

Modifications

All modifications to the Funding Opportunity Announcement are **[HIGHLIGHTED]** in the body of the FOA.

Mod. No.	Date	Description of Modification
0001	8/16/2018	Changed response due date from August 27 th , 2018 until September 5 th , 2018.

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National Wind Technology Center Facility and Infrastructure Investments

DATE: July 27, 2018

SUBJECT: Request for Information (RFI)

PURPOSE: Addressing the growing Research and Development (R&D) Interest in the use of the National Renewable Energy Laboratory's (NREL's) National Wind Technology Center (NWTC) facilities for renewable energy, energy storage, and grid integration technology development and testing.

Description

NREL's NWTC is poised to provide the integration, data collection, and test support services for a much broader and longer-term vision wherein renewables are a principal electricity provider for the nation. Consequently, the Office of Energy Efficiency and Renewable Energy (EERE) is issuing a Request for Information (RFI) to gain input from industry, academia, research laboratories, government agencies, and other stakeholders regarding infrastructure or equipment investments that would enable expanded energy R&D opportunities at the NWTC. EERE's vision is to enable the transition of the facility from a predominantly wind focus to a broader mix of energy research and development, including energy storage and grid integration.

EERE's Technology Offices are requesting public input on specific facility and infrastructure investments which would enable new research and development of value to industry. R&D technology areas of interest include: fuel cells and hydrogen, advanced manufacturing, solar, grid integration and storage, marine hydrokinetic, hydropower, and geothermal technologies.

Background

The NWTC has been a critical part of executing the Wind Energy Technology Office's (WETO's) R&D portfolio during the last 30 years. The site has been utilized to perform blade, drivetrain, foundation, and controls testing as well as the testing and demonstration of individual wind turbines ranging in size from 3 kW to 3 MW. Located at the base of the foothills just south of [Boulder](#), Colorado, the center's test sites experience diverse and robust wind patterns that are ideal for the development of advanced wind energy technologies. The NWTC's 305-acre site comprises field test sites, test laboratories, industrial high-bay work areas, machine shops, electronics and instrumentation laboratories, and office areas.

Most recently, there has been significant R&D interest and investments by the renewable energy industry and other EERE Technology Offices in utilizing the site for R&D and testing purposes. Specifically, the capabilities of the NWTC have been used to conduct water power research and testing including use of the dynamometers for advanced generator testing. NREL

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researchers have leveraged off of years of experience and expertise in fluid dynamics and structural testing to also [advance marine and hydrokinetic water power technologies](#).

Grid integration research has become a major area of interest and growth at the NWTC. The advanced design and architecture at the NWTC already provides a unique capability for fully resolving the transient and dynamic electrical response of individual generation components. The site can be operated (with appropriate controls) to simulate the interconnection of multiple technologies as an isolated grid with very high renewables penetration. This research can be conducted using the NWTC's 6.3 MW Controllable Grid Interface (CGI). The CGI enables researchers to expose MW-scale electrical power devices to precisely-created grid power anomalies (such as grid faults, transients, and frequency fluctuations) under safe conditions isolated from the utility grid. In addition to creating grid faults, the CGI provides grid forming (for microgrid research) and can emulate batteries, generators, and loads. Devices that can be tested include power converters, energy generation and storage systems, and associated power control systems. Any combination of devices that respond directly to electrical grid systems can be selectively interconnected and tested with the CGI and/or with other NWTC grid research assets including MW-scale wind turbines in the field, 2.5MW and 5MW dynamometers, a 1MW/ 1MWh battery storage system, and photovoltaic (PV) arrays. Customer-supplied test devices can be installed in the field, on outdoor test pads, or within high-bay indoor facilities. Supporting infrastructure includes medium-voltage (13.2 kV) switchgear, cabling, meters, transformers, and multiple nodes of synchronized power quality measurement systems to support research objectives, especially validation of grid modeling tools. To enable Power Hardware In-the-Loop (PHIL) research, the NWTC has Real-Time Digital Simulators (RTDS) that interface device control systems to NREL's High Performance Computing (HPC) resources, other National Laboratories, and international research partner organizations.

