Task 2. Request for Proposals: Advancing DERMS Technologies

Task sponsored by Diamond Sponsor El Paso Electric Company
and Gold Sponsor Las Cruces Utilities

Task developed by El Paso Electric Company, Las Cruces Utilities, and NMSU Staff

Background

El Paso Electric Company (EPE) and Las Cruces Utilities (LCU) invite your team to join us as we continue our efforts toward a greener and more sustainable future.

As more renewable and emergent technologies, such as rooftop solar, Battery Energy Storage Systems (BESS), and Electric Vehicle (EV) adoption continue to grow in our region, we are looking for ways to integrate these Distributed Energy Resources (DER) into the electrical grid while supporting customer engagement, education, and outreach.

DER poses challenges of increased variability and potential disruption in the modern grid's operations which warrants advanced digital solutions, such as Distributed Energy Resource Management Systems (DERMS) that can help engage with consumers (households and businesses) on the demand side to help manage these challenges.

One example of DERMS that some utilities have already implemented are demand-response programs that offer consumers incentives to shift their use of electricity, usually through the use of thermostat controls for air conditioners and heaters [1]. Since this technology has already been established, teams will not consider those applications.

Another example of DERMS implemented by some utilities is bi-directional EV charging stations, which have the capability of capturing the stored energy within the battery of an EV and transferring it to the grid or customer facility.

This task challenges your team to expand on this principle by giving consumers the means to automatically control additional household devices in response to a signal sent from the utility, based on the needs of the electrical grid. It is important to introduce flexibility in your designs to ensure that customers are in control of devices in their own home. For example, an EV owner should be able to specify a minimum state of charge (SoC) that should be maintained in the vehicle as well as the preferred vehicle departure time. The ideal design would ensure that the consumer is able to both select which devices can be used to support the grid and determine threshold limits on automatic device controls, without the controls being overly complex for the customer to use.

An important facet of this challenge is developing incentives and educational programs that will encourage customer engagement. Note that it is important to be transparent in all educational programs to mitigate distrust of the technology, reduce the number of opt outs or program unenrollment rates, or the promulgation of misinformation.

Task 2. Advancing DERMS Technologies

Aspects of customer education and engagement programs are limited only by your team's imagination and can include:

1. Informing customers of their ability to make choices that will lower their utility bill and help the environment.
2. Proposing incentives that will encourage consumer participation.
3. Informing customers of potential issues and proposing incentives to offset them.
   For example, would frequent discharge of an EV to power a home or supply energy back to the grid reduce the life of the vehicle's battery? If so, what incentives would you propose to offset this? If not, how would you demonstrate this?

<u>Grid Basics</u>
On the supply side, utility companies need to provide reliable energy. To do so, utilities predict the maximum demand required when loads are expected to reach a peak, such as during extreme weather events (very hot summer days or winter storms), and they design their power generation and Transmission and Distribution (T&D) systems to match the demand expected from peak loads. Their designs must strike a delicate balance between supply and demand, to ensure supply systems are not underbuilt which may result in outages, and are not overbuilt, as building more resources that are used for a limited number of hours may raise the cost of electricity for all rate payers.

Peak Load Events: During extreme events, customers (homeowners and businesses) use more energy than usual to heat/cool their buildings. This can exhaust the energy that the utility company is able to supply. Such peak load events place stress on the grid and may lead to brownouts or blackouts.

Low-Carbon Energy Events: Conversely, during off-peak daytime hours, the amount of solar, wind, or other low-carbon distributed energy sources may far exceed demand. Referred to as a "low-carbon event," this excess energy places a strain on the grid, often requiring a utility to pay neighboring utilities to take the excess energy off of their hands; such "negative pricing" raises costs for the utility company and its rate payers.

<u>Supporting the Grid</u>
Utility companies own the electrical grid infrastructure outside of each building's meter and they determine how power is delivered up to the meter. The customer owns everything behind the meter (BTM), including electrical panels, boxes, wiring, and all devices that require electricity.

Consider that DER consists of two subsets: 1) Power generation sources (solar, wind, nuclear, generators powered by internal combustion engines (ICE)) and 2) stored energy sources of power (EVs and BESS).

DERMS have the ability to shed, shift, modulate, or generate electricity [2]. For example, dimming lights during peak loads will shed the load, pre-heating a water heater will shift the load to off-peak times, EV charging can be shifted to off-peak or provide energy back to the building or the grid, batteries modulate power to maintain the grid, and rooftop solar generates electricity.

Through "smart" BTM technologies, consumers can support the grid during both peak load events and low-carbon energy events. Doing so can reduce a community's carbon footprint while keeping rates low for all customers. Following are the two primary examples.

