Performance Testing to Advance Modular, Moving-Bed Gasification for the Generation of Low-Cost, Clean Hydrogen from Biomass Mixed with Legacy Coal Waste, Waste Plastic, and/or Other Waste

Award No. DE-FE0032180

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Electric Power Research Institute

2024 FECM/NETL Spring R&D Project Review Meeting
Pittsburgh, PA
April 24, 2024

Agenda

- Project Summary
- Team and Structure
- Background & Technical Approach
- Statement of Project Objectives (SOPO)
- Project Schedule and Milestones
- Project Status & Updates
- Questions

Project Summary

Project Award Summary

- **Award Number:** DE-FE0032180
- **Project Title:** Performance Testing to Advance Modular, Moving-Bed Gasification for the Generation of Low-Cost, Clean Hydrogen from Biomass Mixed with Legacy Coal Waste, Waste Plastic, and/or Other Waste
- **Funding:** $1,410,044 ($1,128,034 gov't, $282,010 cost share)
- **Award Effective Date:** 9/1/2023
- **Period of Performance:** 9/1/2023 – 8/31/2025 (24-months)
- **DOE Program Manager:** Drew O'Connell
- **Proposed Under:** DE-FOA-0002400
- **Applicant Name:** Electric Power Research Institute (EPRI)
- **Principal Investigator:** Horst Hack

Technical Objectives of the Project

- Prepare pellet feedstocks (up to 20 compositions) using biomass (both woody biomass and corn stover) with a mixture of legacy coal waste, plastic waste, and refuse-derived fuel (RDF)
- Qualify feedstocks based on performance testing of selected fuel blend compositions in updraft moving-bed gasifier
- Obtain relevant data to advance the modular design of the moving-bed gasification process, and successfully use these feedstocks to produce a high hydrogen content raw syngas that can be shifted to produce clean hydrogen
- Determine the effects of the various fuels on feedstock development, the resulting products (i.e., syngas compositions, organic condensate production, and ash characteristics), and impacts on gasifier operations

