Task 2. Request for Proposals:

Towards Net-Zero—Distributed Energy Resource Management Systems for the Electrical Grid

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

Task Summary

Current efforts toward net-zero carbon emissions are resulting in increased electricity usage and more unpredictability of power flow on the grid. Utility companies need to enlist the help of consumers to balance supply and demand on the grid.

This task challenges teams to utilize software to develop a large-scale system for scheduling power consumption on the grid to level the load peaks and valleys. Teams will develop a plan to lower the overall power demand and improve grid reliability by controlling the use of the consumers' devices and integrating them into the electrical grid system. Solving this task can provide viable solutions to help communities move toward net-zero carbon emissions, provide more reliable energy, and potentially save millions of dollars for customers. There are many abbreviations applicable to this technology. Refer to the Appendix for a glossary of abbreviations and industry-specific definitions, as needed.

Background

Power loads on the grid are complex because, in addition to providing electricity, the grid also accepts energy inputs from renewable and emergent technologies such as rooftop solar, Battery Energy Storage Systems (BESS), and Electric Vehicles (EVs). These energy inputs, known as Distributed Energy Resources (DERs), are smaller-scale energy resources that are implemented in some homes and businesses. DERs consists of power-generation sources (solar, wind, and generators powered by internal combustion engines (ICE)) and stored-energy devices (EVs and BESS).

Note that EVs can be considered a DER in a concept known as vehicle-to-grid ("V2G") where EVs can either be charged from or discharged to the grid when needed. For example, EVs can be scheduled for charging when too much power is flowing on the grid. V2G also provides for EVs to discharge power to the grid during times of peak power demand [1].

DERMS Technologies

Because some DERs, such as solar and wind power, are intermittent, they pose challenges of increased variability and potential disruption in the modern grid's operations, warranting advanced digital solutions such as Distributed Energy Resource Management Systems (DERMS) that engage with consumers (households and businesses) on the demand side to help manage these challenges. DERMS provides a way to schedule consumers' power consumption. See Figure 1 for a graphic illustrating potential DERMS implementations.

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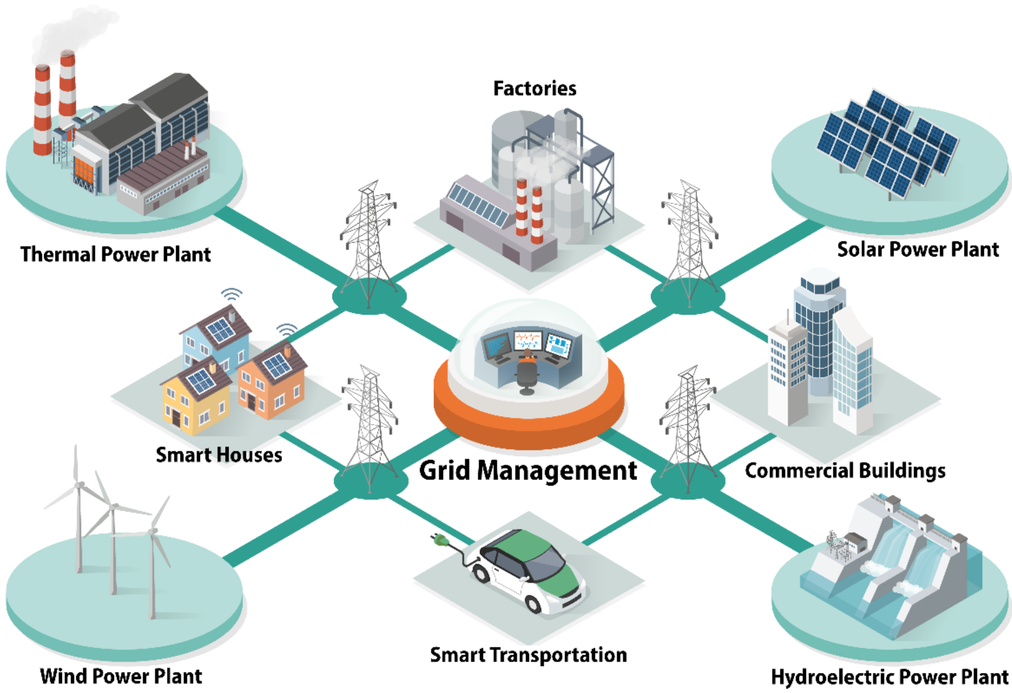

Figure 1. DERMS provides grid management by linking electrical power plants to consumers (renewable power sources, EVs, smart households, commercial buildings, etc.) to optimize power flow.

