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Title of Proposed Initiative:

Standardized Distributed Resource Modeling to Support Grid Operations

Investment Areas:

☒ Applied Research and Development

Electricity System Value Chain:

☒ Demand-side management

Issues and Barriers:

A full operational integration, economic dispatch, and utilization for grid reliability of Demand Response (DR) and Distributed Energy Resources (DER) require representation of the resources' operating characteristics in the form of computer models. Currently, limited modeling standards are available to properly represent demand-side resources for the type of operations needed for full grid economic and reliability applications. Unlike standards established for modeling various types of power plants, e.g., parameters needed to determine operating modes, ramping capability, operating limits, cost curve, etc., standards for modeling distributed resources such as large HVAC systems, thermal storage, etc. do not exist. The proposed standard modeling initiative facilitates incorporation of DR and DER into such applications as forecasting, unit commitment, economic dispatch and network analysis, which are important for full integration of these resources with grid operations.

Initiative Description and Purpose:

This initiative will include a systematic investigation of the modeling requirements for integration of DR-DER into grid operations for economic and reliability applications, assessment of available and applicable IEEE, IEC and other standards, classification of DR and DER assets for modeling purposes, development of preliminary modeling standards for different asset classes, stakeholder workshops, establishment of final recommendations, and working with standards organizations for formalization of the recommendations.

The project team must have in-depth experience in grid operational requirements, operational capabilities of DR and DER assets, and underlying business and technical objectives. These objectives will include utilization of the DR and DER assets for supply of energy, ancillary services, flexibility reserves, and balancing energy; as well as incorporation of these capabilities in economic dispatch considering assets' operational, dynamic response, and cost characteristics, among others.

The funding requirement for this project is $500,000 to $750,000 USD.

Stakeholders:

The following stakeholders are the most relevant to the proposed initiative:

- California Energy Commission
- California Independent System Operator
- IEEE and IEC standards committees
- Leading distributed resource vendors
- Major IOU representatives – system operations and technical/engineering groups
- Power system and market applications and optimizations vendors

Background and the State-of-the-Art:

The following research development and demonstration initiatives have been conducted to advance the proposed technology or strategy:

- IEC 61970 (CIM) and 61968 modeling standards
- IEEE 1547
- CAISO generation resource modeling standards and requirements

Various vendors have developed limited models to support integration of DR and DER with energy market and grid reliability operations, but these do not address requirements to support full operational lifecycle from planning, forecasting, scheduling, dispatch, and settlements.

There are related standards that deal with the proposed technology or strategy, e.g., OpenADR 2.0, Smart energy profile 2.0, CIM, MultiSpeak, and IEEE 1547, but none address the intended requirements.

Justification:

This initiative will facilitate the full integration of DER and DR with energy markets and grid operations, promoting vendors developing interoperable applications and systems and thus reducing the overall cost of the technology deployment and facilitate full integration of distributed clean energy resources with grid operations providing greater level or operational and economic efficiency.

Utilities, CAISO, vendors, and distributed energy vendors will be impacted by, and will directly benefit from, these standards. Consumers will receive indirect benefits through improved operational efficiency of the grid and energy markets.

Ratepayer Benefits:

☒ Promote greater reliability
☒ Environmental benefits (RPS, REC)
☒ Potential energy and cost savings

Based on historical analyses of energy and ancillary service prices in CAISO market, each additional MW of DR enabled through improved standardization and modeling of resources proposed here results in an approximate net present value of $800,000 USD benefits for the state of California. Details can be offered upon request.

Public Utilities Code Sections 740.1 and 8360:

The proposed initiative addresses the following PUC principles:

- Increased use of cost-effective digital information and control technology to improve reliability, security, and efficiency of the electric grid
- Dynamic optimization of grid operations and resources, including appropriate consideration for asset management and utilization of related grid operations and resources
- Deployment and integration of cost-effective distributed resources and generation, including renewable resources
- Development and incorporation of cost-effective DR, demand-side resources, and energy-efficient resources
- Deployment of cost-effective smart technologies, including real-time, automated, and interactive technologies that optimize the physical operation of appliances and consumer devices for communications concerning grid operations and status and distribution automation
- Integration of cost-effective smart appliances and consumer devices
- Deployment and integration of cost-effective advanced electricity storage and peak-shaving technologies, including plug-in electric and hybrid electric vehicles and thermal-storage air-conditioning
- Develop standards for interoperability of appliances and equipment connected to the electric grid, including the infrastructure serving the grid