Project Benefits

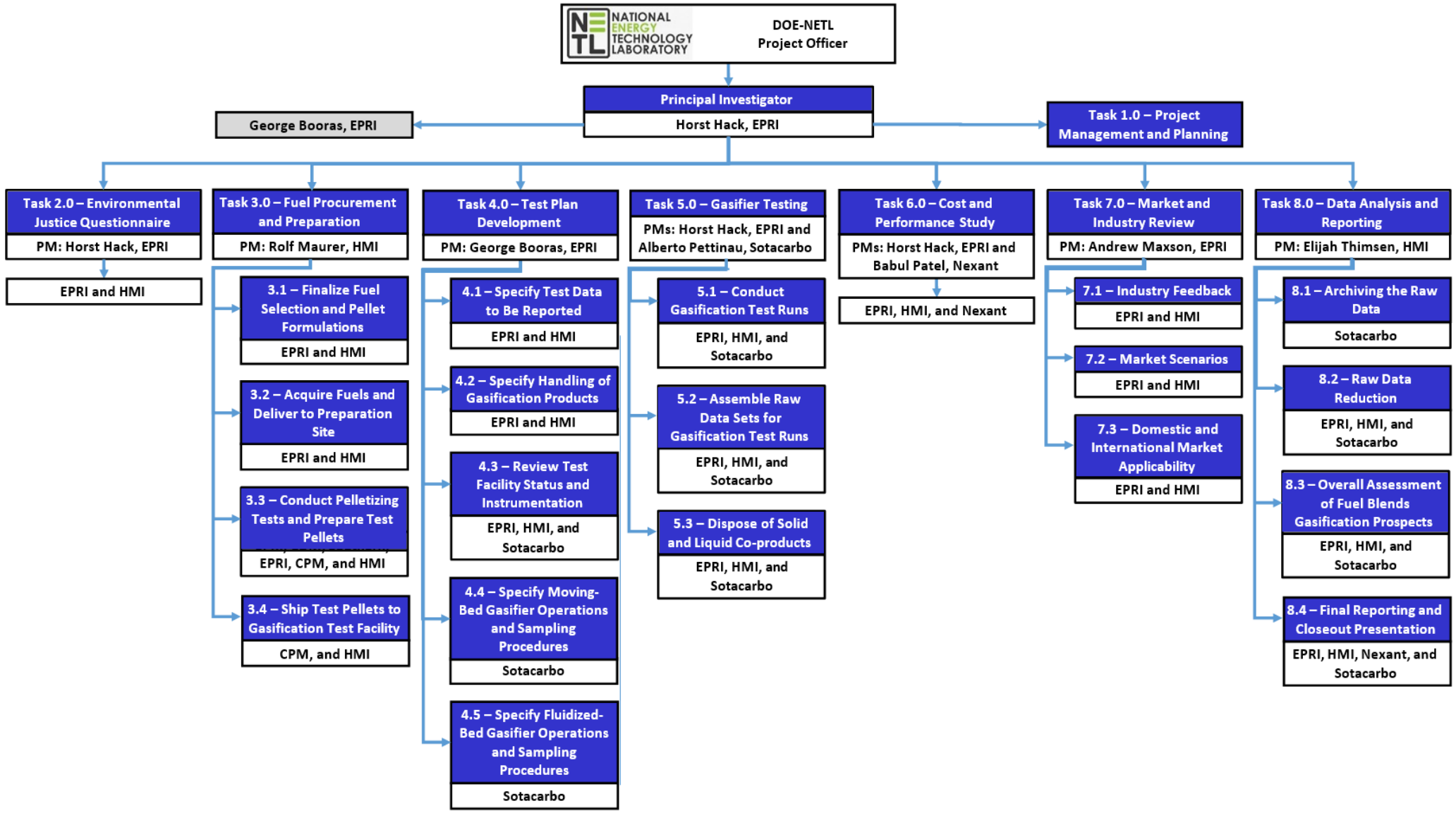
- Support developing technologies enabling clean hydrogen production, transport, storage, and use in the energy sector, including electricity, heat, transportation, and industrial use
- Help to enable production of clean hydrogen consistent with the U.S. Department of Energy's (DOE) Hydrogen Energy Earthshot initiative targeting a cost of $1/kilogram of clean hydrogen by the end of the current decade
- Advance innovative and flexible modular (5–50 MWe equivalent) gasifier technology and gasification processes using a blended feedstock of biomass mixed with variable loadings of legacy waste coal, waste plastics, refuse derived fuel, and/or other wastes to produce greater than 99% hydrogen purity based on the final application
- Focus on improving the performance of gasification unit operations with mixed waste feedstocks, including addressing issues with feedstock preparation and feeding to the gasifier vessel, syngas cleanup, and corrosion

Project Team and Structure

Project Team Organizations

Electric Power Research Institute (EPRI)	• Prime, lead organization, overall project management and administration (Task 1) • Leading EJ Questionnaire (Task 2), Test Plan Development (Task 4), Market and Industry Review (Task 7), and Co-Lead on Cost & Performance Study (Task 6)
Hamilton Mauer International (HMI)	• Gasification technology developer (subrecipient) • Lead Fuel Procurement & Prep (Task 3), Data Analysis & Reporting (Task 8)
NexantECA	• Engineering consulting company (contractor) • Co-Lead on Cost & Performance Study (Task 6)
Sotacarbo	• Gasifier testing facility (subrecipient) • Lead Gasifier Testing (Task 5) and support Test Plan Development (Task 4) and Data Analysis & Reporting (Task 8)

