GRID MODERNIZATION INITIATIVE
U.S. Department of Energy

Institutional Support
Portfolio Overview

Charles Goldman – Institutional Support Technical Area Lead

Lawrence Berkeley National Laboratory

April 18, 2017
Arlington, VA

U.S. DEPARTMENT OF ENERGY

Institutional Support Summary

GRID MODERNIZATION INITIATIVE
U.S. Department of Energy

What is the problem?

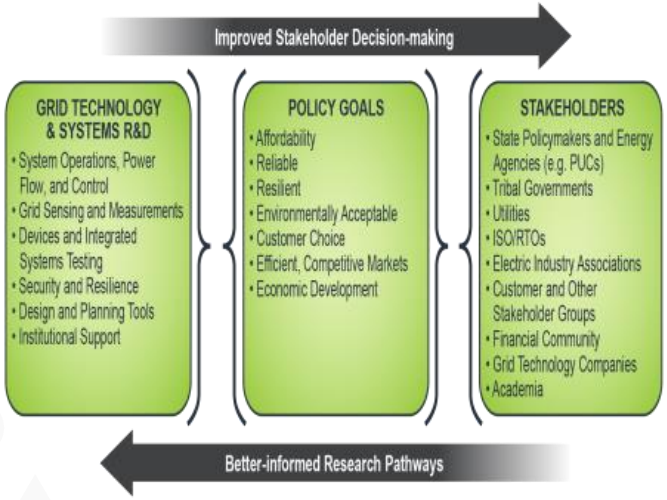
- Supporting and managing Institutional Change in a period of rapid (and potentially disruptive) technological innovation

Expected Outcomes

- Address high priority grid modernization challenges and needs identified by electric power industry stakeholders, with particular emphasis on state policymakers and regional planning organizations

Federal Role

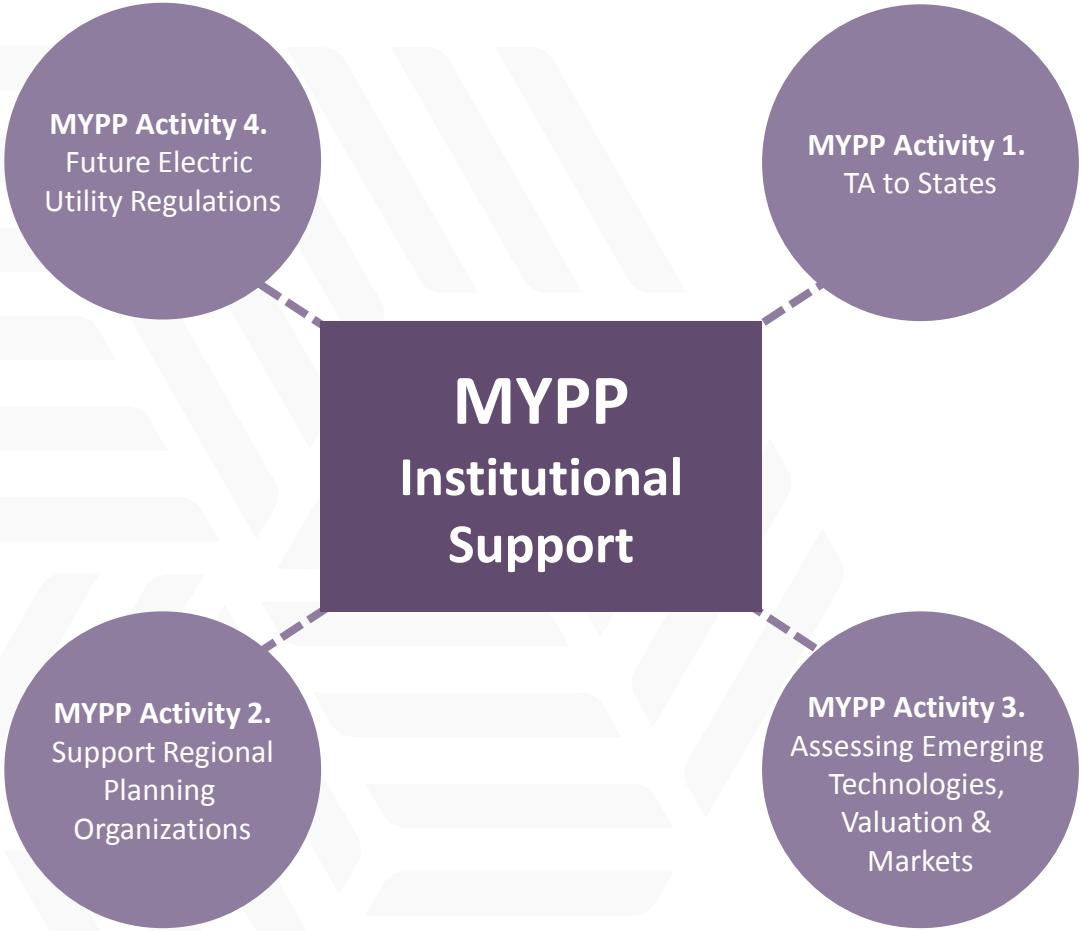
- Convene key grid stakeholders as an honest-broker for collaborative dialogues on grid modernization
- Create an over-arching suite of grid-related “institutional” analysis, workshops, and dialogues to highlight challenges and explore options for transforming the grid, focusing on key policy questions related to new technologies, regulatory practices, and market designs

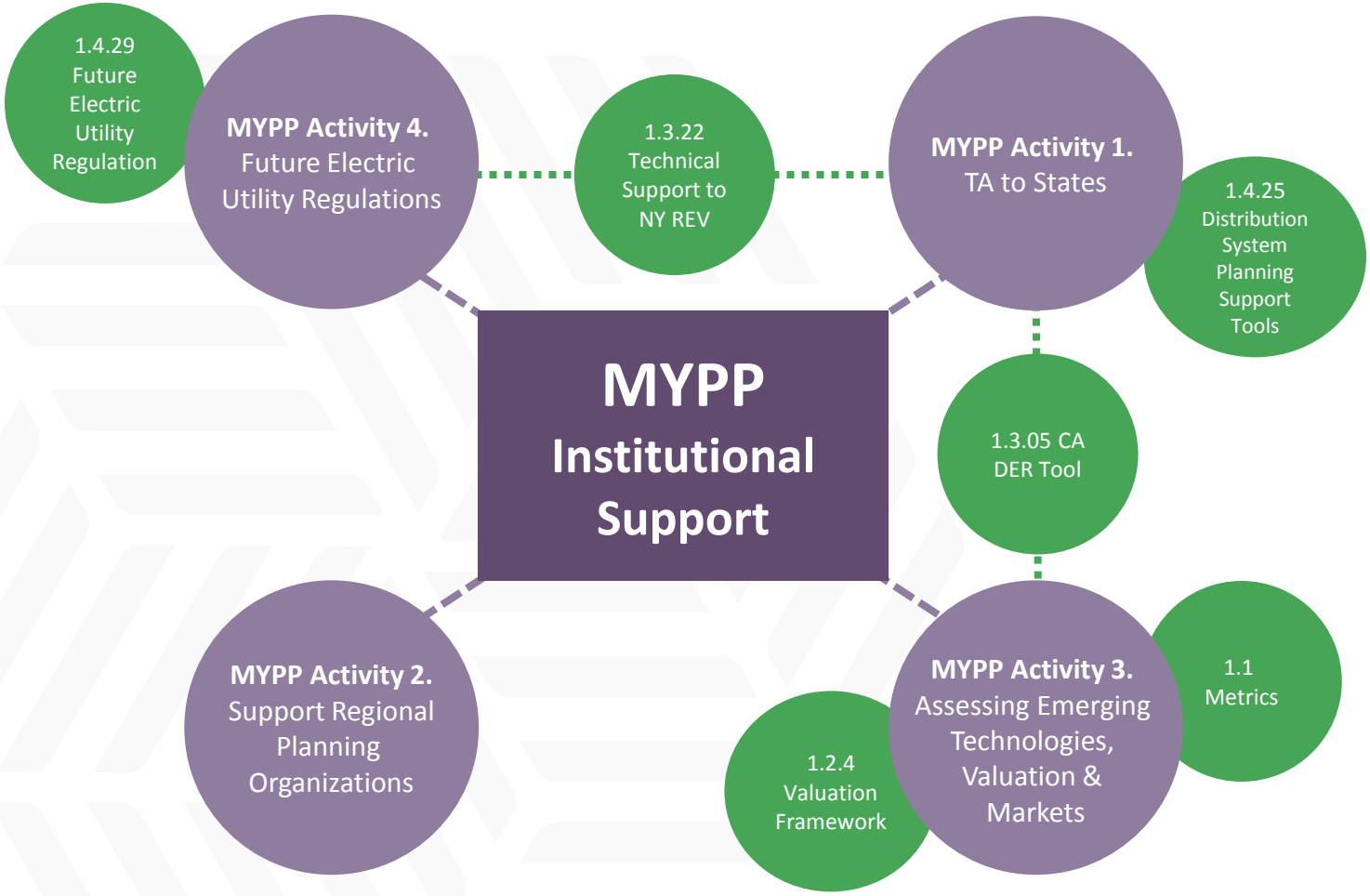


Activities and Technical Achievements
MYPP Activity Description

GRID MODERNIZATION INITIATIVE
U.S. Department of Energy

Activity	Technical Achievements by 2020
1. Provide Technical Assistance to States and Tribal Governments	• Technical assistance to **ALL states** to inform their electricity policy decision making, accelerating policy innovation in **at least 7 states** • Technical analysis results to at least 10 states that allows them to **enhance utility distribution system planning,** including guidance on how to consider Non-Wires Alternatives, DER, and advanced grid components and systems • At least 10 other states have developed comprehensive **energy system infrastructure** plans
2. Support Regional Planning and Reliability Organizations	• Regional planning & reliability organizations develop institutional frameworks, standards, and protocols for integrating new grid-related technologies • Coordinated regional long-term planning process that uses standardized, publicly available databases of transmission and regional resource data and planning assumptions • Facilitated long-term regional planning in each U.S. interconnection
3. Develop Methods, Tools, and Resources for Assessing Grid Modernization	• New methods for valuation of DER technologies and services that are defined and clearly understood by stakeholders and enable informed decisions on grid investments and operations. • Analysis tools and methods that facilitate states' integration of emerging grid technologies into decision-making, planning, and technology deployment. • New Grid Modernization **performance and impact metrics** and data collection methods, which are used by states to track Grid Modernization progress.
4. Conduct Research on Future Electric Utility Regulation	• 3-5 states have **adopted fundamental changes a**nd 8-10 states have **adopted incremental changes** to their **regulatory structure** that better aligns utility interests with grid modernization and clean energy goals.

