GMLC 1.1: Metrics Analysis
(Foundational Analysis for GMLC Establishment)

GRID MODERNIZATION INITIATIVE
U.S. Department of Energy

Project Description

This project assesses the feasibility and usefulness of metrics for measuring change in the evolving electricity infrastructure. Metrics and associated methods are being developed to assess the power grid's evolution with respect to characteristics that are organized into the following six categories: **Reliability, resilience, flexibility, sustainability, affordability, and security.**

Expected Outcomes

- Validation and adoption of metrics with stakeholders and regional partners
- Enhanced metrics that enable DOE to better set priorities on modernization research and development

Significant Milestones	Date
Begin implementing pilot tests with partners	9/2017
Publish validation of new metrics as result of pilot tests	9/2018
Develop final report/briefing material	9/2018

Progress to Date

- Technical report about emerging metrics (March 2017)
- Webinars with key stakeholders, including five federal agencies, seven associations, two regional transmission organizations, three state entities, and one utility
- Working with American Public Power Association (APPA) to implement value-based System Average Interruption Duration Index (SAIDI) on its web platform for use by municipal utilities by summer 2017.

U.S. DEPARTMENT OF ENERGY

Institutional Support

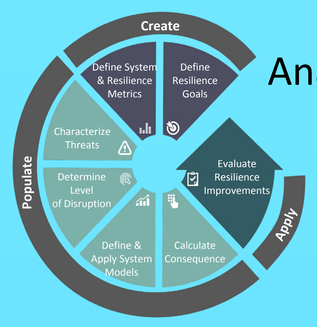
Reliability

New metrics for distribution to represent value-based planning

New metrics for system impacts using North American Electric Reliability Corporation transmission/generation availability data

Approach and tool for and demonstration of probabilistic enhancement of existing transmission planning metrics

Resilience



Analysis Process

Results

Flexibility

Developed large set of candidate metrics that represent network properties of flexibility and lack of flexibility, engaging stakeholders to identify most useful metrics

Lagging indicators
- Requires statistical analysis of market and grid conditions to reveal curtailments, loss of load, or other economic impacts caused by insufficient flexibility.

Leading indicators
- Requires production cost simulations with weather and other uncertainties to design for sufficient flexibility.
- Use production cost models to examine tradeoffs between different sources of flexibility.

Sustainability

Ability of federal greenhouse gas data products to capture changes in electric-sector CO_2 emissions that might result from future grid modernization varies, depending on coverage of certain energy sources anticipated to grow.

	Biomass		
Storage		MSW	
Geothermal		Hybrid	
Dist. Gen.	CHP		

A
B
C
A = No coverage
B = Partial coverage*
C = Full coverage

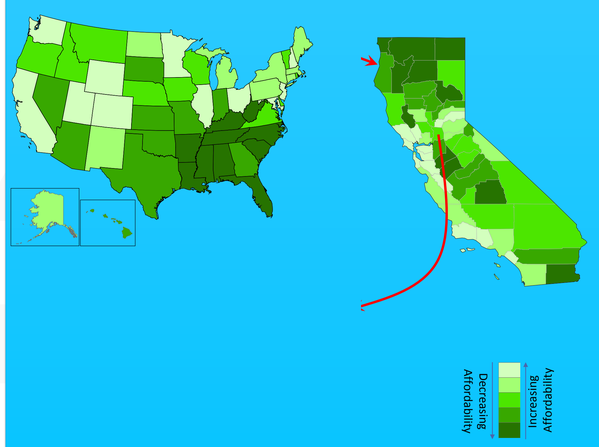
*Either the data product has no coverage or the data are reported separate from the electric sector

- EPA eGRID
- EPA GHGI (elec. gen.)
- EPA GHGRP (power plants)
- EPA CAMP
- EIA AEO (electric power)
- EIA MER (electric power)
- EIA EP Annual
- EIA STEO (electric power)

GHGI = GHG Inventory; GHGRP = GHG Reporting Program; CAMP = Clean Air Markets Program; Dist. Gen = distributed generation; CHP = combined heat and power; MSW = municipal solid waste (non-biogenic portion)

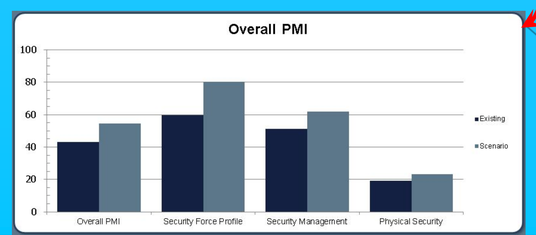
Affordability

Cost Burden Metrics (**emerging**)
- Customer electricity cost burden
- Electricity affordability gap
- Affordability gap headcount
- Temporal indices of these metrics



Security

Protective Measures Index
- Determines protective security posture of an entity.
- Initially developed for and applied by Department of Homeland Security (DHS).
- Stakeholder agreement for use as physical security metrics for Electric sector.
- Allows comparison of physical security posture for similar entities.
- Has been applied to 400-plus electric facilities.