Organization Chart by Tasks



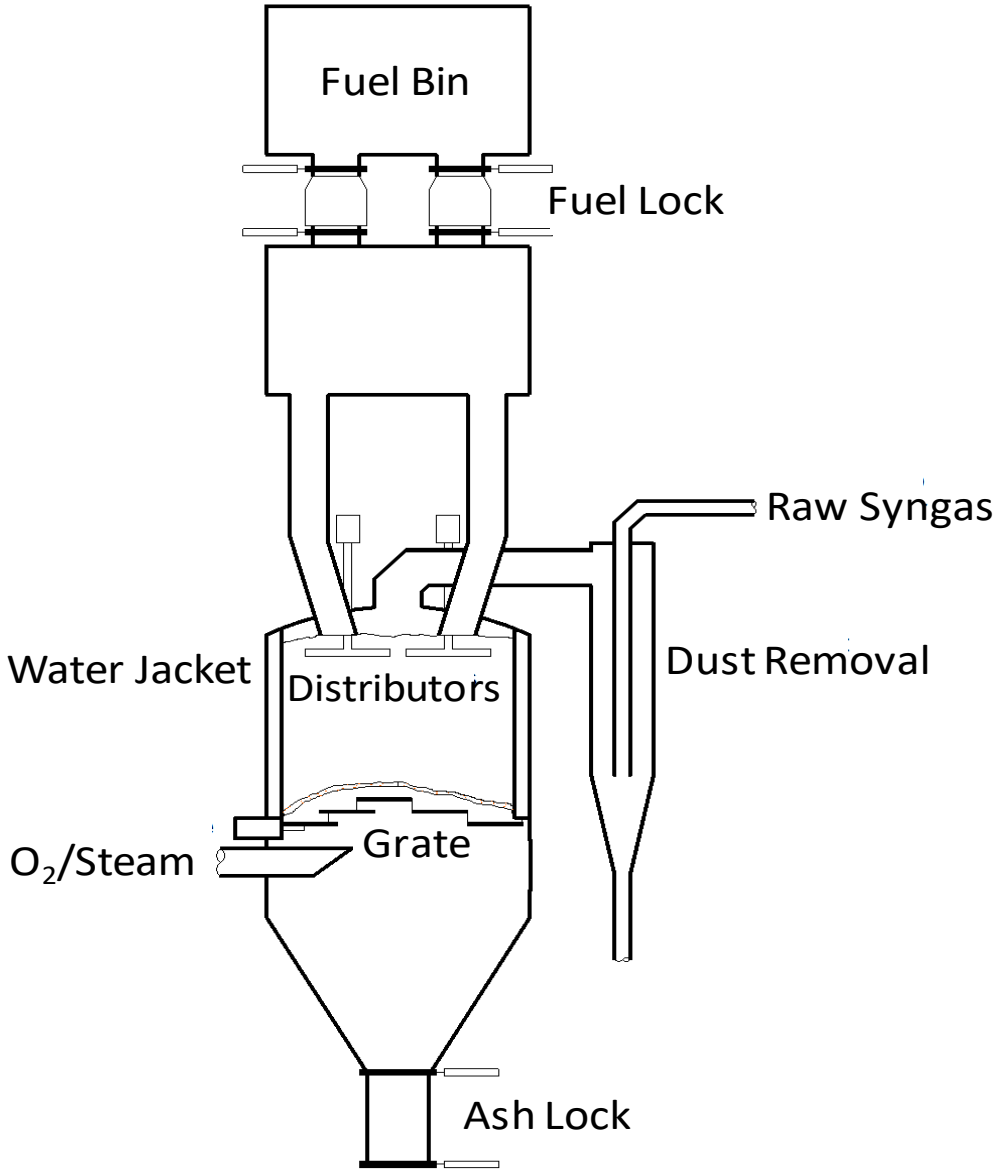
Background & Technical Approach

Background / Motivation for the Project

- Need for hydrogen is growing as the world moves toward a low-carbon future.
- Hydrogen provides long-term energy storage for grid stability in a solar- and wind-dominated power market and can be used to decarbonize other sectors
- One promising process for generating low-cost hydrogen that produces net-negative carbon is to gasify biomass with a mixture of legacy coal wastes, waste plastics, and other wastes with carbon capture
- Use of waste fuels lowers costs and diverts wastes from landfills
- These fuels are often located in disadvantaged communities; therefore, their use for low-carbon energy can relieve the associated burdens faced by these communities and provide benefits in the form of jobs, improved infrastructure, reduced pollution, and the potential for resilient local energy—and addresses environmental justice issues

HMI Moving-Bed Gasifier

- This moving-bed gasifier can gasify nearly all coal ranks as well as biomass (peat, wood)
- Testing suggests that gasifier is suited for corn stover
- As the fuel descends, it is dried, devolatilized, and the resulting char is gasified
- Ash is removed through a grate and collected in a lock hopper for removal
- The CO_2 produced by combustion and the steam from the blast react with the char in the gasification zone to produce CO and H2
- Streams leaving the gasifier are ash out the bottom and dry gas/tar/water vapor/dust out the top



Sotacarbo Test Facility

- Pilot-scale gasification will take place at Sotacarbo's research facility in Italy
- Gasifier has experienced over 2000 hours of operation (2008, 2016, & 2023)
- This facility includes 12" (30.5 cm) ID, refractory-lined, moving-bed gasifier
- Gasifier will be operated with an air/steam blast at flow rates typical of commercial-scale moving-bed gasifiers corrected for fixed carbon content
- Testing will be conducted using air as the oxidizing medium diluted with steam to manage ash agglomeration in the combustion zone of the gasifier

