Request for Proposals:

Heat Pump Rating Representativeness Project

Issued by Northeast Energy Efficiency Partnerships, Inc.:
July 7, 2021

Questions Due Before:
July 19, 5:00 p.m. EST
Please send your questions to Giselle Procaccianti (gprocaccianti@neep.org)
Questions and responses will be posted to the NEEP Website RFP page

Proposals Due:
August 6, 5:00 p.m. EST

NEEP Background

Northeast Energy Efficiency Partnerships (NEEP) was founded in 1996 as a non-profit to accelerate energy efficiency as a least-cost resource in the Northeast and Mid-Atlantic region to meet public policy goals for clean, affordable, reliable, and environmentally sustainable energy supplies. Today, NEEP is one of six Regional Energy Efficiency Organizations (REEOs) supported in part by the U.S. Department of Energy to provide technical assistance to states and municipalities to adopt, develop, and implement efficiency policies and programs. NEEP is also funded by foundation grants, state energy efficiency partnership agreements, the NEEP Allies program, and event revenues.

NEEP's **mission** is to accelerate energy efficiency as an essential part of demand-side solutions that enable a sustainable regional energy system. Our **vision** is that the region embraces next generation energy efficiency as a core strategy to meet energy needs in a carbon-constrained world. And our long-term shared **goal** is to assist the Northeast and Mid-Atlantic region in reducing carbon emissions 80% by 2050, relative to 2001.

Project Context

Standardized performance testing and rating of heat pumps provides the market with valuable information about how the heat pumps perform and are intended to reasonably represent field performance. No rating perfectly characterizes in-field performance; at best, they are standardized estimates that provide consistent and accurate relative ranking of different products. Over the past two decades, utility companies, states, and energy efficiency organizations have noticed that existing ratings (HSPF and SEER) do not provide consistently accurate predictions of, or even relative ranking of, heat pump performance.

This gap in the usefulness of ratings is of interest to stakeholders that offer incentives and consumer information intended to promote high performance. This research seeks to gather data that can be used to improve consumer information about which machines offer consistently better performance. Most of the project co-funders have been involved with improving existing test procedure and rating (AHRI 210-240) and/or developing a new test and rating procedure (CSA EXP-07). Comparisons done to date in test labs confirm that these two approaches result in significantly different ratings, but neither test standard has undergone significant in-field performance validation. This research seeks to compare field results in a controlled environment, compare the field data with lab test results, and gain additional insight into measurements that are most valuable in establishing accurate equipment ratings.

The field data gathered in this project will be analyzed by a USDOE funded national laboratory and used by both industry and energy efficiency organizations to increase stakeholder understanding and guide refinements in a broad range of areas including: future test procedures, consumer information, energy forecasting and modeling, and incentive programs.

Project Objectives

The objective of this research is to evaluate the representativeness of different air-source heat pump (HP) test and rating procedures through observation of HP performance in a controlled field installation and comparison with corresponding laboratory test results. In particular, the Funders would like to see

which of the HP test procedures prevalent in North America (DOE Appendix M1 and CSA EXP07) more realistically represents energy use of HPs that are installed in residential buildings, and to investigate key conditions and sequences (e.g. defrost, variation of compressor speed at part load) that affect instantaneous power demand and overall energy use.

Findings from the research will inform the future adoption or evolution of voluntary and/or regulatory ASHP test procedures and performance metrics.

Services to Be Performed

See Attachment A

Submittal Information

Contact and Communications

All communications between bidders and NEEP are to be directed to:

Giselle Procaccianti, Technology and Market Solutions Manager: gprocaccianti@neep.org, 781-860-9177, ext. 156

Milestone Schedule

To allow adequate time for proposal submission and evaluation, the schedule below will be followed:

RFP Issued	July 7, 2021
Bidder Questions[1] due	July 19, 2021
Written Responses	July 26
Proposals Due	August 6, 2021
Anticipated Notification to Successful Bidder	August 20, 2021
Anticipated Contract Start Date	September 20, 2021

Modifications to the RFP

NEEP may modify the RFP prior to the proposal submission deadline by the issuance of an addendum to all parties who have submitted a notice of intent to bid by the required date.

Response Guidelines and Requirements

Proposals should provide straightforward and concise descriptions of the bidder's ability to satisfy the requirements of this RFP. Omissions, inaccuracies, or misstatements will be sufficient cause for rejection of a proposal. Proposals not submitted as indicated may be rejected.

NEEP seeks proposals that demonstrate creativity, expertise, and experience in how the bidder approaches the work scope – not necessarily a detailed final approach. Once the consultant is selected, an initial task will be to review the scope and deliverables with NEEP and finalize a Scope of Services.

Bidders are requested to provide a concise yet complete description of their proposed approach and capabilities for satisfying the required services outlined in this RFP. Excessive length is discouraged. In addition, bidders are encouraged to proactively present additional information and responses, not specifically requested, that help demonstrate understanding of this project's objectives and needs.

[1] Bidders may submit questions related to this RFP via e-mail to the designated NEEP contact. All questions submitted prior to the deadline noted in the Milestone Schedule will be answered to the best of NEEP's ability and posted to NEEP's website.

