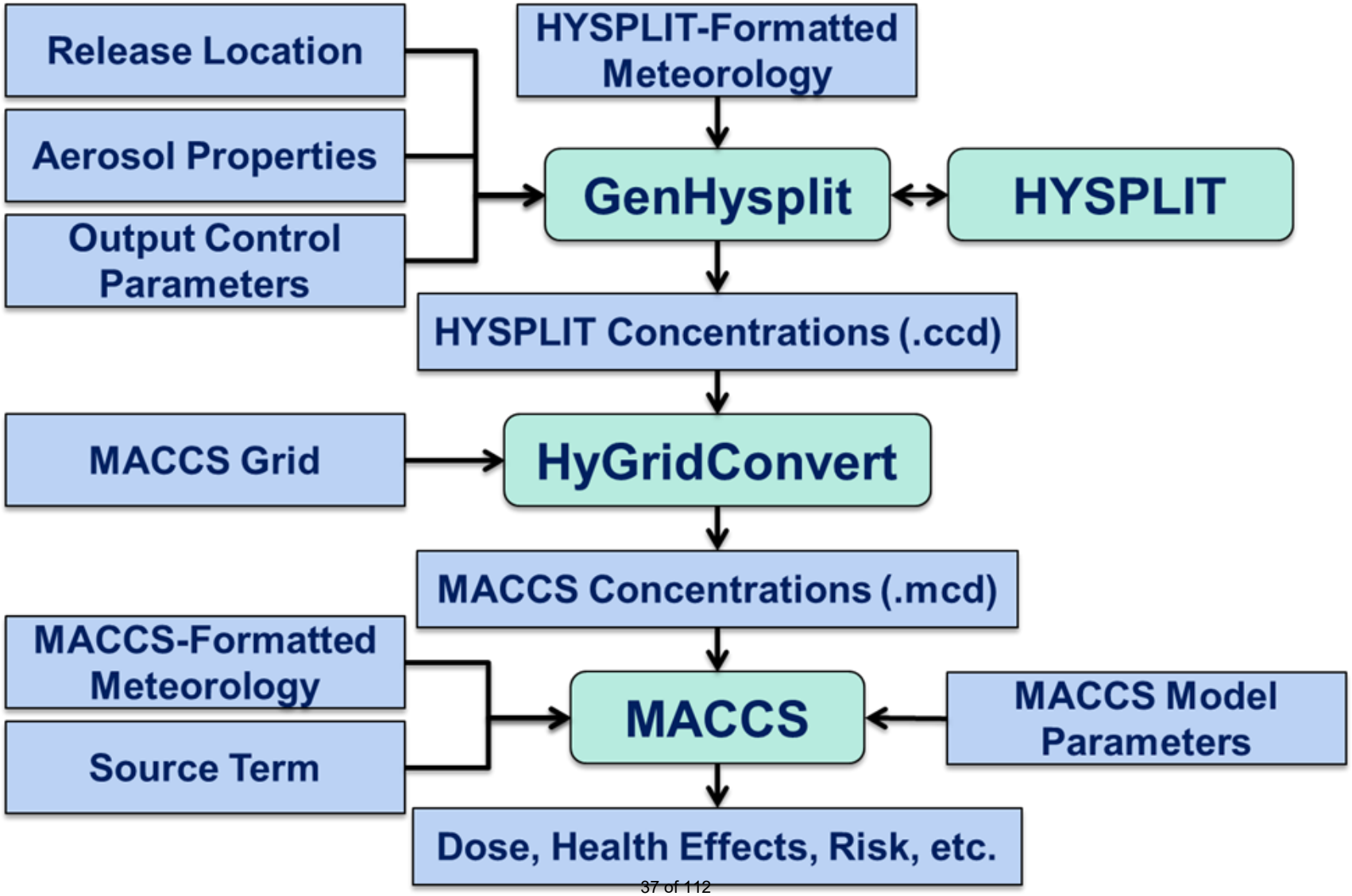
Multiple aerosol diameters with possibilities for dry deposition, wet deposition, both, or neither

- 2*N+2 possibilities for N aerosol diameters

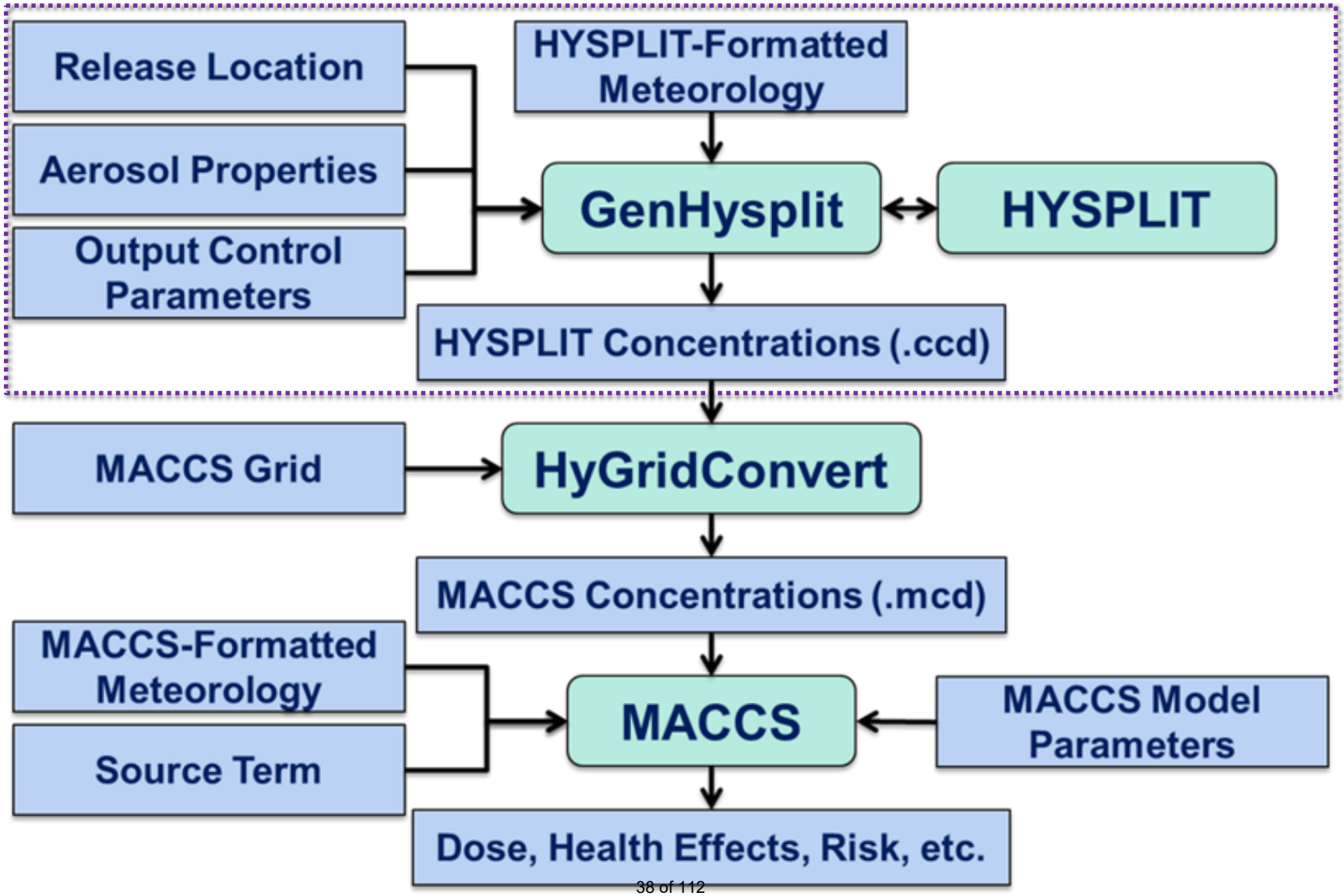
Air and ground concentrations tracked at time interval

- 60 min, 15 min, 5 min, 1 min

Overall Process



Generating HYSPLIT Files



Normalized Release

Release one-Bq of a tracer species for each aerosol size over a 1 hour period and then track during transport

- Generating χ/Q and D/Q values for each period and aerosol size
- One year equates to 8,760 simulations
- Provides enough data to effectively model any source term over every hour for the entire year

Expanded to account for buoyancy effects

- Requires additional sets (8,760 more runs per year) for each additional release level
- Specify sets of release heights or power levels
- Release heights utilize MACCS calculated rise heights
- Powel levels determine rise heights from HYSPLIT buoyancy calculations
- Appropriate file set determined based on weather conditions and plume segment sensible heat

GenHysplit Code

Used to generate and organize the HYSPLIT output concentration files

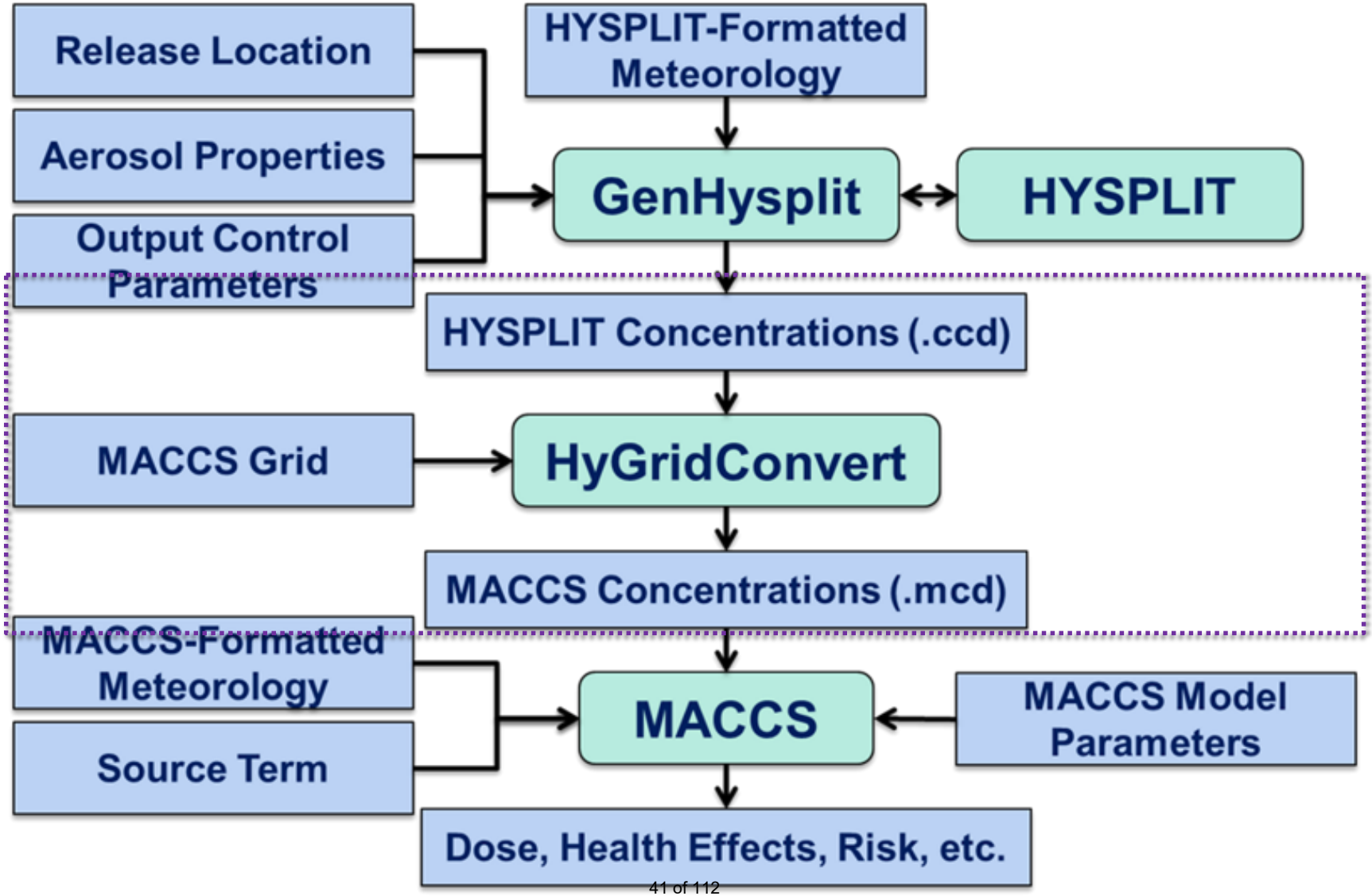
Configured to run on a Linux system to be able to access large computer resources at Sandia National Laboratories

