Microgrid Testbeds & Controller Procurement Opportunity

National Renewable Energy Laboratory (NREL)

May 5, 2017
Agenda

• Background and Overview
• Procurement Process and Schedule
• Evaluation Criteria
• Testbed Descriptions
• Q&A

More information is available at

https://www.nrel.gov/esif/user-call.html
National Renewable Energy Laboratory (NREL)

- Founded as Solar Energy Research Institute (SERI) in 1977
- Designated national laboratory in 1991
- Managed by the Alliance for Sustainable Energy, LLC, for the U.S. Dept. of Energy
- $400M+ annually in R&D activity
- ~1,700 employees
- > 500 active partnerships with industry, academia, and government
The ESIF is the nation’s premier MW-scale research facility addressing the challenges of large-scale integration of clean energy technologies into the energy systems infrastructure.

- NREL’s newest and largest R&D facility
- 182,500 ft²/20,000 m²
- Petascale High Performance Computer (HPC)
- 15 state-of-the-art labs focused on R&D of integrated energy systems
- Office space for 200 staff and visiting researchers
- Integrated electrical, thermal, fuel, and data infrastructure

The ESIF is a National User Facility, open to the broader research community.

http://www.nrel.gov/esif/
ESIF Capabilities- Distribution Grid “in a box”

- Multiple parallel AC and DC experimental busses (MW power level) with grid simulation
- Flexible interconnection points for electricity, thermal, and fuels
- Medium voltage (13.2kV) microgrid test bed
- Virtual utility operations center and 3D visualization rooms
- Smart grid testing lab for advanced communications and control
- Interconnectivity to external field sites for data feeds and model validation
- Petascale HPC and data mgmt system in showcase energy efficient data center
- “Hardware-in-the-loop” simulation capability to test grid scenarios with high penetration of renewables
NREL is piloting a new pre-procurement evaluation process that provides potential offerors with access to state-of-the-art testbeds in ESIF prior to final evaluation and selection for procurement.

Stage 1: Letter of Interest (LOI) - 5 participants
- Controller hardware-in-the-loop (CHIL) evaluation
- Cybersecurity review

Stage 2: Request for Proposal (RFP) - 2 participants
- Power hardware-in-the-loop (PHIL) evaluation
- Cyber-physical testbed evaluation
- Cost proposal evaluation

The top-performing control technology will be installed at ESIF in 2018, pending successful procurement negotiations.
Control technologies should meet the functionality needs of a research testbed where end devices and communications protocols change periodically.

Preferred Characteristics

Successful respondents will demonstrate their technologies are:

- Open
- Flexible
- User-configurable
- Secure
- Able to accommodate multiple microgrid types and use cases.

Example Microgrid Research Testbed
Stage 1: Tech Demo and Evaluation

LOI Responses evaluated to select up to five Stage 1 participants (start date 6/19)

Stage 1 - 14 weeks with staggered start dates

- **Step 1:** Specifications document and cyber posture questionnaire sent to participant
- **Step 2:** 8 weeks for programming the control technology and shipping it to NREL
- **Step 3:** 1-week integration into a controller hardware-in-the-loop testbed, cybersecurity questionnaire due
- **Step 4:** 4 weeks to debug, reprogram, make enhancements to control technology
- **Step 5:** 1-week CHIL testing and evaluation, cybersecurity evaluation

*Participants may work onsite at ESIF for Steps 3 and 5.*

NREL staff conducts final evaluations independently.
Stage 2: Tech Demo and Evaluation

Top two Stage 1 performers will enter Stage 2 (est. start date 10/23)

Stage 2 - 7 weeks with staggered start dates

- Step 6: Request for Proposal (RFP) sent to top two contenders
- Step 7: 1-week integration into a power hardware-in-the-loop (PHIL) testbed
- Step 8: 4-weeks to debug, reprogram, make enhancements to control technology
- Step 9: 2-weeks Cybersecurity testing (concurrent with Step 8)
- Step 10: 1-week PHIL testing and evaluation

Participants may work onsite at ESIF for steps 7 and 10.

Final cost proposals due one week after PHIL evaluation day.

NREL staff conducts final evaluations independently.
https://www.nrel.gov/esif/user-call.html

To be considered, parties MUST
➢ Register online.
➢ Respond to the LOI it’s entirety by the stated deadline
➢ Meet eligibility requirements
➢ Meet minimum qualification requirements
➢ Accept the terms and conditions of the Non-Proprietary User Agreement without modification
➢ Have the necessary organizational support to work onsite at NREL for a period of time.

TIP: Read all three documents carefully
Registration & LOI Submission

Registration is now Open!
All interested respondents must first register and certify that they meet minimum qualifications at [https://tools.eventpower.com/reg/index/x9xDeSUJxV](https://tools.eventpower.com/reg/index/x9xDeSUJxV).