Proposals must include the following:

- Proposal Cover
- Signed Transmittal Letter
- Table of Contents
- Executive Summary
- Work Scope of Services and Schedule
- Staffing and Subcontracting Plan
- Qualifications and Experience
- Budget and Billing Rates
- Appendix – Resumes of Key Staff
- Appendix – Exceptions to NEEP Standard Consulting Agreement (Appendix A), *if any*
- Appendix – Conflicts of Interest, *if any*

The proposal cover must indicate the RFP name, the proposal date, bidder's name, and list of subcontractors. The transmittal letter must state that the person signing the letter is authorized to commit the bidding organization to the proposed work scope, budget, and rates; that the information in the proposal is accurate; and that the proposal is valid for 90 days from the date of submittal.

Proposals should be submitted in both Word and PDF format. Bidders are *not* required to submit print copies of their proposals.

A confirmation of receipt will be sent via e-mail to those who submit proposals on time. Late submittals will be rejected. NEEP also reserves the right to reject as non-responsive any proposals that do not contain the information requested in this RFP. NEEP is not liable for any costs incurred by any person or firm responding to this RFP or participating in best and final interviews.

Minimum Qualifications

A single firm or a team of firms under a single primary contractor may submit bids. Changes in proposed key staff members may not be made during the execution of the work without written approval by NEEP.

Post Proposal Negotiation and Awarding of Contracts

NEEP reserves the right to negotiate both price and non-price factors during any post-proposal negotiations with a finalist. NEEP has no obligation to enter into an agreement with any respondent to this RFP and may terminate or modify this RFP at any time without liability or obligation to any respondent.

Acceptance of Terms and Conditions

The submission of a proposal to NEEP shall constitute a bidder's acknowledgement and acceptance of the terms, conditions, and requirements outlined in this RFP.

NEEP will utilize its standard Consulting Agreement (Appendix A) as the basis for an agreement between NEEP and the selected bidder for the services outlined in this RFP. A list of exceptions to the terms and conditions outlined in the Consulting Agreement should be returned with the bidder's response.

All proposals submitted to NEEP pursuant to this RFP shall become the exclusive property of NEEP and may be used for any reasonable purpose by NEEP.

Evaluation of Proposals

NEEP will base its evaluation of proposals on the scoring matrix below. As noted above, the qualifications of key staff assigned to lead this project and the amount of time they commit to the project will be weighed heavily.

RFP Evaluation Criteria/Scoring Matrix
Part A: General Approach
Proposal quality – comprehension and clarity regarding meeting project objectives and quality of proposed approach for meeting those objectives
Thoroughness and practicality of approach
Creativity of approach
Part B: Management Approach
Dedicated resources
Demonstrated management competence of key staff
Approach to use and management of subcontractors (if applicable)
Part C: Qualifications and Experience
Demonstrated competence and experience of key staff and firm(s)
References
Part D: Cost
Total costs
Billing rates and direct costs/subcontractor mark-up rates (if any)

ATTACHMENT A
Scope of Services & Budget

Objective

Research Goals

The objective of this research is to determine the representativeness of different heat pump (HP) test procedures through observation of HP performance in a controlled field installation and comparison with corresponding laboratory test results. In particular, the Funders would like to see how well the HP test procedures prevalent in North America (CSA EXP07[2] and DOE Appendix M1[3]) represent energy use of HPs that are installed in buildings, and to investigate key conditions and sequences (e.g. defrost, variation of compressor speed at part load) that affect instantaneous power demand and overall energy use.

Research Questions

The specific research questions include:

- How well does Appendix M1 represent field performance?
- How well does CSA EXP07 represent field performance?
- What are essential pieces of information that need to be captured by any HP test procedure in order to accurately represent HP performance? (For example, are there any controls sequences that are particularly impactful to performance?)
- Are there critical performance indicators that could effectively be used to differentiate efficient equipment in a qualified product list? For example, are there identifiable tests or performance parameters that could be used, potentially in combination with existing test results, as an improved metric in the near term, to indicate overall performance? Are there performance parameters that can be used to define a "performance map" that can be used to effectively estimate seasonal ratings?

Proposed Approach

The project requires installing three ductless and three ducted heat pump systems in thermally calibrated construction trailers, located at a common site. These will be operated under identical conditions. Trailers will be calibrated to provide appropriate heating and cooling loads and thermal mass, and heat pumps installed no later than December 31st, 2021 and operated until August 31st, 2022 so that ample data can be collected during both heating and cooling seasons. After field testing, the heat pump units will be shipped to Underwriters Laboratory facility located in Plano Texas to undergo CSA and M1 lab testing. Data gathered during the project will be shared with a DOE national laboratory (TBD) for analysis, so that the contractor can provide synthesis of results and a summary report completed before the end of 2022.

The Contractor will make all efforts to equalize the variables shown in the table below that impact heat pump performance.

[2] CSA EXP07:19 (www.csagroup.org/store/product/CSA%20EXP07:19/) is the current version. The test used for this research is expected to be the 2021 published version update.