Grid Services and Technologies Valuation Framework

GRID MODERNIZATION INITIATIVE
U.S. Department of Energy

Project Description

The project will develop a framework enabling electricity-sector stakeholders to conduct, interpret, and compare valuation studies with high levels of **consistency, transparency, repeatability, and extensibility**. The effort is grounded in a **long-term vision of "Generally Accepted Valuation Principles"** as a paradigm for valuation as a mature, sophisticated process.

Expected Outcomes

- The framework will be ***guidance—not another model***—creating a systematic decision process by which studies can be interpreted and conducted with key assumptions made transparent.
- An industry-vetted, demonstrated, and operationalized process with practical products supporting improved power-sector decision making incorporating **value beyond monetary savings and costs** to build a more affordable, sustainable, flexible, reliable, resilient, and secure grid.

*Creating a **useful and used framework** requires engaging with stakeholders to meet emerging needs, credible demonstration with industry, and working towards a Long-Term Vision of Generally Accepted Valuation Principles*

Progress to Date

- Engaged Stakeholder Advisory Group of **key decision-makers** (including commissioners, legislators, utilities, investors, consumer advocates, and more).
- Development of a **draft framework decision process** grounded in current best practices, challenges, and future needs. **Next step: test cases** to exercise and revise the framework.

Significant Milestones	Date
Establish and engage Advisory Group	Sep 2016
Review state of valuation practices	Jan 2017
Draft Framework	Apr 2017
Bulk-power system test case	Oct 2017
Distribution test case	Jun 2018
Completed Framework	Sep 2018

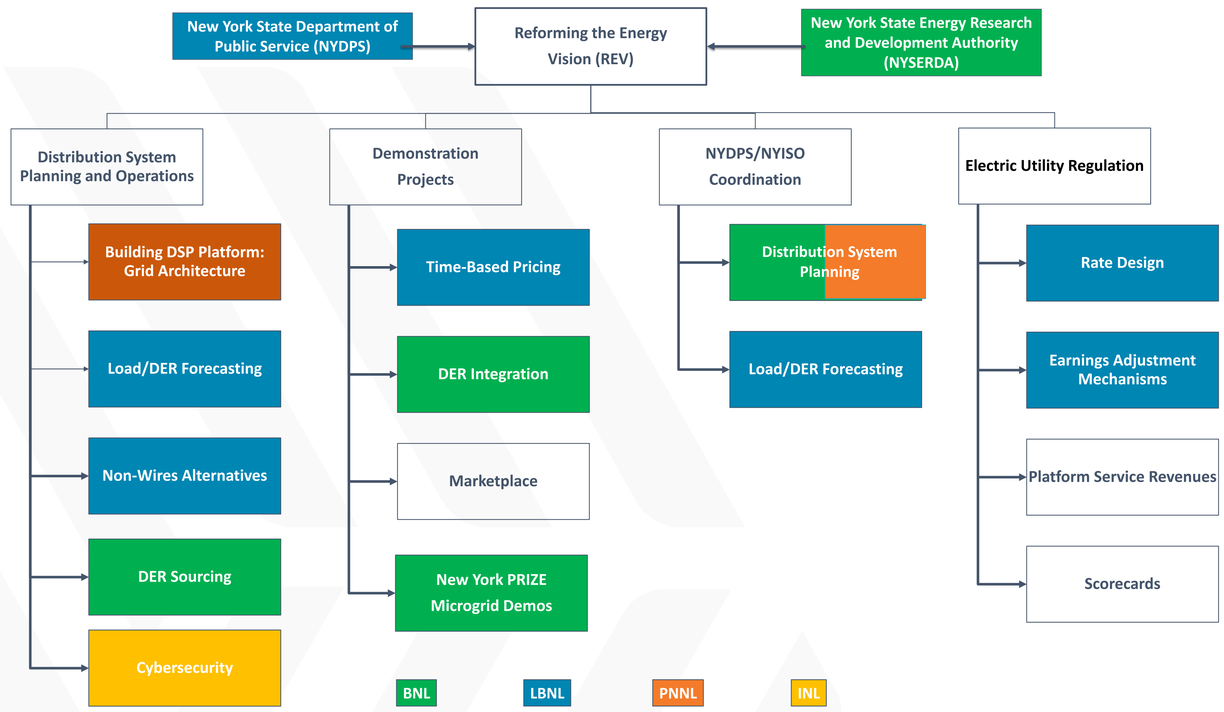
Technical Support to the New York State Reforming the Energy Vision (REV) Initiative