- Has also been run in a Windows environment
- Preliminary testing on a cloud-based machine

Designed to be flexible

- Many options controlled by input file

Converting HYSPLIT Output to MACCS Input



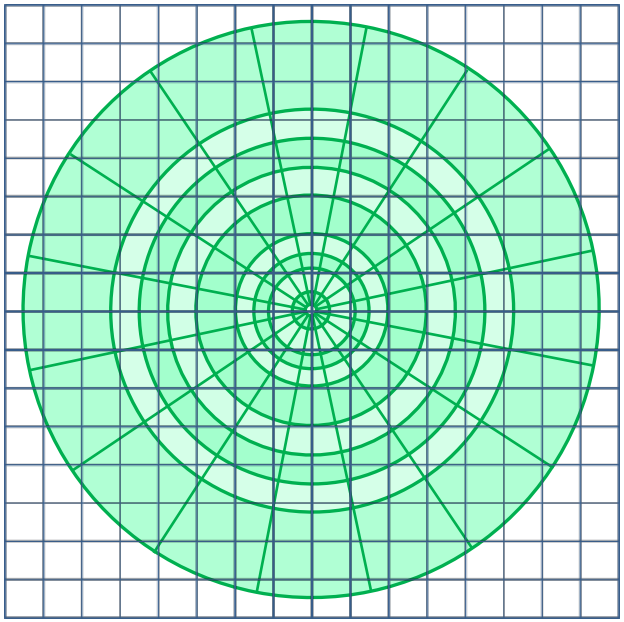
HyGridConvert Code

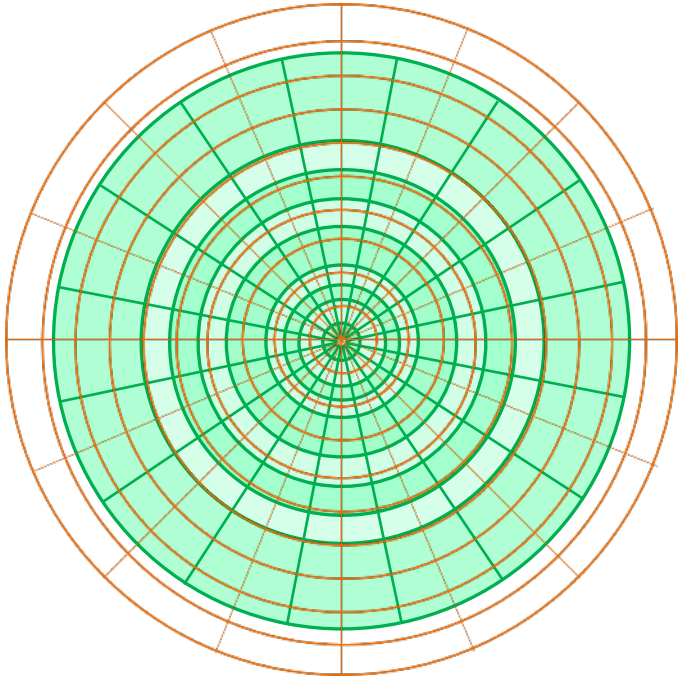
MACCS utilizes a non-uniform polar grid

Converts the HYSPLIT output concentrations to defined MACCS polar grid

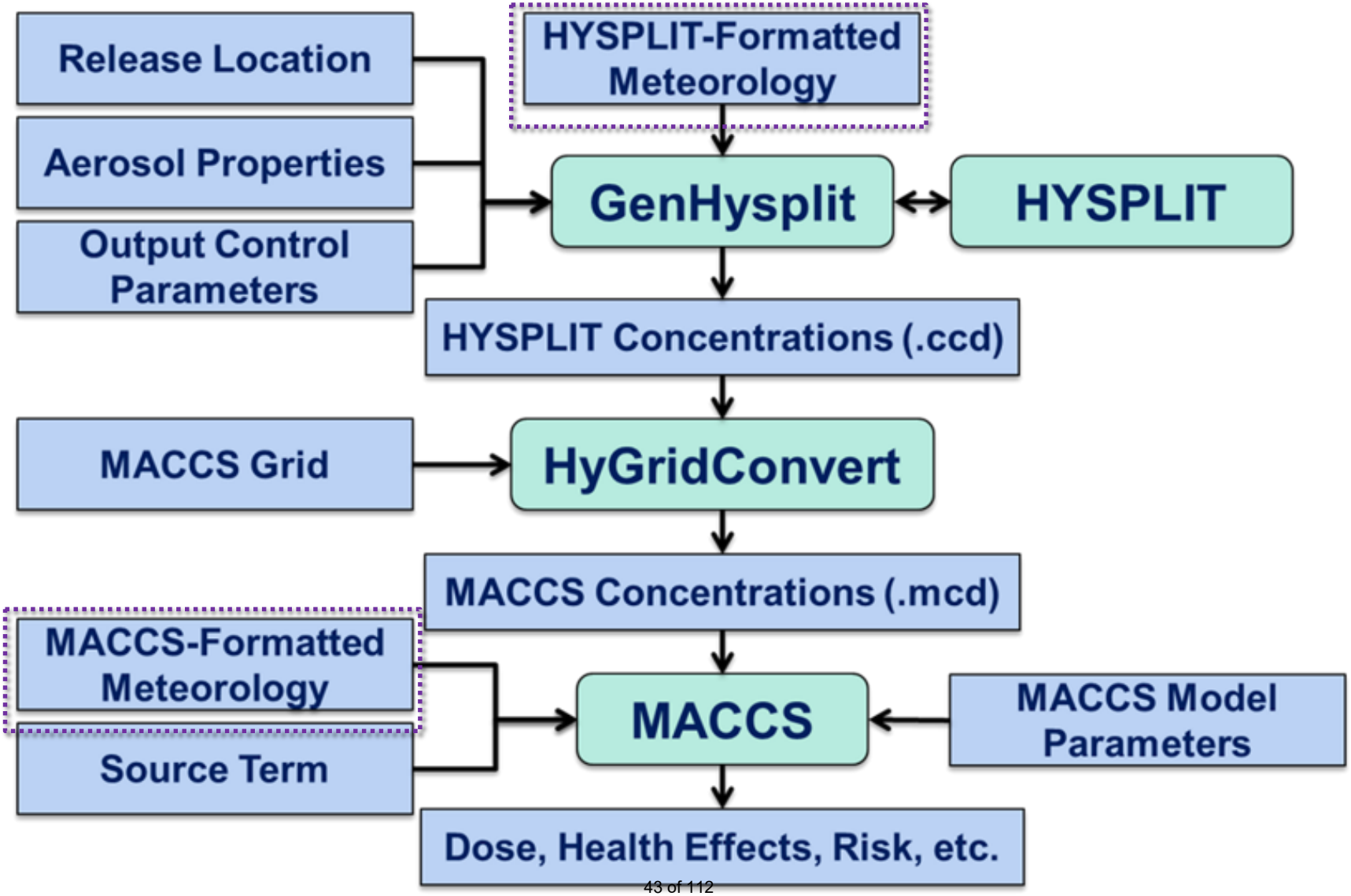
Configured to run on a Windows machine

Can be run separately or called by WinMACCS (preferred).





MACCS Meteorological Preprocessor



MacMetGen Description

MACCS-formatted meteorological file needed for MACCS calculations

- Weather sampling
- Calculating plume rise height (if binned release heights used)
- Precipitation effects on evacuation speed

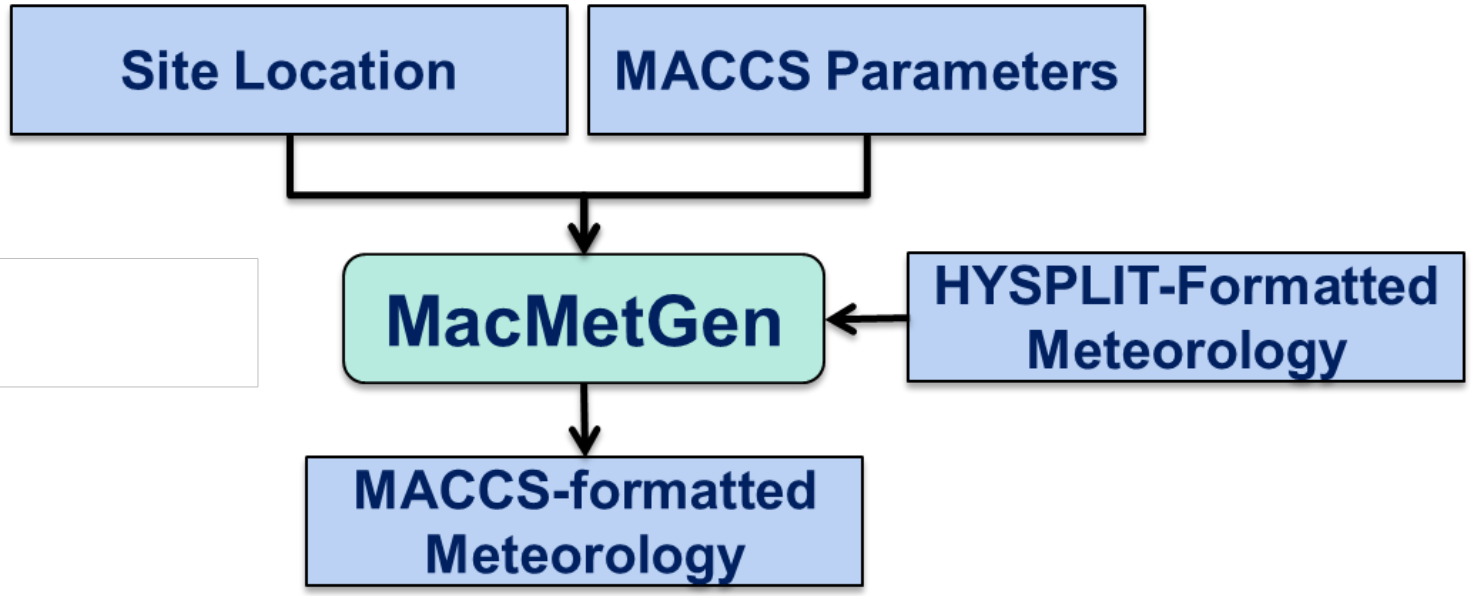
Can be time consuming to collect site data and compile into file