Originally Proposed Test Fuel Blends (Mass Percentages)

Run	Biomass		Legacy Coal Wastes		Wastes	
	Wood Chips	Corn Stover	Raw	Washed	Car Fluff	RDF
1	100					
2	75				25	
3	75					25
4	50					50
5	50				50	
6	50		25		25	
7	50			25	25	
8	50		25			25
9	50			25		25
10	50		25		12.5	12.5
11	25		25		25	25
12	25			25	25	25
13		100				
14		75			25	
15		75				25
16		50			50	
17		50	25			25
18		50		25		25
19		25	25		25	25
20		25		25	25	25

Statement of Project Objectives (SOPO)

Statement of Project Objectives (1 of 2)

1. **Project Management and Planning:** Monitor, control, and reporting for the project, maintenance of the project management plan (PMP), and development of the technology maturation plan (TMP).
2. **Environmental Justice Questionnaire**: Updated questionnaire that addresses how the project is in alignment with current administration priorities outlined in Executive Order 14008.
3. **Feed Procurement and Preparation:** Feedstocks (up to 20 formulations) will be prepared from varying compositions of biomass (both woody biomass and corn stover) with a mixture of legacy coal waste, plastic waste, and refuse-derived fuel (RDF).
4. **Test Plan Development:** Creation of a test plan to define the test runs to be performed. The test plan will detail the different tests to be run, instrumentation to be used, extractive samples to be taken, and the relevant figures of merit and how they should be calculated.

Statement of Project Objectives (2 of 2)

5. **Gasifier Testing:** Tests in the laboratory-scale moving-bed gasifier using selected biomass mixtures with legacy coal waste, plastic waste, and RDF. Provide information on gasification reaction efficiency/performance, yielding relevant data for models used to scale up the gasifier design to 50 MWe (equivalent hydrogen production). Tests will also be performed on a bench-scale fluidized-bed gasifier for comparison purposes.
6. **Cost and Performance Study:** Techno-economic study for the commercial-scale moving-bed gasifier with post-combustion capture designed for clean hydrogen generation from blended fuels
7. **Market and Industry Review:** Review of the potential market and the energy industry's interests for the moving-bed gasifier and its application for generating clean hydrogen from blended fuels.
8. **Data Analysis and Reporting:** Review of the data, determination of figures of merit, and interpretation of the results to be reported. The results will be used to specify the range of feedstock blends that can be successfully gasified as well as quantify gasifier outputs based on specific blends.

Project Schedule and Milestones

Project Schedule (From Current PMP)

			FY 2023	FY 2024				FY 2025			
Task Name	**Start Date**	**End Date**	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
Task 1.0: Project Management and Planning	**9/1/2023**	**8/31/2025**	M1								
1.1: Project Management Plan	9/1/2023	8/31/2025	M2								
1.2: Technology Maturation Plan (initial and final)	9/1/2023	8/31/2025		M3						M4	
1.3: Financial Reporting	9/1/2023	8/31/2025									
1.4: Project Reporting	9/1/2023	8/31/2025		M5	M5	M5	M5	M5	M5	M5	M5
Task 2.0: Environmental Justice Quesionnaire	**6/1/2025**	**8/1/2025**									M6
Task 3.0: Fuel Procurement & Preparation	**10/1/2023**	**6/1/2024**									
3.1: Finalize Fuel Selection and Pellet Formulations	10/1/2023	1/31/2024			M7						
3.2: Acquire Fuels and Deliver to Preparation Site	1/1/2024	3/1/2024									
3.3: Conduct Pelletizing Tests & Prepare Test Pellets	3/1/2024	5/1/2024				M8					
3.4: Ship Test Pellets to Gasifier Test Facility	5/1/2023	6/1/2024									
Task 4.0: Test Plan Development	**1/1/2024**	**6/1/2024**				M9					
4.1: Specify Test Data to be Reported	1/1/2024	3/1/2024									
4.2: Specify Handling of Gasification Products	1/1/2024	3/1/2024									
4.3: Review Test Facility Status and Instrumentation	2/1/2024	4/1/2024									
4.4: Specify Moving-Bed Gasifier Operations and Sampling Procedures	4/1/2024	5/1/2024									
4.5: Specify Fluidized-Bed Gasifier Operations and Sampling Procedures	5/1/2024	6/1/2024									
Task 5.0: Gasifier Testing	**6/1/2024**	**8/1/2025**									
5.1: Conduct Gasification Test Runs	6/1/2024	8/1/2025									
5.2: Assemble Raw Data Sets for Gasification Test Runs	6/1/2025	8/1/2025									M10
5.3: Dispose of Solid and Liquid Co-products	6/1/2025	8/31/2025									
Task 6.0: Cost and Performance Study	**12/1/2024**	**8/1/2025**									M11
Task 7.0: Market and Industry Review	**4/1/2025**	**8/1/2025**									
7.1: Industry Feedback	4/1/2025	5/1/2025									
7.2: Market Scenarios	5/1/2025	7/1/2025									
7.3: Domestic and International Market Applicability	7/1/2025	8/1/2025									
Task 8.0: Data Analysis and Reporting	**6/1/2025**	**9/30/2025**									
8.1: Archiving the Raw Data	6/1/2025	8/1/2025									M12
8.2: Raw Data Reduction	6/1/2025	8/15/2025									
8.3: Overall Assessment of Fuel Blends Gasification Prospects	6/1/2025	8/31/2025									
8.4: Closeout Presentation	8/15/2025	8/31/2025									M14
8.4: Final Reporting	6/1/2025	9/30/2025									M13