Building on its 30-year history of collaboration with major wind turbine original equipment manufacturers and U.S. blade manufacturers, the NWTC continues to expand WETO-developed structural testing expertise and are a lead research team involved with the Advanced Manufacturing Office's (AMO's) Institute for Advanced Composites Manufacturing Innovation (IACMI) via establishment of a new Composites Manufacturing Education and Technology (CoMET) facility at the NWTC. The CoMET facility has enabled NWTC structural testing experts to lead composite research projects for the wind turbine industry, both through IACMI and through NREL partnerships. Composite manufacturing research projects for wind turbine blades currently underway in the CoMET facility include innovations in thermoplastic resin system manufacturing, and wind turbine blade and component recycling.

In summary, current research facilities and capabilities at the NWTC include:

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- [Field research validation sites](#) with various wind turbines and meteorological towers, and room for installation of new MW-scale turbines.
- Three [dynamometers](#) (5.8MW, 2.5MW and 225 kW) for validating wind and water turbine drivetrains and generators, including non-torque loading capabilities.
- Structural research facilities to provide static and fatigue testing of large structural components (including blades) up to 50m in length.
- The [Controllable Grid Interface](#) and associated grid integration research capabilities which provides valuable grid power system performance information.
- The Composites Manufacturing Education and Technology (CoMET) facility.

NREL supports the existing facilities at the site through the expertise and personnel to ensure the overarching safety management, accreditation, equipment maintenance, property management, quality assurance, and environmental compliance.

Purpose

The purpose of this RFI is to solicit feedback from industry, academia, research laboratories, government agencies, and other stakeholders on energy efficiency and renewable energy R&D testing needs and the associated equipment, facilities and infrastructure needed to ensure continued world class energy technology development at the NWTC.

Disclaimer and Important Notes

This RFI is NOT a Funding Opportunity Announcement (FOA); therefore, EERE is not accepting applications.

Any information obtained as a result of this RFI is intended to be used by the Government on a non-attribution basis for planning and strategy development; this RFI does not constitute a formal solicitation for proposals or abstracts. Your response to this notice will be treated as information only. EERE will review and consider all responses in its formulation of program strategies for the identified materials of interest that are the subject of this request. EERE will not provide reimbursement for costs incurred in responding to this RFI. Respondents are advised that EERE is under no obligation to acknowledge receipt of the information received or provide feedback to respondents with respect to any information submitted under this RFI. Responses to this RFI do not bind EERE to any further actions related to this topic.

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Because information received in response to this RFI may be used to structure future programs and/or otherwise be made available to the public, **respondents are strongly advised to NOT include any information in their responses that might be considered business sensitive, proprietary, or otherwise confidential.** If, however, a respondent chooses to submit business sensitive, proprietary, or otherwise confidential information, it must be clearly and conspicuously marked as such in the response.

Responses containing confidential, proprietary, or privileged information must be conspicuously marked as described below. Failure to comply with these marking requirements may result in the disclosure of the unmarked information under the Freedom of Information Act or otherwise. The U.S. Federal Government is not liable for the disclosure or use of unmarked information, and may use or disclose such information for any purpose.

If your response contains confidential, proprietary, or privileged information, you must include a cover sheet marked as follows identifying the specific pages containing confidential, proprietary, or privileged information:

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Pages [List Applicable Pages] of this response may contain confidential, proprietary, or privileged information that is exempt from public disclosure. Such information shall be used or disclosed only for the purposes described in this RFI DE-FOA-0001959. The Government may use or disclose any information that is not appropriately marked or otherwise restricted, regardless of source.

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Federal employees are subject to the non-disclosure requirements of a criminal statute, the Trade Secrets Act, 18 USC 1905. The Government may seek the advice of qualified non-Federal personnel. The Government may also use non-Federal personnel to conduct routine, nondiscretionary administrative activities. The respondents, by submitting their response, consent to EERE providing their response to non-Federal parties. Non-Federal parties given access to responses must be subject to an appropriate obligation of confidentiality prior to

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being given the access. Submissions may be reviewed by support contractors and private consultants.