MacMetGen developed to automate MACCS formatted meteorological file generation

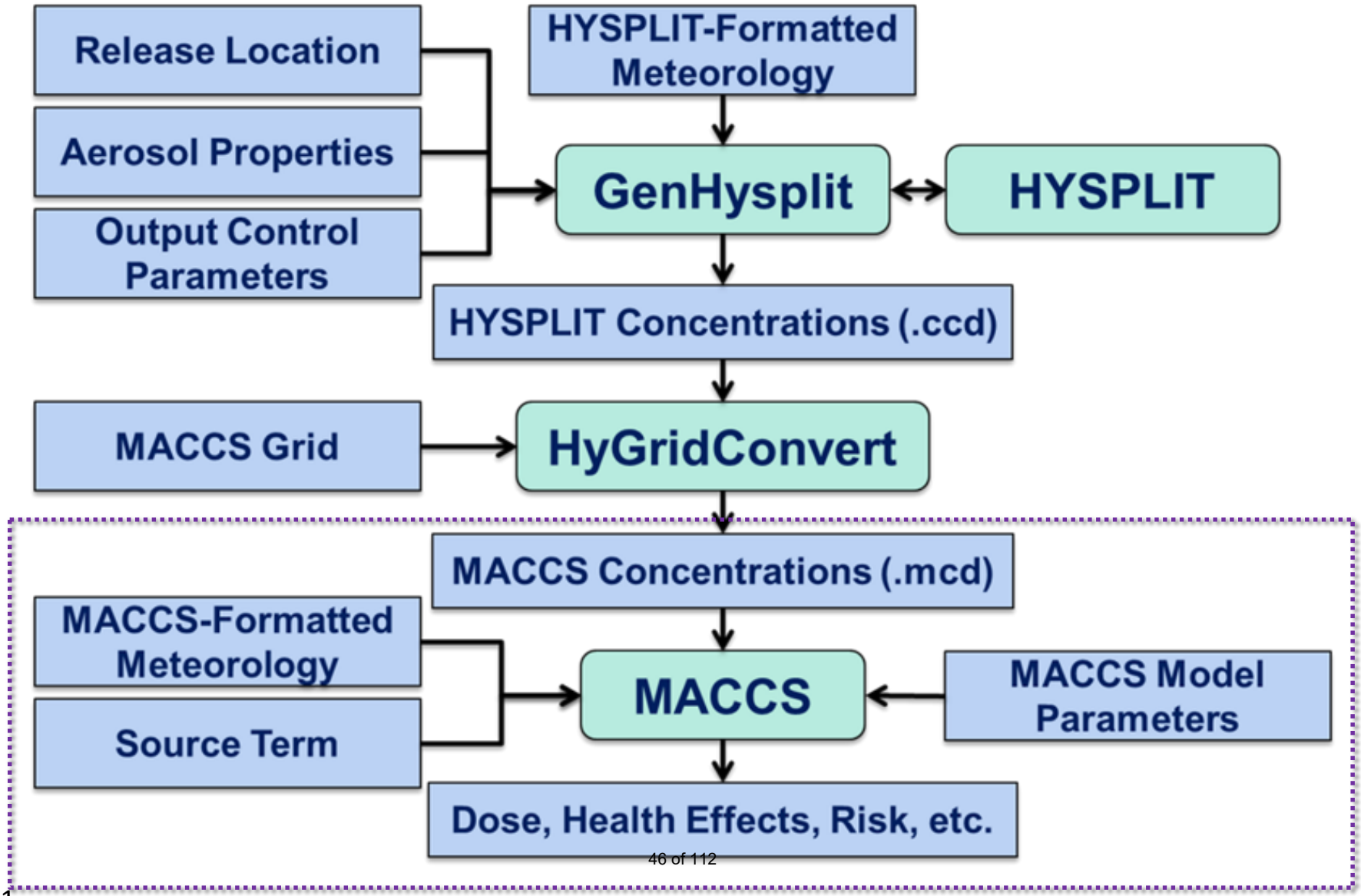
Makes use of same meteorological files used to drive HYSPLIT

- Ensure consistency
- Can be any data set if in similar format

MacMetGen Information Flow



MACCS Use of HYSPLIT Data



Combination with Source Term

Break each plume into one-hour segments and associate each one hour segment with a single HYSPLIT converted file (mcd file)

For each segment, multiply the normalized concentrations for each aerosol bin by the actual hourly release amounts for each different radionuclide/aerosol size

Account for the radioactive decay and ingrowth at the time in the calculation

Results in an air and a ground concentration array as a function of radionuclide, grid cell and time in MACCS

These concentrations are then used by MACCS to determine consequences using the EARLY and CHRONC modules

Verification

Verification Test Cases

Test cases were created to verify the implementation of the HYSPLIT/MACCS coupling

Compared results from HYSPLIT/MACCS with HYSPLIT standalone

Modified Inputs

- Single plume segment -> Multiple plume segments
- Single, fixed deposition velocity -> Ten aerosol sizes, each with own deposition velocity calculated from internal HYSPLIT model
- Constant weather -> Spatially and temporally varying weather
- Insignificant radioactive decay -> Significant radioactive decay
- No evacuation -> With evacuation

Compared Results

Atmospheric Model Outputs

- Peak (around the compass) time-integrated air concentration (χ/Q, s/m^3) over the region
- Peak (around the compass) ground concentration (D/Q, $1/m^2$) over the region
- Land areas (km^2) that exceed various levels of contamination

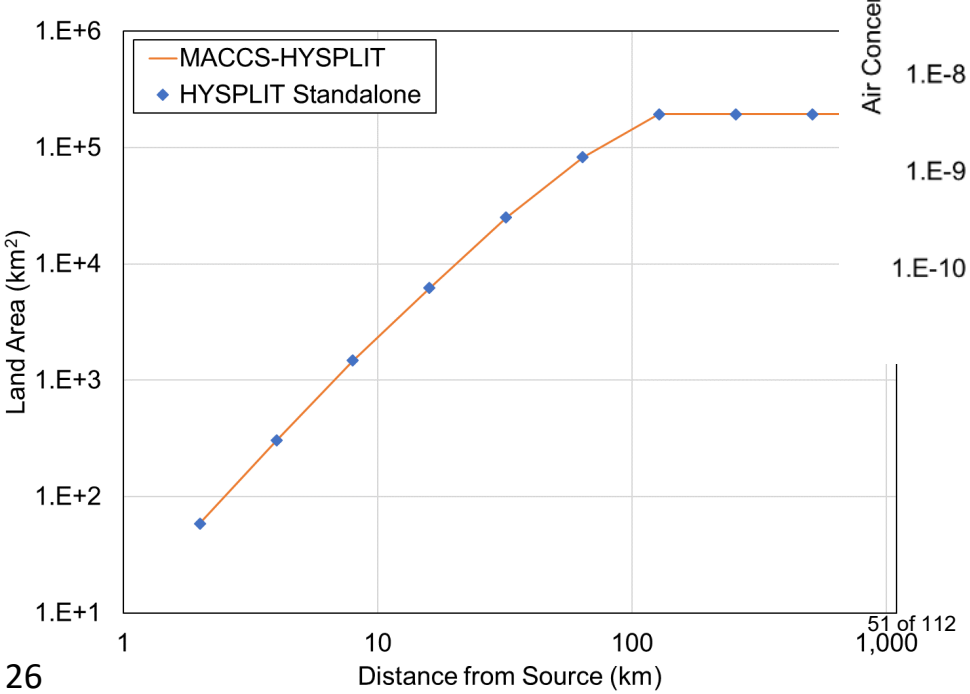
Consequence Output

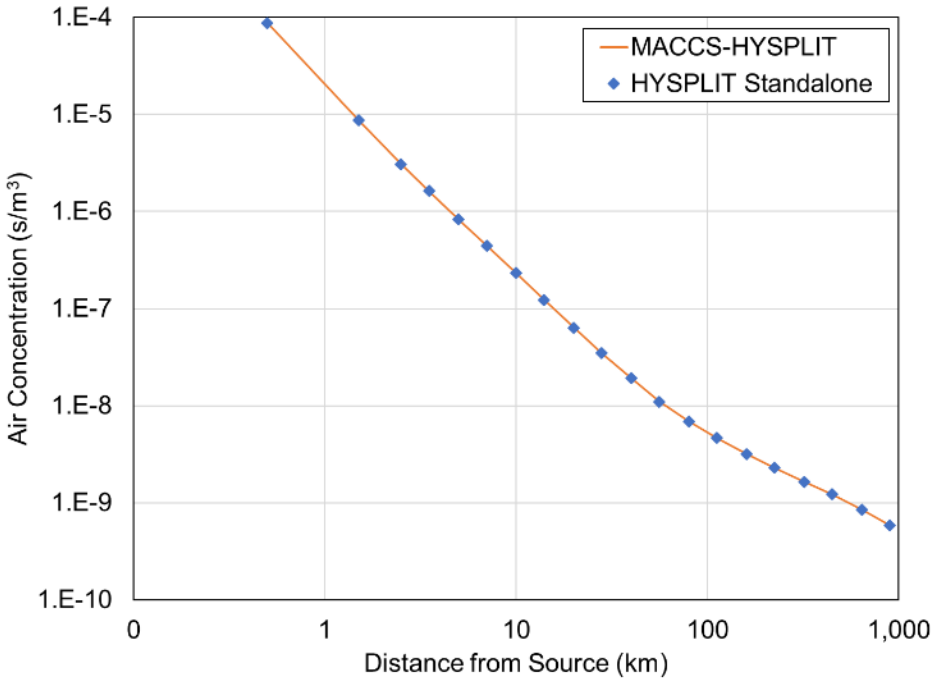
- Peak (around the compass) ionizing radiation dose (Sv) over the region

Test Result Summary

All quantities for all six text cases match at all distances

Test Case 1 comparison of peak air concentration





Test Case 1 comparison of land areas that exceed 1,000 μCi/m²

Wrap-up

Summary

MACCS coupled with **HYSPLIT** has been **implemented** and **verified**

- Supplements Gaussian plume segment model in MACCS with an alternative

The **ability to incorporate HYSPLIT** model results in MACCS is a **major improvement** in the capabilities of **MACCS** simulations and provides a **state-of-the-art alternative** to the use of the Gaussian plume segment model

Need to **balance** the need for **higher fidelity models** with associated **higher computational costs**

Status and Plans to Develop Regulatory Guide Endorsing the Advanced Non-LWR PRA Standard

Advanced Reactor Stakeholder Meeting
January 21, 2021

Michelle Gonzalez, RES

Agenda

- Update of Staff Endorsement of the ASME/ANS Advanced Non-LWR PRA Standard
- Development of Staff White Paper on PRA Acceptability for ANLWRs
- Schedule

Update on Staff Endorsement

- JCNRM ballot of the ANLWR PRA Standard ASME/ANS RA-S-1.4-2021
  - Initial ballot- May 2020
  - Recirculation ballot- August, 2020
  - Final issuance by ANSI anticipated February 2021 (tentative)
- NEI 20-09 (Rev 0)- Performance of PRA Peer Reviews Using the ASME/ANS Advanced Non-LWR PRA Standard
  - Initially submitted May 2020. Public meetings held July, October and December 2020.

Staff Activities

- Comparison of the ANLWR PRA standard to other related LWR PRA standards and guidance
- Development of the staff position for an acceptable ANLWR PRA
- Identify and resolve technical and policy issues
  - Early communication of staff views and perspectives – draft white paper
- Development of trial use regulatory guide
- Engagement with internal stakeholders (management, OGC, ACRS). Engagement with external stakeholders (public, potential applicants)
- Update the action plan for ANLWR PRA Standard Endorsement

Development of Regulatory Guidance on PRA Acceptability for ANLWRs

Considerations

- Consistency with current regulatory principles for LWR PRA acceptability
- Support LMP implementation (RG 1.233, NEI 18-04, Rev. 1)
- Endorsements:
  - ANLWR PRA standard, ASME/ANS RA-S-1.4-2021
    - Based on LWR PRA standards (only the L1+LERF PRA standard has previously been endorsed in RG 1.200)
  - Peer review guidance, NEI 20-09
    - Based on NEI 17-07, Rev. 2 which has been endorsed
- Approach for providing staff views:
  - Draft white paper: provides staff views and perspectives, not formal staff positions
  - Trial-use regulatory guide: provides formal staff position and endorsement
- Timing:
  - Support near-term applicants
  - Promote long-term regulatory stability

Draft White Paper

- NRC Staff Draft White Paper: Demonstrating the Acceptability of Probabilistic Risk Assessment Results Used to Support Advanced Non-Light Water Reactor Plant Licensing
- Issued January 15, 2021 - ML21015A434
- Meeting planned for February 2021 to discuss in detail

Schedule

Milestone	Activity
1/15/2021	Issue staff draft white paper
1/21/2021	Present staff draft white paper at Advanced Reactors Stakeholders meeting
Late February 2021	JCNRM publishes ASME/ANS RA-S-1.4-2021 NRC begins review of latest available version of NEI 20-09
February/March 2021	Tentative public meeting on draft white paper and NEI 20-09
June 2021	RG technically complete; start RG publication process
December 2021	RG issued for trial use
TBD	Revise trial-use RG to incorporate lessons learned and revision to ASME/ANS RA-S-1.4 (anticipated in 2023-2024)

