PERFORM—Performance-based Energy Resource Feedback, Optimization, and Risk Management

PROJECT DESCRIPTIONS

National Renewable Energy Laboratory – Golden, CO

An Integrated Paradigm for the Management of Delivery Risk in Electricity Markets: From Batteries to Insurance and Beyond - $3,408,526

The National Renewable Energy Laboratory (NREL)-led project team will develop an operating paradigm that leverages flexibility from distributed and bulk resources to cost-effectively manage delivery risk of intermittent resources, like solar and wind. Today, flexibility from a limited number of Distributed Energy Resources (DERs) is offered in wholesale energy markets, and the value of flexibility is not yet recognized for economic hedging of delivery risk. The project team will develop transparent and verifiable risk scores for DERs that combine insights from advanced artificial intelligence methods and domain expertise. The team's risk scores will quantify asset delivery risk and inform bidding strategies of aggregators and utilities. To acknowledge the value of flexibility for economic hedging, the project team will investigate how the economic efficiency of power system operations could change when a flexibility auction is added to energy markets and novel insurance products are offered.

Energy and Environmental Economics, Inc. – San Francisco, CA

Deploying E3's RESERVE Tool to Enable Advanced Operation of Clean Grids - $595,000

E3 will partner with the California Independent System Operator (CAISO), the operator of California's electricity grid, to develop the existing E3 RESERVE modeling tool into a publicly available tool that can help enable more efficient grid operations to reduce costs and improve the utilization of large-scale renewable electricity resources, distributed energy resources, and conventional power generation technologies. RESERVE is designed to enable dynamic determination of essential grid services under high levels of variable renewable electricity production. RESERVE will use machine learning to continuously improve forecasts of system reserve needs to maintain the real-time balance of supply and demand on the electric grid. The team will create a database of historical forecast errors and other data as well as a model of CAISO's grid to evaluate how RESERVE performs compared with CAISO's existing models. If successful, the RESERVE tool will be customizable for other grid operators.

Rensselaer Polytechnic Institute – Troy, NY

Risk Segmentation and Portfolio Analysis for Pareto Dominance in High Renewable Penetration and Storage Reserves - $2,664,000

Rensselaer Polytechnic Institute will develop market mechanism and risk assessment techniques to support cost-effective and risk-informed integration of renewable energy resources into the grid. The team will holistically apply risk segmentation, adaptive credit scoring, and network-based portfolio analysis techniques from financial engineering and risk management for risk analytics of power systems in an approach that integrates asset and system levels. The team will introduce risk segmentation of an asset's throughput by applying tranching similar to collateralized debt obligations, and will analyze the system-wide risk in meeting an

increasingly stochastic demand with supply at different time scales using network-based portfolio analysis techniques. Adaptive risk scores will help to determine the type of services for which generation and/or storage assets' service tranches are most suitable.

Lehigh University – Bethlehem, PA

Application of Banking Scoring and Rating for Coherent Risk Measures in Electricity Systems - $2,500,623

Lehigh University will develop a framework for asset and system risk management that can be incorporated into current electricity system operations to improve economic efficiency through the establishment of an electric assets risk bureau. Currently, discrepancies exist between the power scheduled by a system operator and actual power generated and/or consumed. To address this issue, Lehigh will use scoring and rating concepts from banking and financial institutions as well as optimization methods in dispatching power systems to help system operators and electricity markets schedule resources. Lehigh's research will counteract two failures in electricity system operations—imperfect information and missing markets for risk management products—by developing risk scores at the asset level with the collected historical data and incorporating scoring into decision making at the system level.

Castalune, LLC – Boston, MA

Predicting Events to Enable Robust Renewable Grids - $1,770,760

Castalune will develop a software system that identifies and monitors complex leading indicators of key grid events associated with individual assets and regional grids, such as price volatility events, curtailment, and reliability failure. The team will produce new risk metrics and evaluation methodologies that inform generator dispatch within electric grids subject to increasingly dynamic underlying drivers of demand (e.g., electric vehicles, on-site generation, or storage) and supply (e.g., weather-driven renewable generation, storage). The project will garner early-stage engagement from industry leaders, including utilities and renewable energy operators, facing similar challenges in managing highly dynamic grids, with the intent of helping them transition from conventional generation sources toward renewable energy and storage sources while maintaining grid reliability.

Tabors Caramanis Rudkevich, Inc. – Newton, MA

Stochastic Nodal Adequacy Platform (SNAP) - $2,000,000

Tabors Caramanis Rudkevich's (TCR) Stochastic Nodal Adequacy Platforms (SNAP) will determine the value of resource adequacy for the electric power industry given significant penetration of intermittent and distributed generation. SNAP is based on the premise that uncertainty in resource availability characterizes real-time utility operations. As such, SNAP will probabilistically measure operational uncertainty and economic risk for system operators and asset owners to calculate individual contributions to system adequacy and produce a nodal adequacy pricing structure for consumers. SNAP's added economic efficiency will reduce fossil fuel use and risk to large-scale integration of intermittent technologies.