Request for Information Categories and Questions

EERE is interested in enhancing the testing facilities and infrastructure at the NWTC to accommodate not only future wind technology development needs, but also the growing interest in utilizing the site and its facilities by other energy research and development stakeholders including hydrogen, fuel cells, solar, marine hydrokinetic, hydropower, geothermal technology areas. EERE requests information from stakeholders regarding R&D testing needs and the potential use of the NWTC to satisfy this R&D. Individual EERE technology office interests are summarized below. Two general areas of R&D interest that EERE is seeking input on include:

- (1) **Investment in a 2nd Controllable Grid Interface:** The NWTC's existing controllable grid interface, CGI, is a powerful and unique grid integration research tool. It enables multi-megawatt research experiments (up to 6.3 MW) aimed at ensuring safe, reliable, and resilient grid power. It supports U.S. electrical grid evolution toward greater contribution from variable power generators (e.g. wind, solar), increased levels of energy storage, and "smarter" grid devices (e.g. electric car charging during off-peak hours, autonomous grid services).

The existing single CGI enables researchers to expose MW-scale electrical power devices to precisely-created grid power anomalies (such as grid faults, transients, and frequency fluctuations) under safe conditions isolated from the utility grid. Investment in a second CGI would allow actual power generation devices (wind turbines, batteries, solar arrays, etc.) to be subjected to various grid load profiles. A second CGI working in tandem with the existing CGI would enable full hybrid system and microgrid research. One CGI could be configured to create an isolated research grid (i.e. a simulated microgrid with optional grid anomalies such as faults, voltage dips, etc.) while the second CGI could be programmed to emulate various types and combinations of power devices on the same isolated research grid. Optionally, actual power devices could also be connected to the research grid. Tandem CGIs could also be utilized to validate and demonstrate grid recovery and restoration procedures after disasters, and cyber and physical grid attacks.

- (2) **Investment in a Centralized Control and Data Collection Center to Enable Remote Management of Field Campaigns and Hybrid Systems/Grid Integration R&D:** The need to demonstrate improved energy performance and technology viability at scale is driving integrated systems development and validation testing to be performed in field campaigns under actual operating conditions with joint industry partners including

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owner operators, original equipment manufacturers (OEMs), and service providers. The future of integrated technology and systems testing will likely involve the central dispatch of experienced technicians and test engineers to plant locations around the world, instrumenting a multitude of diverse technologies, utilizing advanced data monitoring, interconnection, and collection methods. The advanced data collection and transfer capabilities needed to make remote monitoring and data collection a reality already exist and have been demonstrated in the past.

Investment in a central control center at the NWTC would serve a dual function for enabling remote field campaign data collection and analysis involving diverse research portfolios while also conducting grid integration research. It is envisioned that the center would accommodate space to allow for multiple parallel project field campaigns; a visualization room capable of providing state-of-the-art, high-resolution visual imagery that illustrate research findings to stakeholders; high speed data links to NREL's Energy System Integration Facility (ESIF), other National Laboratories involved in micro-grid and grid integration research, and field campaign sites; a conference room and partner offices.

The control center would also serve as the central hub for NWTC grid integration research including research systems monitoring, data collection and archive, and visualization and analysis of research data. The center would allow for centralized control of grid integration R&D including CGI configuration and real-time monitoring of interconnected power devices (turbines, solar arrays, loads, etc.).

Key Questions:

Based on the two investment opportunities described above, EERE is interested in understanding the following from external stakeholders:

- 1) Are the capabilities described above of interest to industry?
- 2) Is there an interest on the part of owners and operators of commercial or large scale energy generation in partnering on R&D field campaigns?
- 3) What other facilities and equipment might be needed to conduct R&D?
- 4) What technology innovations and advances can be envisioned if these facilities were available?

Below are the R&D visions of various EERE Technology Offices regarding future use of the NWTC. Each Office is seeking input on the vision and associated questions.