[3] CFR Title 10 Part 430 Appendix M1 (http://ecfr.io/Title-10/Part-430/Appendix-M1#10:3.0.1.4.18.2.13.6.23)

Variables that impact performance	Proposed Test Plan
Building construction	• Use calibrated construction trailers with thermal characteristics closely matched to EXP07 load lines and heat pump capacities • Adjust infiltration through weatherization techniques • Adjust heating load using rigid foam insulation • Adjust cooling load by blocking windows as needed • Adjust thermal capacitance using CMU blocks
Equipment installation and commissioning	• Ensure length of refrigerant lines are the same and match Appendix M1 • Commissioned so refrigerant charge and air flows meet manufacturer specifications • Thermostats in the same location in each trailer (interior wall away from window & supply air)
Occupancy patterns	• Unoccupied • Test with consistent simulated internal gains- resistance heaters and humidifiers to a defined specification and schedule
Thermostat settings	• Use consistent thermostat settings & setpoints • For primary testing, eliminate the use of setback, to eliminate that source of variability and uncertainty • For a secondary test period each season (approximately 2-3 weeks/season, but no more than 25% of total season test time) investigate the use of setback to determine the response of different units and the effect on energy use, and instantaneous power demand. • User settings for conditioning, fan settings, vane operation (for ductless), and others will be as specified.
Location/Climate of field test site	• Heating design temp ~5°F • Significant hours in cooling season at 95°F • Potentially parked in mobile home or RV park • If general location is identified, NEEP and Funders may assist in locating and securing a specific test site • Specific location TBD by Contractor & confirmed with Funders
Ductwork (applies to central ducted units only)	• All ductwork installed interior to the construction trailer. Ductwork shall be sufficient to distribute airflow throughout trailer and shall be constructed of fiberboard or sheet metal. Install balancing damper(s) to meet static pressure requirements in CSA EXP07 and Appendix M1 at full-load air flow
Emergency Heat	• Backup heat measured and provided by electric resistance heaters in trailers. Electric resistance heat to be approximately 3 kW, based on building load and heat pump capacity at design.

	• Control by wall-mounted relay thermostat mounted next to heat pump control/thermostat, but set a few degrees lower to set indoor temperature "floor".
Types of units	• Both central ducted and ductless HP units
Target HSPF	• Cohort #1: Lower, all approximately HSPF 9. Three units, mix of ducted & ductless. • Cohort #2: Higher. All approximately HSFP 12. Three units, mix of ducted & ductless. • Analysis will include comparison of field results with ratings, normalized by lab test rating
Unit Sizing & Selection	• Funding organizations/ Advisory Group are in the process of establishing partnerships with specific manufacturers as subsequent M1 lab testing will require direct manufacturer involvement. NEEP expects to have these partnerships established by the time of contractor selection. • Units will be nominally sized 1 to 1-1/2 tons based on rated cooling capacity

Each test unit will be lab tested to both CSA EXP07 and Appendix M1 after field testing is complete. This testing will be arranged separately by the Funders.

Collaboration

This is a highly collaborative project with multiple interested parties. The Contractor will be required to collaborate with several consultees who have actively participated in the development of this test plan. While these groups continue to evolve, current requirements for collaboration are listed below.

Advisory Group Coordination

All direct funding and in-kind contribution organizations will be part of an Advisory Group that will meet at least monthly to coordinate the work and guide the direction of the project at major decision points. NEEP or another participating organization will take the role of hosting and setting the agenda for these meetings. The NRCan team working on CSA EXP07 will be an essential member of this advisory group to ensure this work is complimentary to their work. The Contractor will attend these meetings to provide updates and receive input on decision points.

AHRI and Manufacturer Participation

AHRI researchers have expressed initial interest in this project and in the desire to test units to Appendix M1 after the field monitoring. Manufacturers whose products stand to gain from more accurate in-field performance ratings have expressed interest in participation in this project. All reporting of which products are tested will be anonymous, but data and participation by manufacturers will be actively sought to ensure the systems are installed and operated according to their specifications. NEEP and funders are still in the process of establishing manufacturer partners who will agree to assist in M1 testing, and products will be selected from among their catalogs based on suitability for this project (including rated efficiency and capacity).

Tasks & Deliverables

Task 1: Conduct Study Kick-off Meeting

Contractor shall conduct a Kick-off Meeting with the Advisory Group to present the Contractor's initial plan and collect input. The selected Contractor is expected to work closely with the Advisory Group throughout the study. The Contractor will present their proposed research plan and schedule, how the plan achieves the studies research goals and objectives, establish points of contact, and discuss points of coordination between the Contractor and the Advisory Group.

The kick-off meeting will allow the Contractor to obtain input on the research goals and proposed research plan, which will feed into the work plan described in Task 2.

Deliverable:

- Slide deck presentation and meeting minutes.

Task 2: Build Out Work Plan

The Contractor will develop a detailed work plan incorporating feedback received at the kick-off meeting and the project goals. The Work Plan will include details about important steps and progress milestones along with an associated timeline.

Deliverable:

- Draft and Final work plan

Task 3: Finalize Measurement & Verification Plan

General requirements for measurement and verification are presented in this RFP. The Contractor shall finalize a detailed measurement and verification plan based on data requirements and Contractor's experience.

Deliverable:

- Final M&V Plan detailing the sensors that will be used, locations, and accuracy and/or calibration information.

Task 4: Trailer Setup & Calibration and Equipment Installation

Site Procurement

Contractor is responsible for procuring an appropriate location for the test. One of the funders is exploring use a secure site on utility property that may be considered as a cost saving option. The chosen site must be capable of fitting all six units. All heating tests must be performed in one location and all cooling tests must be performed in one location. Trailers could be moved in-between testing, if proper commissioning is done after relocation, or all tests may be conducted at one site.

Heating tests should be performed in an area with a heating design temperature close to 5°F. The bin data used in AHRI210/240 for Region IV ratings suggests a design temperature close to 5°F, which is the colder side of DOE Region IV (as defined in AHRI 210/240)..

Cooling tests should be performed in a climate that are expected statistically to include hours at or above 95°F. Ideally the tests will be conducted at an elevation between 500 and 1500 ft above sea level, to avoid the need to normalize the results to typical operating conditions. .