Peak Load Events: During times of peak demand, reducing energy loads in each building can help the grid. An obvious solution is to employ the binary solution of turning BTM devices off/on. If a device is needed, but could operate at a reduced power level, the concept of throttling – allowing a device to pull power, but at a lower level – is an analog solution that can be used to help reduce peak loads. DERMs could orchestrate this seamlessly by allowing a utility company to digitally signal BTM devices to determine which binary, analog, or other protocols should be followed, based on thresholds set by the customer.

Low-Carbon Events: When renewable energy is abundant on the grid, it may be advantageous for customers to strategically shift the load by using more electrical power than they might ordinarily use at that time. A good example is to charge EVs when renewable energy is flowing abundantly on the grid. Since EVs need to be charged regularly, taking advantage of clean, low-carbon energy during low-carbon events will help manage excess energy on the system, potentially keep rates low by avoiding negative pricing, and, at the same time, be a better choice for the environment than charging during peak load times when high-carbon energy sources may be powering the grid.

Research and Challenges

DERMS requires more interaction between the utility and BTM devices, introducing its own layer of regulations and liability issues, since the utility is asking for control over customer equipment. For this reason, when utility companies embark on new technologies, they engage in "benchmarking," a term to describe research to evaluate similar programs proposed and/or implemented by other utilities. Teams are expected to conduct their own benchmarking for their proposed solutions and report their findings in the technical report.

EVs can be considered additional load, or a DER, in a concept known as vehicle-to-grid ("V2G"), where EVs can be charged and discharged in order to provide grid services when needed. The current challenges associated with V2G include vehicle availability, battery degradation, the need for communication software and hardware between the vehicles and the grid; effects on grid distribution equipment; infrastructure changes; and social, political, cultural and technical obstacles.

Additional DER technologies such as BESS and solar power systems each have special considerations. BESS can be considered an additional load since a certain charge must be maintained on the batteries. In addition, residential facilities may have stand-by generators that could be brought online and paralleled with the grid.

A problem with all BTM power sources such as solar, battery, or ICE generators is that there is a physical limit: the supply cannot exceed the transformer rating supplying the residential facilities. Also, existing regulatory frameworks may limit the amount of electricity they will buy from the consumer based on the power the consumer uses.

Task 2. Advancing DERMS Technologies

Problem statement

Design and develop a DERMS grid-tied solution (Application Program Interface (API), app, applet, etc.) that communicates with one or more household devices of your choice that manages the output or consumption of BTM devices (excluding heating, and air conditioning), taking input from both the utility and the household device to determine how to optimally control the reduction of, or increase in, power flow. Your plan must take into consideration utility regulatory frameworks and applicable standards.

Your team's design should allow the customer to select a small number of desired constraints, such as minimum lighting, temperature, or minimum state of charge (for an EV), according to a time schedule. It should also allow overrides between the utility and the customer in the event of emergencies.

Also included in your project will be a customer tariff that sets up incentives for customer participation and incorporates a customer education and engagement plan.

In developing their designs, teams will:

- Research and evaluate the suitability of each of the renewable and emergent BTM technologies below as they apply to the New Mexico service territory. The most suitable solutions will have the greatest net-positive impact on the utility, customer, and environment, including one or more of the following DERs to be controlled through the DERMS platform:
    - Distributed Generation (Solar, Wind, Hydro, etc.)
    - Storage (BESS)
    - Usage (e.g., EV, household appliances and lighting, electric water heaters, etc.)
- Benchmarking
    - Research similar programs that have been considered or implemented by other utilities.
        - Search publicly accessible Dockets or regulatory filings online or call a utility for basic information.
        - Review utilities' plans as well as the Commission's and intervenor comments.
        - Review strategies for managing the grid and continuing to provide comfortable living environments for consumers.
    - Structure your proposed DERMs implementation design with consideration to the Commission that has jurisdiction over New Mexico utilities.
- Develop a customer engagement program to educate the customer in:
    - Off-peak vs. peak demand and their effect on the electrical grid.
    - How DERMs-controlled devices can save money for all rate payers.
    - The safety of smart devices and dispelling rumors of adverse health effects.
    - How customer choices can help the environment.
    - Advantages/disadvantages of supporting the grid and informing consumers of incentives (see customer tariff, above).
    - How to use the team's app (API, app, applet, etc.) to control smart devices.

Task 2. Advancing DERMS Technologies

Design requirements

In addition to Problem Statement requirements, your proposed design should address the following.