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Title of Proposed Initiative:

Integration of High-Penetration Clean-Energy Resources in Distribution and Transmission Operations

Investment Areas:

☒ Technology Demonstration and Deployment

Electricity System Value Chain:

☒ Distribution

Issues and Barriers:

With high penetration of clean energy resources, operating the power system of today is presenting many new challenges to the system operator. This is true both at the wholesale/bulk power as well as at the Retail/Distribution levels. At the distribution grid level, the increasing numbers of distribution and customer-side solar generation assets, which for the most part are rolled out without any coordinated planning, are impacting the safety and the reliability of the distribution system. In addition, at the retail level and in certain areas, the increasing numbers of plug-in electric vehicles offer additional challenges, as well as opportunities, to the distribution grid operator. At the bulk power level, the increasing proliferation of renewable energy resources such as wind and solar, coupled with their inherent variability and unpredictability, is presenting challenges in provision of balancing energy and ancillary services. The problem is exacerbated by the lack of energy storage capability in the system.

To address the challenges at the bulk power level, regulatory agencies have stepped in by encouraging or mandating the use of customer-side resources, such as Demand Response (DR) and Distributed Energy Resources (DER) for the provision of much needed balancing energy and flexible reserves. At the retail level, distribution grid operators are requiring better visibility to customer side load and generation assets. As such, the use of customer side resources in support of the system operations, both at the transmission and distribution levels, is being seen as the key in addressing many operational challenges. As a result, there are increasing requirements for capabilities to provide visibility and control in the distribution grid, not only at the distribution substation and primary circuit levels, but also at the secondary circuit and at the customer side.

Conventional Distribution Management Systems (DMS) installed today employ tools such as State Estimators and Power Flow Calculators originally developed for the bulk power Energy Management Systems using sophisticated mathematical-based algorithms. These algorithms combine detailed mathematical models of the grid equipment with the limited available real-time telemetry to provide observability into the system. However, at the distribution levels, especially for last mile secondary circuits connecting to the customers, models of the distribution grid may not be readily available. As such, the coverage of most DMS installations is limited to the boundaries of substations and primary feeders and circuits.

Advanced Metering Infrastructures (AMI), on the other hand, provide a wealth of information from the customer side of the equation. The abundance of data combined with topological connectivity information can provide an accurate picture of the distribution grid. This is achieved without a need for employing complex mathematical algorithms or relying on accurate three-phase network models and parameters. In addition, the ubiquitous Internet and Internet based communication technologies, coupled with proliferation of inexpensive gateways and sensors and remote controllable devices, present another opportunity of remote sensing and control. As a part of the proposed project, OATI will demonstrate the capabilities of harvesting AMI data, coupled with telemetry from remote sensing equipment, to present an accurate and consistent picture of the distribution grid all the way from distribution substation to the DER as well as DR resources on the customer side of the meter. Through the control capabilities at the end-customer side, OATI will demonstrate the capability to manage and control such devices. Overall, the improved Supervisory and Control capabilities will facilitate:

- Management and administration of distributed generation resources at the customer level
- Coordinated planning for the installation and roll out of such devices
- The ability for the distribution system operator to employ customer side assets to address distribution grid reliability issues

- The provision of much needed balancing energy, flexible ramping and other ancillary services in support of overall system operation and to allow integration of renewable/variable energy resources both at the retail and the bulk power/wholesale levels.

Initiative Description and Purpose:

As a part of the proposed project we will demonstrate how through the incorporation of inexpensive measuring and control devices and employing the public Internet as the primary communication technology, as well as incorporating available data from AMI we can provide the complete visibility to the system operator of the locations and capabilities of these DR and Distributed resources and to provide the capability to manage and to control such devices to address various operational and supply economy issues.

The required level of funding for the proposed demonstration project will be between $2,000,000 to $3,000,000 USD.