Trailer Setup & Calibration

The Contractor will be responsible for procuring, setting up, and calibrating the construction trailers to closely represent the thermal characteristics of single-family homes using values consistent with the load lines in EXP07, as well as to perform as similarly as possible to each other, to maintain comparability across the trailers. The Contractor will perform blower-door tests, co-heating tests, and dynamic pulse heat tests in each trailer using resistance heaters to estimate UA and thermal capacitance.

Blower-door Tests

After a preliminary blower-door test, the Contractor will use weatherization techniques to adjust infiltration rates of each trailer to be as similar as possible to each other (ideally within 5%) and to represent typical residential homes (e.g., a normalized leakage value around 1.0 or ACH50 value around 5 may be appropriate, although the specific value should be selected and validated by the Contractor in consultation with the Advisory Group). The Contractor shall record pre-adjustment and post-adjustment values as part of setup and commissioning.

Co-heating Tests

The co-heating test involves heating the building to a constant internal temperature, over a period of time, typically 1 to 3 weeks. The Contractor shall use electric resistance heaters with separate small fans to ensure good air mixing so that there is an even temperature throughout the building. For optimum testing there should be a temperature difference of at least 10°C (18°F) between the interior and exterior. Nighttime temperatures and/or daily averages may be used to calculate UA values.

The Contractor shall perform an energy balance to establish an overall UA value. The Contractor will use rigid insulation to adjust the overall UA values in each trailer to match the heating load line in EXP07, Equation B.21.

Dynamic Pulse Heat Tests

The Contractor will use lightweight CMU blocks (stacked on their sides with space for surface exposure) to adjust thermal capacitance mass in each trailer to match the thermal capacitance in EXP07, Equation B.6. Calibrated values should be identical (ideally within 5%) from trailer to trailer. The target is a thermal capacitance in Btu/°F of C = 0.8 * Qc(95) /24 (where Qc(95) is the rated cooling capacity), which is a time constant approximately 4.5 hours.

Heat Pump Installation and Ductwork

The Contractor shall ensure systems are properly installed and commissioned, with refrigerant charge verified to be correct based on the manufacturer specifications. Included below are specific installation considerations the Contractor shall follow.

Controls Settings: During the majority of the test period, keep thermostat set to either heat (for heating tests) or cool (for cooling tests). All trailers should use identical thermostat set points (with no setback) including any identifiable offset, to maintain the indoor temperature as specified in EXP07 - and "auto" fan speed. Ductless vanes shall be set in an open position, without modulation. In addition, each season shall include a short test period (approximately 2-3 weeks/season, but no more than 25% of the test period) to investigate the use of setback (5-10°F, exact amount TBD) to determine the response of different units and the effect on energy use and instantaneous power demand.
Thermostat location inside trailer: Use interior wall in the middle of trailer; mount thermostats 5' above floor, away from direct sun, supply air, and exterior walls. Units that have manufacturer- supplied wall-mount thermostats will use those. Units that are not supplied with thermostats (if any) will have a "non-smart" thermostat – specific make and model TBD. Ductless units will have wall-mount controls.
Use of strip heat. Electric strip heat provided with the HP unit shall not be used. Backup heat may be needed to maintain consistent indoor conditions for comparable tests; but Contractor needs to ensure consistent use of backup heat and limit it to making up only the "difference" between HP capacity and building load as needed for the coldest temperatures. Backup heat shall be measured and provided by ER heaters in trailers. Contractor shall install 2-3 kW of heat, with sizing based on building load and heat pump capacity at the outdoor design temperature. Control of these heaters will be by wall-mounted relay thermostat mounted next to the heat pump control/thermostat, but set approximately 3°F degrees lower to establish an indoor temperature "floor". Backup heat shall turn off when room is warmed above 2°F below the heat pump setpoint.
Duct systems. All ductwork shall be installed inside the conditioned space to eliminate duct losses and gains. Ductwork may be constructed from sheet metal or fiber board, and shall have balancing dampers to adjust static pressure. Static pressure shall be consistent with rating test procedures. Table B.2 in EXP07 lists these values.

Instrumentation Installation

To estimate system performance, two measurements are needed: power consumed and capacity delivered. However, additional parameters may be needed to understand how the unit is consuming power and better differentiate important parameters or characteristics that affect performance. In addition, Contractor shall collect sufficient measurements to ensure that the heating and cooling loads in each trailer is consistent throughout the test period. Contractor shall arrange to monitor sensors on an ongoing basis, whether by remote uplink or by actually collecting data from loggers, and make adjustments as necessary

This list is meant to be a starting point from which the selected field test contractor can develop the specific plan needed to fully address the research questions and objectives stated above. Suggested data collection points:

- Outdoor unit power
- Compressor speed
- Indoor unit power
- Backup heat power
- Outdoor air temperature and humidity
- Indoor air temperature and humidity
- Return air temperature
- Supply air temperature

- RH (relative humidity) measurement at return and supply (of indoor head if ductless)
- Indoor air flow rate (obtained via system fan curve using tachometer correlation, or fan electrical consumption correlation)
- Vapor line temperature, for device status with a strap or clamp on thermistor
- System runtime
- Power & water used for simulated internal gains
- Any unit controls, sensors, or outputs that can be accessed and recorded
- Condensate flow - useful for validation of latent capacity
- Refrigerant side pressure and temperature measurement at critical locations such as liquid/vapor lines.