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Category 1: The Fuel Cell Technologies Office (FCTO)

R&D and Facility Vision:

The FCTO envisions a National Energy Integration Center at the NWTC with the R&D and testing infrastructure and capabilities necessary to enable the H2@Scale Vision. H2@Scale is a concept that explores transformational technologies to reduce the cost of hydrogen production and distribution, diversify the possible feedstocks for making economically competitive hydrogen, enhance the flexibility of the power grid through large-scale energy storage and industrial uses, generate jobs, and provide global technology leadership for export of next-generation energy solutions.

Ten million metric tons of hydrogen are currently produced in the United States every year (95% of which is via [centralized reforming of natural gas](#)). Other approaches include hydrogen production from water splitting, such as electrolysis, photoelectrochemical cells, or solar thermochemical systems. The primary uses of hydrogen today are in the oil refining and ammonia industries. Other emerging applications of hydrogen include fuel cell vehicles, metals refining, and liquid fuel production.

NREL has established core capabilities at the Energy Systems Integration Facility (ESIF) in Golden, Colorado for sub-MW-scale electrolysis, 35 MPa and 70 MPa vehicle fueling, and critical infrastructure component research. NREL's fuel cell and hydrogen technologies research program dates back to 1999 and their hydrogen and fuel cell systems engineering research and development spans 15 years – from a 10 kW electrolyzer producing 2 kg/day in 2003 to a 250 kW electrolyzer producing 100 kg/day. The hydrogen infrastructure research cross-cuts production, delivery, storage, manufacturing, safety, analysis, grid integration, and end-use. Increasing system efficiency, lowering cost, increasing renewables and improving reliability of systems through analysis, experiments, and industry/agency partnerships are all active research at ESIF. The current capabilities need to be scaled up (> 1 MW) in order to support H2@Scale goals for low-cost hydrogen production from variable electricity sources and end-use applications. These research capabilities need to be leveraged with active public-private collaborations for a balance of accelerating early-stage research results into commercial applications.

The FCTO team is investigating potential investment in the infrastructure and equipment needed to research hydrogen's many roles to support making use of low-cost intermittent electricity at a scale meaningful for utilities and large project developers to enable large-scale

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penetration of renewables with the grid to allow for daily and seasonal fluctuations. These investments would enable early-stage research of hydrogen systems, integrating with upstream and downstream systems (e.g., wind generation and industrial end-use applications) that require flexible, scalable capabilities to address challenges of our energy system (e.g., domestic sourcing, resiliency, economic viability, and efficiency). Examples of some of the end-use applications for this hydrogen are to produce i) electricity at a later time, ii) fuel for autos, buses, and trucks, and iii) other products such as liquid fuels and ammonia/fertilizer. Since many wind farms are located in farming areas, production of ammonia/fertilizer would be a positive co-located benefit. The FCTO is investigating hydrogen for more than light-duty vehicle fueling, including use of hydrogen for medium and heavy fuel cell vehicles where battery-powered drivetrains aren't as practical due to weight, volume, range, and fueling time requirements. Three major research challenges that an enhanced NWTC could address are:

- Realizing zero electricity curtailment
- Achieving economically viable electrolysis at scale
- Optimizing hydrogen technologies for security, footprint, energy source, and end-use.

Potential enhanced capabilities at the NWTC needed to support these research challenges could include: (a) the ability to switch (at the sub-second level) turbine power output between providing electricity to the grid or generating hydrogen based on optimal economics; (b) transmitting energy in the form of molecules vs. electrons; (c) determining optimal configuration of electrolyzer and power electronics for low cost and high reliability; (d) evaluation of electrolyzer cycling under stressful duty cycles; (e) heavy-duty vehicle fueling technology development; (f) bulk storage of hydrogen locally at a wind site; (g) quantifying impacts of production and consumption relative to economics, security, resiliency, and efficiency; and (h) integration (direct and simulated) multiple H₂@Scale pathways for early-stage research (de-risking, identification of gaps, and proof-of-concept experiments).