Stakeholders:

The proposed project will promote the implementation of DER and allows their incorporation and participation in support of distribution grid, wholesale transmission and generation system, as well as market operations. As such, the stakeholders will primarily include:

- End-use Customer - The project will allow better management and roll out of DER and opens doors for participation of these resources in various operational and economic scenarios thus providing better services to all customers and additional sources of revenues for owners of such assets
- Distribution System Operators - The project will allow complete visibility and control to all distributed assets in the distribution network. Through the improved visibility and control the distribution system operator can better manage the roll out of these assets and will be able to use these assets to deal with distribution grid operations issues such as phase balancing, reduction in losses, system overload and voltage conditions as well as outage management and restoration
- Transmission Grid/Bulk Power generation operations - The Bulk Power system operations will benefit through improved capabilities to forecast and to control distributed assets in the provision of energy, fast ramping, and other ancillary services in support of operations
- Market Operators - The market operator will have more flexible resources that are predictable and viable for the provision of various market products

Overall, the proposed project will help reduce the cost of energy in state of California and will provide better liquidity in energy and Ancillary Service markets.

Background and the State-of-the-Art:

The proposed demonstration project will leverage OATI's existing webSmartEnergy suite of applications and products as well as OATI GridControl gateway and control devices.

The ARRA funded projects where the proposed technology has been implemented include: (1) Kansas City Power and Light-Green Zone demonstration project, (2) Electricity Power Board of Chattanooga Tennessee, (3) Burbank Water and Power

Justification:

The proposed project will impact the energy value chain in the state of California from end-use energy customer, to distribution grid operations, to transmission, to Bulk Power operation, ending with wholesale market operations.

Performance improvements will include:

- Management and coordinated deployment of distributed clean energy resources (DR/DER) at the customer level,
- Phase balancing and reduction in grid losses,
- Addressing distribution grid reliability and safety issues and improving quality of service through improved visibility and control of customer side assets,
- Forecasting and scheduling of distributed assets in support of Bulk Power system operations,
- Provision of various flexible market products to wholesale markets.

This research is appropriate for public funding since it has a profound impact on many sectors in the energy industry in California. There are end-use customer benefits from reduction in energy costs in addition to benefits from new opportunities to participate in grid and market operations. The distribution system operator benefits from improved visibility to the grid as well as from access to more resources which improve grid reliability and quality of service. Furthermore, the Bulk Power system operator will benefit through access to a larger pool of resources and assets to deal with imbalance issue resulting from the proliferation of

variable energy resources such as wind and solar at the wholesale level. The energy and ancillary services markets benefit through the increased numbers and availability of flexible resource that will provide better market liquidity and help reduce costs for energy and ancillary services. The project, overall, will help increase the penetration levels of clean and renewable resources both at the wholesale and at the retail levels.

Ratepayer Benefits:

- ☒ Promote greater reliability
- ☒ Potential energy and cost savings
- ☒ Increased safety
- ☒ Societal benefits
- ☒ Environmental benefits
- ☒ GHG emissions mitigation/adaptation in the electricity sector at the lowest possible cost
- ☒ Low emission vehicles/transportation
- ☒ Economic development

The following provide additional detail:

- Promote greater grid reliability - Through the improved visibility and control capability, the distribution grid operator will have more resources and assets at his/her disposal to address overload, and over/under voltage issues. The improved visibility will also allow him/her to better manage the roll out and deployment of distributed assets in the distribution grid
- Potential energy and cost saving - From the point of view of the end-use customer, the capability to earn additional revenues through participation in addressing grid reliability issues or by participating in energy and A/S markets will help offset energy costs. From the overall system and market perspective the capability of customer side distributed generation and DR assets will help reduce the wholesale energy and ancillary service prices which can trickle down to retail levels. Additional benefits will include improved phase balancing and the resulting reduction in system losses
- Increased Safety - Improved visibility to the secondary distribution circuits and customer-side generation equipment directly translate to improvements in safety
- Societal Benefits - The society will benefit through increased penetration of clean and renewable assets, and resulting reduction in greenhouse gas emissions, improved quality of service, energy cost reductions, and customer satisfaction
- Environmental benefits/GHG Emissions Mitigation - The proposed system will facilitate the roll out of customer side clean/renewable/distributed energy resources and will facilitate their incorporation in various aspects of system and market operations and various levels. These clean renewable resources will help reduce reliance on environmentally unfriendly sources of energy and will directly result in reduction in GHG emissions
- Low emission vehicles/transportation - The coverage of the project will include all customer side assets including plug-in electric vehicles. The project will facilitate the scheduling of charge/discharge of charging stations and allow their incorporation, like other customer side resources, in grid and market operation. On a separate project, OATI has already demonstrated the capability to manage vehicle charging stations through OATI products and services
- Economic development – The overall reduction in energy costs resulting from the proposed project will stimulate the economy. In addition, the capability of controlling customer side assets, individually, will create many other new opportunities that will further improve the economy in the state of California.