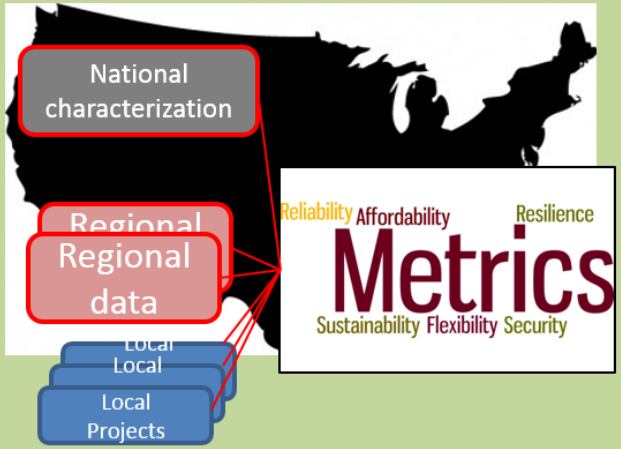

MYPP Activity 4.
Future Electric Utility Regulations
MYPP Activity 1.
TA to States
MYPP
Institutional
Support
MYPP Activity 2.
Support Regional Planning Organizations
MYPP Activity 3.
Assessing Emerging Technologies, Valuation & Markets


1.4.29 Future Electric Utility Regulation
MYPP Activity 4. Future Electric Utility Regulations
1.3.22 Technical Support to NY REV
MYPP Activity 1. TA to States
1.4.25 Distribution System Planning Support Tools
MYPP Institutional Support
1.3.05 CA DER Tool
MYPP Activity 2. Support Regional Planning Organizations
MYPP Activity 3. Assessing Emerging Technologies, Valuation & Markets
1.1 Metrics
1.2.4 Valuation Framework

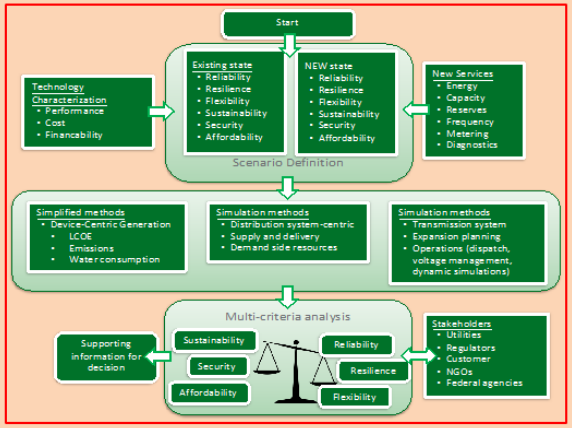
Institutional Support Projects

GRID MODERNIZATION INITIATIVE
U.S. Department of Energy

Metric Analysis



Valuation Framework Development



Distribution System Decision Planning

FUTURE ELECTRIC
Utility Regulation

Foundational Projects

GRID MODERNIZATION INITIATIVE
U.S. Department of Energy

1.1 Metrics: Foundational Analysis for GMLC

- Work directly with *strategic* stakeholders to confirm the usefulness of *new and enhanced existing* metrics that will guide grid modernization efforts to maintain and improve: reliability, resilience, flexibility, sustainability, affordability, and security
- Definition, Validation and Adoption of metrics by leading industry stakeholders and regional partners

1.2.4 Grid Services and Technologies Valuation Framework Development

- Develop a **valuation framework** that will allow stakeholders to conduct, interpret, and compare valuation studies of existing/emerging grid technologies and services with high levels of consistency, transparency, repeatability, and extensibility
- Valuation drives investments

1.4.25 Distribution System Planning Support Tool

- Identify strategies and provide technical assistance (TA) to state PUCs and utilities on advanced electric distribution planning methods and tools, with a focus on incorporating deployment of DER
- Develop & conduct training course(s) for State PUCs on emerging issues in distribution system planning

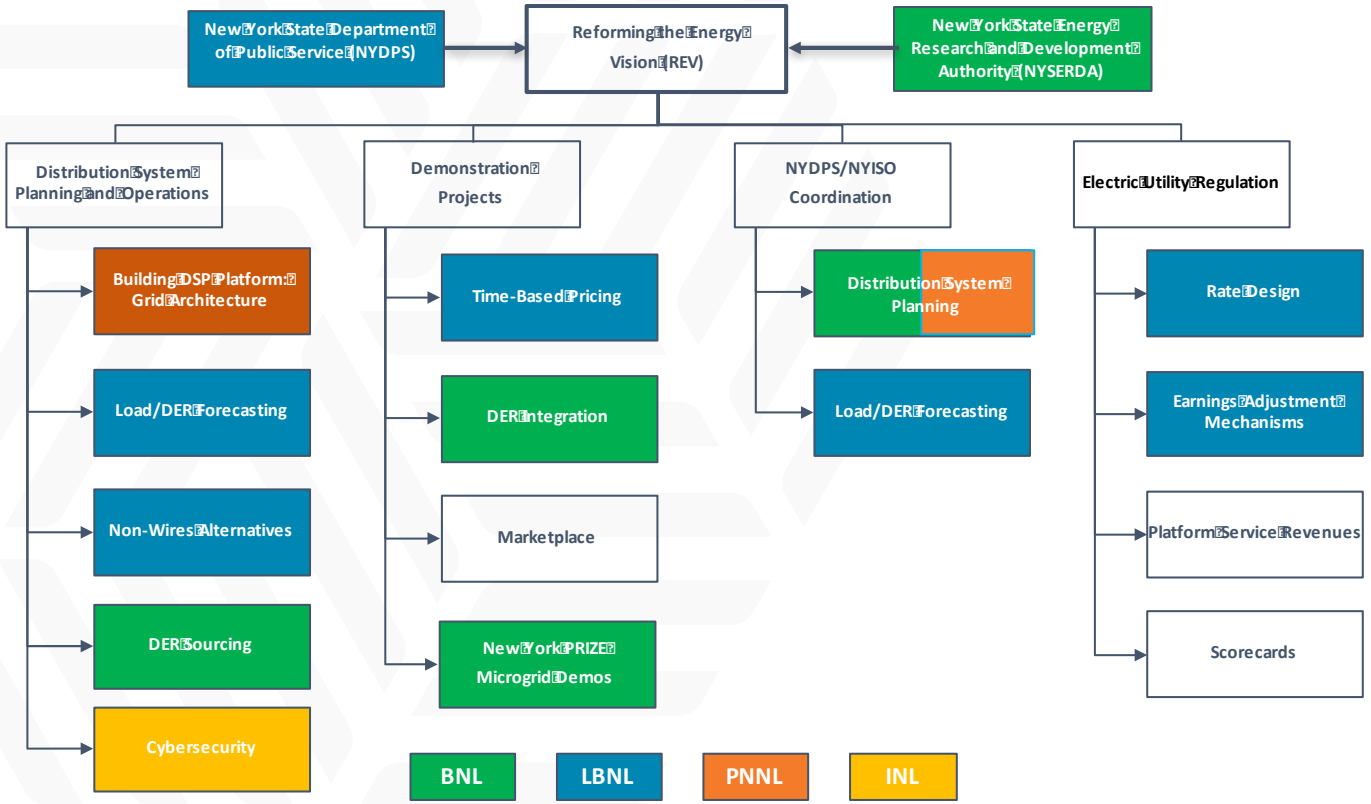
1.4.29 Future of Electric Utility Regulation

- Provide TA, tools, and analysis on trends in utility regulation and business models
- States will have improved capability to consider alternative regulatory approaches to enable grid modernization investments that will better tie utility earnings to consumer value, economic efficiency and other policy goals

Regional Partnership Project: 1.3.22 -Technical Support to NY REV Initiative

GRID MODERNIZATION INITIATIVE
U.S. Department of Energy

- Providing technical support to NY State energy agencies (NYDPS and NYSERDA) to enable the REV vision
- Focus on creating Distributed System Platform (DSP), utility regulation and changes to utility business model, and DER demonstration projects.
- Leverage knowledge gained to support DOE's broader GMI; summarize lessons learned for other states



U.S. DEPARTMENT OF ENERGY

Accomplishments and Emerging Opportunities

Accomplishments

- 1.1 Reference document (v2.0) on approach and focus in each metric area (v2.0); Impressive engagement process (19 Working Partners)
- 1.2.4 Completed Draft Valuation Framework and Long-term Vision document
- 1.4.25 Completed report on distribution planning tools; Significant progress on training program for state PUCs
- 1.4.29 Provided TA to 5 states (MN, PA, MT, VT, CA) on regulatory/utility business models or and ratemaking; Completed two reports in Future of Electric Utility Regulation series industry
- 1.3.22 Review of Joint Utility Dist System Implementation Plan filings; TA on DER Demonstrations