Contractor will verify proper operation and measurement tolerances. Equivalent quality assurance measures, such as an ice bath calibration test for thermocouple probes, may be acceptable.

To increase the accuracy, a minimum of 3 air temperature sensors (at left, center and right on a grid) will be installed each side of the indoor coil for ductless unit. Temperatures should be measured near indoor head inlet, but shielded from indoor coil and other radiant heat sources. For ducted unit, have 2 temperature sensors each on supply and return side.

Deliverables: Commissioning documents showing, for each trailer:

- pre- and post-calibration results for blower door testing, co-heating, and dynamic pulse heating tests
- calibrated normalized Leakage, UA values, and thermal capacitance
- proper installation of heat pumps, thermostats, and ductwork
- calibration and installation documentation for all instrumentation

Task 5: Conduct Tests

Heating Tests

Contractor shall conduct heating tests with all trailers in the same location such as a trailer park or mobile home site (site to be determined, coordinated, and procured by the Contractor). Data shall be collected for at least 3 months and up to 6 months. Data shall be collected at 5-minute intervals or shorter. Data logger should be configured for remote communication via a land-line modem, wireless modem, internet, or equivalent method. Data should be transferred at an interval such that modem faults and sensor issues may be noticed and corrected before critical data are lost. To ensure continuous data quality, for each building, Contractor shall compile and submit a monthly data summary depicting the performance of each trailer/HP over the preceding month (except that the data summary shall be provided after the first week of heating tests). Key metrics to report shall be agreed upon with the Advisory Group prior to submitting the first report.

For approximately 2-3 weeks, but no more than 25% of total season test time, Contractor shall investigate HP unit behavior when using night setback at a range of outdoor temperatures.

Deliverables:

- Monthly data summary depicting the performance of each trailer/HP over the preceding month.

Cooling Tests

Contractor shall conduct cooling tests with all trailers in the same location such as a trailer park or mobile home site. This location may be different than the heating tests, but Contractor must perform all of Task 4 items again to assure quality data.

Data shall be collected for at least 3 months and up to 6 months. Data shall be collected at 5-minute intervals or shorter. Data logger should be configured for remote communication via a land-line modem, wireless modem, internet, or equivalent method. Data should be transferred at an interval such that modem faults and sensor issues may be noticed and corrected before critical data are lost. To ensure continuous data quality, for each building, Contractor shall compile and submit a monthly data summary depicting the performance of each trailer/HP over the preceding month (except that the data summary shall be provided after the first week of heating tests). Key metrics to report shall be agreed upon with the Advisory Group prior to submitting the first report.

For approximately 2-3 weeks, but no more than 25% of total season test time, Contractor shall investigate HP unit behavior when using night setback at various outdoor temperatures.

Deliverable:

- Monthly data summary depicting the performance of each trailer/HP over the preceding month.

Task 6: Lab Tests

Contractor shall prepare units from the field test location and ship to NEEP specified test lab, where the units will be tested according to EXP07 and M1. It is anticipated that NEEP and Funders will identify manufacturers who will partner with the lab to conduct M1 testing. NEEP will arrange lab testing directly with the lab.

Deliverables:

- Tracking data for shipments to specified lab.

Task 7: Data Analysis and Reporting

U.S. DOE has agreed to provide national lab (Lawrence Berkley National Laboratory, LBNL) staff support in conducting the analysis of the collected data, both in-field and lab. It is expected that the lab support will be primarily responsible for completing the following analysis. The contractor is expected to be sure the data collected from in-field and lab tests are made available to LBNL. LBNL will then share the results of their analysis to the Contractor, who will then complete a written report capturing the research activities and analysis results. The division of responsibilities for final reporting between LBNL and the Contractor shall be determined during the field data collection process.

Research goals and questions as listed may evolve, but the following represents some key questions to which the funders are seeking answers:

At end of heating test, interim heating test results should include the following:

- Calculated Field Seasonal COP for each unit as explained in Data Analysis Requirements section below.

- Calculated COP map across the range of heating temperatures (may be binned).
- Analysis of heat pump performance across a range of heating temperatures.
    - Do compressor speeds smoothly modulate down at milder temperatures and smoothly modulate up at lower temperatures?
    - Is turn-down ratio a good indicator of heat pump heating performance?
    - What is the cycling penalty under part-load conditions?

At end of cooling tests, interim cooling test results should include the following:

- Calculated Field Seasonal COP for each unit as explained in Data Analysis Requirements section below.
- Calculated COP map across the range of cooling temperatures (may be binned).
- Analysis of heat pump performance across a range of cooling temperatures.
    - Do compressor speeds smoothly modulate down at milder temperatures and smoothly modulate up at higher temperatures?
    - Is turn-down ratio a good indicator of heat pump cooling performance?
    - What is the cycling penalty under part-load conditions?

M1 & EXP07 Representativeness Comparison

As field data is collected, the analysis procedure for each model is as follows:

- Measure/calculate field COP vs OAT (outside air temperature)
    - Use daily data to calculate COP vs OAT
    - This data should include defrost and standby power, as measured
- Calculate normalized field-tested Heating Seasonal COP ($FSCOP_h$) using bin hours from Region IV and from EXP07
- Calculate normalized field-tested Cooling Seasonal COP ($FSCOP_c$) using bin hours from Region IV and from EXP07
- Obtain EXP07 SCOP values using lab test results for each model
- Obtain M1 SEER2/HSPF2 values using lab test results for each model
- Compare M1, CSA EXP07, and $FSCOP_h$ ratings
    - Focus in particular on relative rankings and performance
    - Unit performance will need to be normalized to the rating procedures (calculate a percent difference from ratings- e.g. % from HSFP2, % from $SCOP_h$)

Critical Indicators Analysis

The minute-by-minute data will be used to investigate how different units vary compressor and fan speed under different circumstances. The Funders are particularly interested in how smoothly compressors load and unload in the part-load conditions (at roughly 47°F and 82°F).