Public Utilities Code Sections 740.1 and 8360:

The proposed project is in line with all the principles articulated in California Public Utilities Code Sections 740.1 and 8360.

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Title of Proposed Initiative:

New Market Structure to Facilitate High-Penetration DR-DER Integration

Investment Areas:

☒ Technology Demonstration and Deployment
☒ Market Facilitation

Electricity System Value Chain:

☒ Grid operations/market design

Issues and Barriers:

The current energy market structure in California under the CAISO Market Redesign and Technology Update (MRTU) has certain limitations for supporting high-penetrations of distributed solar PV, distributed storage and demand-side capabilities. More specifically, the market structure was built around centralized generation and transmission serving load on distribution grid through supply substations. The model has deficiencies dealing with high levels of generation on distribution grid, especially renewable intermittent resources, as well as dealing with distributed storage and demand response. These deficiencies limit economic and grid reliability benefits that can be realized through operational and market integration of distributed clean energy technologies. Significant revenue streams can be created for the owners of distributed clean energy resources if the energy market structure is adjusted to accommodate the high penetrations of such resources.

Initiative Description and Purpose:

This initiative will analyze, develop, and evaluate, in a demonstration project, the concept of Distribution System Operator (DSO) within the context of the CAISO energy market and grid operation. The concept provides for many DSOs, each responsible for a portion of the distribution grid, each connected to the bulk power system (CAISO) at one or more supply substations (CAISO interface points). Each DSO will be responsible for managing, forecasting, and dispatching intra-DSO resources. Each DSO will interact with the ISO similar to a neighboring Balancing Area or a metered subsystem (MSS); reliably and economically serve its native load while maximizing economic benefits to its customers by leveraging its distributed and clean energy resources. By aggregating and netting its supply and demand, the DSO concept can lower many of the existing CAISO and IOU barriers for support of distributed generation (PV) and storage at high-level penetration levels. It also gives the DSO and resource owners greater opportunity to participate in the CAISO energy, ancillary service and balancing markets, and provides new opportunities for creation of localized energy and balancing markets for distributed energy resources.

The estimated funding requirements for this initiative, concept demonstration, and evaluation will be $1,000,000 to $3,000,000 USD, with the pilot demonstration project involving a distribution utility, a number of existing distributed clean energy resources, CAISO support, as well as subject matter expertise, resources, and vendor DSO management technology.

Stakeholders:

- A California distribution utility with distribution circuit having existing clean energy resources, e.g., solar PV, at commercial, industrial and/or residential customer sites, and potentially battery or other storage capabilities
- End-use utility customers with clean energy resources
- California ISO – market design, operations, and Demand Response (DR)
- California Public Utilities Commission (CPUC)
- Vendor for data communication and control of Distributed Energy Resources (DER)
- Vendor for DSO management software, distribution grid operation, and required functionality for resource scheduling, optimization, and market operation

Background and the State-of-the-Art:

The initiative requires analysis, development, and evaluation of market structure, as well as operating and business practices for the proposed DSO. The initiative also requires bringing together a diverse set of existing technologies and adopting them for the demonstration and evaluation of the proposed DSO concept. The

individual base technologies needed for support of the initiative are currently available; however they need to be assembled and integrated, creating a platform for end-to-end demonstration and evaluation of the DSO concepts. Some of the existing research, development, and demonstration capabilities that are relevant and can be used in this project include:

- CAISO DR and DER Integration Roadmap and existing programs
- Energy Imbalance Market initiatives by CAISO/PacifiCorp as well as other entities within Western Electricity Coordinating Council (WECC)
- DOE ARRA Smart Grid demonstration and grant projects at Burbank Water and Power (BWP), Kansas City Power & Light (KCP&L) and at Electric Power Board of Chattanooga (EPB)
- OATI webSmartEnergy suite applications for management of DR and DER, including load forecasting, roof-top and distributed PV generation forecasting, DR-DER availability forecasting, resource aggregation and Virtual Power Plant (VPP) creation, creation of Dispatchable resources including ancillary services and balancing energy from DR-DER. Optimal scheduling and dispatch of demand-side resources, measurement, verification and settlement, among others
- NERC CIP and NIST NISTR Cyber Security requirements
- PJM and ERCOT market experience for DR
- Smart Invertors for residential and commercial solar PV deployments
- Grid integrated energy storage capabilities
- CA CEC and CA utilities' initiatives for integration of demand-side resources