Path Forward

- 1.1 Validation of metrics and approaches with Working Partners and Regional Partnership projects
- 1.2.4 Test two use cases applying valuation framework; “Generally Accepted Valuation Principals”
- 1.4.25 Conduct training course(s) for state PUCs on emerging issues in distribution system planning (summer 2017 and 2018)
- 1.4.29 Continue TA to state PUCs to support decision-making, linked with financial model/tool development and Future Electric Utility Regulation series
- 1.3.22 Support on Business Models (Design of Earning Adjustment Mechanism metrics; Summary report with insights learned from NY REV

Summary

- Institutional Support significantly impacts pace of Grid Modernization Investments
- Many key elements of the Multi-Year Program Plan included in GMLC-funded projects (and other DOE funded activities)
- Foundational Projects
  - Metrics Analysis
  - Valuation Framework
  - Distribution System Decision Support Tools: Development & Application
  - Future Electric Utility Regulation
- TA to State PUCs: NY Reforming Energy Vision (REV) and other states through Foundational Projects
- Accomplishments and Emerging Opportunities

GRID MODERNIZATION INITIATIVE PEER REVIEW

GMLC 1.1 – Metrics Analysis

MICHAEL KINTNER-MEYER (PNNL)

April 18-20, 2017

Sheraton Pentagon City – Arlington, VA

GMLC1.1: Metrics Analysis
High Level Summary

GRID MODERNIZATION INITIATIVE
U.S. Department of Energy

Project Objectives

Work directly with *strategic* stakeholders to confirm the usefulness of *new and enhanced existing* metrics that will guide grid modernization efforts to maintain and improve:

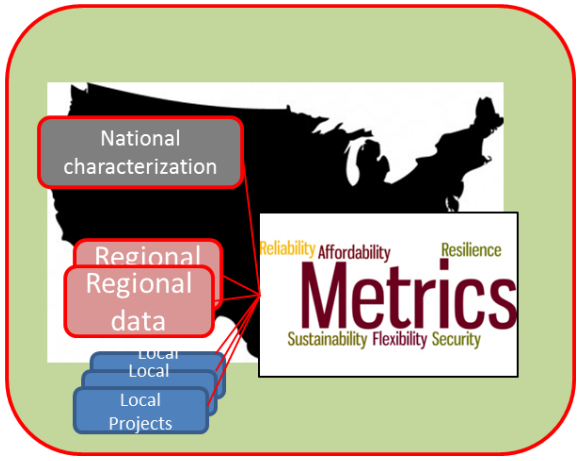
- **Reliability,**
- **Resilience,**
- **Flexibility,**
- **Sustainability,**
- **Affordability, and**
- **Security.**

Expected Outcomes

- ✓ Definition, Validation, and Adoption of metrics and analysis approaches by leading industry stakeholders and regional partners
- ✓ Better alignment of DOE R&D priorities with stakeholder and public-interest objectives

Value Proposition

- ✓ Ensuring that all stakeholders understand how grid modernization investments will affect and benefit them
- ✓ Audiences: grid modernization technology developers and investors; utility and ISO technology adopters or sponsors; federal, state, and municipal regulatory or oversight authorities; **and electricity consumers** (i.e., the ratepayers**)**



GMLC1.1: Metrics Analysis
Project Team

GRID MODERNIZATION INITIATIVE
U.S. Department of Energy

Project Participants and Roles

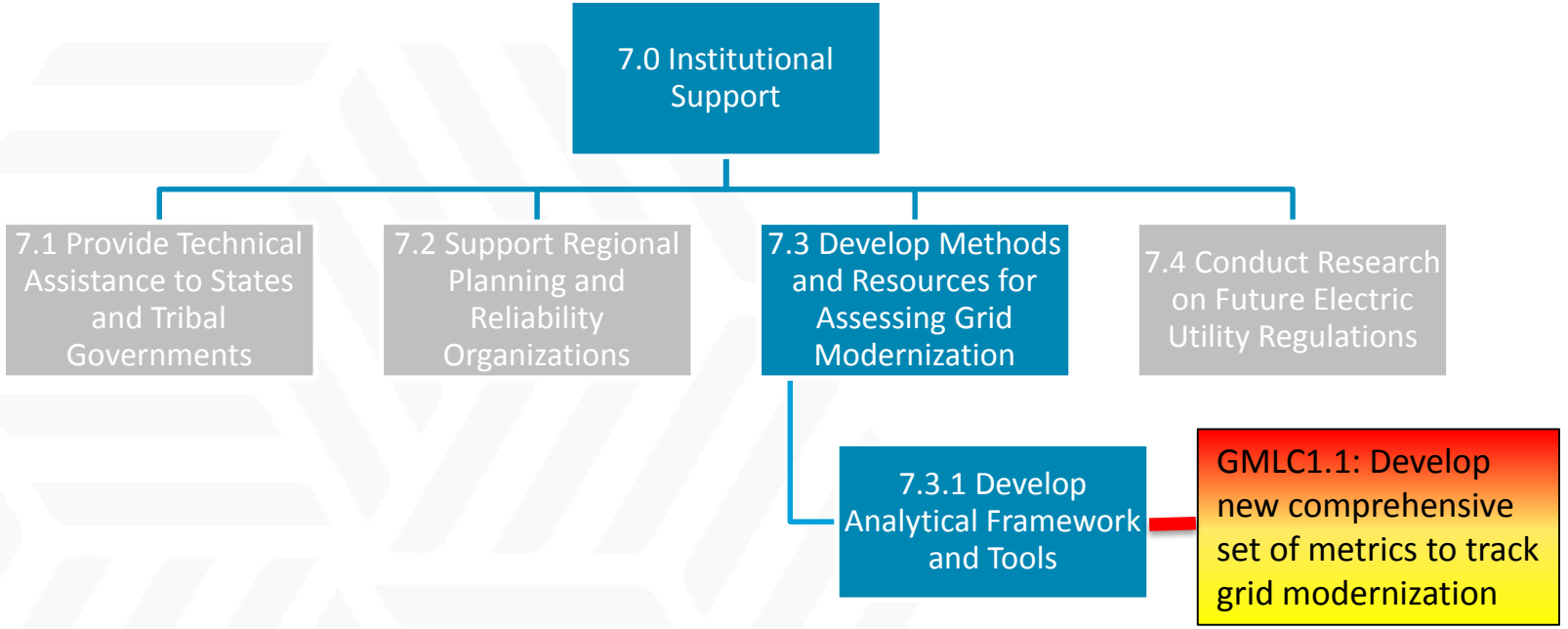
ANL – **Security and synthesis lead,** resilience contributor
BNL – Reliability contributor
LANL – Synthesis contributor
LBNL – **Reliability lead,** Flexibility, Sustainability contr.
LLNL – **Flexibility lead**
NREL – **Sustainability and stakeholder engagement lead,** flexibility contributor
ORNL – Affordability contributor
PNNL – **Affordability lead** and project manager
SNL – **Resilience lead**

Working Partners

- ✓ 5 Federal : FERC, EIA, DHS, EPA, DOE/EPSA
- ✓ 7 Assocs: APPA, NARUC, IEEE, EPRI, EEI, NASEO, NERC
- ✓ 2 ISOs: ERCOT, CAISO
- ✓ 2 GMI Regional Partners: Alaska, New Orleans

PROJECT FUNDING			
Lab	FY16 $	FY17$	FY18 $
ANL	206	62.5	57.5
BNL	57	7.5	7.5
LANL	27	0	0
LBNL	226	42.5	42.5
LLNL	146	35	35
NREL	333	102.5	97.5
ORNL	70	12.5	12.5
PNNL	343	215	235
SNL	173	35	35
Reserve		***1072***	***1061.5***
Total	**1581**	**1584.5**	**1584**

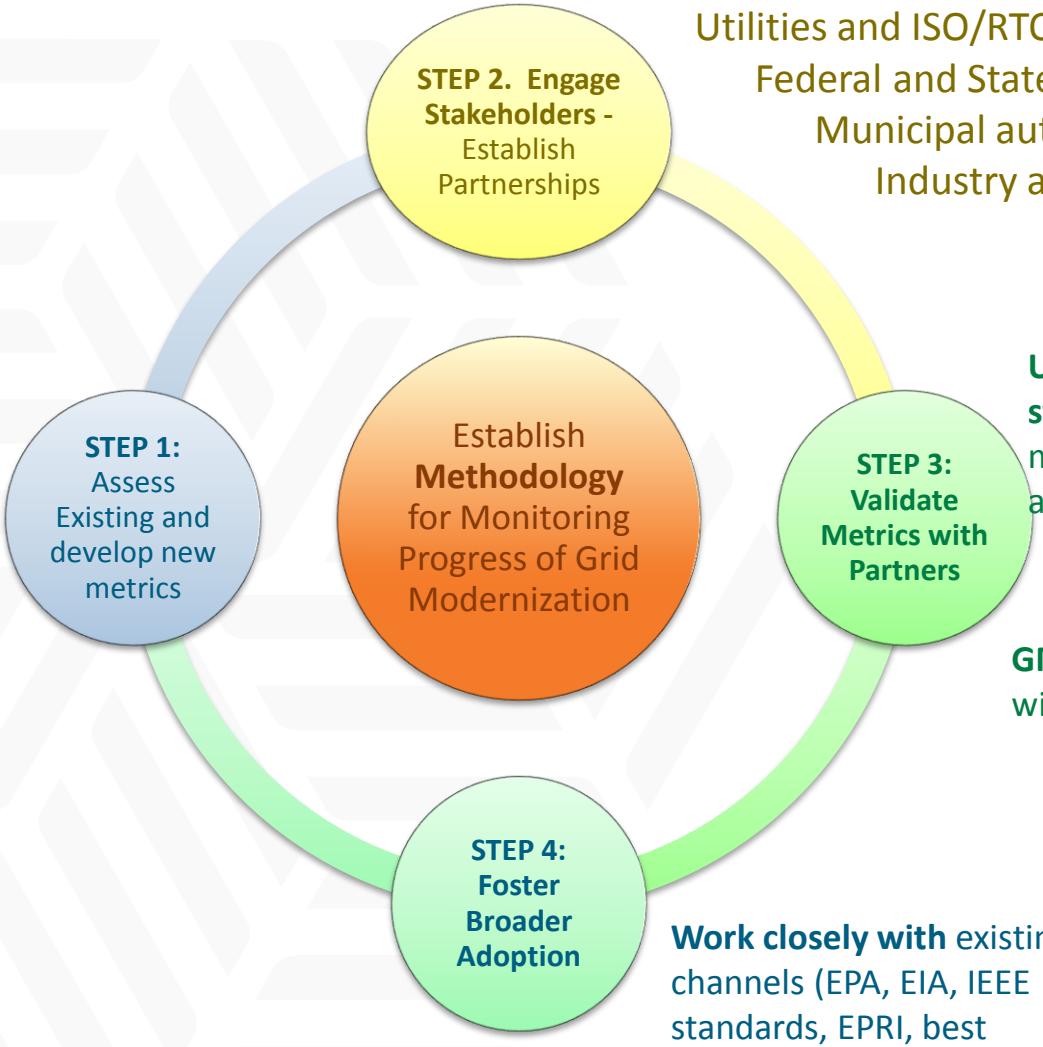
GMLC1.1: Metrics Analysis
Relationship to Grid Modernization MYPP