GRID MODERNIZATION INITIATIVE
U.S. Department of Energy

Project Description

The New York State **Reforming the Energy Vision** (REV), initiated in 2014, will fundamentally change the operation of the electric grid in New York State to a more distributed, consumer-focused energy delivery system.

This GMLC project is providing objective technical assistance by a team of experts from the national laboratories to New York State agencies and policy makers to enable the REV, and, as a result, gain knowledge that can be leveraged for DOE's Grid Modernization Initiative.



The REV Team will help address many of the key challenges facing grid modernization and will take advantage of a unique opportunity for obtaining insights and lessons learned that can be applied throughout the nation.

Expected Outcomes

- Technical guidance provided to regulators, policy makers and stakeholders to address challenges associated with establishing a Distributed System Platform envisioned by REV
- Insights on what business models work and why, as well as customer adoption of the REV model
- Lessons learned from REV on deploying DER at the distribution level that can be applied to grid modernization efforts in other states

Milestone (FY16-FY17)	Due Date
Identify high priority TA tasks by NYS agencies	7/15/16
Annual progress report and lessons learned from REV	12/31/16
Midterm progress report and lessons learned from REV	5/1/17
Final Annual progress report	10/1/17
Summary report with insights and lessons learned from REV	10/1/17

Highlights of Accomplishments

TA Provided	Impact
Supported NYPSC and NYDPS review of Joint Utilities Supplemental DSIP filings	Directly impacted PSC Order concerning next wave of filings on DSIPs
Provided input to Avangrid and National Grid on their respective residential time-based rate pilots	Improved pilot design to reduce complexity and improve likelihood that results will be actionable
Developed a use case on addressing two-way power flow on the grid for NYSERDA	Improved utility understanding on how to address this issue
Supported NYDPS on grid architecture issues and DSIP implementation planning; developed analysis of selected communication network issues and relationship to data services models	Provided insights on legacy and forward looking architecture issues in preliminary DSIP filings to be addressed during implementation of REV
Worked on a draft NY REV Security framework with security leads from NY utilities	Improved security framework includes wide range of capabilities from joint utilities