Various elements of the proposed technology have been successfully deployed and tested at different utilities across the North America. This project is focused on development, demonstration, and evaluation of a new energy market structure using these software and hardware technologies. The technology elements are mostly at a commercial scale deployment level; however, the combination of technologies used, their configuration, integration, business, operational, and market rules for their operation, as well as evaluation process, is the subject of this EPIC project.

Justification:

This initiative will lower the technical and operational barriers for higher deployment levels of distributed clean energy resources including solar PV, storage and DR, and will enhance the economics of such resources by facilitating participation of said resources in energy markets for the supply of energy, ancillary services, and balancing services. The beneficiaries are consumers, utilities, and the CAISO. Consumers will receive higher return on clean energy investments via new revenue streams (ISO and DSO and bilateral energy markets, as well as potentially lower rates) and utility incentives (DR programs). Through management of local distributed and DR resources, utilities can manage their load shape and improve system balancing, thus reducing the need for centralized generation and the ISO to provide ancillary services and balancing energy, as well as creating additional flexibility against market price dynamics. For the CAISO, it will reduce operational and technology costs for support of high penetrations of DER and allow for more efficient market operation.

Ratepayer Benefits:

☒ Promote greater reliability
☒ Potential energy and cost savings
☒ Societal benefits
☒ Environmental benefits - specify
☒ GHG emissions mitigation/adaptation in the electricity sector at the lowest possible cost

Studies show that proper integration of distributed demand-side resources in California can yield approximately $800,000 USD Net Present Value (NPV) benefit per each MW of capability (the value is NPV over ten years). This figure represents energy market and grid level benefits and does not include the economic benefits associated with deferred capital investment in distribution and transmission infrastructure, nor does it include the environmental benefits of clean energy resources. The proposed DSO will enable greater levels of distributed resource deployments across the CAISO member utilities as well as other utilities in the state.

Public Utilities Code Sections 740.1 and 8360:

This proposed initiative will address the following elements of the Public Utilities code:

- It increases the value of cost-effective digital information and control technology to improve reliability, security, and efficiency of the electric grid

- It provides for dynamic optimization of grid operations and resources, including appropriate utilization of grid operations and resources with cost-effective full cyber security
- Deployment and integration of cost-effective distributed resources and generation, including renewable resources
- Development and incorporation of cost-effective DR, demand-side resources, and energy-efficient resources
- Deployment of cost-effective smart technologies, including real time, automated, interactive technologies that optimize the physical operation of appliances and consumer devices for metering, communications concerning grid operations and status
- Integration of cost-effective smart appliances and consumer devices
- Provide consumers with timely information and control options
- Identification and lowering of unreasonable or unnecessary barriers to adoption of Smart Grid technologies, practices, and services

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Title of Proposed Initiative:

Transactive Energy for Bilateral and Coordinated Retail Operations

Investment Areas:

☒ Technology Demonstration and Deployment
☒ Market Facilitation

Electricity System Value Chain:

☒ Demand-side management

Issues and Barriers:

Currently, there are no established models or business practices to support bilateral or market-based arrangements between two or more retail customers, e.g., two or more large commercial buildings for sharing utilization of their Distributed Energy Resources (DER). Establishing mechanisms to facilitate sharing of these and similar capabilities as on-site storage can enhance deployment of such technologies and their benefit to cost ratio.

Initiative Description and Purpose:

There are well established business practices and mechanisms for bulk power bilateral trading, scheduling, and utilization of energy resources, e.g., bulk generation while addressing transmission requirements and congestion. However, there are no established capabilities for scheduling and sharing distributed resource capabilities on the distribution grid or among owners of distributed resources (prosumers). With high penetrations of clean distributed energy, e.g., solar PV and the cost electric storage capabilities, it is beneficial for mechanisms to be put in place to facilitate sharing capabilities of such resources while also considering distribution grid utilization and constraints. The shared capabilities will facilitate building-to-building, microgrid-to-microgrid, or related types of transactions on the distribution grid, and also will enhance the provision of energy and reserves from building or micro-grids to the distribution and transmission grids.