Questions:

- 1) Does the FCTO research vision outlined above for at the NWTC site fit with the needs for the H₂ and fuel cell industry, utilities, regulators, and other stakeholders?
- 2) What are additional stakeholder research needs not identified here?
- 3) What are the priority capability and equipment investments that would be required to achieve other stakeholder needs?
- 4) What scale (in MW) would be necessary at the NWTC to support making use of low-cost intermittent electricity at a scale meaningful for utilities and large project developers?
- 5) What additional hydrogen and fuel cell R&D is needed, and what appropriate investments would be required to perform this research?

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- 6) What are the opportunities for innovation for which further strategic R&D investments by EERE would be most beneficial relative to the NWTC site?
- 7) When are H2@Scale research capabilities needed to facilitate stronger public-private collaboration?

Category 2: The Water Power Technologies Office (WPTO)

R&D and Facility Vision:

WPTO supports partnerships among the national laboratories, universities, and industry to conduct research and development (R&D) activities related to marine and hydrokinetic energy and hydropower. This includes addressing fundamental science and technology problems to achieve necessary cost reductions and environmental performance improvements for new modular hydropower designs, as well as research of new technologies that enable hydropower to provide increased flexibility and grid-reliability services, and efforts to model and quantify the cost and value of essential services that hydropower and pumped-storage hydropower (PSH) projects provide to the grid. In marine and hydrokinetic technologies, this includes research and development to reduce costs, increase energy capture and reliability of systems, and reduce barriers to testing to facilitate rapid iteration of innovation and improvements. This includes understanding the characteristics of power from waves and water currents, how they affect the grid – e.g. through complementarity to other resource’s generation profiles, or through constantly fluctuating power output – and evaluating different approaches to power smoothing or power quality enhancement.

WPTO envisions that a dedicated facility to test the integration of the full range of generation sources as a virtual micro-grid could be useful in achieving many of these aims: in particular valuing the grid services provided by hydropower under a wide range of power system conditions; testing new technologies and control systems that allow multiple run-of-river hydro plants to be operated as a single, dispatchable, plant; and better understanding the characteristics of electricity generated from the waves and free-flowing water.

WPTO recognizes, however, that NWTC has no hydroelectric or marine and hydrokinetic resources on site. Dry test facilities have been used to test MHK devices, but they are not unique to MHK nor do they have the ability to mimic in high fidelity the complexity of moving water. On the other hand, there may be opportunities to connect externally operated hydroelectric and marine and hydrokinetic systems via hardware in the loop technology.

Questions:

1. What is the value to hydropower operators, developers, utilities, or researchers to have a national lab-owned, dynamically reconfigurable virtual micro-grid that could provide insight into hydropower operation and value in closed systems with high penetrations of

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renewable energy? Will this provide useful insight into how hydropower contributes to, and can be optimized for, flexibility and grid reliability services and the value of those services under different conditions?

2. Is it necessary (or preferable) to have a dedicated, physical hydropower system that can be controlled exclusively for the benefit of testing, or is it sufficient to connect external systems, which will be operated for their existing purposes, through hardware-in-the-loop?
3. What is the value to marine energy technology developers, test centers, utilities, or researchers of a national lab-owned, dynamically reconfigurable virtual micro-grid that could provide insight into power characteristics of marine and hydrokinetic electricity, the grid value of such technologies under different conditions, and how marine and hydrokinetic power can be most effectively integrated into the grid?
4. Can the characteristics of waves and free-flowing water, and their interactions with marine and hydrokinetic devices be effectively reproduced through modeling, or is it essential that any virtual micro-grid be connected to a physical device in a realistic deployment setting?
5. Please provide any other information that would be useful to assess the value of the proposed facility to hydropower, and critical features for that value to be realized.
6. Please provide any other information that would be useful to assess the value of the proposed facility to marine and hydrokinetic energy, and critical features for that value to be realized.

Category 3: The Solar Energy Technologies Office (SETO)

R&D and Facility Vision:

Solar energy technologies, installations, and value propositions have evolved rapidly over the last decade. In 2011, solar power comprised less than 0.1% of the U.S. electricity supply with an installed capacity of just 1.2 gigawatts (GW). Solar now supplies nearly 2% of the annual U.S. electricity demand¹ with an installed capacity of roughly 47 GWs², and is continuing to grow. According to U.S. Energy Information Administration (EIA), in some states and regions, solar represents up to 15% of total annual electricity generation. Instantaneous solar generation can reach a much higher level, more than 40% in some cases.³ Higher penetration regions have shown opportunities for solar to provide more flexible services to the grid as well as synergies between solar and diverse generation technologies, energy arbitrage and load shifting technologies, and end users.