Directly aligned with all principal GMLC MYPP project areas:

- Devices and integrated system testing
- System operation, power flow, and control
- Design and planning tools
- Security and resilience

GMLC1.1: Metrics Analysis
Approach



Utilities and ISO/RTOs
Federal and State regulators,
Municipal authorities,
Industry associations

Utilities and key stakeholders will test metrics for self-assessment

GMLC Regional Partners will apply metrics

Work closely with existing channels (EPA, EIA, IEEE standards, EPRI, best practice

Work closely with existing channels (EPA, EIA, IEEE standards, best practice

Collaborate with GMLC Portfolio researchers

GMLC1.1: Metrics Analysis

Key Project Milestones

GRID MODERNIZATION INITIATIVE
U.S. Department of Energy

Milestone (FY16-FY18)	Status	Due Date
Develop program plan and stakeholder engagement strategy	**Completed June 30, 2016**	**June 30, 2016**
Develop a booklet illustrating initial approach, methodologies, and data requirements	**Completed – initial reference document with focus areas for each metrics category**	**June 30, 2016**
Initial meetings with working partners	**Completed – overview of project and Year 1 focus in each metric category**	**August 30, 2016**
Plans in place for testing specific metrics	**Ongoing – holding discussions GMI RP to identify pilots for each metric**	**December 31, 2016**
Develop report with initial new metrics	**Ongoing – specific deliverables and outline developed**	**March 2017**
Revise program plan and communication strategy. This will make recommendations for budget allocations from reserve to topical areas	Not initiated	April 30, 2017
Final report documenting use case metrics applications	Not initiated	August 31, 2018
Briefing material for implementation of metrics in a web-based dashboard	Not initiated	August 31, 2018

GMLC1.1: Metrics Analysis
Accomplishments to Date

GRID MODERNIZATION INITIATIVE
U.S. Department of Energy

Reliability

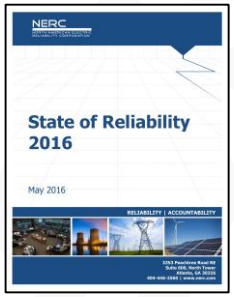
Lead: Joe Eto (LBNL)

Value: new metrics for reliability value-based planning and bulk power system assessment

New metrics for distribution that capture the economic cost of interruptions to customers

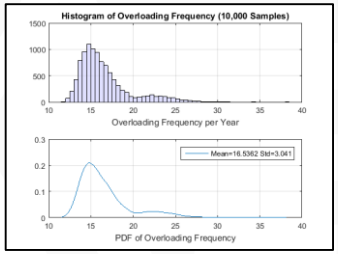
AMERICAN PUBLIC POWER ASSOCIATION
Powering Strong Communities

eReliabilityTracker



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



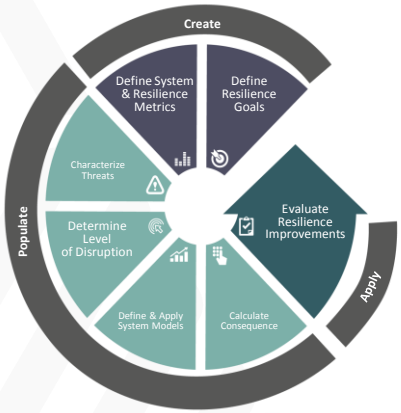
Next steps: new metrics/processes for:
- NERC State of Reliability report
- transmission planning

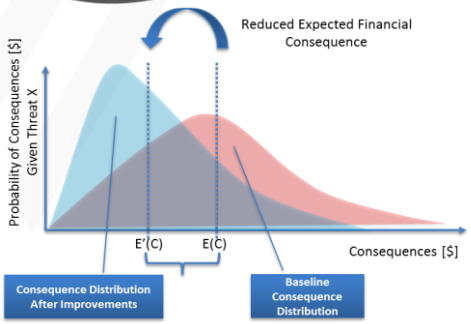
Resilience

Lead: Eric Vugrin (SNL)

Value: create new metrics/process for resilience investm.

Analysis Process





Results

Next steps: Validate with New Orleans

GMLC1.1: Metrics Analysis
Accomplishments to Date

GRID MODERNIZATION INITIATIVE
U.S. Department of Energy

Flexibility

Lead: Tom Edmunds(LLNL)

Value: Develop and demonstrate usefulness of new flexibility metrics

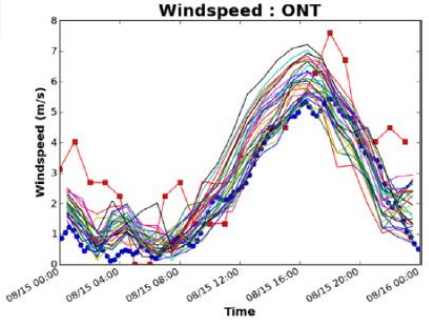
Developed large set of candidate metrics that represent network properties of flexibility and lack of flexibility, engaging stakeholders to identify most useful metrics

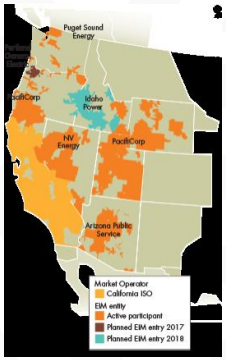
Lagging indicators

- 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.





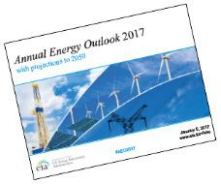
Next steps: Work with CAISO, ERCOT to adopt flexibility metrics

Sustainability

Lead: Garvin Heath (NREL)

Value: Identify needed improvements to GHG reporting

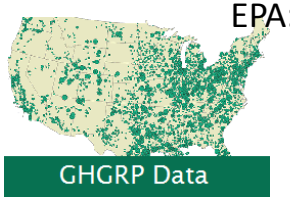
Ability of federal greenhouse gas data products to capture changes in electric-sector CO_2 emissions that might result from future grid modernization varies, depending on coverage of certain energy sources anticipated to grow.



EIA: AEO

EPA: eGRID

EIA: MER



EPA: GHGRP

Next steps: Assess usefulness and availability of data for impacts on water resources

GMLC1.1: Metrics Analysis
Accomplishments to Date

GRID MODERNIZATION INITIATIVE
U.S. Department of Energy

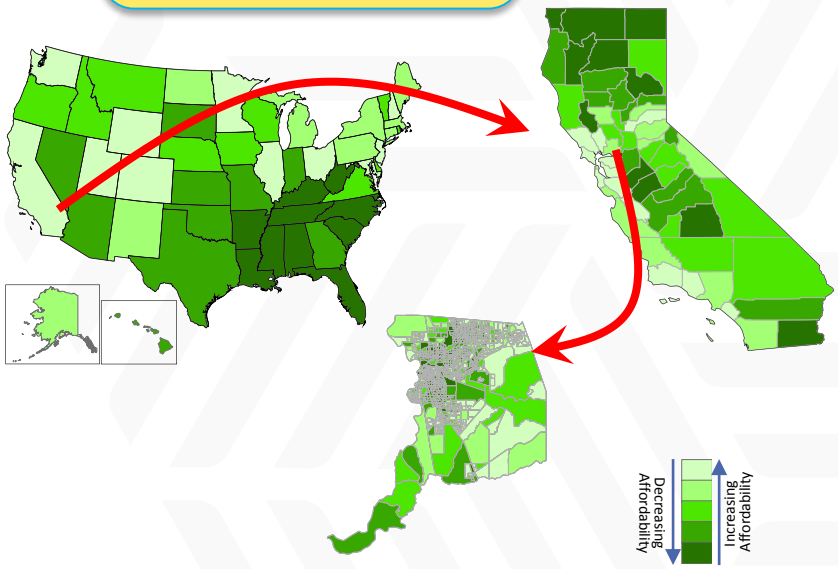
Affordability

Lead: Dave Anderson (PNNL)

Value: Establish new metrics based on cost burden to consumers

Cost Burden Metrics (**emerging**)

- Customer electricity cost burden
- Electricity affordability gap
- Affordability gap headcount
- Temporal indices of these metrics



Next steps: Validating metrics with Regional Partners (Alaska, New Orleans)