Deliverable: Full report with appendices of field test data. Critical results must include:

- Comparison of Appendix M1 ratings to normalized field results
- Comparison of EXP07 ratings to normalized field results

- Analysis of heat pump performance at a range of temperatures, including a focus on low temperatures (5°F) and at mild temperatures (e.g. 47°F.)
- Analysis of heat pump performance at a range of temperatures, including a focus on high temperatures (95°F) and at mild temperatures (e.g. 82°F.)
- Analysis shall include identification of any factors that significantly influence performance (turn-down ratio, cyclic behavior, defrost energy use, etc.)
- Recommendations for what factors or procedures are critical to include in a HP test procedure to effectively represent and differentiate performance
- Recommendations for what factors or performance indicators could be considered in the short term to effectively identify high-performing units

Schedule

The anticipated timeline of this project is from September 2021 to December 2022.

Anticipated dates	Action
July-August 2021	• Issue RFP • Select Contractor
PHASE 1	
September-December 2021	• Sign contract • Finalize Work Plan • Finalize EM&V Plan • Trailer Setup & Calibration and Equipment Installation
PHASE 2	
January 2021 –April 2022	• Data collection (heating)
April - May 2022	• Initial analysis & reporting (heating)
May – August 2022	• In-field setup (cooling) • Data collection (cooling)
September – October 2022	• Appendix M1 & EXP07 testing
November – December 2022	• Final analysis & reporting

ATTACHMENT B
Payment and Invoicing Guidelines

1. Invoices will be issued monthly or after completion of the specified deliverable for services and expenses up to the approved budget.
   A. Invoices are due by the 20th of each month for services and expenses in the previous month or after completion of the specified deliverable.
   B. Invoices must be consistent with the approved Scope of Work and not exceed the contract budget.
   C. Invoices must be itemized by line item as shown in Scope of Work.

2. Invoices should be billed to the following address and via email to billing@neep.org:

   Northeast Energy Efficiency Partnerships, Inc.
   Attn: Accounts Payable
   81 Hartwell Avenue, Suite 220
   Lexington, MA 02421

3. Invoice documentation should include:
   A. Contractor's Taxpayer Identification Number
   B. For Contractor labor/services:
      1. Total hours worked during the billing period.
      2. Approved billing rate.
      3. Total amount billed for the month.
      4. Overhead charges for billable hours (as approved in budget).
      5. Summary of activities during billing period.
   C. For expenses:
      1. A list of expenses.
      2. Receipts for all expenses.
      3. Explanation of breakout for shared expenses as applicable (i.e., for travel costs shared with another project).

4. Invoices must include an itemized budget summary that indicates:
   A. Total Approved Budget
   B. Total of Previous Invoices
   C. Total Current Invoice
   D. Remaining Budget

5. Invoice should clearly indicate the name and address of the authorized person to whom payment must be sent.

6. All invoice payments will be made payable to Contractor within 30 days of receipt of invoice.

ATTACHMENT C
Insurance Requirements

Provide Certificate of Insurance to NEEP with signed Agreement and provide 30-day Notice of Cancellation for all insurance coverage.

Coverage	Minimum Limits
Commercial General Liability Bodily Injury & Property Damage Premises Liability Products/Completed Operations Personal & Advertising Injury Contractual Liability	$1,000,000 per occurrence (Combined BI PD) $1,000,000 Personal & Advertising Injury $2,000,000 Aggregate $2,000,000 Products/Completed Operations Aggregate
Professional E & O Liability	$1,000,000 Policy Limit
Automobile For Owned, leased, hired, and non-owned automobiles	$1,000,000 Combined Single Limit per accident
Umbrella	$3,000,000 each occurrence and aggregate Products/Completed Operations included
Workers' Compensation	Statutory coverage
Disability Coverage	If located in New Jersey or New York, provide confirmation of State Disability Coverage
Employers Liability	$1,000,000 each accident $1,000,000 disease – each employee $1,000,000 disease – policy limit

Additional Insured Wording	Contractor shall include Northeast Energy Efficiency Partnerships, Inc. and their respective subsidiaries, affiliates, directors, officers, and employees as additional insured under Commercial General Liability, Professional E & O Liability, Commercial Automobile Liability, and Commercial Umbrella Liability policies.
Waiver of Subrogation	Contractor shall include Waiver of Subrogation in favor of Northeast Energy Efficiency Partnerships, Inc. and their respective subsidiaries, affiliates, directors, officers, and employees as additional insured under Workers' Compensation, Commercial General Liability, Commercial Automobile Liability, and Commercial Umbrella Liability policies where allowed by law.
Primary & Non-Contributory	Contractor's Commercial General Liability, Commercial Automobile Liability, and Commercial Umbrella Liability policies shall be primary and noncontributory with any other insurance carried by Northeast Energy Efficiency Partnerships, Inc.