- Design a DERMS grid-tied solution (API, app, applet, etc.) that communicates with one or more household devices of your choice that manages the output or consumption of BTM devices.
- Select household devices that will have the greatest impact on energy output or consumption.
- Take input from both the utility and the household device to determine how to optimally control the power flow (binary, analog, combination, or advanced).
- Allow the customer or the utility to select operating parameters and override settings when necessary.
    - The customer should set initial power-flow benchmarks (time of day, SoC, etc.)
    - The utility may override the customer settings in the event of a power emergency.
    - The customer may override the utility's override in the event of a household emergency.
- Consider demand response types (binary, analog, combination, or advanced) that will optimize energy savings.
- Select the communication type that will provide the greatest advantages (such as local [own phone or similar], with the utility's signal, or other advanced communication options).
- Respond to a minimum of one event (only peak load or only low-carbon). Teams may opt for more functionality by responding to two events (peak demand + other), or more than two events.
- Report findings from your team's benchmarking research.
- Incorporate a customer rate tariff that sets up incentives for customer participation.
- Develop a customer education, outreach, and engagement plan to encourage participation.
- Develop an operational protocol for DER engagement: how will the utility keep track of available DERs capacity and energy for dispatch? How much of this capacity is firm?
- Adhere to regulations within the utility regulatory framework and applicable standards from the Federal Energy Regulatory Commission (FERC), the North American Electric Reliability Corporation (NERC), and the National Electrical Code (NEC) standards.
- Present a Techno-Economic Assessment and Analysis (TEA) to construct a DERMS grid-tied solution (API, app, applet, etc.) that communicates between a New Mexico utility company and BTM household devices and/or electric vehicles to manage their output or consumption. The TEA will include your estimate of capital costs (CAPEX), operational costs (OPEX), including customer education costs and incentive costs. Include appropriate graphical representation of your cost data.
- To be considered for the WERC P2 Award (an award available to all teams that participate in the contest), in a separate section of the report (titled "Pollution Prevention"), document success in improving energy efficiency, pollution prevention, and/or waste minimization. Note that this task already focuses on energy efficiency. To stand out in this award category, consider implementing additional pollution prevention or waste minimization measures.
- Addressing of any safety aspects of implementing your design solutions.

Bench-Scale Demonstration

At the bench-scale demonstration in Las Cruces, teams will demonstrate their software solution for controllable operation of household devices.

In addition to the bench-scale demonstration, teams may include video productions, computer simulations, tabletop displays, and scale or architectural models to assist in the presentation; these inclusions can be beneficial to your presentation, but shall not be substitutes for the bench-scale demonstration.

Task 2. Advancing DERMS Technologies

The bench-scale demonstration will be conducted at the IDEAL Center at New Mexico State University (NMSU). The Center is a medium-to-high voltage test facility where NMSU researchers conduct experiments integrating renewables into the microgrid and smart grid infrastructures.

Teams will provide WERC with the number and type of devices that they intend to control and the voltage, current, and power ratings of each. This will help the IDEAL Center prepare for your team's demonstration (due January 31, 2023).

Pre-contest Bench-scale Testing

Teams should pre-test their equipment at their home location power systems laboratory or similar.

Analytical Testing at the Contest

Teams will connect to the IDEAL Center's power infrastructure and demonstrate their app's functionality to the contest judges.

At the contest, each team will be provided with testing infrastructure consisting of:

- 120V or 240V electrical connections, as needed (up to five electrical connections will be provided to each team for the bench-scale demonstration. However, the team's software should not necessarily be restricted to five controllable connections).
- Load banks emulating controllable devices of your team's choice.
- Wi-Fi connection.
- The equivalent of a demand response (DR) communications event from a utility company (watch task FAQs for details).

Teams are expected to bring to the contest:

- All necessary software and hardware control infrastructure needed for demonstration of up to five electrical connections.

30% Project Review

Suggested submission date: Feb. 6, 2023
Final submission date: February 24, 2023

An engineering "30% Project Review" reviews the engineering firm's preliminary design and aspects of a project with a client. It provides the client an opportunity to suggest modifications for inclusion in the final design. The goal is to define the scope of the project, present a project schedule, report progress to date to meet the final deadline, and determine fatal flaws, if any.

For the design contest, the review should not exceed four pages. Submit the project review as soon as possible. You are allowed to change your plans after submitting it. Although the review is not scored, your team will receive feedback from the judges for improving your project. (The higher the quality of your review, the more help you will get from the judges.)

At a minimum, the review must include:

- **A brief description of your project:** One bulleted list outlining: goals, planned solution to the problem, and any anticipated drawbacks.
- **A project schedule** (schedule for completion of the contest solution, including progress to date)
- **Process flow diagram** with all mass and energy balances, as needed.
- **Table of Contents** planned for the technical report (place topics in order, one line per topic)

Task 2. Advancing DERMS Technologies

Experimental Safety Plan (ESP)

The ESP outlines your team's plans for safely operating your bench-scale demonstration at the contest. This document is submitted in February (see dates below). Instructions are provided in the team manual. The Team Leader, or a designated team member, shall attend a mandatory short course that outlines the ESP process. Teams will not be able to run a bench-scale demonstration if the ESP is not received by the deadline. Your team should follow your school's safety procedures while conducting tests prior to attending the contest.