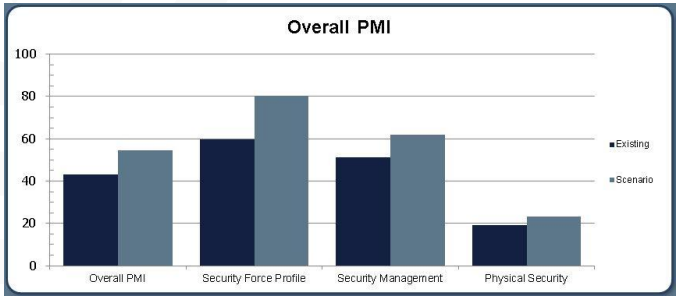
Security

Lead: Steve Folga (ANL)

Value: Spur electric industry adoption of DHS Protective Measures Indices (i.e., security metrics)

Survey/analysis Process

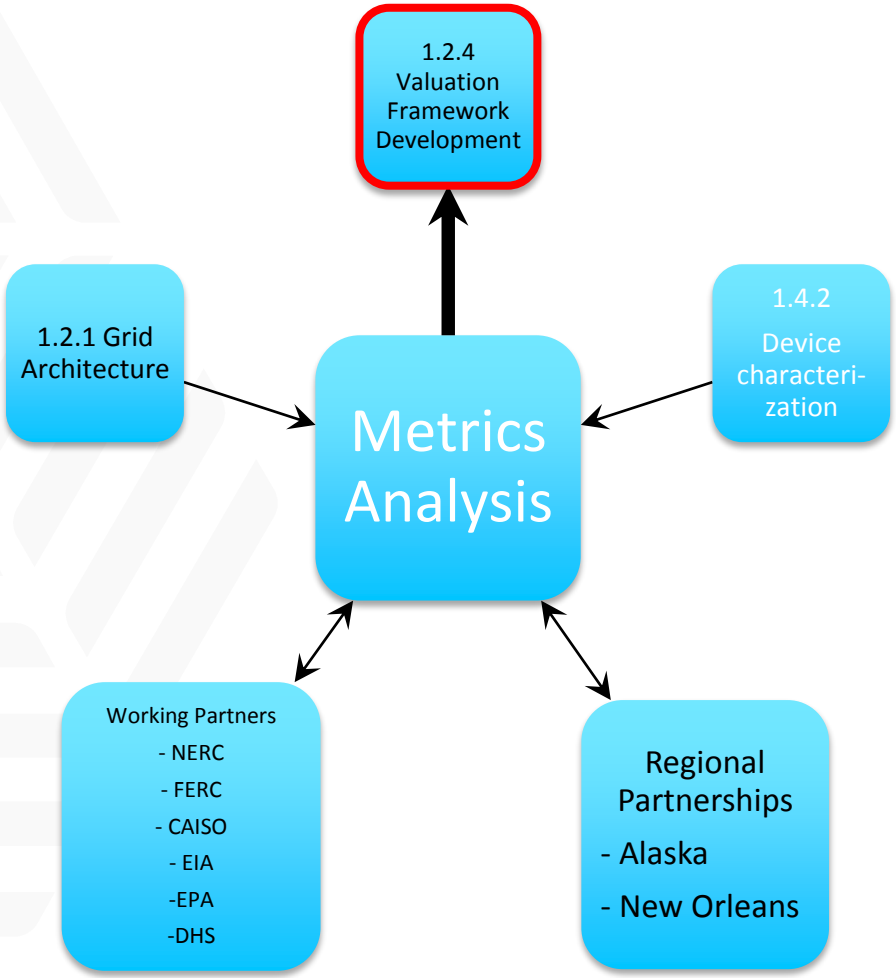
Results



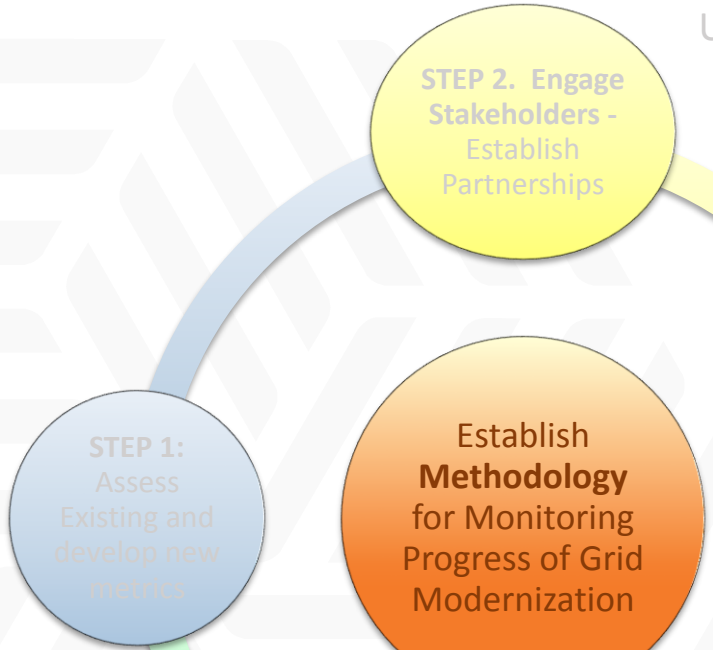
Next steps: Validate PMI Approach with ComED and Idaho Falls

GMLC1.1: Metrics Analysis
Project Integration and Collaboration

- 1.2.4 Valuation Framework Development: provides integral support to the 1.1 project by developing methods for applying prospective metrics (e.g., reliability, resilience, flexibility,) in decision-making processes
- 1.2.1 Grid Architecture: utilizing same definitions of terms and assuring compatibilities of metrics in emerging grid architectures
- 1.4.2 Device Characterization and Testing: assuring compatibilities in terminology for defining use-cases and duty cycles
- GMI Regional Partnerships



GMLC1.1: Metrics Analysis
Next Steps



Utilities and ISO/RTOs
Federal and State regulators,
Municipal authorities,
Industry associations

Work closely with existing channels (EPA, EIA, IEEE standards, best practice

Collaborate with GMLC Portfolio researchers

Utilities and key stakeholders will test metrics for self-assessment

GMLC Regional Partners will apply metrics

Work closely with existing channels (EPA, EIA, IEEE standards, EPRI, best practice

GMLC1.1: Backup Slides

GMLC1.1: Metrics Analysis
Response to December 2016 Program Review

Recommendation	Response
Please provide a baseline and measuring success: During development of the lab call, this project was designed to help identify and clearly define key metrics for the grid that could be used to provide a baseline for regions of the country. As DOE, utilities, and others implemented demonstrations on the grid, these metrics could be used to measure improvement (or decline) in these basic grid attributes. This feature cannot be lost.	Baseline approach established in the Reference Document 2.0 (March 31, 2017)
Please identify the customer: These metrics need to have value both internally (within DOE and the labs), but they must have legitimacy to outside stakeholders as well. It is understood that finding legitimacy across a broad set of stakeholders is difficult.	each metric area will have different customers. There is not single customer for metrics in all 6 metrics areas We will address specific users in the next version of Reference Document
Please prioritize: Within world of limited resources, how does DOE and the labs prioritize funding across these metrics? Some are more mature than others. How does DOE and the labs consider a need for new metrics not covered today?	The labs consulted with stakeholders to gauge value of each metric area. Labs and DOE will determine in Year 2 what the prioritization will be. Labs will propose prioritization to be discussed and approved by DOE.

GMLC1.1: Metrics Analysis
Next Steps and Future Plans

GRID MODERNIZATION INITIATIVE
U.S. Department of Energy

Use-cases and baselining (selected next steps)

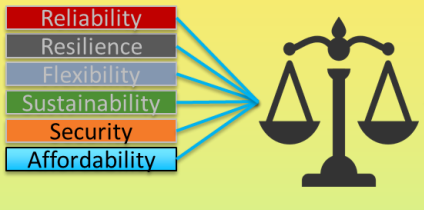
Affordability
Baselining lagging and leading metrics with Alaska Villages

Resilience
Use-cases analysis with New Orleans validating the process for leading metrics

Flexibility
- Reducing the set of lagging metrics by statistical analysis (CAISO, ERCOT)
- Reducing the set of leading metrics by modeling (CAISO)

Coordination with other GMLC Projects

Valuation Project



Outreach and Dissemination
- Reference Document 3.0
- EPRI webinars
- High visibility event(??)

Implementation Plan in Year 3
- Identifying who will own metrics
- who will have access to data

GMLC1.1: Metrics Analysis
Next Steps and Future Plans

Affordability Baselining: Alaska Villages

Village	Average Proportion of Income Spent on Electricity (Customer Burden)						Affordability Gap Factor @ 3% Threshold						Affordability Gap Index (2010=1)					
	2010	2011	2012	2013	2014	2015	2010	2011	2012	2013	2014	2015	2010	2011	2012	2013	2014	2015
Chefornak	3.21%	3.00%	2.68%	2.86%	2.52%	2.28%	1.07	1.00	0.89	0.95	0.84	0.76	1.00	0.94	0.84	0.89	0.79	0.71
Shungnak	4.28%	3.69%	3.71%	3.91%	3.85%	4.02%	1.43	1.23	1.24	1.30	1.28	1.34	1.00	0.86	0.87	0.92	0.90	0.94
AK Villages Weighted Average	3.08%	3.03%	3.01%	3.09%	3.10%	3.10%	1.03	1.01	1.00	1.03	1.03	1.03	1.00	0.98	0.98	1.00	1.01	1.01

Village	Percent of HH with Unaffordable Electricity						Affordability Headcount Gap Index					
	2010	2011	2012	2013	2014	2015	2010	2011	2012	2013	2014	2015
Chefornak	38.0%	36.1%	33.8%	38.6%	31.3%	22.7%	1.00	0.95	0.89	1.01	0.82	0.60
Shungnak	44.4%	40.3%	30.9%	36.8%	37.5%	44.9%	1.00	0.91	0.69	0.83	0.84	1.01
AK Villages Weighted Average	32.1%	32.6%	32.5%	33.2%	32.9%	32.6%	1.00	1.02	1.02	1.04	1.03	1.02

GRID MODERNIZATION INITIATIVE PEER REVIEW

Project 1.2.4: Grid Services and Technologies Valuation Framework

PATRICK O'CONNOR, ORNL

April 18-20, 2017

Sheraton Pentagon City – Arlington, VA

Valuation Framework
High Level Summary

GRID MODERNIZATION INITIATIVE
U.S. Department of Energy

Project Summary

Development a **valuation framework** that will allow electricity-sector stakeholders to conduct, interpret, and compare valuation studies of existing and emerging grid services and technologies with high levels of **consistency, transparency, repeatability, and extensibility**.