Certificate Holder to read: **Northeast Energy Efficiency Partnerships, Inc.**
81 Hartwell Avenue, Lexington, MA 02421

Appendix A:
NEEP Standard Consulting Agreement

Northeast Energy Efficiency Partnerships, Inc.
Consulting Agreement with
COMPANY NAME

This Agreement is made and entered into as of DATE by and between Northeast Energy Efficiency Partnerships, Inc. at 81 Hartwell Avenue, Suite 220, Lexington, MA 02421, USA (hereinafter referred to as "NEEP"), a Massachusetts non-profit corporation, and COMPANY NAME, a consulting company, at ADDRESS, CITY, STATE ZIP (hereinafter referred to as "Contractor").

WHEREAS, NEEP is a 501(c)(3) tax-exempt non-profit corporation organized for the purposes of accelerating energy efficiency as an essential part of demand-side solutions that enable a sustainable regional energy system in the Northeast and Mid-Atlantic states, and

WHEREAS, Contractor is engaged in the business of providing professional consulting services.

NOW, THEREFORE, in consideration of the promises, the mutual covenants and agreements herein contained, and other valuable consideration, the receipt, adequacy and sufficiency of which are hereby acknowledged, the parties do hereby agree as follows:

1. **Scope of Services and Work / Special Terms & Conditions**
   Contractor shall, at the direction of NEEP, perform the services outlined in Attachment A, Scope of Services and Budget.

   Contractor's work shall be carried out by NAME, and shall be overseen by NAME of NEEP. Contractor agrees that it may not substitute any individual for NAME to carry out its work under this Agreement without the prior written consent of NEEP.

   Contractor agrees to meet or exceed the customary standards of care and professionalism expected in Contractor's industry or area of expertise in performing all services under this Agreement.

2. **Independent Consultant**
   Contractor shall at all times be deemed to be an independent consultant. Nothing contained in this Agreement shall be construed as creating the relationship of employer and employee between NEEP and Contractor. Contractor acknowledges and agrees that neither it nor its employees are employees of NEEP and that Contractor is solely responsible for all federal and/or state tax and Social Security liability that may result from performance of and compensation for services under this Agreement. Contractor represents and warrants that all of its employees are eligible to work in the United States and that it has confirmed such eligibility using E-Verify, the Internet-based system that compares information from an employee's Form I-9, Employment Eligibility Verification, to data from U.S. Department of Homeland Security and Social Security Administration records to confirm employment eligibility. NEEP acknowledges and agrees that Contractor is free to provide services to

other clients as long as such provision of services does not interfere with its obligations under this Agreement.

3. Term

The period of performance shall begin on the date of this Agreement as set forth above and continue as outlined in Attachment A.

4. Compensation and Payment

Services performed by Contractor will be billed for completion of deliverables, as outlined in Attachment A and consistent with the process outlined in Attachment B, Payment and Invoicing Guidelines. Total billings shall not exceed the budget, as outlined in Attachment A, without prior written approval of NEEP.

5. Indemnification

Contractor shall indemnify and hold NEEP harmless against all loss, cost, expense, injury and damage resulting in any way from any negligent act or omission on the part of Contractor or any of its subcontractors or resulting directly or indirectly from Contractor's performance under this Agreement, except to the extent that any such loss or expense is due solely to the negligence of NEEP.

6. Insurance Requirements

Contractor shall provide a current Certificate of Insurance ("COI") to NEEP when signing this contract evidencing that it maintains insurance sufficient to cover all work to be performed under this Agreement and the indemnity obligation herein. All such insurance shall be maintained in force throughout the term of this Agreement. Contractor shall ensure that NEEP is added as an additional insured as provided in Attachment C. All insurance coverage shall be provided by insurance companies acceptable to NEEP and having ratings of A- or better as rated by Best's Key Rating Insurance Guide. Minimum insurance coverage is outlined in Attachment C: Insurance Requirements.

7. Termination

a) This Agreement shall terminate upon completion of all services that Contractor has agreed to perform pursuant to Paragraph 1 above. NEEP, by written notice, may terminate this Contract for any reason, with or without cause, in whole or in part, at any time. In the event of termination of the Agreement without cause, NEEP will make a pro-rata payment to Contractor based upon the percent of work completed as of the termination date, which payment shall in no event exceed the estimated budget as set forth in Attachment A, and shall have no further liability to Contractor. In the event NEEP has pre-paid for any services or work not satisfactorily completed as of the termination date, Contractor shall return a pro-rata portion of the payment that corresponds to the unfinished work.

b) NEEP shall have the right to terminate this Agreement for cause in the event the Contractor is responsible for repeated, persistent or substantial violations of the Agreement, fails to perform, or becomes unable to perform its obligations under this Agreement or fails to provide adequate assurances if requested in writing that it will perform its obligations under the Agreement. In the event NEEP terminates for cause, no further payment will be due.

c) The Contractor may terminate this Agreement upon 30 days' written notice to NEEP. In the event NEEP has pre-paid for any services or work not satisfactorily completed as of the termination date, Contractor shall return a pro-rata portion of the payment that corresponds to the unfinished work.

d) The scope of work is structured into two phases. While funding has been committed by a collection of funders, in the case that NEEP is not able to secure Phase 2 funding from the project's partners, NEEP may be forced to terminate or modify the contract at the end of Phase 1.

8. Assignment

Neither party may assign its obligations or rights under this Agreement without the written consent of the other party.