Advanced Reactor Stakeholder Public Meeting

Break

Meeting will resume at 1pm EST

Microsoft Teams Meeting
Bridgeline: 301-576-2978
Conference ID: 644 910 374#

GAIN Overview

NRC Advanced Reactor Stakeholder Meeting

Christine King, GAIN Director

January 21, 2021

GAIN
Gateway for Accelerated Innovation in Nuclear

Mission and Vision

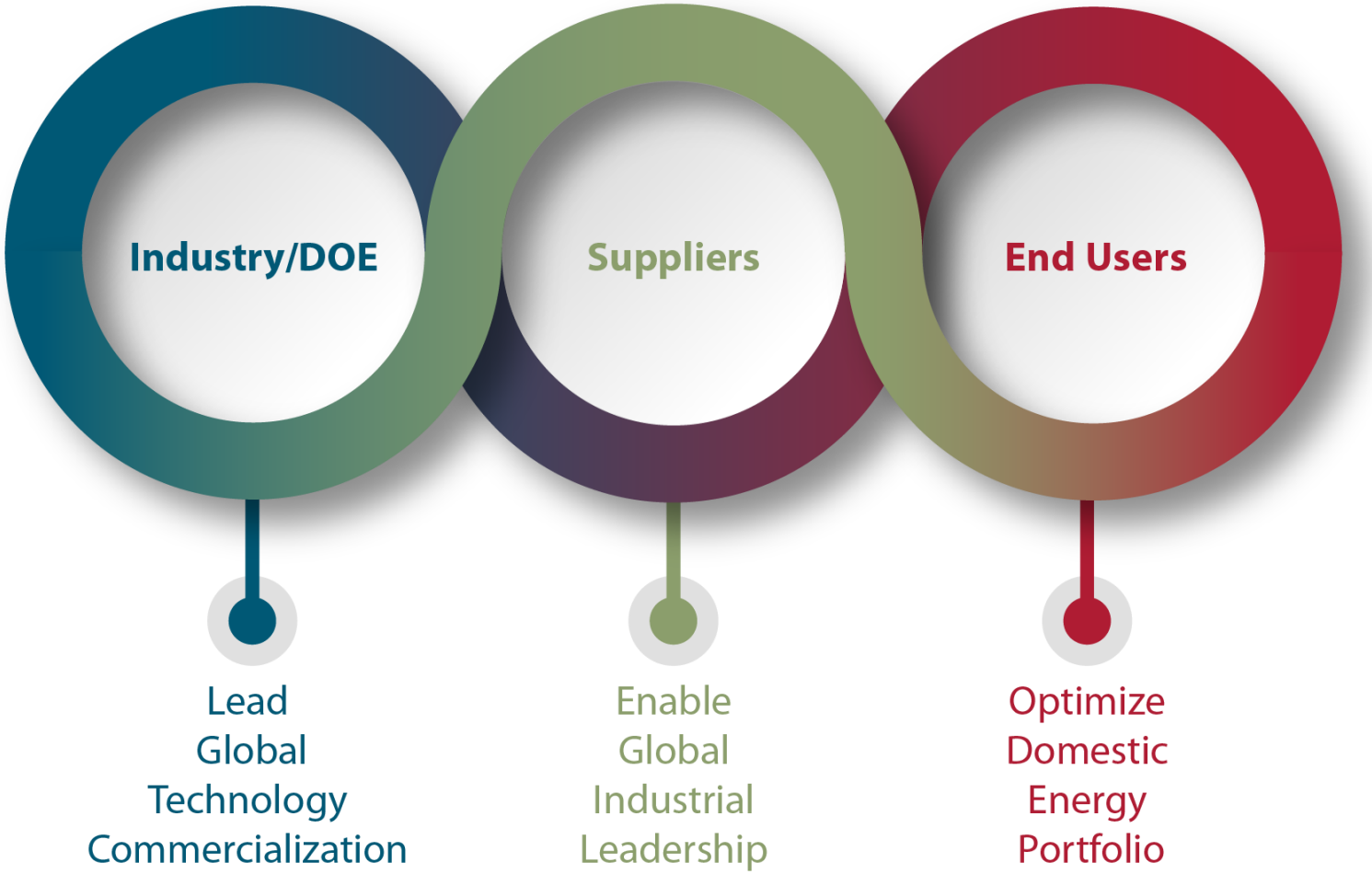
Vision (2030)

The U.S. nuclear industry is equipped to lead the world in deployment of innovative nuclear technologies to supply urgently needed abundant clean energy, both domestically and globally.

Mission

Provide the nuclear energy industry with access to cutting-edge R&D, along with the technical, regulatory, and financial support necessary to move innovative nuclear energy technologies toward *commercialization* in an accelerated and cost-effective fashion.

NUCLEAR ENERGY STRATEGIC GOALS



NRIC and GAIN are Complementary and Coordinated Efforts to Support the Nuclear Energy Industry

GAIN
Gateway for Accelerated Innovation in Nuclear

GAIN

- Established in 2015 as a resource for accelerated development of nuclear innovations with lab partners
  - Comprehensive resource to entire nuclear innovation ecosystem at all development stages
  - Provides streamlined access to testing, MASL, experimental facilities, lab expertise, and legacy data
  - Regulatory expertise (e.g. NRC advanced reactor licensing strategy support)
  - Manages NE Vouchers

NRIC

- Provides a capability for building and demonstrating reactor concepts
  - Focused program to enable innovators nearing demonstration stage
  - Provides access to sites, required upgrades, site services, fuel material/fabrication facilities, and demonstration process support
  - Provides regulatory assistance related to demonstration
- Facilitates NRC observation/ learning

GAIN Goals for FY 2020-2025:

Goal #1. Provide nuclear industry entities access to financial support opportunities and national laboratory capabilities (facilities, expertise, and tools) to accelerate commercialization of innovations through research, development, demonstration, and deployment.

Goal #2. Work with industry to identify gaps, gather needs, and develop viable paths forward to inform DOE research programs and remove barriers for industry.

Goal #3. Work with industry stakeholders and NRC as means of communicating and resolving common (industry-wide) issues through regulatory interactions.

Goal #4. Facilitate the advanced nuclear industry's access to information to support their technology commercialization efforts.

Goal #5. Contribute tailored, factual information to key stakeholders to motivate the integration of clean nuclear energy for long-term success.

How to do Business with GAIN

- Provides *Contract Mechanisms* on one side and *Funding Opportunities* on the other
- Information applies to all the DOE national labs in their contracting discussions with industry

How to do Business through GAIN

GAIN Gateway for Accelerated Innovation in Nuclear

Funding Opportunities

Funding Opportunities	Description	Timeframe	Funding*
Advanced Nuclear Technology Development (iFOA)	Provides funding to support innovative, domestic, nuclear industry-driven designs and technologies that have high potential to improve the overall economic outlook for nuclear power in the U.S. The iFOA is comprised of three tiers focused on first-of-a-kind demonstration, advanced reactor development, and regulatory support. gain.inl.gov	Continuously open Award: Quarterly Duration: up to 3 years	Tier 1: $10-40M Tier 2: $0.5-10M Tier 3: $50K-0.5M (Tiered cost share)
Consolidated Innovative Nuclear Research (CINR)	Provides competitively awarded access to the Nuclear Science User Facilities (NSUF) by industry for non-proprietary nuclear materials and fuels research. CINR is the primary means to award irradiation and post-irradiation examination (PIE) access. It also supports DOE-NE mission and program directed work scopes primarily led by universities or national labs with the possibility of industry participation. gain.inl.gov	Call: August Award: July Duration: up to 3 years for R&D; up to 7 years for PIE and testing	Up to $500K for R&D Up to $4M for irradiation and PIE (NSUF) (0% cost share)
GAIN Nuclear Energy (NE) Vouchers	Provides competitively awarded access to DOE national labs for U.S. businesses to tap into the intellectual and technical resources needed to overcome critical technology challenges for their advanced energy products and gain a global competitive advantage. Awarded funds are sent directly to a national laboratory to perform work on behalf of an awardee. gain.inl.gov	Continuously open Award: Quarterly Duration: 12 months	$50–500k (20% cost share)
NSUF Rapid Turnaround Experiments (RTE)	Offers an avenue for researchers to perform irradiation effects studies of limited scope on nuclear fuels and materials of interest utilizing NSUF facilities. R&D funding is not provided, and work is to be completed within 9 months. nsuf.inl.gov/Page/rte	3 times per year Duration: 9 months	Up to $50K (0% cost share)
Small Business Innovation Research (SBIR)	Offers competitively awarded funding to small businesses to encourage development and commercialization of their technologies. SBIR targets the entrepreneurial sector and seeks to offset the risk and expense of necessary R&D. SBIR is comprised of three phases, each contingent on building from the results of the previous phase. science.energy.gov/sbir/funding-opportunities/	Phase 1: 6 months Phase 2: 2 years Phase 3: Refer to website	Phase 1: up to $150K Phase 2: up to $1M Phase 3: $0 SBIR Funds (Refer to website)
Technology Commercialization Fund (TCF)	Seeks commercialization of laboratory technology with industry partners. Leverages R&D funding in applied energy programs to mature promising energy technologies that are originally conceived at national laboratories with the potential for high impact. gain.inl.gov	Call: February Award: July Duration: 1-2 years	Topic 1: $100 - 150K Topic 2: $250 - 750K (Refer to website)

*Contingent upon Congressional appropriations. Note: DOE National Laboratory (lab)

Contact gain.inl.gov for additional information.

3/11/19

How to do Business through GAIN

GAIN Gateway for Accelerated Innovation in Nuclear

Contract Mechanisms

Agreement	Description	Highlights
DOE Cooperative Agreement	A contract that is signed by DOE and an industry awardee to perform work at the Awardee's facilities and/or national lab. This is the mechanism used by DOE to fund awards made through the **iFOA**.	• Allows DOE to fund competitively awarded research directly.
Cooperative Research and Development Agreement (CRADA)	DOE lab partnering with one or more non-federal entities (including industry) that facilitates private sector research utilizing, for example, lab technologies, facilities, R&D capabilities, or expertise. The CRADA participant must contribute in-kind resources (personnel, equipment, facilities, etc.), and/or cash. A funding source for the lab work must be identified before work can start; this may be either participant funds, federal funds, or a combination. Commonly used for **GAIN NE Voucher** awardees who are large businesses or foreign influenced. Terms and conditions are non-negotiable.	• Up to 5 years of data protection. • Both parties may take title to their own inventions. • May negotiate exclusive license to inventions. • Advance payment required if participant is contributing funds to lab.
GAIN Small Business Voucher CRADA	Used ***exclusively*** for a **GAIN NE Voucher** awarded to a small business/non-profit voucher requester with NO foreign ownership/control/influence. Terms and conditions foster commercialization and are non-negotiable. This CRADA is intended to speed up the process of signing an agreement to complete awarded GAIN NE Voucher work.	• In addition to standard CRADA terms, provides the participant a nonexclusive license, at a minimum, to inventions conceived or first reduced to practice under the CRADA.
Nondisclosure Agreement (NDA)	Establishes the obligations regarding the exchange of proprietary or confidential business information between a DOE lab and an industry entity in order to allow them to progress toward a specific objective, commonly a contract under which work may be performed.	• Enables business relationships to develop work scope for joint projects.
Strategic Partnership Project (SPP) (Work for Others)	This is a fee-for-service contract that enables industry, non-profit institutions, and other non-federal entities to pay labs to perform a defined scope of work or tasks. Work must draw upon the unique facilities, equipment, or personnel intrinsic to the lab. The rights to the inventions and data (subject inventions) may vest in the sponsor if the sponsor is a U.S. entity and pays for the work with private funds; however, if the sponsor is providing federal funds to the lab to support the work (typically received through a competitive process) or if the sponsor is a non-U.S. entity or has foreign influence, then the rights of subject inventions will vest with the lab performing the work with no rights for protection of generated data.	• Generated data may be designated as proprietary. • Sponsor typically retains right to elect title to subject inventions. • Advance payment required.
User Facility Agreement	A User Facility Agreement provides access to facilities to conduct research. It may be possible to perform proprietary or non-proprietary (e.g., **NSUF**) research at the designated user facilities. In certain circumstances, access to facilities is available to U.S. companies on a full cost recovery basis. Access generally begins with an invitation from an employee or through submission and approval of a peer-reviewed proposal.	• IP belongs to inventor/company. • No charge for users who are performing non-proprietary research. • Non-proprietary users are expected to publish results.

Contact gain.inl.gov for additional information.

3/11/19

GAIN NE Voucher Awards for Round 1, FY2021

- The TerraPower voucher represents the first voucher to be awarded for work at LANL and involves characterization of the properties of plutonium chloride salt using neutron beam imaging in the LANSCE facility.
- The two vouchers to be completed at ORNL involve utilization of modeling and simulation capability in support of innovations in additive manufacturing.