¹ U.S. Energy Information Administration (EIA), Electric Power Monthly with Data for November 2017, published in January 2018. https://www.eia.gov/electricity/monthly/current_month/epm.pdf

² Source: Solar Energy Industries Association (SEIA), <http://www.seia.org/>

³ For example, in the California Independent System Operator (CAISO) Monthly Renewables Performance Report, the 5-minute market data shows that at the maximum solar served almost 45% of the load in September 2017. See <http://www.caiso.com/Documents/MonthlyRenewablesPerformanceReport-Nov2017.html>

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This ongoing area of focus of SETO includes understanding the impacts of increasing penetration of solar energy on grid reliability and power quality, developing best practices for interconnecting and integrating solar with energy storage and synergistic technologies, addressing the variability of solar generation, researching power electronic technologies for flexible power flow control, enhancing situational awareness of solar generation at the grid edge and informing the standardization of interconnection, interoperability, and cybersecurity for PV and other distributed energy resources (DER) systems. Taking these all together, the goal is to advance the knowledge-base and the ability to integrate solar generation, at scale, into electric transmission and distribution systems in a cost-effective, secure, and reliable manner.

SETO is interested in ensuring that the NWTC meets best-in-class functionality for solar resource and technology performance characterization, as well as understanding the potential of the NWTC to provide testing and validation services for technologies and methodologies that improve the sophistication and lower the costs of monitoring, communications, control, and integration of solar assets or hybridized solar systems within the bulk power or distributions systems.

Upgrades and enhancements to the NWTC testing and validation capabilities that support the following (non-exhaustive) subject areas could potentially advance the SETO R&D vision, and may be of interest for further investigation: (a) Hybrid systems: integration of solar with one or more of the following: wind energy technologies, water energy technologies, building energy management systems, thermal or electrochemical storage technologies, vehicle or vehicle support infrastructure technologies, fuel cells, hydrogen production, other fuel production, high-intensity industrial loads or technologies for enhanced industrial flexibility at bulk power system or distribution system; (b) solutions to grid integration challenges in high penetration of solar energy for improved grid reliability and resilience; (c) Understanding the value of solar energy through wholesale energy market and transactive energy technologies and methodologies; (d) Cybersecurity considerations for devices and microgrids; (e) Devices, communications and data management for enhanced solar observability through machine learning and other methodologies.

Questions:

- 1) What hybrid systems (Solar + X(s)) have not been sufficiently validated, either from a technical or economic performance perspective? What infrastructure or data capabilities and granularity would be necessary to complete these validations?
- 2) Is there a need for the testing and validation of optimized hybrid energy system approaches?

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- 3) Are there any communications or information management system needs that are not present at the NWTC today, particularly needs for improved usability by machine learning, transactive energy technologies, or autonomous grid approaches?
- 4) Are there any remote access, control or coordination needs that are not met by the current NWTC configuration?
- 5) Are there specific grid integration testing infrastructure needs such as computing power, black start testing capability, the flexibility to test bulk power or distribution system etc. that are not sufficiently addressed by current NWTC capabilities?
- 6) Is there any additional infrastructure that would be useful for investigating cybersecurity considerations at the generation or microgrid level?
- 7) Are there any infrastructure improvements that would improve interoperability with other test and simulation facilities such as other national laboratories, the Energy Systems Integration Facility (ESIF) or other facilities (please identify the specific facility in your response)?
- 8) What solar resource sensors and infrastructure do you view as necessary in a state-of-the-art testing, demonstration and validation facility for solar technologies (i.e. irradiance sensors, pyranometers, all-sky cameras, etc.)?
- 9) Is there any specific need for devices and sensors to test solar observability?
- 10) Given the geographic location of the NWTC, are there concerns about lessons learned at site being applicable to different areas of the US and US territories? If so, how could these concerns be mitigated?