The proposed Transactive Energy project provides the framework and tools, and it defines business rules for energy transactions between two or more parties or systems, while considering distribution grid and operational constraints. The business rules identify the type of transactions and associated stakeholders, in addition to defining the initiation and approval process by impacted stakeholders as well as financial elements, transactable products, applicable distribution grid charges, measurement and verification requirements, and settlements. Rules also define distribution grid-related issues associated with such transactions and the need for transmission or other grid services for transactions across two entities on different distribution circuits.

This project will establish straw-man rules for Transactive Energy at distribution grid and retail operation level, and it will develop and demonstrate Transactive Energy operation in a pilot project involving several buildings with diverse load profiles, resources, and distribution utility companies. The funding requirements for this project range from $750,000 to $1,500,000 USD.

Stakeholders:

The following stakeholders support the initiative:

- Commercial buildings, industrial customers, campuses, and microgrids
- Residential customers
- Distribution utilities
- Public Utilities Commission
- Transactive Energy Service Providers

Background and the State-of-the-Art:

The Department of Energy (DOE) has sponsored a number of projects in this area, including the ARRA funded Pacific Northwest Smart Grid Demonstration project led by Pacific Northwest National Laboratories (PNNL) and supporting initiatives for Building-to-Building (B-2-B) integration. These initiatives have led to conference

publications, panel sessions, workshops, and a conference resulting in industry interest and several different models for Transactive Energy operations.

The DOE/PNNL Pacific Northwest demonstration project has increased industry awareness, though its acceptance by participating utilities has been limited due to the R&D nature of the project and the lack of alignment with regulatory frameworks.

The bilateral trading and scheduling model has been successfully in use in wholesale operations with energy tagging, transmission capacity reservations, and transmission congestion management, along with the tag and reservation approval process by all impacted stakeholders. Thus, it acts as a good reference model for similar concepts in distribution and retail operation. Lessons learned from over 17 years of successful bulk power operations in this area can be applied to the retail space.

As indicated above, DOE has an on-going research initiative for Transactive Energy.

Justification:

The proposed initiative will allow for minimizing costs associated with variable load with high demand periods and variable on-site generation resources for consumers with demand charges or who might become subject to balancing energy charges. This also allows coordinated operation of DER, benefiting communities and utilities by shaping load profiles and minimizing balancing energy charges.

The opening of transmission access and resulting bilateral wholesale energy markets has caused a more efficient and economic utilization of available grid resources. The proposed Transactive Energy initiative will enable similar operations on the distribution grid, while enabling distribution grid operators to maintain grid reliability and cover capital and operational costs associated with maintaining a reliable distribution operation.

Ratepayer Benefits:

- ☒ Promote greater reliability
- ☒ Potential energy and cost savings
- ☒ Societal benefits
- ☒ Environmental benefits – specify: allow for greater penetration of solar PV
- ☒ Economic development

Specific benefits (qualitative and quantitative of the proposed initiative:

By enabling the sharing of capabilities of DER, e.g., PV generation and storage, or by allowing one customer to purchase available generation or Demand Response (DR) from another customer to avoid excessive demand, the power system can operate at greater levels of economic efficiency

Public Utilities Code Sections 740.1 and 8360:

This initiative will address the impact of the following elements of the PUC Code sections 740.1 and 8360:

- Increased use of cost-effective digital information and control technology to improve reliability, security, and efficiency of the electric grid
- Dynamic optimization of grid operations and resources, including appropriate consideration for asset management and utilization of related grid operations and resources, with cost-effective full cyber security
- Deployment and integration of cost-effective distributed resources and generation, including renewable resources
- Development and incorporation of cost-effective DR, demand-side resources, and energy-efficient resources
- Deployment of cost-effective smart technologies including real-time, automated, and interactive technologies that optimize the physical operation of appliances and consumer devices for metering, communications concerning grid operations and status, and distribution automation
- Deployment and integration of cost-effective advanced electricity storage and peak-shaving technologies, including plug-in electric and hybrid electric vehicles and thermal-storage air-conditioning