Qualified respondents will receive a link to the Letter of Interest (LOI) response template and online submission portal. Foreign entities are encouraged to register as soon as possible. Letters of Interest do not need to be submitted at the time of registration.

LOI Response has 3 Parts:
1. Online questionnaire about the product functionality

2. Up to 10 page response including
   - Title Page
   - Body
   - Supporting documentation

3. Clarifying call (15-30 minutes) between June 5 and June 9, 2017. Respondents will indicate availability during the registration process.
Minimum Qualifications

Cybersecurity Requirements
- Compatible with the IP protocol (including support for TLS), which is needed for secure connection at the application layer.
- Support strong username/password (12+ characters including numerals, letters and symbols).
- Role-based access control with distinction between user and administrator privileges.
- Alarming capability for abnormal state of operation.
- Secure firmware upgrades methodology.

Functional and Communications Requirements
The respondent’s technology must communicate, monitor and control a minimum of:
- Four (4) isochronous/droop operated generators;
- Ten (10) distributed renewable plants or inverters (wind, solar, hydro);
- Three (3) energy storage systems;
- Seventy-five (75) intelligent relays/circuit breakers;
- Five (5) Home Energy Management Systems;
- Support at least three (3) utility feeders.
- ModBusTCP, IEC61850 GOOSE, or provides a means of translation.
## Selection Criteria - Letter of Interest Responses

<table>
<thead>
<tr>
<th>Criterion</th>
<th>Assigned Weight (%)</th>
<th>Description</th>
</tr>
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<tbody>
<tr>
<td>ESIF Research Testbed Compatibility</td>
<td>50%</td>
<td>Extent to which the technology is open, interoperable, flexible and user-configurable such that it allows for many types of microgrid experiments to be conducted in the future.</td>
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<tr>
<td>Product Offering</td>
<td>30%</td>
<td>The strength and depth of the existing product functionalities (including cyber security) and additional functionalities that will be implemented during this pre-procurement competition.</td>
</tr>
<tr>
<td>Team Capabilities and Support</td>
<td>20%</td>
<td>Level of confidence reviewers have in the team’s capability to implement additional functionality with access to the CHIL and PHIL testbeds with a good chance of success, including (but not limited to) the team’s qualifications, relevant experience, and organizational support.</td>
</tr>
<tr>
<td>Total</td>
<td>100%</td>
<td><strong>Total</strong></td>
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<table>
<thead>
<tr>
<th>Important Dates*</th>
<th>Item</th>
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<tbody>
<tr>
<td>April 13, 2017</td>
<td>Notice of Intent issued</td>
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<tr>
<td>May 1, 2017</td>
<td>Request for Letters of Interest (RLOI) issued</td>
</tr>
<tr>
<td>May 5, 2017, 11:30-12:30 Eastern</td>
<td>Informational Webinar</td>
</tr>
<tr>
<td>May 15, 2017, 5 PM Eastern</td>
<td>Register at <a href="https://tools.eventpower.com/reg/index/x9xDeSUJxV">https://tools.eventpower.com/reg/index/x9xDeSUJxV</a></td>
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<tr>
<td>May 26, 2017, 5 PM Eastern</td>
<td>Last day to submit questions</td>
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<tr>
<td>June 2, 2017, 5 PM Eastern</td>
<td>LOI responses due</td>
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<td>June 5-9, 2017</td>
<td>Clarifying Calls with qualified Respondents</td>
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<tr>
<td>June 12-15, 2017</td>
<td>Notification to selected responders</td>
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<tr>
<td>June 19, 2017</td>
<td>Stage 1 begins (start dates staggered 6/19-7/17)</td>
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<tr>
<td>October 13 - 20, 2017</td>
<td>Down-selection to top 2 performers</td>
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<tr>
<td>October 23, 2017</td>
<td>Stage 2 begins (RFP issued 10/23 and 10/30)</td>
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<tr>
<td>December 8 and 15, 2017</td>
<td>RFP responses/ Cost Proposals due</td>
</tr>
<tr>
<td>December 18-22, 2017</td>
<td>Final selection and notification</td>
</tr>
<tr>
<td>January 2018</td>
<td>Purchase Order issued</td>
</tr>
</tbody>
</table>

*Dates are subject to change if unanticipated events occur.*
Four Reconfigurable Microgrid Hardware Testbeds

• Each testbed has:
  o Real-time simulation platform to model actual locations
  o Fully controllable AC sources
  o Smart PV inverter(s)
  o Load banks(s)

• 10 kW- grid-forming inverter, battery, home, master PLC

• 100 kW- commercial grid-forming battery inverter, genset, genset control, micro-turbines, electric vehicle, POI switch

• 1,000 kW- utility battery inverter, DC source, gensets, hydrogen facilities, 13 kV yard, POI switch, master control