GAIN 2021 1st Round NE Voucher Recipient	Awarded Proposal	Partner Facility
Exelon Generation Kennett Square, PA	Advanced Nuclear Fuel Pellet Designs	Oak Ridge National Laboratory
TerraPower, LLC Bellevue, WA	Density Measurements of Plutonium Bearing Salts via Neutron Beam Dilatometry	Los Alamos National Laboratory
Westinghouse Electric Company, LLC Columbia, SC	Multiphysics Design Optimization and Additive Manufacturing of Nuclear Components	Oak Ridge National Laboratory

Date to Remember:
NE Vouchers Round 2 2021: Close on Feb 1, 2021

iFOA Round 1 2021: Close on Feb 28, 2021

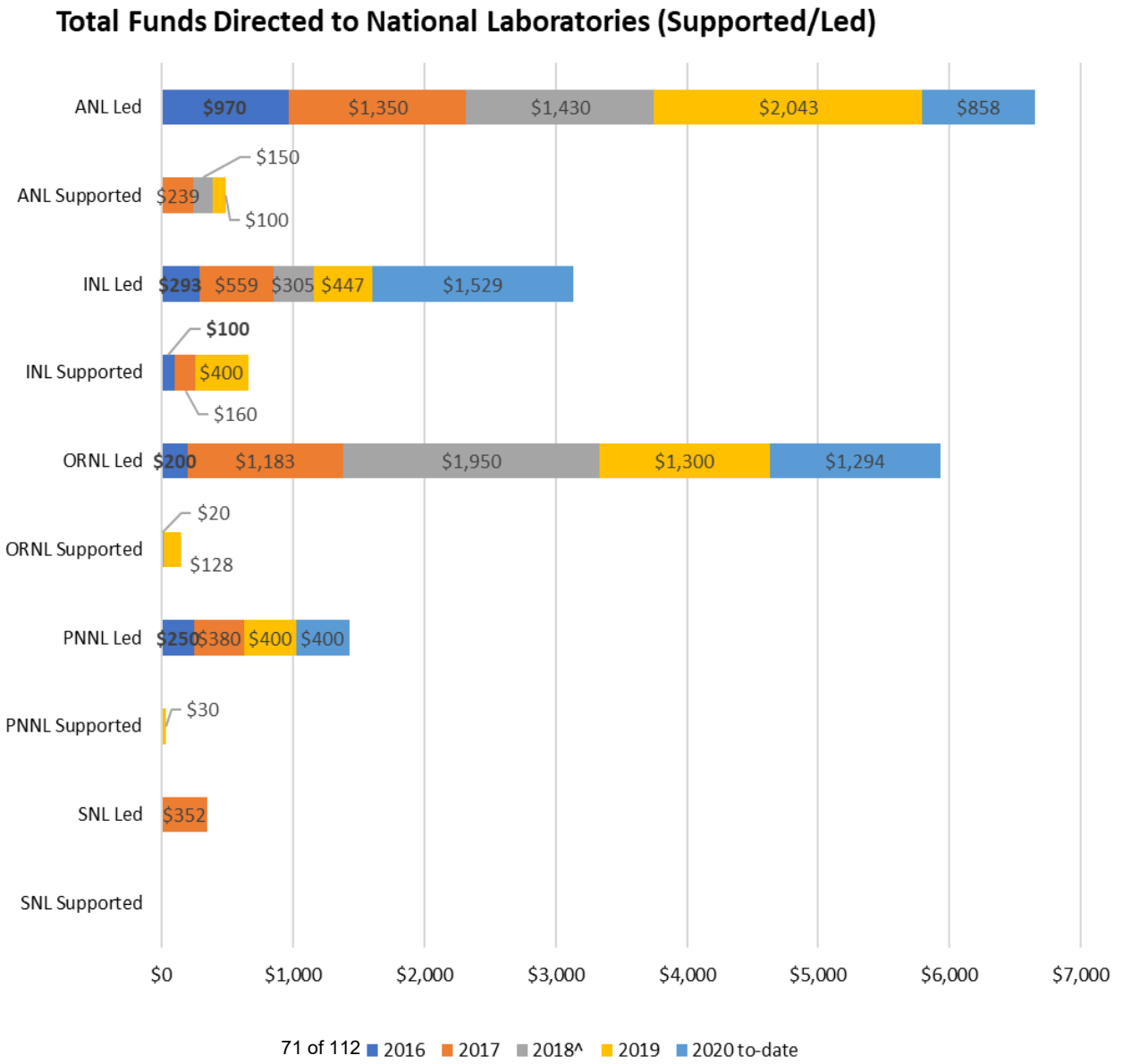
GAIN FY2020 Voucher Awards

FY 2020	Voucher Recipient	Proposal	Lab
Round 1	Hydromine, Inc.	On-Line Lead/Water Heat Exchanger Sensor/System Feasibility	PNNL
Round 1	Lightbridge Cor	Advanced Test Reactor experiment design for measurement of Lightbridge Fuel™ thermophysical properties	INL
Round 2	Neutroelectric	Combined effects testing of high-temperature and neutron fluence to support qualification of NE-300, a high-temp Neutron shielding Material	ORNL
Round 2	Oklo, Inc.	Address gaps in legacy data on fuel steel interactions	INL
Round 3	SMR, LLC	Coupled neutronic and thermal hydraulic analysis of a natural circulation based small modular reactor using VERA-CS	ORNL
Round 3	Ultra Safe Nuclear Corp	Graphite finite element model verification	ORNL
Round 4	Kairos Power	Pebble Bed Large Eddy Simulations for Lower Order Methods Benchmarking and Uncertainty Quantification Development	ANL
Round 4	Natura Resources, LLC	RELAP5-3D Development and Assessment for Liquid-fuels Molten Salt Reactor Licensure	INL
Round 4	TerraPower, LLC	Thermophysical Properties Measurements of NaCl-PuCl3	ANL

GAIN Voucher Impact - 2020

Voucher Summary

- 54 Awarded
- 27 Completed
- $18.8 M to National Labs
- Total Project Costs $23.6 M



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GAIN Assistance on Process Improvement

NE Advance Class Patent Waiver

- DOE forgoes taking title to patentable inventions conceived using DOE funding
- Advance: Available when contract negotiations begin
- Class: large domestic businesses in DOE-NE related funding opportunities.(note: small business have this with Bayh-Doyle legislation)
- This waiver will speed up negotiations for iFOA and ARD awards and reduce uncertainty in negotiations

More info on gain.inl.gov

GAIN Access CRADA (in process)

- Enable an industry partner to sign an agreement with a single lab that grants them simultaneous access to other labs in the complex.
- Conceptually how this works:
  - Industry partner with workscope that crosses multiple labs
  - Identify the “lead lab” and negotiate CRADA
  - Partner Labs review CRADA and sign on to agreement.
- Allows us single agreements across DOE Offices of NE and Science

Legacy Documents / Industry Access

Initial **Fast Reactor (FR) Technology List** provides access to 4250 openly published FR documents available from OSTI (December 2018)
Initial **Molten Salt Reactor (MSR) Technology** List provides access to 210 cataloged MSR documents available on OSTI (February 2017)
OSTI Spreadsheet of 12,000 Applied Technology (AT) Documents with abstracts provided to GAIN. List released with abstracts on February 28, 2019. Provided to TWG Chairs on March 8, 2019.
Clinch River Breeder Reactor (CRBR) Project documents. Contract initiated in Feb 2020. Scanning on hold (COVID-19). Iron Mountain will proceed as soon as possible (235 boxes + 75 reels of microfilm).
LOFT and other LWR Experiments. Fauske and Associates developed a pilot knowledge preservation activity in March 2019. Phase II contract will proceed in FY2021.
New Production Reactor (NPR) documents at INL Storage (125 boxes-Idaho Falls). Working with Red Ink to scan and organize files for Export/Classification Reviews. Effort is underway.
Loft Experiment Data for code validation (Box of data –INL – to be scanned & reviewed. **PBF Documents** (3 boxes at INL) will be scanned and reviewed.

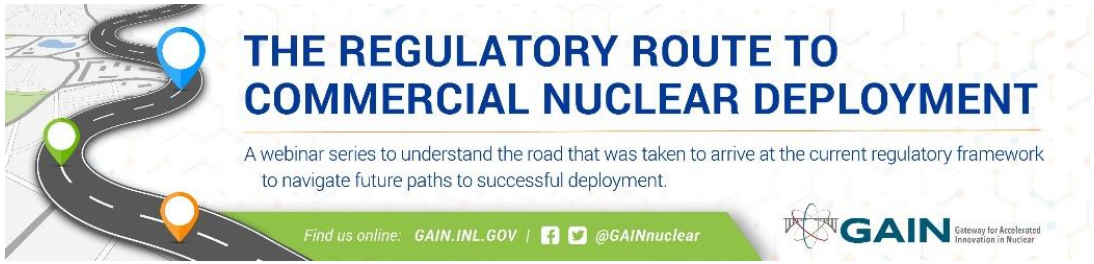
Databases of Experimental Information

Database	Lab	Status (18Jan21)
TREXR TREAT Experiment Relational Database	ANL	https://www.trexr.anl.gov/ External access available by application
NaSCoRD Sodium System & Component Reliability Database	SNL	https://www.sandia.gov/nascord/ Phase II Complete – FY20.
ETTD EBR-II Transient Testing Database	ANL	https://ettd.ne.anl.gov/ External access available by application
FIPD EBR-II Metallic Fuel Irradiation Database	ANL	https://fipd.ne.anl.gov/ External access available by application. Data for U-Zr fuel type employed in commercial designs being qualified in accordance with NRC approved QAPP.
FFTF Passive Safety Testing & Metal Fuel Irradiation Database	PNNL	https://pnnl.gov/projects/fftf/ External Access Plan Complete; will be implemented FY21.
OPTD Out of Pile Transient Testing Database	ANL	https://optd.ne.anl.gov/ External access available by application
EBR-II and FFTF Metal Fuel Experiment PIE Data	INL/ANL	Organized effort to supplement the FIPD and FFTF Databases. Complete in 2021.
MSRE Molten Salt Reactor Component Reliability Database	ORNL/EPRI	Available FY-2021– under export control review https://newton.ornl.gov/test/msre/app/

All databases will have links available at gain.inl.gov

What's New? GAIN Workshops and Webinars - 2021

GAIN Webinar Series Focused on Multi-Industry Stakeholders



- January 27, 2021: Paving the Way - A Historic Journey to Deployment
- February 2021: Understanding and Navigating Within the Existing Regulatory Framework
- March 2021: Identifying and Managing Regulatory Risk on the Paths to Successful Deployment

- **GAIN Net Zero Carbon Webinar Series**
  - February-March 2021: First Webinar in the Series

  Stay tuned for more information !!!