9. Subcontracts

Contractor shall provide written notice to NEEP of its intention to use a Subcontractor prior to commencement of the Subcontractor's services. NEEP shall have the right of refusal regarding the use of a Subcontractor and approval shall not be unreasonably withheld. Contractor shall remain fully responsible to NEEP for performance under this Agreement, and shall be responsible for the timely delivery of services and quality of work of Subcontractor. Contractor shall not charge NEEP a rate higher than that in Attachment A for specific tasks.

The Contractor shall assume toward the Subcontractor all obligations and responsibilities that NEEP, under this agreement, assumes toward the Contractor, and the Subcontractor shall assume toward the Contractor all obligations and responsibilities which the Contractor, under this agreement, assumes toward NEEP. The Contractor shall have the benefit of all rights, remedies and redress against the Subcontractor that NEEP, under this agreement, has against the Contractor, and the Subcontractor shall have the benefit of all rights, remedies and redress against the Contractor that the Contractor, under this agreement, has against NEEP, insofar as applicable to the Subcontractor.

10. Intellectual Proprietary Rights

All works, materials, information, protocols, processes, data, results, work product, and other items conceived, created, developed, or produced by Contractor or any of its Subcontractors under this Agreement (the "Works and Materials") shall constitute "works made for hire" as that term is defined in Section 101 of the Copyright Act (17 U.S.C. §101) or have similar status under relevant intellectual property law. All right, title, and interest in and to all Works and Materials, including licenses, copyrights, trademarks, patents, and all other intellectual property rights, as between NEEP and Contractor/Subcontractors, shall be owned exclusively by NEEP, and neither Contractor nor any Subcontractor shall have any right, title, or interest in or to such Works and Materials. Contractor agrees to execute any documents of assignment requested by NEEP. To the extent that title to any such Works and Materials may not, by operation of law, vest in NEEP or such Works and Materials may not be considered works made for hire, all rights, title and interest herein, including all intellectual property rights therein or thereto, are hereby irrevocably assigned to NEEP.

The paragraph immediately above shall not apply to Contractor Property. The term "Contractor Property" shall mean all pre-existing material, including, but not limited to, any products, software, materials and methodologies proprietary to Contractor or provided by Contractor or its suppliers

and any trade secrets, know-how, methodologies and processes related to Contractor's products or services, all of which shall remain the sole and exclusive property of Contractor or its suppliers. Contractor hereby grants to NEEP a non-exclusive, non-transferable, irrevocable license to use the Contractor Property contained in the Works and Materials and deliverables provided hereunder for NEEP's nonprofit purposes only.

11. Non-Disclosure

The parties acknowledge that under this Agreement Contractor will likely receive or be shown in hard copy or electronic form "Confidential Information" of NEEP. Contractor agrees that it will not use, share or disclose any "Confidential Information" of NEEP without prior written consent, except for the purpose of performance under this Agreement. Access to the Confidential Information will be limited to those of Contractor's employees who must have access to enable such performance. "Confidential Information" for these purposes includes, but is not limited to, all information marked confidential by NEEP, as well as all intellectual property and proprietary information of NEEP, and information relating to NEEP's personnel, board, strategies, tactics, finances, plans and operations. Contractor shall return or destroy all copies of Confidential Information upon termination or expiration of this Agreement.

12. Representations

Contractor represents and warrants that it has the legal right and authority to enter into this Agreement and that its performance hereunder will not conflict with or violate any commitment, agreement, or understanding it has to or with any other person or entity.

13. Access to Books and Records

NEEP, and any of its duly authorized representatives, shall have access to any books, documents, papers, and records of Contractor which are directly pertinent to this contract for the purposes of making audits, examinations, excerpts and transcriptions. Such access shall be provided as requested, at reasonable times, during the Term of this Agreement and for two (2) years thereafter.

14. Governing Law

Any actions arising out of this Agreement shall be governed by the laws of the Commonwealth of Massachusetts, and shall be brought in a state or federal court within the Commonwealth, which shall have exclusive jurisdiction thereof.

15. Notices

Any notice required to be given or otherwise given pursuant to this Agreement shall be in writing and shall be hand delivered, mailed by certified mail, return receipt requested, or sent by recognized overnight courier service as follows

If to Contractor: NAME
TITLE
COMPANY NAME
ADDRESS
CITY, STATE ZIP

If to NEEP: Robert M. McTighe

Director of Finance & Administration
Northeast Energy Efficiency Partnerships, Inc.
81 Hartwell Avenue, Suite 220
Lexington, MA 02421

16. Severability

If any term of this Agreement is held by a court of competent jurisdiction to be invalid or unenforceable, then this Agreement, including all of the remaining terms, will remain in full force and effect as if such invalid or unenforceable term had never been included.

17. Amendment

No amendment, modification, extension, or rescission of any term or provision of this Agreement shall be effective unless agreed upon in writing by both parties.

18. Waiver

The failure of either party to enforce any provision of this Agreement shall not be construed as a waiver or limitation of that party's right to subsequently enforce and compel strict compliance with every provision of this Agreement.

19. Entire Agreement

This Agreement and all attachments hereto contain the entire agreement of the parties with respect to the matters covered herein and cannot be modified, except in writing signed by both parties.

IN WITNESS WHEREOF, the parties hereto have executed this Agreement by their duly authorized representatives on the day and year set forth below.

Northeast Energy Efficiency Partnerships, Inc.	COMPANY NAME
By: _____	By: _____
Name: Robert M. McTighe	Name: NAME
Title: Dir. of Finance & Administration	Title: TITLE
Date: _____	Date: _____
EIN: 81-3283869	EIN / TIN: EIN OR TIN NUMBER