Distribution System Decision Support Tool Development and Application

GRID MODERNIZATION INITIATIVE
U.S. Department of Energy

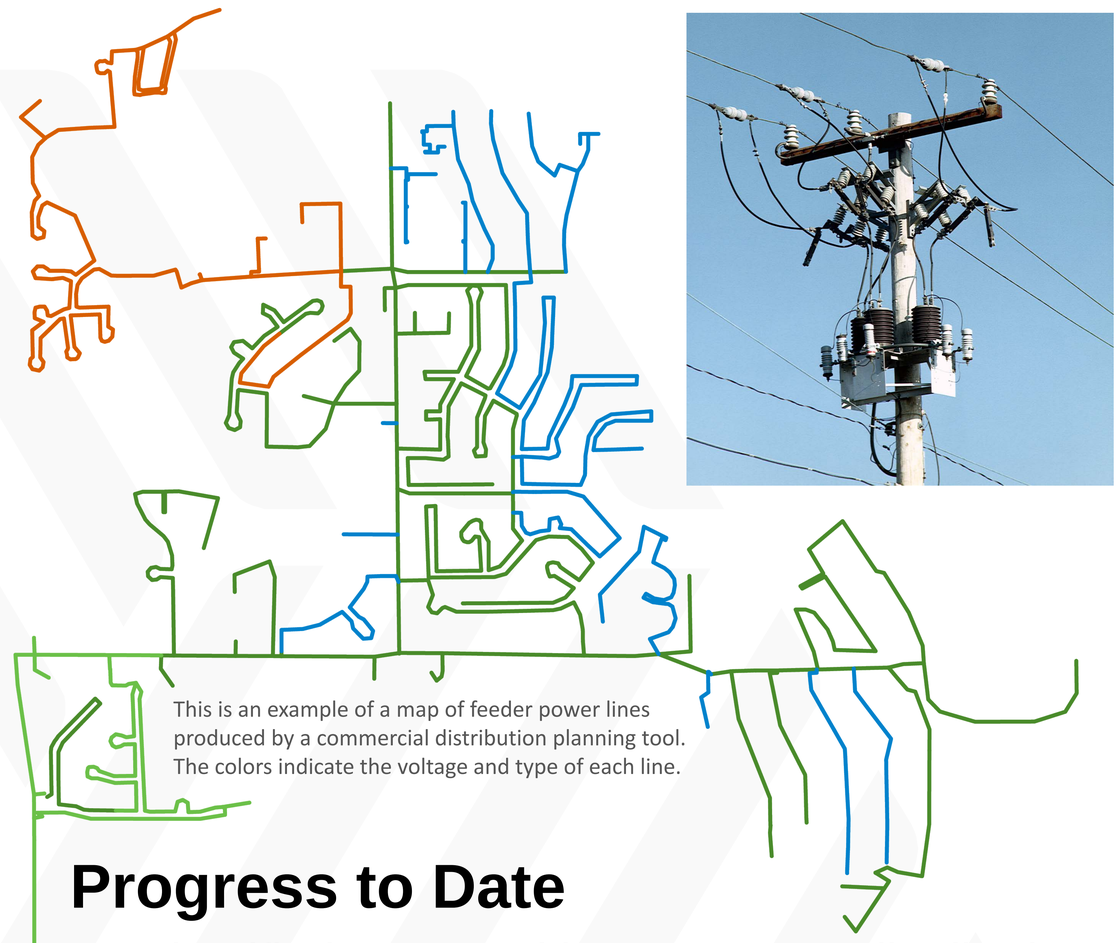
Project Description

Identify strategies and provide technical assistance to state regulators and utilities on advanced electric distribution planning methods and tools. These efforts focus on incorporating emerging grid modernization technologies and the significant deployment of distributed energy resources.

Expected Outcomes

- State utility regulators have the training they need to oversee modernization of the grid and approve utility cost recovery for prudent grid modernization investments.
- Gaps between existing and emerging distribution planning practice are identified, and utilities and regulators have recommended strategies and tools to advance planning processes.

Significant Milestones	Date
Publish a technical report that summarizes major distribution system analyses, applications and tools.	April 2017
Conduct training for state utility regulators on distribution system planning and emerging issues.	Early Summer 2017
Publish a technical report that identifies remaining gaps, development requirements, and lessons learned on distribution system planning tools.	April 2018



This is an example of a map of feeder power lines produced by a commercial distribution planning tool. The colors indicate the voltage and type of each line.

Progress to Date

- Identified opportunities to support distribution planning activities of the American Public Power Association and National Rural Electric Cooperative Association.
- Organized an education program on distribution planning at the IEEE Smart Grid conference.
- Established an advisory group of state public utility commissions (PUCs) to identify distribution planning needs and a training program to help meet those needs.
- Facilitated and presented at PUC workshops on integrating the distribution planning process with resource and transmission planning.
- Published a report on emerging distribution planning practices in six leading states.

1.4.29 Future Electric Utility Regulation

GRID MODERNIZATION INITIATIVE
U.S. Department of Energy

FUTURE ELECTRIC
Utility Regulation

Project Description

- Provide technical assistance and analysis for public utility commissions and a series of reports with multiple perspectives on evolving utility regulation and ratemaking, utility business models and electricity markets:
  - Adapting to new technologies and services
  - Assessing potential financial impacts on utilities and customers
  - Engaging consumers
  - Addressing utility incentives to achieve grid modernization goals

Expected Outcomes

- States will have improved capability to consider alternative regulatory and ratemaking approaches to enable grid modernization investments.
- Approaches will better tie utility earnings to consumer value, economic efficiency, and other policy goals.
- Ultimately, states will provide utilities with regulatory guidance and incentives to efficiently deploy capital to achieve grid modernization goals.