Value Proposition

- ✓ **Valuation drives investments**—from equipment purchases to rate-making to multi-billion dollar research portfolios
- ✓ But**… current approaches are difficult to directly compare and reconcile**
- ✓ **Decision makers** need information they can **reliably interpret and compare**

Project Objectives

- ✓ Produce **a framework—not a new model**: a systematic approach to conducting, and interpreting valuation resulting in…
- ✓ …increased **transparency in modeling assumptions and methods** used in evaluating grid technologies and services
- ✓ …the ability of stakeholders to identify **value beyond monetary savings and costs** (sustainability, reliability, etc)
- ✓ …**useful and used guidance** for the broad range of valuation applications
- ✓ … the **foundation of reaching a long-term vision** of improved, broadly consistent valuation practices

Valuation Framework
Project Team

GRID MODERNIZATION INITIATIVE
U.S. Department of Energy

Project Participants and Roles

Laboratories
ORNL – Project manager
PNNL – Review state of valuation (+1)
ANL – Taxonomy and glossary (+1)
NREL – Test cases
LBNL – Review and taxonomy support
SNL – Framework development support
LANL – Framework development support

Industry
NARUC – partner supporting Stakeholder Advisory Group engagement

PROJECT FUNDING			
Lab	FY16 $	FY17$	FY18 $
ORNL	375k	355k	415k
PNNL	200k	175k	205k
NREL	95k	200k	170k
ANL	155k	85k	60k
LBNL	105k	50k	60k
SNL	40k	80k	60k
LANL	30k	55k	30k
TOTAL	**$1M**	**$1M**	**$1M**

The project leverages the diverse expertise of the National Laboratory system to address the breadth of challenges in creating a transparent process of valuing technology, policy, and service impacts to the grid

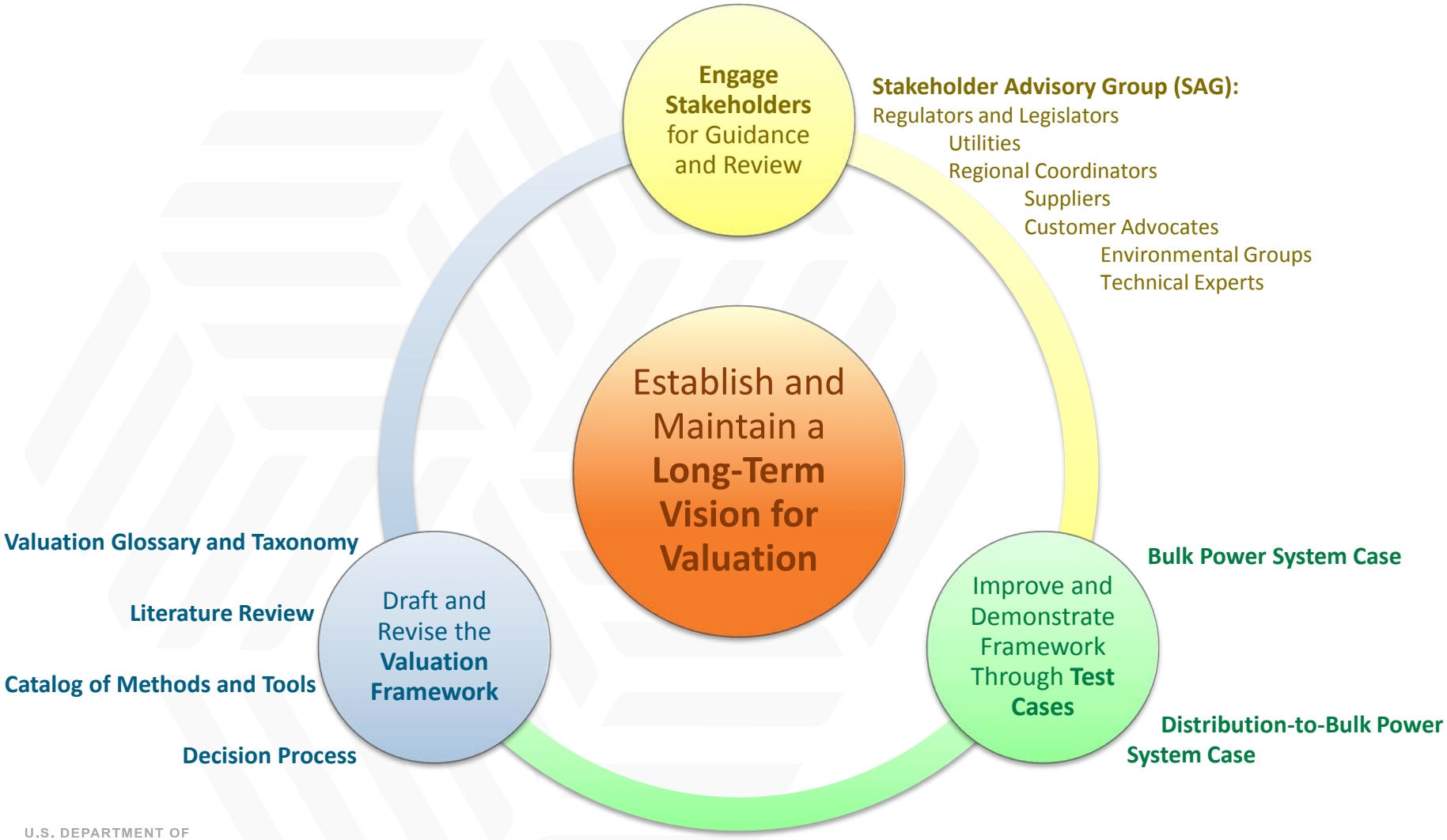
Valuation Framework
Relationship to Grid Modernization MYPP

7.0 Institutional Support

- **7.1 Provide Technical Assistance to States and Tribal Governments**
- **7.2 Support Regional Planning and Reliability Organizations**
- **7.3 Develop Methods and Resources for Assessing Grid Modernization**
  - **Task 1: Analytical framework and tools for valuing impacts of distributed energy resources**
- **7.4 Conduct Research on Future Electric Utility Regulations**

Additional feedback and integration with other MYPP areas (e.g. 5.0 Design and Planning Tools; 8.0 Regional Partnerships) to incorporate new methods and findings

Valuation Framework
Approach



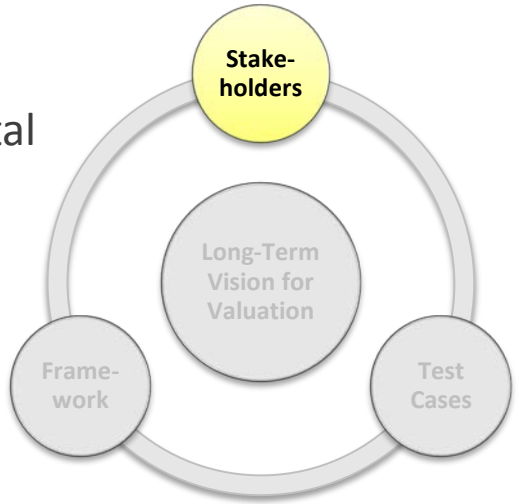
Valuation Framework

Accomplishments to Date: Drawing Value from the Advisory Group

GRID MODERNIZATION INITIATIVE
U.S. Department of Energy

Identifying stakeholder needs—and practical outputs

One-on-one and group conversations with SAG have been instrumental in shaping what the project should produce:

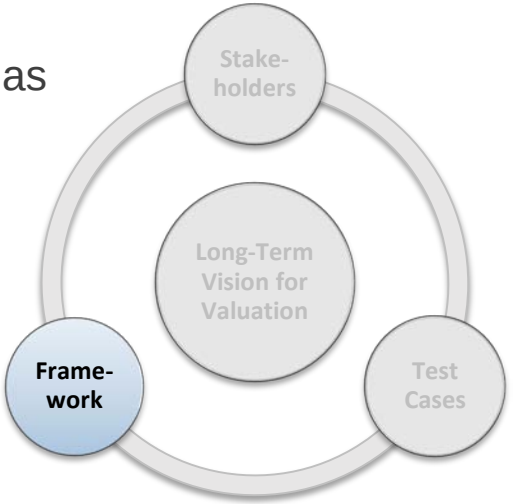


- Guidance
  - Stated need from SAG members to understand systematically how to work through valuation problems
  - DOE and Laboratory neutrality and expertise is valued along multiple dimensions
- Don't take simple products off of the table—*"I need a Valuation Checklist"*
- Project additionally viewed as a learning opportunity to some—teaching mechanism to others
- Valuable input to other project tasks

Valuation Framework

Accomplishments to Date: Assessing the Current State of Valuation

GRID MODERNIZATION INITIATIVE
U.S. Department of Energy



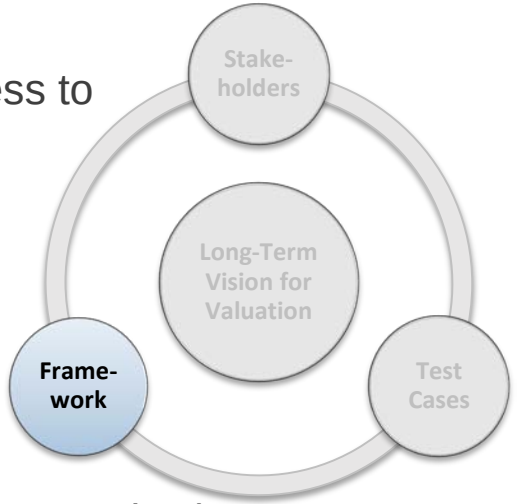
- Primary focus of value estimates centered on ***affordability*** defined as (Benefit/Cost); reliant on simplified calculation methodologies
- Next most frequent valuation category includes ***sustainability*** as expressed in GHG emissions; typically monetized via regulatory costs or social cost of carbon
- ***Reliability*** value not estimated, but used as requirement in many valuations
  - E.g. as *constraint* and not *objective* in modeling
- Value of ***resilience*** only discussed in context of microgrids; ***Flexibility*** value discussed qualitatively; ***Security*** value only mentioned
- Emphasis placed on traditional monetized cost and benefits; formal (or even informal) multi-objective analysis is limited
- Treatment of *uncertainty* is highly varied

Valuation Framework

Accomplishments to Date: Abstracting for extensibility; outlining the framework decision process

The "framework" is ultimately systematic guidance and a decision process to construct and interpret valuation studies based on **key questions**:

1. **Why** are we conducting a valuation study?
2. **Who** are the stakeholders (and what do they care about)?
3. **What** is being measured?
4. **How** are we measuring it given resource constraints?
5. **How will metrics be used** to inform decision making?
6. **What matters** to support the ultimate decision (transparency and uncertainty)?