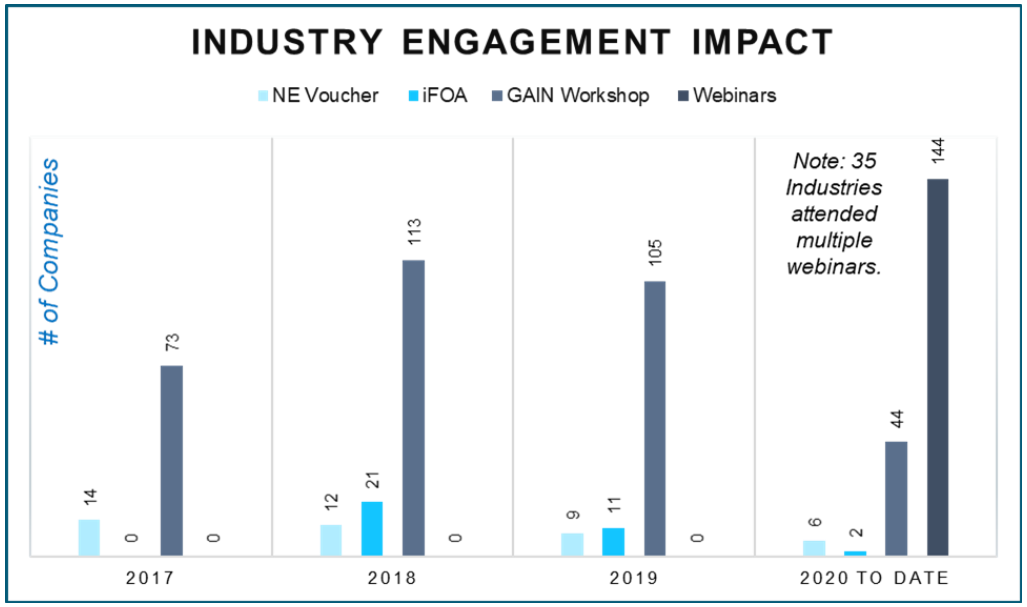
Workshops Focused on Advanced Nuclear Needs and Feedback

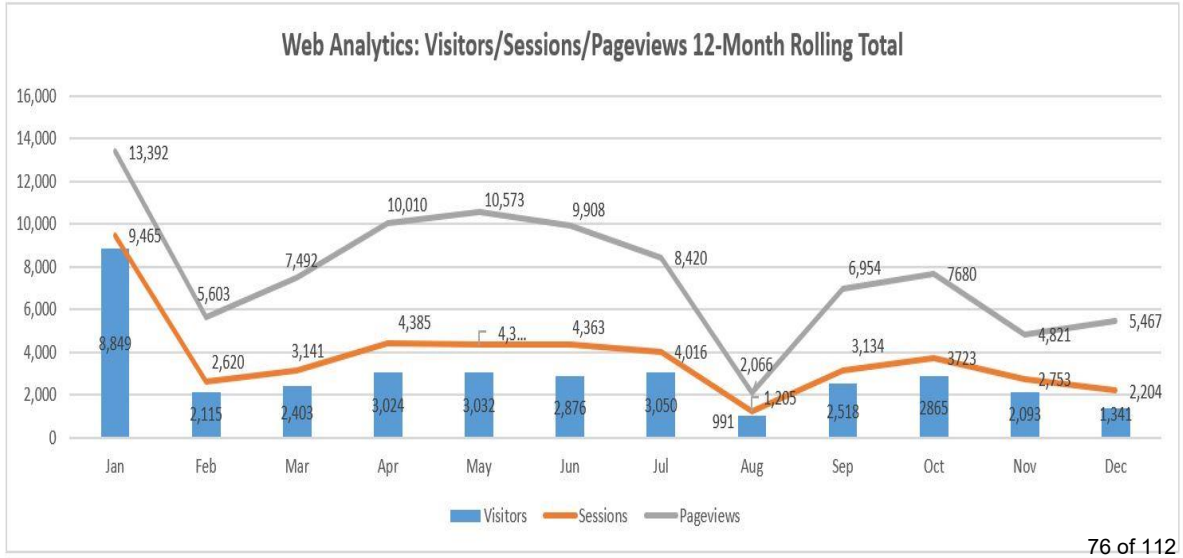
- April 13-15. 2021: GAIN-EPRI-NEI Safeguards Program Virtual Workshop
- May 12-13, 2021: GAIN-EPRI-NEI Microreactor Program Virtual Workshop
- August 24-26, 2021: GAIN-EPRI-NEI Advanced Methods for Manufacturing Qualification

GAIN Outreach

Nuclear-focused Collaborators

- Nuclear Energy Institute
- Electric Power Research Institute
- Envoy Public Labs
- Third Way
- Clearpath
- Titans of Nuclear
- Generation Atomic
- American Nuclear Society
- Nuclear Innovation Alliance





1,182 Facebook Followers

1,964 Facebook Reach

2,370 Twitter Followers

27.4K Twitter Impressions

748 Instagram Followers

176 LinkedIn Followers

GAIN Social Media – December 2020

Titans of Nuclear GAIN-NRIC Miniseries: Realizing the Nuclear Future

Titans of Nuclear produces podcasts featuring interviews with experts across technology, industry, economics, policy and more.

"Connect with what excites you about nuclear today and imagine nuclear tomorrow."

Ep. 287, GAIN-NRIC Miniseries: Christine King — Dec 7, 2020

1) Christine King reflects on her time at EPRI where she focused on solving inherited material problems related to the use of Alloy 600 in steam generators
2) Christine shares her personal journey to find purpose and how it impacted her career path in the nuclear sector
3) The role of GAIN in the nuclear sector and the many ways it supports developers, investors, end users, and government programs
4) A look at how new technology demonstrations ...

Listen, Watch, View Shownotes & More...

Ep. 288, GAIN-NRIC Miniseries: John Jackson — Dec 14, 2020

1) John Jackson shares his experience growing up living off-the-grid and how he got involved in mechanical engineering and fracture mechanics
2) How John reconnected with the Idaho National Lab and got involved with the Gateway for Accelerated Innovation in Nuclear
3) How the GAIN vouchers connect nuclear technology developers and the resources available at the National Labs
4) Why the nuclear industry must unite to work towards demonstrations o...

Listen, Watch, View Shownotes & More...

https://www.titansofnuclear.com/

Ep. 289, GAIN-NRIC Miniseries: Nicholas Smith — Dec 21, 2020

1) How Nick Smith's early professional career on the football field led him to the energy industry in an unconventional way
2) Nick reflects on his personal discovery of nuclear power and how it led to a major career shift to advanced nuclear R&D
3) An overview of the current projects underway at the National Reactor Innovation Center (NRIC) to enable advanced reactor demonstrations
4) The role of the Zero Power Physics Reactor (ZPPR) and the Exp...

Listen, Watch, View Shownotes & More...

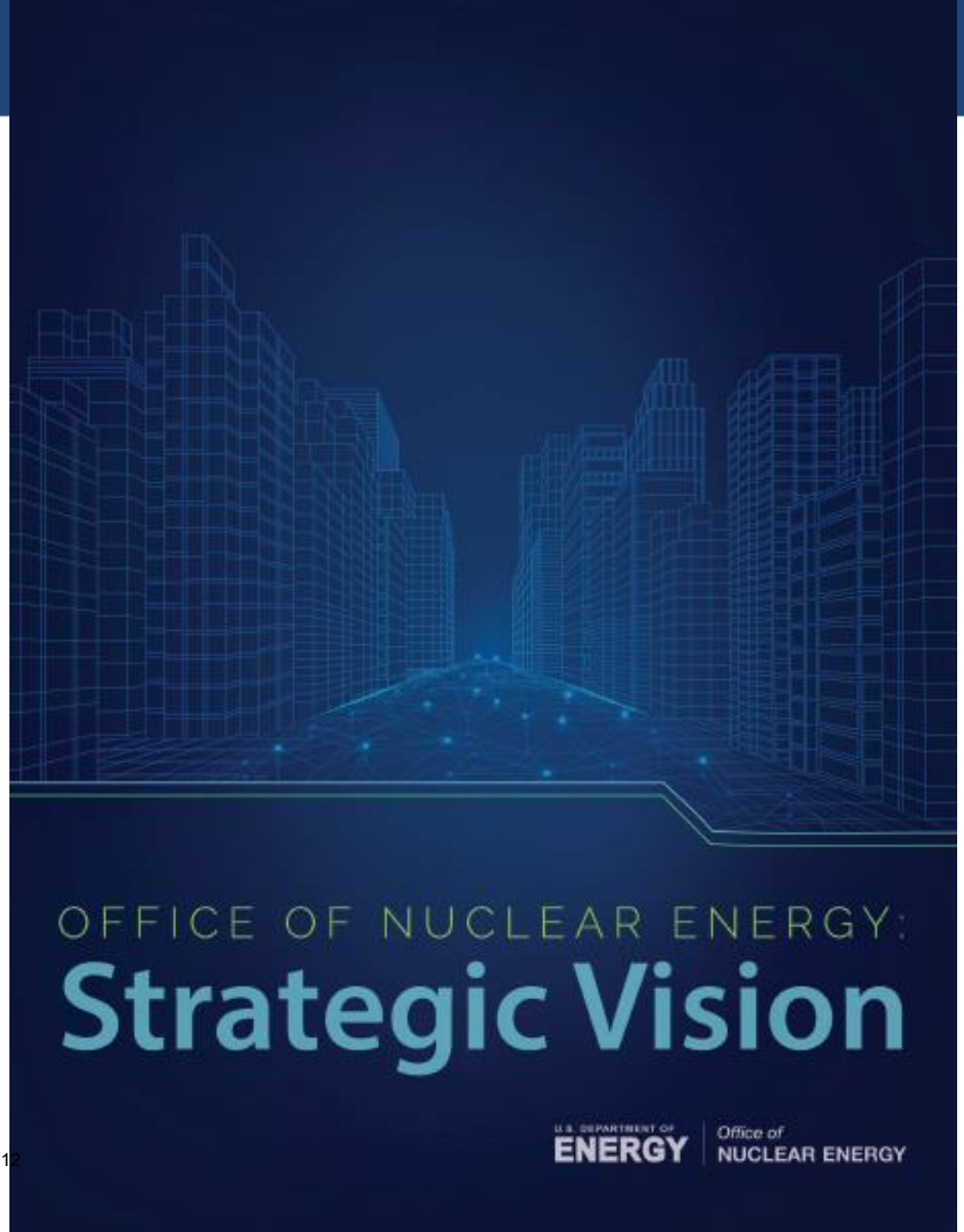
NE STRATEGIC VISION

VISION

A thriving U.S. nuclear energy sector delivering clean energy and economic opportunities.

MISSION

Advance nuclear energy science and technology to meet U.S. energy, environmental, and economic needs.



STRATEGIC GOALS

Goal 1: Enable continued operation of existing U.S. nuclear reactors.

Goal 2: Enable deployment of advanced nuclear reactors.

Goal 3: Develop advanced nuclear fuel cycles.

Goal 4: Maintain U.S. leadership in nuclear energy technology.

Goal 5: Enable a high-performing organization.

Goal 1: Enable continued operation of existing U.S. nuclear reactors.

OBJECTIVES

Develop technologies that reduce operating costs.

Expand to markets beyond electricity.

Provide scientific basis for continued operation of existing plants.

PERFORMANCE INDICATORS

By 2022, demonstrate a scalable hydrogen generation pilot plant.

By 2025, begin replacing existing fuel in U.S. commercial reactors with accident tolerant fuel.

By 2026, complete engineering and licensing activities needed to demonstrate successful deployment of a digital reactor safety system in an operating plant.

By 2030, achieve widespread implementation of accident tolerant fuel.

Goal 2: Enable deployment of advanced nuclear reactors.

OBJECTIVES

Reduce risk and time needed to deploy advanced nuclear technology.

Develop reactors that expand market opportunities for nuclear energy.

Support a diversity of designs that improve resource utilization.

PERFORMANCE INDICATORS

By 2024, demonstrate and test a fueled microreactor core fabricated by advanced manufacturing techniques.

By 2025, enable demonstration of a commercial U.S. microreactor.

By 2027, demonstrate operation of a nuclear-renewable hybrid energy system.

By 2028, demonstrate two U.S. advanced reactor designs through cost-shared partnerships with industry.

By 2029, enable operation of the first commercial U.S. small modular reactor.

By 2035, demonstrate at least two additional advanced reactor designs through partnerships with industry.

Goal 3: Develop advanced nuclear fuel cycles.

OBJECTIVES

Address gaps in the domestic nuclear fuel supply chain.

Address gaps in the domestic nuclear fuel cycle for advanced reactors.

Evaluate options to establish an integrated waste management system.

PERFORMANCE INDICATORS

By 2021, begin procurement process for establishing a uranium reserve.

By 2022, demonstrate domestic HALEU enrichment.

By 2023, make available up to five metric tons of HALEU from non-defense DOE material.