Category 4: The Wind Energy Technologies Office (WETO)

R&D and Facility Vision:

As the wind industry has rapidly grown and technology has continued to change, the R&D needs and facility testing requirements have changed.

Turbines have continued to grow in size often beyond facility testing capabilities. New ways of testing critical sections of components in combination and validation with high performance modeling will offer ways to certify components at reasonable cost and timeline.

The maturing market and need to demonstrate improved performance and technology viability at scale is driving integrated systems development and validation testing to be performed in field campaigns under actual operating conditions with joint industry partners including owner operators, OEMs and service providers. The future of integrated technology and systems testing will likely involve the central dispatch of experienced technicians and test engineers to plant locations around the world, instrumenting a multitude of diverse technologies, utilizing advanced sensors, data monitoring, interconnection and collection methods. A NWTC support facility could serve as a central hub for systems monitoring, data collection, analysis,

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comparison and data sharing for onshore and offshore field campaigns. It is expected that the NWTC would also serve as a test bed in the development of new sensors and instrumentation ahead of such field deployments.

System grid integration supporting research that enables diverse generation sources to be seamlessly coupled is a next logical step for an expanded NWTC vision. All renewable generation sources depend on numerous power conversion strategies and architectures to transfer power from the generation source to the grid utilizing full and/or partial power conversion electronics. Inherent in this transfer and the use of PE is production of dynamic electrical transients driven by both the resource, transfer architectures, and the local grid interconnection characteristics. Insuring resiliency, robustness and stability requires modeling the coupling behaviors of these diverse generation sources and an infrastructure testing capability to systematically verify and validate the modeled physics accuracy. Similarly, new grid integration and ancillary services are required to support dispatchability, proving real time inertia equivalence, curtailment management and power estimation.

WETO foresees continued development and testing of advanced blades utilizing new, recyclable materials, carbon fiber composites, and segmented blades. Development of cutting-edge technologies and science to address environmental challenges such as bird and bat detection and deterrence will also be a critical part of future research.

Questions:

- 1) What future research and development technology and science challenges will require new/additional testing facilities? Examples include:
 - a. Advanced materials and manufacturing processes
 - b. Atmospheric science research
 - c. Prototype testing
 - d. Field testing (large-scale or unique turbine configurations)
 - e. Grid integration research including Controllable Grid Interface grid simulation and other generation or load devices
 - f. Power Hardware In-the-Loop (PHIL) research,
 - g. High-performance computing
 - h. Cybersecurity
 - i. Component and subcomponent design, structural testing, model development and validation
 - j. Electrical power system design and testing, controls development
 - k. Energy storage (including conventional and novel battery technologies, hydrogen, compressed air)
 - l. Modeling and analysis
 - m. Sensor and instrumentation development

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- n. Environmental monitoring
 - o. Unmanned Aerial Vehicle (UAV) applications
 - p. Performance, health monitoring, reliability, accelerated lifetime and failure testing
 - q. Advanced Operations and Maintenance (O&M), preventative maintenance, and installation optimization
- 2) What are the near and long-term research, development and testing facility, infrastructure and equipment needs associated with the technology and science areas identified in question 1?
 - 3) What are the big opportunities, and the most innovative areas for which further strategic R&D Investments by DOE would be most impactful as they pertain to doing research, development and testing?
 - 4) Is there a need, or an opportunity to conduct field campaigns on existing equipment utilizing a remote control and data collection center?
 - 5) Is there a need to design, develop and validate standardized field instrumentation and data acquisition equipment to support field test campaigns?
 - 6) Are there specific grid integration testing infrastructure needs that aren't present at the NWTC today?
 - 7) Is there a need for the testing and validation of optimized hybrid energy system approaches?