- Reliability
- Resilience
- Flexibility
- Sustainability
- Security
- Affordability
- Economic Impact

	Simple	**Complexity**	Involved
Coarse	Purpose: Screening Data required: Low		Purpose: Multi-region evaluation of technologies and services Data required: Geographic or technology high
Accuracy			
Precise	Purpose: Single Project developer Data required: High for project, low for rest of grid		Purpose: Rate-setting, major project construction decision Data required: High

Valuation Framework
Key Project Milestones

GRID MODERNIZATION INITIATIVE
U.S. Department of Energy

Milestone (FY16-FY18)	Status	Due Date
Stakeholder Advisory Group workshop is held	Initial workshop held. Engagement is ongoing: members involved individually on an ad-hoc basis and collectively on a quarterly basis	10/1/16
Draft framework completed	Literature review executed 1/17. Draft framework completed and undergoing heavy revision and population	4/1/17
Test case applying framework to bulk system power issue is completed	Test-case subject and approach undergoing finalization	10/1/17
Second Draft of framework is issued encompassing lessons learned from test case		4/1/18
Final framework encompassing lessons learned from second test case is completed and issued		10/1/18

Valuation Framework

Response to December 2016 Program Review

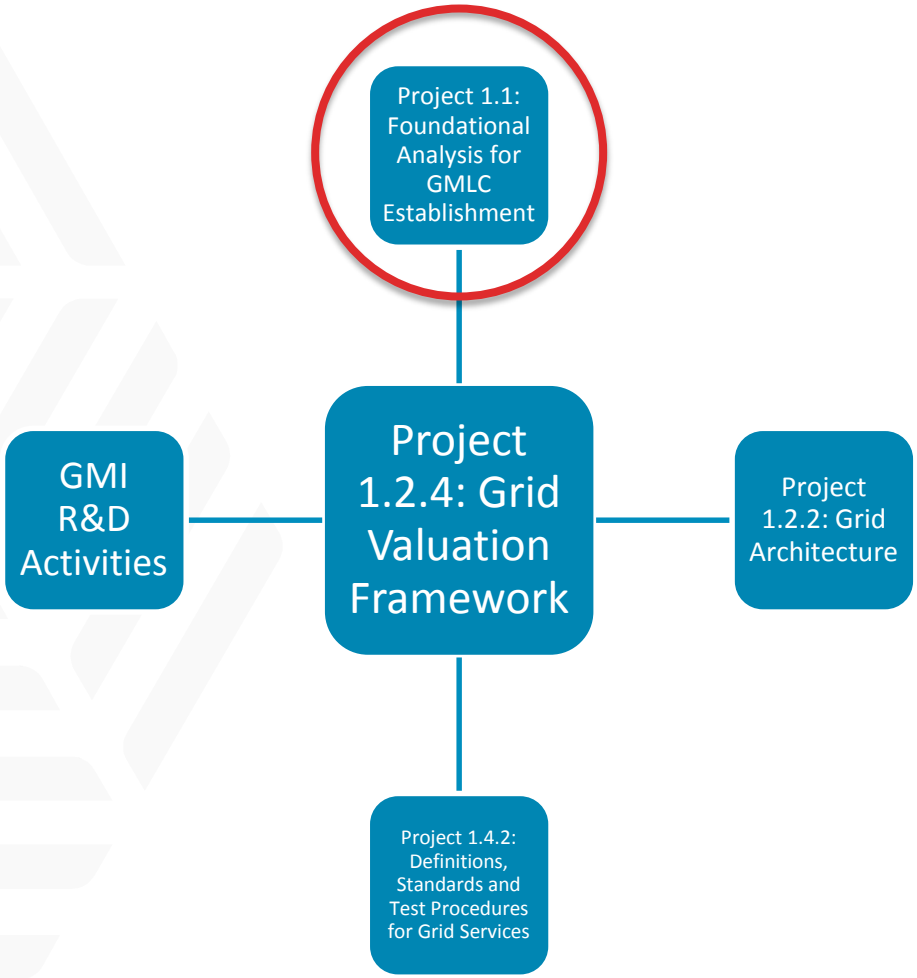
GRID MODERNIZATION INITIATIVE
U.S. Department of Energy

Recommendation	Response
*The principle investigator (PI) mentioned the need to develop **generally accepted valuation principles analogous to principles in more mature area (like accounting)**. DOE agrees with that approach.*	These "GAVP" principles are an **essential component of the Long-Term Vision**.
*As mentioned in the meeting, developing a framework for valuation is extremely important. **The value of this project is enabling an "apples to apples" comparison of valuation studies across a range of regions**. At the Annual Peer Review, please demonstrate this capability.*	Regional differences and future impacts are key design considerations; the project will **demonstrate both capabilities in the project's test cases**. However, the framework initially developed under this project will allow apples-to-apples understanding of why differences exists**—true comparative ability is a long-term goal—requires "GAVP"**
*Please **develop an approach that takes into account both regional differences and future impacts** on value must be addressed by this model.*	
*While the project has a strong technical resource committee, **other important stakeholders were mentioned in the meeting that should be included if possible** (e.g. RMI, E3).*	Outreach to these stakeholders is ongoing.
***Please coordinate closely with other partnership projects** like 1.3.5 and 1.3.10.*	Coordination with these projects is ongoing (see next slide). Insights from these specific projects and others (e.g. NY REV) will be essential at document **cutting edge practices for distribution-scale valuation**

Valuation Framework

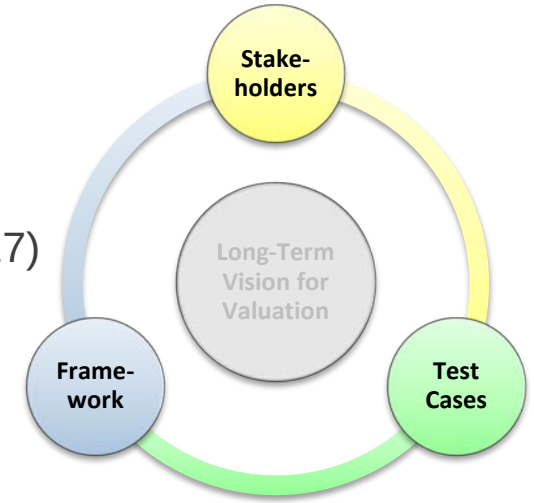
Project Integration and Collaboration

- ✓ **Project 1.1: Foundational Analysis for GMLC Establishment/Analysis** – Collaborate and use the metrics developed to capture the different value categories.
- ✓ **Project 1.2.2: Grid Architecture** – Utilize a compatible process with the architecture defined in this project to ensure interoperability, transparency, and a rigorous discipline.
- ✓ **Project 1.4.2:** Definitions, Standards and Test Procedures for Grid Services – Collaborate with this project in defining a standard set of grid services to ensure interoperability and coherence.
- ✓ **Support and draw from other GMI R&D activities**:
  - ✓ Incorporate new modeling approaches from broad array of valuation-related projects
  - ✓ Glossary of terms useful to provide common language for grid modernization
  - ✓ Valuation process provides insights into value



Communications/Workshops/Visibility:
August, 2016: DOE Electricity Advisory Committee
September, 2016: SAG Kick-off Meeting
November, 2016: DOE Go/No-Go
January, 2017: NARUC "Valuing Baseload" Workshop
January, 2017: SAG Update Webinar
February, 2017: NARUC Rate Design Subcommittee

Valuation Framework
Next Steps and Future Plans



- **Immediate**—(5/2017)
  - Add detail to framework and solicit feedback from SAG
  - Finalize first test case subject and approach (bulk power system)
- **Mid-Term**: execute test case at bulk power system scale (10/1/2017)
  - SAG Advice: *Don't (and don't appear to) cherry-pick a use-case*.
    - Solution: Tackle a class of Valuation question and systematically evaluate framework against published studies
  - Two options currently being discussed: (1) Valuing Nuclear Power (Investment/Divestment/Subsidy); (2) Valuing Grid Storage
- **Long-Term**
  - Case 1 leads into Go/No-Go for last phase of project
  - Revise framework based on case 1, SAG feedback (Early FY 18)
  - Second test case—Distribution System—Likely in depth case with SAG volunteer—test *and* operationalize framework (Mid FY 18)
  - Final framework revision (Late (FY 18)

- As we round into the final year—planning of **practical outputs and dissemination strategy becomes critical**