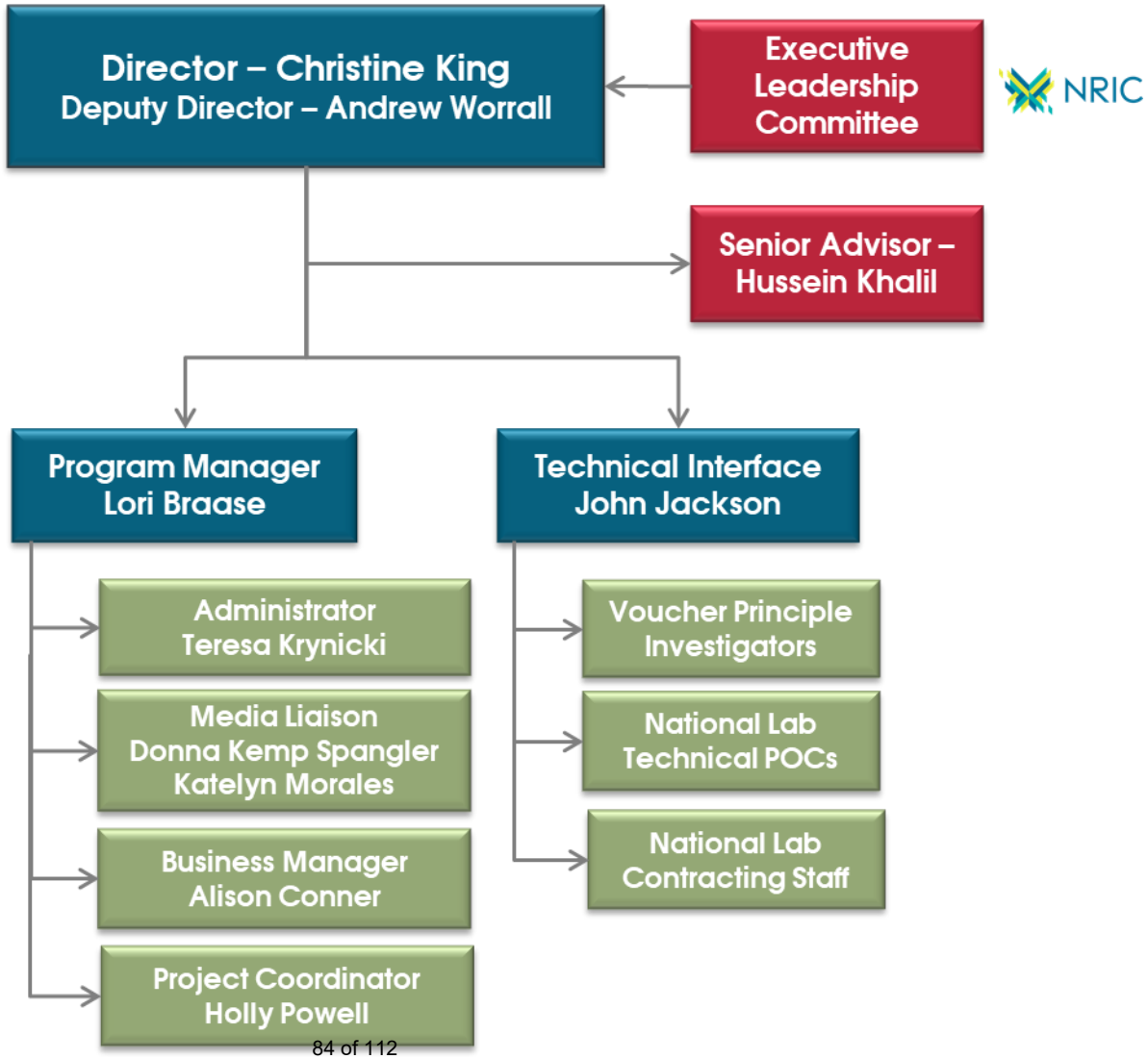
By 2030, evaluate fuel cycles for advanced reactors.

Gateway for Accelerated Innovation in Nuclear

- Accelerated must match advanced nuclear developer pace and reflect the market window (next 5-10 years).
- Innovation is not just about technology. Be creative in all spaces with a bias to taking risks.
- Focus on initiating and completing projects that support commercial deployment.

Questions? Reach out to gain@inl.gov (or one of our team members.)

GAIN Organization



U.S. DEPARTMENT OF ENERGY | Office of NUCLEAR ENERGY

Clean. Reliable. Nuclear.

Overview of Advanced Reactor Demonstration Program

January 21, 2021

Tim Beville – Director, Advanced Reactor Demonstration Program

Office of Nuclear Energy

Topics to be Covered

- Advanced Reactor Demonstration Program (ARDP) Overview
- Advanced Reactor Demonstration Funding Opportunity Announcement (FOA) Overview
- Announced ARD FOA Awards
- Summary/Questions

Advanced Reactors: U.S. Landscape

- Dozens of U.S. companies are working on advanced nuclear projects for a wide array of capabilities to meet the energy needs of the future
  - Light water-cooled advanced small modular reactors
  - Advanced sodium-, gas-, lead-, molten salt-cooled reactors
  - Significant levels of private sector investment
- Motivation for advanced reactor development
  - Potential for improved safety and operational capability
  - Various options for future commercial, limited-grid and remote applications
  - Potential for improved nuclear resource utilization and reduced nuclear waste
  - Flexible operation to support the national grid of the future containing many energy-source options

Advanced Reactor Demonstration Program

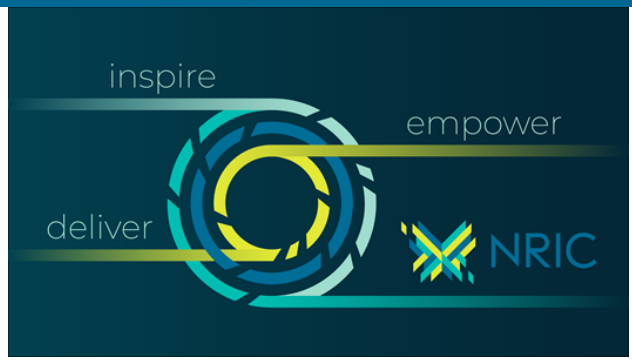
- Established in fiscal year (FY) 2020 budget language ($230 million (M))
- Focuses DOE and non-federal resources on **actual construction** of real demonstration reactors
- Establishes ambitious timeframe for demonstration reactors – five to seven years from award, including design, licensing, construction and start of operations
- Program also addresses technical risks for less mature designs
- Desired outcomes:
  - Support diversity of advanced designs that offer significant improvements to current generation of operational reactors
  - Enable a market environment for commercial products that are safe and affordable to both construct and operate in the near- and mid-term
  - Stimulate commercial enterprises, including supply chains
- Overall FY21 budget for ARDP activities $250 M

ARDP Program Elements

- Advanced Reactor Demonstrations (Demos)
  - Cost-shared partnerships with industry (up to 50 percent (%) government, not less than 50% industry) to build two advanced demonstration reactors with significant improvements compared to current generation of operational reactors
  - Demos to be constructed and operational in a 5-7 year window after award
  - $160 M appropriated for fiscal year (FY) 2020 ($80 M per award)
  - $160 M appropriated for FY 2021 ($80 M per award)
- Risk Reduction (RR) for Future Demonstrations
  - Cost-shared research and development (R&D) activities with industry (up to 80% government, not less than 20% industry) to address technical risks in advanced reactor designs to support potential future advanced reactor demonstrations
  - $30 M appropriated for FY 2020 (up to 5 awards)
  - $40 M appropriated for FY 2021 (To be distributed among awards based on agreed-upon cost requirements)

ARDP Program Elements (cont.)

- **National Reactor Innovation Center (NRIC)**
  - Empower innovators with access to facilities, sites, materials, and expertise to enable demonstration of at least two advanced reactor technologies
  - Support advanced reactor regulatory readiness for demonstrations
  - Develop enduring demonstration support infrastructure
  - Establish methods for efficient coordination among national laboratories



Recent Activities:

- Establishing NRIC through planning and engagement with industry, NRC, national laboratories, and other key stakeholders
- Performed gap assessment for demonstration capabilities
- Developing a demonstration resource network, such as experimental facilities, test beds, and demonstration site identification and preparation

- $20 M appropriated for FY 2020; $30 M for FY 2021

ARDP Program Elements (cont.)

- **Advanced Reactor Regulatory Development**
  - National laboratory-led R&D to resolve technical challenges with licensing advanced reactors
  - Supporting efforts with NRC and industry stakeholders to develop cross-cutting advanced reactor licensing frameworks
    - Licensing Modernization Project (LMP)
    - Technology-Inclusive Content of Application Project (TICAP)
  - Focused R&D to address technology-specific regulatory challenges for NE advanced reactor campaigns
  - $15 M appropriated for FY 2020; $15 M for FY 2021
- **Advanced Reactor Safeguards**
  - Applies laboratory R&D to address near term challenges that advanced reactor vendors face in meeting domestic requirements for U.S. builds.
  - Project focus areas - Materials Accountancy, Physical Protection, Gen-IV & IAEA Interface
  - $5 M appropriated for FY 2020; $5 M for FY 2021

Advanced Reactor Demonstration FOA

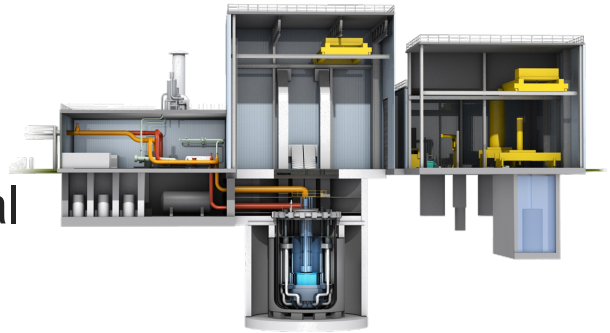
- Advanced Reactor Demonstration FOA solicited applications under 3 funding pathways aligned with different technology maturity levels:
  - Advanced Reactor Demonstration (Demos) awards
    - Cost-shared demonstration of two reactor designs that have potential to be operational in five to seven years following award finalization
  - Risk Reduction for Future Demonstration (Risk Reduction) awards
    - Support for 2-5 additional, diverse advanced reactor designs that have potential to be operational in ten to twelve years following award finalization
  - Advanced Reactor Concepts-20 (ARC-20) awards
    - A new solicitation (to be known as ARC-20) for at least 2 new public-private partnerships focused on advancing reactor designs moving toward demonstration phase
    - Not formally part of ARDP; funded under separate budget line. Included in ARD FOA to allow developers to select best pathway.

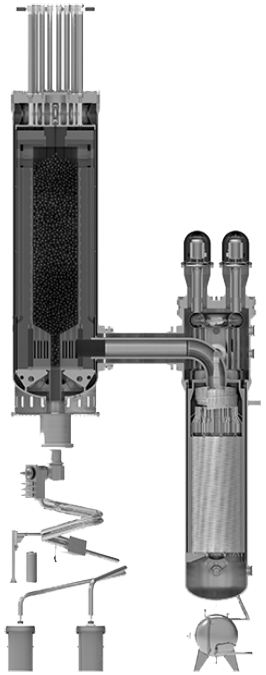
Advanced Reactor Demonstration and Risk Reduction Pathway Merit Review

- Two sets of reviewers: non-federal subject matter experts (SMEs) and federal merit review panel (MRP).
- Congressional language that established the Advanced Reactor Demonstration Program directed the selection of projects be advised by subject matter experts:
  - Electric utility that operates a nuclear power plant
  - High-temperature process heat users (e.g., hydrogen production, industrial processing)
  - Design, manufacturing and operation of nuclear reactors
  - Finance industry with background in nuclear field
- Non-federal SMEs independently reviewed applications and provided individual feedback.
- Federal MRP members individually reviewed applications and then developed consensus recommendations, taking SME input into account.
- **Coordinated with NRC on applicant proposed licensing strategies and schedules**

Demonstration Pathway Selected Technologies

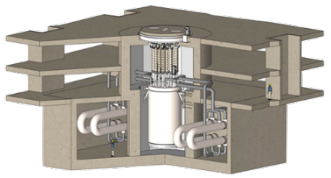
- TerraPower LLC – Natrium Reactor
  - Sodium-cooled fast reactor that leverages of decades of development, including fuel
  - High temperature reactor coupled with thermal energy storage for flexible electricity output
  - New metal fuel fabrication facility
  - Visit: https://natriumpower.com/
- X-energy – Xe-100 reactor
  - High temperature gas-cooled reactor that leverages decades of development and robust fuel form
  - Provides flexible electricity output and process heat for a wide range of industrial heat applications
  - Commercial scale TRISO fuel fabrication facility
  - Visit: https://x-energy.com/





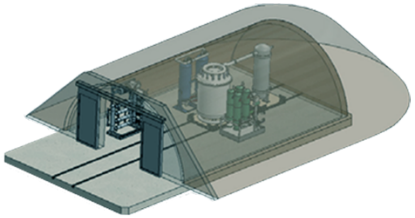
Risk Reduction Pathway Selected Technologies