<u>DERMS Management Protocols</u>

Teams will use the following DERMS management protocols, as needed, in their designs to optimally control power flow [2].

- Shaving peak-demand (e.g., dimming lights during peak loads will shave the load)
- Shifting demand (e.g., EV charging during off-peak times can shift the load)
- Modulating demand (e.g., EV batteries can provide energy back to the building or the grid to modulate power flowing to the grid)
- Generation (e.g., using rooftop solar to generate electricity).

<u>Grid Basics – Grid reliability, Peak Load Events and Excess Supply Events</u>

On the supply side, utility companies need a plan for providing reliable energy during expected peak loads such as extreme weather conditions (very hot summer days or cold winter days). Their transmission and distribution systems must strike a balance, ensuring that supply systems are not underbuilt (which may result in outages), and are not overbuilt (which results in mostly unused, but expensive, infrastructure).

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.

Each customer's electrical power usage can be adjusted to accommodate grid needs. Through "smart" technologies that can automatically control BTM devices, consumers can support the grid and thereby reduce a community's carbon footprint while keeping rates low for all customers. Some utilities have already implemented DERMS by offering thermostat controls for air conditioners and heaters [3]. Since this technology has already been established, teams will not consider those applications.

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Teams will research historical energy usage in New Mexico and propose DERMS solutions for two primary electrical load situations (called "events"):

Peak Load Events

During extreme conditions, customers (homeowners and businesses) use more energy than usual to heat/cool their buildings (termed "peak load events"). 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. A potential DERMS solution is for the electric company to send a signal to BTM devices to shave the power, either by turning off devices or reducing their power level, according to customer thresholds. For example, customers can specify what time they need their EV fully charged but allow the utility to stagger EV charging to avoid a secondary demand peak; or indoor agricultural customers could specify a minimum number of illuminated hours per day but allow the electric company to determine the optimal time(s) of day to run the lighting. In tandem with this, stored-energy devices could be enlisted to provide more power to the grid.

Excess Renewable-Supply Events

Conversely, during off-peak daytime hours, solar, wind, and/or other renewable low-carbon energy sources sometimes add excess power to the grid that may far exceed demand. 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.

To emphasize that the energy comes from renewable sources, in this document, we will refer to these excess supply events as "excess renewable-supply events." Other terms used in the literature are "reverse demand response," "low-carbon events," or "low-to-no-carbon events" because the excess power that is added to the grid comes from low-carbon renewable energy sources.

Since solar and wind power is intermittent and sometimes unpredictable, DERMS can be used to manage these energy supply variations. When renewable energy is abundantly flowing on the grid, DERMS can strategically encourage more electrical consumption, such as charging EVs. Taking advantage of clean energy during excess renewable-supply 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 since EVs are charged by renewables instead of by high-carbon sources that are most likely to be needed during times of peak loads.

DERMS Challenges

There are multiple challenges associated with DERMS technologies:

- DERMS requires interaction between the utility and BTM devices, introducing a layer of regulation and liability issues since the utility is asking for control over customer equipment. For this reason, utility companies engage in "benchmarking" to evaluate similar programs that have been proposed and/or implemented by other utilities.
- V2G incurs challenges such as vehicle availability, potential 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, and cultural obstacles.
- Additional DER technologies such as BESS and solar power systems each have special considerations. BESS can be considered an additional load since a charge must be maintained on the batteries. In addition, residential or commercial facilities may have stand-by generators that could be brought online and paralleled with the grid.
- For all BTM power sources (solar, battery, or generators) the supply cannot exceed the transformer rating that is supplying the residential facilities. Note that the existing local regulatory framework may limit the amount of electricity they can buy from the consumer, based on the amount of power the consumer uses.

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Regulations and Cost Recovery

All utilities programs in New Mexico are subject to approval by the New Mexico Public Regulatory Commission (NMPRC). Since DERMS is an emerging technology with no established regulations, teams will follow a subset of the typical "benchmarking" used by utilities when seeking approval from the NMPRC for new technologies. Teams will be asked to propose an implementation plan, a budget, and a cost-recovery plan.

Task-Specific Information

To help level the power flow on the grid, El Paso Electric Co. and Las Cruces Utilities are seeking solutions that will give New Mexico consumers the means to automatically control BTM devices in response to a signal sent from the utility, based on the needs of the electrical grid during both peak-demand and excess-supply events. Of particular interest to this task are finding ways to maximize the control of energy flow to/from the grid by looking at the large-scale effects on the grid that would be made by a large aggregate of customers (businesses, neighborhoods, or large industrial facilities).