Evaluation Criteria

Each team is advised to read the 2023 Team Manual for a comprehensive understanding of the contest evaluation criteria. As described in the manual, there are five events: a written report, a formal oral presentation, a demonstration of your technology using a bench-scale representation, a poster presentation, and a Flash Talk. Criteria used by the judges in evaluation of these five components are described in the Team Manual.

For a copy of the Team Manual, Public Involvement Plan, and other important resources, visit the WERC website: Guidelines | werc.nmsu.edu

Your response to the problem statement will include consideration of the following points specific to this task.

- Demonstrated research and understanding of DERMS and application to New Mexico regulations
- Thoroughness and quality of schematic and/or data-flow diagrams with specifications for each device, sensor, etc.
- Number of devices controlled (higher points for more unique devices controlled)
- Demand response type (binary, analog, combination, or advanced—points increase as complexity increases)
- Communication type (local [own phone or similar], with the utility's signal, other advanced)
- Response to events (one event (only peak or low-carbon), two events (peak demand + other), > 2 events) – points increase as number of events increase.
- Ability of both the utility and the customer to override settings.
- Energy reduced (or increased) (measured in kWh)
- Demand reduced (or increased) (measured in kW)
- Customer cost savings (measured in US dollars)
- Customer Education and Engagement Plan
- Customer Incentive plan
- Potential for real-life implementation, including ease of use, expected reliability, and maintainability.
- Thoroughness and quality of the economic analysis.
- Other specific evaluation criteria that may be provided at a later date (watch the FAQs online).

Short Courses

WERC is offering two short courses:

- ***Mandatory:*** Preparing the Experimental Safety Plan. The Team Leader, or a person assigned by them, must attend the course prior to submitting the ESP. (Attend before February 20, 2023.)
- *Optional:* Environmental Health and Safety (EH&S). The course is designed to prepare teams to complete the EH&S portion of their technical report. Individuals can earn a digital badge to add to their professional development portfolio. Course fees will be waived for contest-registered students, faculty, and judges. Watch the WERC website for schedules and registration information.

Task 2. Advancing DERMS Technologies

Dates, Deadlines, FAQs (*dates subject to change—watch website FAQs*)

- Today: Email us to let us know you are interested in this task. We will contact you with breaking news.
- Opening mid-December, 2022: Optional Course: WERC Safety and Environmental Topics. Live—See website for dates and times. See Team Manual for more information.
- Opening mid-December, 2022: Mandatory Course: Preparing the Experimental Safety Plan. February 20, 2023: deadline for attending. On-demand—See website & Team Manual for information.
- January 31: Email to WERC (werc@nmsu.edu) the number and type of devices your team intends to control; include the voltage, current, and power ratings of each.
- February 6 - 24, 2023: 30% Project Review Due
- February 6 - 24, 2023: Experimental Safety Plan (ESP) due.
- April 7, 2023: Technical Report due
- Weekly: Check FAQs weekly for updates:
  - Task-specific FAQs: 2023 Tasks/Task FAQs
  - General FAQs: 2023 General FAQs
- All dates or task requirements are subject to change. Check FAQs for updates online.

References

[1] Example: Voltron. Connecting Energy System Data. https://www.pnnl.gov/volttron

[2] Lavrova, O. and D. Zigich. July 6, 2021: Non-Wires Grid Alternatives: Behind-The-Meter. Whitepaper submitted to New Mexico Energy Manufacturing. (Available upon request; email: werc@nmsu.edu)

[3] H. Goldstein. 2022. What V2G Tells Us About EVs and the Grid: Vehicle-to-grid technology adds another layer of complexity to the electric-vehicle transition. *IEEE Spectrum*, vol. 59, no. 8, pp. 2-2, August 2022, doi: 10.1109/MSPEC.2022.9852404.

[4] Dumiak, M. 2022. A Road Test for Vehicle-to-Grid Tech: Utrecht leads the world in using EVs for grid storage. IEEE Spectrum, vol. 59, no. 8, pp. 20-25, August 2022 10.1109/MSPEC.2022.9852399.

Glossary of Abbreviations

API – Application Program Interface
BESS – Battery Energy Storage System
BTM – Behind the Meter
DER – Distributed Energy Resources
DERMS – Distributed Energy Resource Management Systems
EPE – El Paso Electric
EV – Electric Vehicle
ICE – Internal Combustion Engine
LCU – Las Cruces Utilities
SoC – State of Charge
T&D – Transmission and Distribution
V2G – Vehicle-to-grid