Prime Applicant	Commercial Target Reactor Type and Fuel	Risk Reduction Project Key Deliverables
Kairos Power. LLC	KP-FHR - 140 Mwe thermal spectrum fluoride salt-cooled MSR, TRISO annular pebble fuel	Design, construction and operation of Hermes reduced-scale test reactor (precursor to commercial-scale KP-FHR)
Westing-house	eVinci - 4.5 MWe heat pipe-cooled microreactor, TRISO UCO compact HALEU fuel	Technical risk reduction for moderator design, wick manufacturing, refueling and licensing.
BWXT	BANR - 50 MWt transportable microreactor HTGR with UN TRISO	Maturation of technology, including the development of UN TRISO fuel, to improve the commercial viability of BANR
Holtec	SMR-160 - 160 MWe LW-cooled natural circulation PWR	Early stage design, engineering, and licensing activities for the SMR-160.
Southern Company	Molten Chloride Fast Reactor –180 MWt pool-type MSR fast reactor with liquid salt fuel	Design, construction and operation of Molten Chloride Reactor Experiment (MCRE)



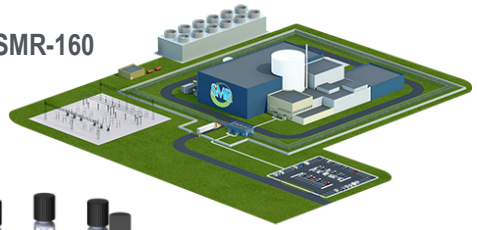
Kairos KP-FHR

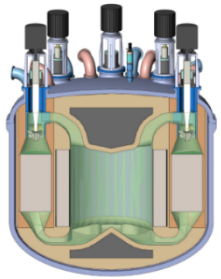
WEC eVinci



BWXT BANR

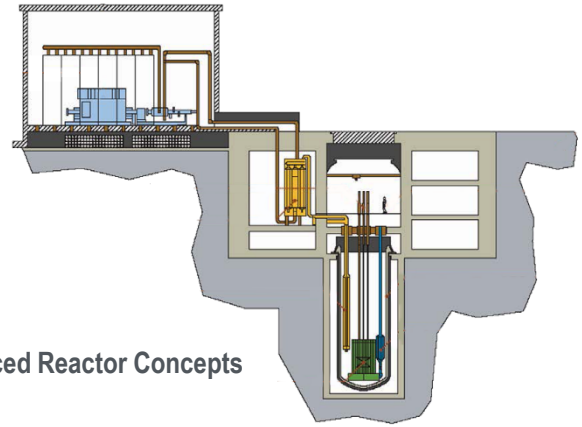
Holtec SMR-160



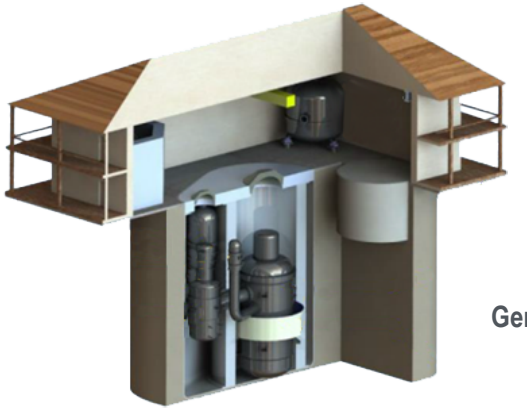


TerraPower MCFR

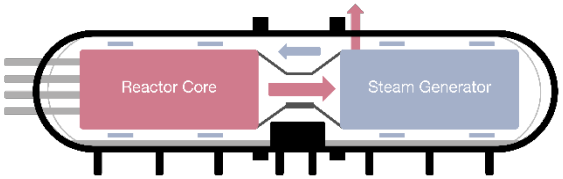
ARC-20 Pathway Selected Technologies



Advanced Reactor Concepts



General Atomics



MIT

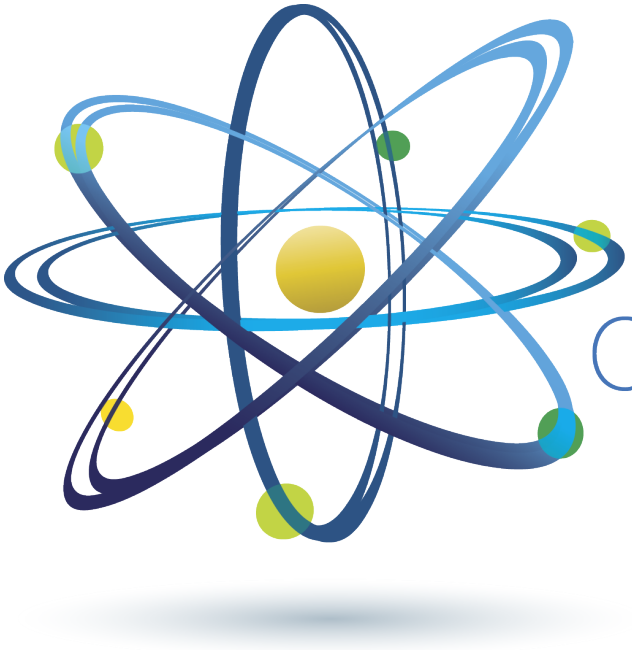
Prime Applicant	Commercial Target Reactor Type	ARC-20 Project Key Deliverables
Advanced Reactor Concepts	**ARC-100 100 MWe pool type sodium-cooled fast reactor**	Conceptual and preliminary design of a seismically isolated advanced sodium-cooled reactor facility
General Atomics	**GA-EMS 50 MWe gas-cooled fast modular reactor**	Conceptual design of the GA-EMS 50 MWe FMR, increase TRL on systems and components, develop prelim. cost estimates
MIT	**Modular Integrated Gas-cooled High Temperature Reactor (MIGHTR)**	Conceptual design for MIGHTR and support for future commercialization as a safe and cost-competitive HTGR concept

Summary

The Advanced Reactor Demonstration Program:

- Supports a diversity of U.S. advanced reactor designs for near-term or mid-term commercial demonstration
- Employs innovative technologies and fuel cycles to improve economic competitiveness, safety, and resiliency of nuclear energy systems
- Ensures nuclear energy continues to serve as a resource capable of meeting the Nation's energy, environmental and energy security goals
- Will require continued coordination with NRC to meet aggressive deployment schedules

Questions?



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NRC Review and Endorsement of ASME BPVC Section III, Division 5 - Update

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Office of Nuclear Reactor Regulation

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Office of Nuclear Regulatory Research

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Purpose

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- Provide status of NRC's review and endorsement of 2017 ASME BPVC Section III, Division 5, "High Temperature Materials"
- Provide status of contractor reports supporting NRC's review

Background

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- NRC Staff is developing two guidance documents related to review/endorsement of ASME Section III-Division 5 and associated code cases.
- NUREG - "Technical Review of the 2017 Edition of ASME Section III, Division 5, "High Temperature Reactors"
  - Document the staff's technical evaluation of the 2017 Edition of Section III, Division 5 and associated Code Cases for acceptability and endorsement.
- Regulatory Guide (RG) - Acceptability of ASME Section III, Division 5, "High Temperature Reactors" (DG-1380)
  - Describes an approach that is acceptable to the NRC staff to meet regulatory requirements for components constructed in elevated temperature environments that are subject to time-dependent material properties and failure modes.
  - Will contain any conditions arising from staff's review.
  - The regulatory guide will update the guidance of RG 1.87.

Overview

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- Staff is finalizing the draft NUREG and draft regulatory guide.
- Staff was supported by PNNL, ANL, ORNL, NUMARK/EMC2
- Conditions are likely in the areas of general requirements, mechanical design, metallic materials properties, and graphite design and materials.

Status of Contractor Reports

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- **See NRC's Advanced Reactor Public Website:** https://www.nrc.gov/reactors/new-reactors/advanced.html#endorev

- **All reports are final and publicly available (except ANL)**
  - **PNNL** – (ML20269A145)
  - **ORNL** – (ML20269A125)
  - **NUMARK/EMC²** –
    - Metallic Appendices HBB-T, HBB-II, HCB-I, HCB-II, and HCB-III (ML20349A003)
    - Graphite Materials (ML20358A145)
    - Code Cases N-861 and N-862 (ML20349A002)
  - **ANL** – ANL input is being finalized.
    - Input provides historical context and perspective on materials properties.

Contractor Assignments

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- **Elevated Temperature Metallic Components**
  - PNNL
    - Design, Fabrication, Examination, Testing (HBB; HCB; HGB-3000, -4000, -5000, -6000),
    - Rules for Strain, Deformation, and Fatigue Limits (Mandatory Appendix HGB-I)
    - Rules for Construction of Core Support Structures Without Explicit Consideration of Creep and Stress-Rupture (Mandatory Appendix HGB-II)
    - Rules for Buckling and Instability (Mandatory Appendix HGB-III)
    - Rules for Time-Temperature Limits (Mandatory Appendix HGB-IV)
  - ORNL
    - Materials (HBB; HCB; & HGB-2000)
    - Tables and Figures (Mandatory Appendix HBB-I)
    - Guidelines for Restricted Material Specifications (Non-Mandatory Appendix HBB-U)

Contractor Assignments

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- **Elevated Temperature Metallic Components** (continued)
  - NUMARK/EMC^2
    - Rules for use of SA-533 Type B (Mandatory Appendix HBB-II)
    - Rules for Strain, Deformation, and Fatigue Limits (Nonmandatory Appendix HBB-T)
    - Rules for Stress Range Reduction Factors (Mandatory Appendix HCB-I)
    - Rules for Allowable Stress Values for Class B Components (Mandatory Appendix HCB-II)
    - Rules for Time-Temperature Limits (Mandatory Appendix HCB-III)
- **Graphite**
  - NRC Staff (General Requirements)
  - NUMARK/EMC^2 (Technical Requirements)
- **Code Cases N-861 and N-862**
  - NUMARK/EMC^2 (All aspects)

General Requirements

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- HAA & HAB (General Requirements) will contain several conditions to ensure consistency with the 2017 Edition of NCA, Division 1 and address oversights that were corrected in the 2019 Edition of Division 5

Mechanical Design

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- Staff has reviewed portions of PNNL and NUMARK reports related to the design of mechanical SSCs, as well as related Division 5 Articles.
- The staff is considering some conditions and recommendations on design, some of which are already included in 10CFR50.55a and in Section III Mandatory Appendix XII, and some from RG 1.87 Rev. 1

Metallic Materials

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- Independent analysis of materials allowable stresses and other materials properties by ORNL and NUMARK implied some Division 5 values are nonconservative.
- NRC staff is considering these findings in a holistic manner, including how these properties are used, inherent conservatism of the Division 5 design rules, and historical context.
- Some conditions on allowable stresses are likely for reasonable assurance of safe designs.
- Input from ANL provides historical context and perspective on materials properties.

Graphite Materials and Design

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- Numark Associates Inc. provided a technical assessment of Subsection HH, “Class A Nonmetallic Core Support Structures,” Subpart A, “Graphite Materials.”
- Staff has completed the review of the above report and all applicable sections of ASME Section III, Division 5 and obtained clarifications and feedback from NRC contractors (Numark and INL) in order to come up with the conclusions identified in the NUREG.
- The staff's deliberations and independent review of the code requirements will take into account the holistic design of graphite core support structures.

INL Expert Assistance

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- INL is providing on-call technical expertise related to NRC's endorsement of ASME BPVC Section III, Division 5.
  - Technical assistance to facilitate the staff's efforts in drafting a RG and the NUREG
  - Providing the review team with the technical basis and historical perspective on ASME BPVC Section III, Division 5.

Current Status – Next Steps

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- The NRC has shared NRC contractor comments with the ASME Code committees
- At the current time, we have not found any issues that would be show stoppers
- Staff is expecting to complete the NUREG and draft RG for public release by April 2021
- Incorporate SSC classification guidance for high temperature reactors (similar to RG 1.26) into draft RG

Future Meeting Planning

2021 Tentative Schedule for Periodic Stakeholder Meetings
January 26, 2021 (Part 53 – Options for Fusion)
February 2, 2021 (ACRS – Advanced Reactor Fuel Qualification)
February 4, 2021 (Part 53)
February 18, 2021 (ACRS – Part 53)
February 25, 2021 (Periodic (AM), TICAP/ARCAP (PM))

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