Category 5: The Geothermal Technologies Office (GTO)

R&D and Facility Vision:

GTO envisions a National Energy Integration Center at the NWTC with capabilities to test or simulate the geothermal industry's ability to provide grid services. In the near term, GTO sees this approach falling under two categories: first, researching the capabilities of geothermal heat pumps (GHPs) and direct use of geothermal heat to provide demand response that is unique to these geothermal technologies; and second, gaining a better understanding of the challenges and opportunities that geothermal electricity generation faces in operating flexibly to provide grid services. A longer term goal is to gain a better understanding about how geothermal heat can play a role in seasonal storage through large scale subsurface thermal energy storage to include borehole thermal energy storage and aquifer thermal energy storage. Input is requested on the following areas:

- 1) Instrument a GHP system at the NWTC so that the performance can be thoroughly evaluated by testing DOE funded and other software packages.

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- 2) Evaluate the VRF (Variable Refrigerant Flow), Multi-Split Standards Working Group by using the NWTC GHP system validation to develop a performance baseline where ASHP (Air Source Heat Pump)/VRF/GS (Ground Source)/WS (Water Source) HP (Heat Pump) are measured.
- 3) Evaluate the use of micro-grids for electrification where “single wire” technology or single-phase electronic power is sent to a GHP system (earth or water) and returned to the grid avoiding the need for a return wire, focusing on:
 - Data acquisition systems, instrumentation, calibrations
 - Data analysis and processing systems and tools
- 4) Evaluate combinations of devices that respond directly to electrical grid systems that can be selectively interconnected and tested to develop GHP fields that would show how GHPs can balance net load profiles when paired with wind. Evaluate the use of GHP systems (beneficial electrification) to enhance wind or other technology generation instead of battery storage.

In addition, geothermal electricity generation has been frequently overlooked in many of the grid integration discussions because it is typically centralized, high capacity factor generation that does not face the same challenges as distributed or variable generation assets. Lately, the utilities are seeking grid services to ameliorate the challenges with integrating higher percentages of distributed and variable generation sources onto the grid. Geothermal as a firm but flexible resource is strategically positioned to provide these services, especially in states like California, Nevada, and Hawaii where there are high renewable portfolio standards and an abundance of geothermal resources. While grid services can be provided by flexible operations of traditional geothermal plants, there are additional opportunities to use geothermal resources to provide grid services when paired with other technologies (such as solar, coal, or natural gas) in hybrid systems. GTO envisions flexible and hybrid geothermal generation capabilities to be emulated with the CGI at the NWTC to help gain a better understanding of the value of grid services they can provide along with identifying the challenges with operating them in such a fashion.

Questions:

- 1) Does the GTO potential vision outlined above for R&D at the NWTC site fit with the needs of the geothermal industry for research in:
 - a. Geothermal heat pumps and direct use of geothermal to provide demand response, and/or

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- b. Flexible operations and hybrid configurations of geothermal generation to provide grid services?
- 2) What are the priority infrastructure and equipment investments that would be required to implement an R&D vision described in the RFI?
- 3) As it is described, do you envision the CGI emulation capabilities to be adequate to identify the challenges and opportunities in geothermal generation to provide grid services?
- 4) Are there additional geothermal R&D needs beyond what GTO envisioned that should be considered at the NWTC site? If so, please describe the need for additional R&D, potential benefits to the grid, and the amount of investments that would be required.

Request for Information Response Guidelines

Responses to this RFI must be submitted electronically to [NWTC EERE RFI@ee.doe.gov](mailto:NWTC_EERE_RFI@ee.doe.gov) no later than 5:00pm (ET) on **September 5th**, 2018. Responses must be provided as attachments to an email. It is recommended that attachments with file sizes exceeding 25MB be compressed (i.e., zipped) to ensure message delivery. Responses must be provided as an attachment to the email, and no more than 10 pages in length, 12 point font, 1 inch margins. Only electronic responses will be accepted.

Please identify your answers by responding to a specific question or topic if applicable. Respondents may answer as many or as few questions as they wish.

EERE will not respond to individual submissions or publish publicly a compendium of responses. A response to this RFI will not be viewed as a binding commitment to develop or pursue the project or ideas discussed.

Respondents are requested to provide the following information at the start of their response to this RFI:

- Company / institution name;
- Company / institution contact;
- Contact's address, phone number, and e-mail address.

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