• 10,000 kW- wind turbines, dyno, solar array, PMU system, 115 kV t-line, substation, container pads, energy storage
Microgrid Hardware Testbeds

- **10 kW**
- **100 kW**
- **1,000 kW**
- **10,000 kW**

See NWTC backup slide.
Banshee Model + PHIL Testbed

MIT LL Banshee Model

ESIF Power-Hardware-in-the-Loop Testbed
Power Systems Testbed Schematic

Testbed Components:
- Microgrid controller – provided by participant
- Real time power simulation – (RTS) Opal RT and Mathworks - Matlab & Simulink
- Operator interface (HMI) and data manager- SEL RTAC
- Ametek 270kW bidirectional programmable AC source/sink,
- Research electrical distribution bus (REDB),
- ABB 100kW solar inverter w/ MagnaPower programmable DC source (solar array emulator),
- Loadtec 250kW RLC load bank,
- Caterpillar 250kW battery inverter w/ AV900 bidirectional programmable DC source/sink (battery emulator),
- Onan Cummins 80kW diesel genset w/ Woodward paralleling controller
- Nissan Leaf w/ electric vehicle service equipment (EVSE) and Sparkmeter

Power-Hardware in-the-Loop (PHIL) Testbed at ESIF
All Key Performance Parameters (KPP)s will be converted to USD and the sum of KPPs will be presented as a microgrid operator’s bill.

**Resiliency and Reliability**
Measured by calculating the energy delivered to predetermined categories of load. A penalty will be added for any outage on critical loads.

**Microgrid Survivability**
Keeping battery State of Charge (SoC) below the predetermined level during grid connected conditions will result in a penalty.

**Power Quality**
Voltage and frequency violating IEEE 1547a-2014 clearing times (Tables 1 and 2 of the standard) will be counted. of the standard will be counted.

**Fuel-Free Asset Utilization**
The amount of energy generated from PV to supply 1MWh of loads in the microgrid and PV energy generation will be measured.

**Interconnection Contract**
The price of energy during the test sequence will vary to allow the controller to benefit from various choices (e.g. dispatching energy from battery).

**Distribution Service Operator (DSO) Commands**
The microgrid controller can allow additional revenue by providing services to DSO on request. Failing to provide required services will result in a penalty.

**Operation and Maintenance**
The cost places a value on device degradation from use (e.g. causing faster failure, circuit breakers use).

*NREL built upon existing KPPs developed by MIT Lincoln Laboratories. Relative weighting of KPPs derived from two focus groups held in Nov.*
CHALLENGE:
Distributed intelligence creating new cybersecurity vulnerabilities on the grid

SOLUTION:
A new, disruptive approach to system security based on 9 layers

The layered approach provides security at all 9 logical layers of a typical information system (7-layer OSI model + 2 upper layers of Gridwise Architecture Council Stack).
Cybersecurity Evaluation

Stage 1: Cybersecurity Posture Review
NREL will ask all participants to answer a series of 12 questions that will inform a custom cybersecurity vulnerabilities mitigation strategies report, delivered to each participant.

Participants will respond (in writing) to the strategies report and be evaluated on the strength of the current cybersecurity posture and plans to implement improvements.

Stage 2: Comprehensive Cybersecurity Evaluation
The top two controllers from Stage 1 will undergo comprehensive testing in the in NREL’s Cyber-Physical Testbed. A custom report will be given to each participant.

Minimum cybersecurity requirements for participation:

- Compatible with the IP protocol (including support for TLS) – needed for secure connection at the application layer.
- Support strong username/password (12+ characters including numerals, letters and symbols).
- Role based access control with distinction between user and administrator privileges.
- Alarming capability for abnormal state of operation.
- Secure firmware upgrades methodology.
NREL’s Cyber-Physical Testbed

Secure testbed with power systems SCADA, grid simulation, and an inverter on a routed and firewalled network (one control center + two substations) with five function-specific cybersecurity technologies.
Attribution and Treatment of Data

The identity of the selected respondents and offerors will not be publicly announced or made known to each other at any time before, during or after the competitive procurement. NREL will publicize the winner of the procurement contract once all agreements have been executed.

Non-Proprietary User Agreement (excerpt)
• User may elect to retain title to any subject inventions created solely by User’s employees. The government retains the right to use these inventions for U.S. government purposes.
• User’s pre-existing proprietary data may be designated as such and ownership of such data will remain with User. NREL will protect this information from disclosure.
• The government (i.e., NREL) and the User share broad rights to use any data generated by either NREL or the User under the agreement.
• NREL or User may publish the data, but will allow the other party to review prior to publication.

NREL intends to publish a report that contains insights learned from this procurement for the benefit of the broader community. All parties will have the chance to review information prior to publication.
For more information, check [www.nrel.gov/esif](http://www.nrel.gov/esif)
or contact:

**Sarah Truitt**  
sarah.truitt@nrel.gov  
(303) 275-4684