In developing their designs, teams will:

- ***Base your design on historical and projected peak demands*** in Texas/New Mexico (See reference [4]).
- ***Identify how your scenario could utilize excess loads on*** the grid. Note that in the Texas/New Mexico area, excess supply occurs most often during the "shoulder months" of Spring and Fall.
- ***Research and evaluate the suitability of each of the renewable and emergent BTM technologies*** as they apply to the New Mexico service territory.
    1) ***Select the most effective DERs technologies*** (those that have the greatest net-positive impact on the utility, customer, and environment), and devise plans to control one or more of the following DERs through the DERMS platform.
        - V2G
        - Distributed Generation (solar, wind, low-head hydropower, etc.)
        - Storage (BESS)
    2) ***Consider the power loads associated with residential, commercial, and industrial users.*** Select devices that can most contribute to power leveling on the grid.
    3) ***Consider the impact of an aggregate of customers.*** Teams are given freedom to develop a scenario for an aggregate of customers (an aggregate of homes or businesses or a large industrial facility).
    4) ***For their chosen scenario (1 + 2 + 3)***, teams should demonstrate the degree of power-demand leveling per dollar spent.
- ***Utilize an analytical simulation (MATLAB, Excel, PowerWorld, etc.)*** to compare DERMS-managed load profiles against unmanaged load profiles to demonstrate that demand can be effectively leveled.
- ***Include flexibility in the designs to allow customers to control their devices.***
    1) 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.
    2) 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.

- ***Additional benchmarking deliverables (a subset of "benchmarking"):***
    1) Propose an implementation plan – describe how the devices will be implemented and who will be affected by it (device control, customer bills, grid impact, etc.)
    2) Develop a total budget for full-scale implementation.

- ***Assess the environmental and ecological impacts of the solution. These may include:***
    1) Reduced greenhouse gas (GHG) emissions due to one or more:
        - replacing fossil fuels with low-carbon renewable energy sources.
        - effective use of low-carbon energy sources such as solar power.
        - other positive impacts on GHG emissions.
    2) Reduced water consumption (i.e., if water is used for cooling at a power plant)
    3) Long-term ecological impacts (habitats, land use, heat index, etc.)
    4) Additional environmental impacts, positive or negative, as applicable.

- ***Develop educational programs and incentives to encourage customer engagement.*** The program is only effective if rate payers participate. Note that transparency is important in all educational programs to ensure trust of the technology and to reduce the number of opt-outs, unenrollment, or the promulgation of misinformation.

  Imaginative customer education and engagement programs are encouraged and can include:
    - Designing a monetary incentive program (often called a customer tariff) to encourage consumer participation.
    - Educating the customer in off-peak vs. peak demand and their effect on the electrical grid.
    - Explaining the advantages of DERMs-controlled devices (save money for rate payers, help the environment, etc.).
    - Describing the safety of smart devices and dispelling rumors of adverse health effects.
    - 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?
    - Teaching consumers how to use the team's app (API, app, applet, etc.) to control smart devices, including programming flexibility and overrides.

Resources

El Paso Electric Company's Sustainability Report [5] includes data on distributed generation in EPE's service territory, EPE's resource portfolio, decarbonization plans, power generation vs. water consumption, and other quantitative ESG/Sustainability information.

The New Mexico Integrated Resource Plan meetings webpage [6] illustrates public outreach and provides links to EPE's plans for reaching their goal of 100% of all retail sales of electricity in New Mexico to be from zero-carbon sources by 2045. The plan is EPE's effort to identify the most cost-effective portfolio of resources to meet customer needs for the next twenty years and considers various resource options, including supply-side and demand-side options.

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Problem statement
Design and develop an analytical simulation that demonstrates power flow during grid variability and the associated BTM response for both peak-demand and excess renewable-supply events. The simulation should reflect the communication between the utility and the local DERMS. Incorporate a bench-scale demonstration as proof-of-concept of the design.

Teams will select a scenario consisting of an aggregate of households, commercial businesses or large industrial facilities to cost-effectively manage BTM devices to reduce demand and/or spread demand over peak and off-peak times. The ultimate goal is selecting an application that will yield the greatest power demand leveling per dollar spent with consideration to implementing the program in an environmentally conscious way.

Include a customer education and engagement plan and incentives to encourage participation.