Georgia Institute of Technology – Atlanta, GA

Risk-Aware Market Clearing for Power Systems (RAMC) - $3,250,000

The increasing role of renewable energy sources is challenging grid operations, which have traditionally relied on highly predictable load and generation. Future grid operations must balance generation costs and system-level risk, shifting from deterministic to stochastic optimization and risk management. The Risk-Aware Market Clearing (RAMC) project will provide a blueprint for an end-to-end, data-driven approach where risk is explicitly modeled, quantified, and optimized, striking a tradeoff between cost and system-level risk minimization. The RAMC project focuses on challenges arising from increased stochasticity in generation, load, flow interchanges with adjacent markets, and extreme weather. RAMC addresses these challenges through innovations in machine learning, sampling, and optimization. Starting with the risk quantification of each individual asset

obtained from historical data, RAMC learns the correlations between the performance and risk of individual assets, optimizes the selection of asset bundles, and quantifies the system-level risk.

Energy Trading Analytics, LLC – Phoenixville, PA

Stochastic Market Auction Redesigned Trading System (SMARTS) - $3,360,000

The proposed effort is to develop a novel, state-of-the-art stochastic redesign for wholesale real-time energy and reserve markets coupled with intelligent energy-portfolio risk management tools that enable consumers to prioritize their flexible demand assets (such as air conditioners, water heaters, energy storage) to offer their flexibility into markets as demand reserves. This project will evaluate the risk and performance of the proposed market trading system and conduct simulation and pre-pilot tests to demonstrate the approach in the world's largest wholesale electricity market, PJM Interconnection. The redesigned market trading system will advance price-responsive risk management, foster robust decentralized decision making for real-time operations and operational planning under uncertainty, and attract innovation and investment opportunities.

Boston University – Boston, MA

A New Risk Assessment and Management Paradigm (NewRAMP) in Electricity Markets - $3,000,000

The proposed work offers a New Risk Assessment and Management Paradigm (NewRAMP) in the evolving electric power sector, which comprises cascaded/decreasing look-ahead timeframe markets that co-optimize energy and reserves provided/demanded by assets with stochastic and correlated capacities. NewRAMP develops innovative approaches for quantifying the risk of individual assets based on their performance and ability to deliver on their assumed obligations. NewRAMP effectively translates this risk to the system level to increase the efficiency of power system operation and planning in the presence of extensive market participation by "risky" assets. NewRAMP synthesizes ideas and theories from finance and insurance, operations research, power system engineering, and electricity market design into methodologies constituting a risk-driven paradigm to achieve higher adoption of stochastic resources and more efficient and reliable system operation.

Princeton University – Princeton, NJ

Stochastic Models, Indices & Optimization Algorithms for Pricing & Hedging Reliability Risks in Modern Power Grids - $3,500,000

Modern electricity markets face new sources of uncertainty and risk due to a growing adoption of renewable sources, such as wind and solar power, which deliver energy intermittently. Princeton will quantify the impact of multiple layers of uncertainty on daily system operation. The team will develop methods to quantify the stochasticity and variability in load, renewable generation, outages, and other uncertainties, and incorporate these to yield a probabilistic distribution of the system-wide operational cost. Princeton will develop system risk and reliability indices, akin to the volatility or credit risk indices, and price formation algorithms to ascribe reliability costs to contributors that are consistent with broad deployment. The team's envisioned reliability pricing and uncertainty quantification will ultimately yield a next generation of hedging and insurance products to mitigate and transfer risk to financial markets. Princeton will build and demo prototypes to independent system operators and utilities.

Duke University – Durham, NC

A Grid that's Risk-Aware for Clean Electricity – GRACE - $2,437,443

A Grid that's Risk-Aware for Clean Electricity (GRACE) is an energy management system (EMS) framework for characterizing the uncertainty of electric power system assets to optimize their performance. The proposed EMS determines the scheduling, dispatch, and compensation of different resources in organized wholesale electricity markets and vertically integrated utilities by building upon industry-implemented market structure and algorithms to incorporate risk considerations. The team will characterize uncertainty of grid asset performance, determine risk-aware reserve targets and asset commitment and dispatch, and translate performance

uncertainty into risk scores and associated compensation for energy and reserves. GRACE will be ready for seamless near-term integration into industry practice and reduce system-wide costs and emissions.

Columbia University – New York, New York

Risk-Aware Power System Control, Dispatch and Market Incentives - $2,061,355

Columbia University will develop a risk dashboard to enable independent system operators (ISOs) of the electrical grid to compute and analyze engineering and financial risks occurring on operational time scales ranging from several minutes to days. This dashboard will facilitate efficient, accurate interpretations of complex system and asset scenario-based risk analyses. The dashboard will rely on stress-testing statistical factor models and newly designed energy asset and systemic risk metrics to continuously track system and market conditions and proactively dispatch available resources to avoid insecure operations. To reconcile technical risks identified using these risk metrics, the team will leverage financial risk management instruments hedge against losses under severe or complex energy scenarios. This project aims to inform ISOs how to use renewable, demand, and storage resources for reducing such risk and compensate these resources accordingly. A second goal is to educate ISOs on the stochastic risk versus cost tradeoff to facilitate increased penetration by renewable resources.