Significant Milestones	Date
Upgrade financial modeling tools and assess financial impacts of new technologies and services on utilities and customers	10/1/16, 10/1/17
Complete 6 reports for Future Electric Utility Regulation series by electric industry thought-leaders	4/1 and 5/15/17, 4/1 and 10/1/18
Publish technical report on performance-based regulation (PBR) with case studies and results of productivity and incentive power research	5/15/17
Provide technical assistance on financial impacts for 3-4 states per year	10/1/17, 10/1/18
Provide technical assistance on PBR, distribution services markets, energy services pricing to 2-4 states per year	10/1/17, 10/1/18

Progress to Date

- Technical assistance to states:
  - Alternative cost recovery mechanisms for demand response (MN)
  - Cost recovery approaches for grid resiliency and security investments (PA)
  - Revenue decoupling (MT)
  - Impacts of tariff changes on financial performance of solar PV systems (Puerto Rico)
  - Performance-based regulation (VT)
  - Utility investor valuation framework and incentives (CA)
- Financial modeling tools and analysis
  - Upgraded FINancial impacts of Distributed Energy Resources model and assessed combined financial effects of aggressive 10-year ramp-up of energy efficiency and distributed solar on utility costs and returns and customer rates and bills
  - Upgraded Integrated Energy System Model and evaluated impact of several time-of-use rate designs on energy consumption patterns and associated distribution grid impacts
- New reports in the Future Electric Utility Regulation series
  - *The Future of Centrally-Organized Wholesale Electricity Markets* (published March 2017)
  - *Regulatory Incentives for Utilities — and Disincentives — to Invest in Grid Modernization* (under review)
  - *Value-Added Electricity Services: New Roles for Utilities and Third Parties* (underway)
  - See **feur.lbl.gov**

Markets for Essential Reliability Services

Partners: NREL, ANL, EPRI

GRID MODERNIZATION INITIATIVE
U.S. Department of Energy

Economic and Reliability Impacts

Wholesale electricity markets exist to schedule and dispatch generating units, given demand and the transmission network configuration, at minimum cost to the system.

The goal of this project is to create a **multi-timescale market and reliability modeling framework**, encompassing both the planning (decades) and operational time frames (seconds), to assess **reliability** and **revenue sufficiency** challenges and solutions under a wide range of market design options and revenue sources. Key research questions include:

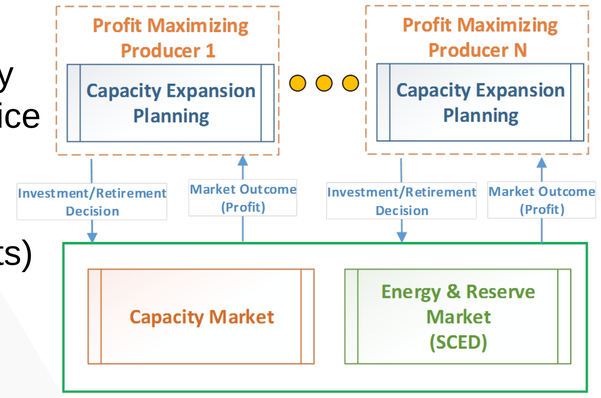
- How do essential reliability service needs evolve with different system fleets?
- As the system evolves, how well does the system meet needs?
- What are the options to meet those needs?

Revenue Sufficiency									
Reliability					Market Efficiency				
Resource Adequacy	*Flexibility Needs and Incentives*			*Essential Reliability Services Incentives*	*Price Impacts and Formation*			*Differing decision making criteria*	*Market Solver*
	Flexible Capacity	*Operational Flexibility*	*A/S*		*Self-Scheduling*	*Behavior*	*Rules*		
Capacity payments	Add flex. cap. incentive	High Gen Outage	Spin, Reg, Flex Up	PFR rules	Self-Commit	Dynamic Markups	Price caps	Different ownership structures	Market op. sequence
Premature retirement		Lower Ramp Rates	Up and Down	SFR rules	Self-Dispatch	Static Markups	LRMC		Storage dispatch methods
		High Trans. Outage	Vary reserve req't uncertainty bands		Model bilateral contracts	Cournot	Lumpy costs		Complexity in solver vs. bids
		High Congestion	Multi-mode CC			Bertrand	Pay for Performance		
		High Forecast Errors	ERCOT Reserves				Uplift		
		Limited ngas fuel supply	ORDC						
		Low/High storage	Add nonspin						
		Low/High DR	Adjust reserve req't during curtailment						

Multi-Market Analysis

Approach

- Analyze historical capacity market data
- Develop a game theoretical model for capacity expansion; link with energy and ancillary service market production cost models
- Investigate the efficiency of different market designs (e.g., energy only vs. capacity markets) for different wind and solar penetration levels



Bi-level expansion model

Expected Outcomes

- Improved insights into the functioning of electricity markets
- Increased understanding of strategic decision making for investments and operations
- Quantitative impact of various electricity market designs for ensuring system reliability and economic efficiency in an evolving power system