Project Status & Updates

Task 1 – Project Management & Planning

- Updated Project Management Plan
  - Completed (9/27/23)
- Initial Technology Maturation Plan (TMP)
  - Completed (12/15/23)
- Project Reporting
  - Ongoing / quarterly

Task 3 – Fuel Procurement & Preparation

- Contacted sources for fuel (waste coal, corn stover, wood waste, and waste plastics – auto shredder residue & wire insulation tailings)
- Agreed with DOE to focus on wire insulation as the plastic waste feedstock, replacing auto shredder residue (ASR)
  - Major source of landfill associated with copper wire recycling
- Established contract with logistics company for transport of the fuels from sourcing locations to the pelletization site (supersacks & drums)
- Worked with pelletization vendor to finalize the work scope and verify ability to support fuel pellet production per project schedule
- Fuels have been shipped to staging warehouse in Indiana

Task 3.1 – Finalize Fuel Selection

- Summary Report issued (2/9/24)
  - Legacy coal from Pennsylvania – confirmed
  - Wood waste from Pennsylvania – confirmed
  - Corn stover from Illinois – confirmed
  - Waste plastics from Indiana (wire insulation tailings) – confirmed
  - RDF from Massachusetts – confirmed

Task 4.0 – Test Plan Development

- Specify test data to be reported from the gasifier testing
- Specify handling of gasification products
- Review test facility status and instrumentation
- Specify gasifier operations and sampling procedures

Task 4.0 – Test Plan Development

- Based upon experience obtained during recently completed testing (DE-FE0032044), Sotacarbo has recommended opportunities for equipment modifications to improve gasifier operations and quality of results:
  - Control system upgrades and maintenance for real time analysis
  - Instrumentation replacement
  - Tar/dust sampling system upgrades
  - Loading and feeding system modification
  - Real time bed height monitoring

Currently Defining Impact of Changes on Cost & Schedule

Task 4.0 – Test Plan Development

- Developing a revised SOPO to incorporate changes
  - Working with Sotacarbo to document the proposed equipment upgrades
  - Costs can be maintained by reducing number of test runs (20 to 12)
  - HMI defining an updated set of pellet compositions for testing
    - Using learnings from recently completed gasification testing (DE-FE0032044) on tri-fuel pellets, including corn stover, coal and ASR
  - Defining the schedule extension will be needed to accommodate equipment upgrades
  - Working with DOE to update the SOPO to address changes

Recommended Changes Support Project Objectives

Key Accomplishments

- Identified fuel sources for all proposed pellet formulations
- Confirmed change of waste plastic from auto shredder residue (ASR) to wire insulation tailings
- Finalized agreements with pelletization and transport vendors
- Shipped the fuels
- Incorporated learnings from recently completed gasification testing at Sotacarbo facility(DE-FE0032044)
- Identified opportunities for key equipment upgrades at Sotacarbo test faculty to improve operations and quality of test results

Acknowledgment and Disclaimer

- **Acknowledgment**: This material is based upon work supported by the Department of Energy under Award Number DE-FE0032180.
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Questions

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