Design requirements

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

- Research and report actual power usage from the communities, sets of businesses or industrial facilities considered.
- Discuss the chosen large-scale application and report its advantages over other applications considered.
- Develop scalable solutions that demonstrate your solution's impact on grid support. BTM solutions will be applied to a neighborhood or business application, as outlined in the task problem statement.
- Utilize computer software or design and develop a computer simulation that demonstrates power flow during grid variability and the associated BTM response during both peak demand and low-carbon events. The simulation should reflect the communication between the utility and the local DERMS in terms of load profiles.
- Demonstrate the feasibility of the design through a bench-scale demonstration using grid-tied DERMS for local control (API, app, applet, etc.) that communicates with one or more household devices of your choice that manages the output or consumption of BTM devices. Your setup should:
    - 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 excess renewable-supply). Teams may opt for more functionality by responding to two events (peak demand + excess), or more than two events.
- Propose a plan for
    - Device implementation
    - Budget for full-scale implementation
    - Customer rate tariff that sets up incentives for customer participation

- Report predicted environmental impacts of the design.
- Develop a customer education, outreach, and engagement plan to encourage participation.
- 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 aggregate customers 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.
- Address 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 or commercial devices.

To demonstrate feasibility of the design, develop a bench-scale demonstration using grid-tied DERMS for local control (API, app, applet, etc.) that communicates with and manages the output and consumption of at least one device that will represent communication with a device from an aggregate of households, aggregate of commercial buildings, and/or large industrial plants. Additional points will be added to the score for additional devices (up to three). See rubric below for details.

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.

Pre-contest Bench-scale Testing and Form Submission

- Teams should pre-test their equipment at their home location power systems laboratory.
- To help us prepare for your team's demonstration, complete the DERMS Bench-Testing Form and include it with your 30% Project review. In the table, teams will give detailed information about the devices to be controlled at the contest, including the voltage, current, and power ratings, battery specifications, etc. The Excel table is provided separately on our website.

WERC will provide at the contest:

- 120V 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. Teams must request beyond 120 V.
- Wi-Fi connection.

Bench-Scale Testing at the Contest

Teams will bring to the contest all necessary software and hardware-control infrastructure needed for demonstration of up to five electrical connections. At the contest, teams will demonstrate to judges their app's functionality under different scenarios during the bench-scale demonstration.

30% Project Review
Submission date: March 1, 2024 (you may submit earlier if you wish to receive feedback sooner).

Submit the 30% Project Review as early as possible. It should not exceed four pages. Although the review is not scored, your team will receive feedback from the judges for improving your project. You are allowed to change your plans after submitting it. Include as many items listed below as possible. The more detail provided in your review, the better direction you will get from the judges (See Team Manual for more information.)

As available, please include:

- ***Table of Contents*** planned for the technical report (place topics in order, one line per topic)
- ***A brief description of your project:*** One bulleted list outlining: planned solution to the problem and any anticipated drawbacks.
- ***The current schematic of your planned process flow or block diagram*** with mass and energy balances, as available.
- ***Preliminary data and/or calculations that support the proposed design**.* This might include expected chemical reactions (reactants, reaction times, etc.), flow volumes and rates, etc.
- ***Any cost estimates that show feasibility of the project.*** This will give your team and the judges a chance to consider modifications that might improve feasibility of the project.
- ***Bench-Testing Form***. See link to Excel sheet on website.

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.

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.
- October 15, 2023 - December 31, 2023 – Early Bird Registration (discounts apply).
- December 1, 2023 - March 31, 2024: Optional On-demand Course: WERC Safety and Environmental Topics. See Team Manual for more information.
- December 1, 2023 - February 20, 2024: Mandatory On-demand Course: Preparing the Experimental Safety Plan. See website and Team Manual for information.
- February 15 - 24, 2024: Experimental Safety Plan (ESP) due.
- March 1, 2024: 30% Project Review due. Include the DERMS Bench-Testing Form.
- March 8, 2024: Final date to register a team.
- March 31, 2024: Technical Report due
- Weekly: Check FAQs weekly for updates:
  - Task-specific FAQs: 2024 Tasks/Task FAQs
  - General FAQs: 2024 General FAQs
- All dates or task requirements are subject to change. Check FAQs for updates online.

References

[1] 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.

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

[3] 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)

[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.

[5] El Paso Electric Company 2022 Corporate Sustainability Report. 2022. https://www.epelectric.com/files/html/Sustainability%20Report/2022%20Corporate%20Sustainability%20Report.pdf

[6] New Mexico Integrated Resource Plan Public Advisory Process Meetings. 2021. https://www.epelectric.com/company/regulatory/2020-2021-new-mexico-integrated-resource-plan-public-meetings

Appendix

Glossary of Abbreviations and industry-specific definitions

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
Load—Electrical consumption
SoC – State of Charge
T&D – Transmission and Distribution
V2G – Vehicle-to-grid
Tariff—fixed rebates (or charges), especially for use of gas or electricity. For the purpose of this task, the tariff is a monetary incentive to encourage customer participation