Valuation Framework
Defining Success; Ensuring Impact

GRID MODERNIZATION INITIATIVE
U.S. Department of Energy

Project Objectives

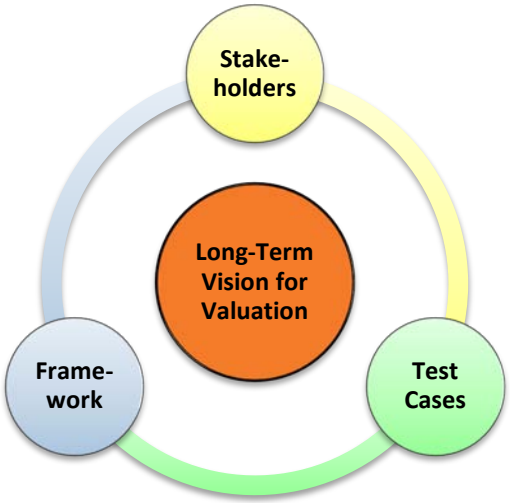
- ✓ Produce **a framework—not a new model**: a systematic approach to conducting, and interpreting valuation resulting in…

- ✓ …increased **transparency in modeling assumptions and methods** used in evaluating grid technologies and services → A "better way" Illustrated through test cases

- ✓ …the ability of stakeholders to capture **value beyond monetary savings and costs** (sustainability, reliability, etc) → Checklist and other "simple" products in the hands of SAG and others

- ✓ …**useful and used guidance** for the broad range of valuation applications → Framework itself used by SAG and others—second test case and beyond

- ✓ … the **foundation of reaching a long-term vision** of improved, broadly consistent valuation practices → Modeling gaps identified; beginnings of "Generally Accepted Valuation Principles" taking shape



Valuation Framework

Technical Details: Stakeholder Advisory Group Membership

GRID MODERNIZATION INITIATIVE
U.S. Department of Energy

- ► Sectors
- ✓ Regulators/ Legislators
- ✓ Utilities
- ✓ Regional Coordinators
- ✓ Suppliers
- ✓ Customer/ Environmental Groups
- ✓ Technical Experts

Organization	Name	Position
Maine Public Utilities Commission	Denis Bergeron	Director of Energy Program
North Carolina Utilities Commission	Ed Finley	Chairman
Minnesota Public Utility Commission	Matthew Shuerger	Commissioner
Iowa Public Utility Commission	Nick Wagner	Commissioner
Federal Energy Regulatory Commission	Ray Palmer	Chief, Energy Innovations
Washington State Legislature	Jeff Morris	Representative
Kansas State Legislature	Tom Sloan	Representative
Tennessee Valley Authority	Gary Brinkworth	Director of Technology Innovation
Electric Power Board, Chattanooga	Lilian Bruce	Strategic Research
Commonwealth Edison	Val Jensen	Senior VP of Customer Relations
Pacific Gas & Electric	Enrique Mejorada	Director of Energy Policy Modeling and Analysis
Western Electricity Coordinating Council	Michael Bailey	Senior Engineer, System Adequacy
Eastern Interconnection Planning Collaborative	David Whiteley	Director
Midcontinent ISO	J. T. Smith	Director, Policy Studies
American Wind Energy Association	Betsy Beck	Director, Transmission Policy
Solar City	Ryan Hanley; Alt. Rohan Ma	VP of Grid Engineering Solutions
Citizens Utility Board	David Kolata	Executive Director
Western Clean Energy Advocates	Ron Lehr	Consultant
Continental Economics	Jonathan Lesser	President
EPRI	Bernard Neenan	Technical Executive
Johns Hopkins University	Ben Hobbs	Director – Environment, Energy, Sustainability & Health Institute

Valuation Framework

Technical Details: Literature Review Content

- *Thirty-eight papers and reports dealing with valuation reviewed*
- *Combined with similar topics into buckets*
- *Numbers refer to number of studies/papers*

- **Technology Portfolios**
  - IRPs (4)
  - Transmission planning (4)
  - Distribution resource planning (3)
- **Policy Options**
  - Net energy metering (4)
  - Rate design (4)
  - Resource adequacy assessment (1)
  - Value of reliability Improvement (1)

- **Individual Technologies or Assets**
  - Distributed PV (4)
  - Nuclear (3)
  - Electric Vehicles (3)
  - Microgrids (2)
  - Storage (3)
  - HVDC line (1)
  - Hydropower (1)

Valuation Framework

Technical Details: Literature Review High-Level Findings (numerical)

GRID MODERNIZATION INITIATIVE
U.S. Department of Energy

Metrics	Economic Values: Discounted Cash Flow That Quantifies Net Benefit (Cost/Benefit)					Engineering Values/Methodologies That Determine How Assets are Used	
	COST (Capital)	COST (Operations)	AVOIDED COST (Capital)	ADVOIDED COST (Operations)	Real Option Analysis	Complex System Analysis	Simple Load Balancing (Spreadsheet Analysis)
Reliability	23%	23%	23%	23%	3%	9%	27%
Resilience	10%	10%	10%	10%	0%	2%	10%
Flexibility	13%	13%	13%	20%	0%	3%	17%
Sustainability (GHG)	27%	13%	30%	37%	0%	10%	23%
Sustainability (Air Quality)	13%	13%	17%	23%	0%	3%	17%
Sustainability (Water)	7%	7%	3%	3%	0%	1%	3%
Affordability	100%	100%	100%	100%	7%	22%	77%
Security	3%	3%	3%	3%	0%	0%	3%

GRID MODERNIZATION INITIATIVE PEER REVIEW

GMLC 1.3.22 – Technical Support to the New York REV Initiative

J. PATRICK LOONEY, BNL

April 18-20, 2017

Sheraton Pentagon City – Arlington, VA

Technical Support to the New York State REV Initiative

High Level Summary

GRID MODERNIZATION INITIATIVE
U.S. Department of Energy

Project Description

Provide objective technical assistance by a team of experts from the national laboratories to New York State agencies and policy makers to enable the **Reforming the Energy Vision** (REV), and, as a result, gain knowledge that can be leveraged for DOE's Grid Modernization Initiative.

Value Proposition

- ✓ The REV vision is for New York State to be an early adopter of advanced grid technologies at scale, resulting in significant penetration of DER.
- ✓ Key questions with regard to grid modernization will be addressed, including what business models work and why, as well as which technologies provide the most benefit and how they should be implemented.
- ✓ REV offers an important and unique opportunity to participate in a ground-breaking effort to develop future utility business models.

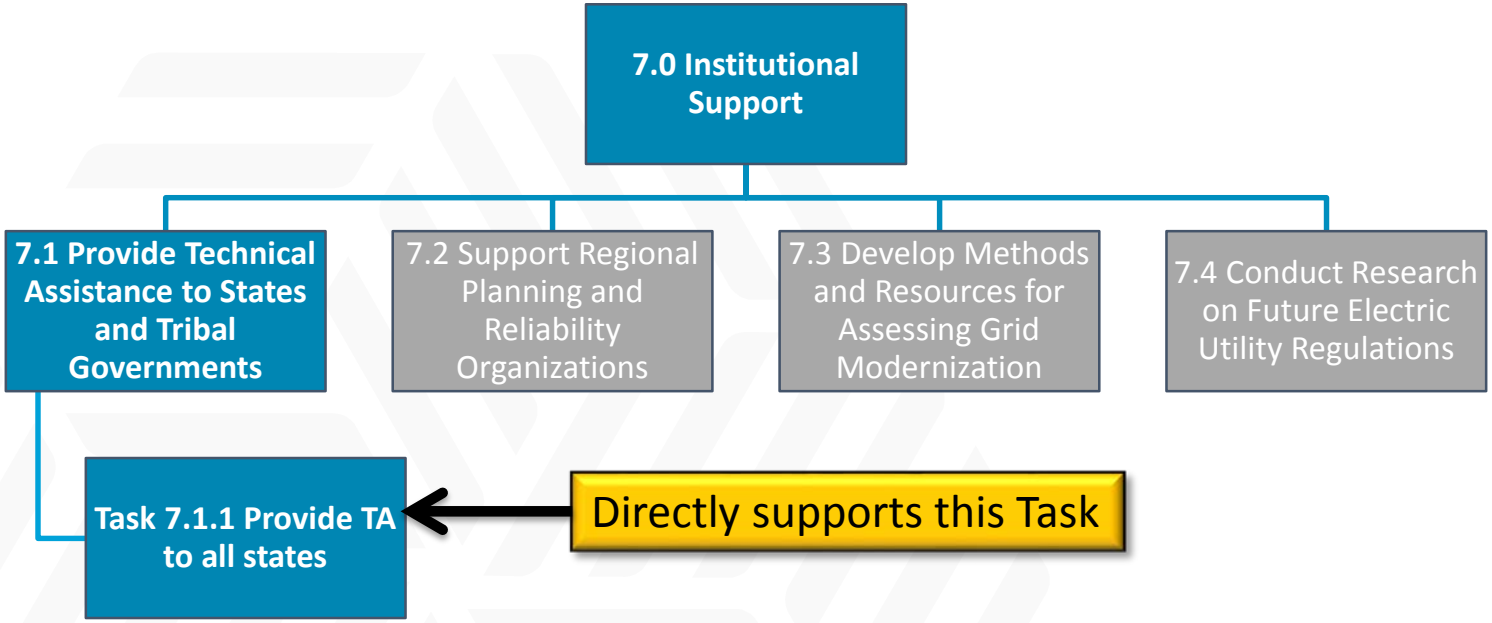
Project Objectives

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

PROJECT FUNDING			
Lab	FY16 $	FY17$	FY18 $
BNL	$225,000	$200,000	-
LBNL	$200,000	$200,000	-
PNNL	$ 75,000	$ 50,000	-
INL	$ 50,000	-	-
Total	**$550,000**	**$450,000**	-

Technical Support to the New York State REV Initiative

Relationship to Grid Modernization MYPP



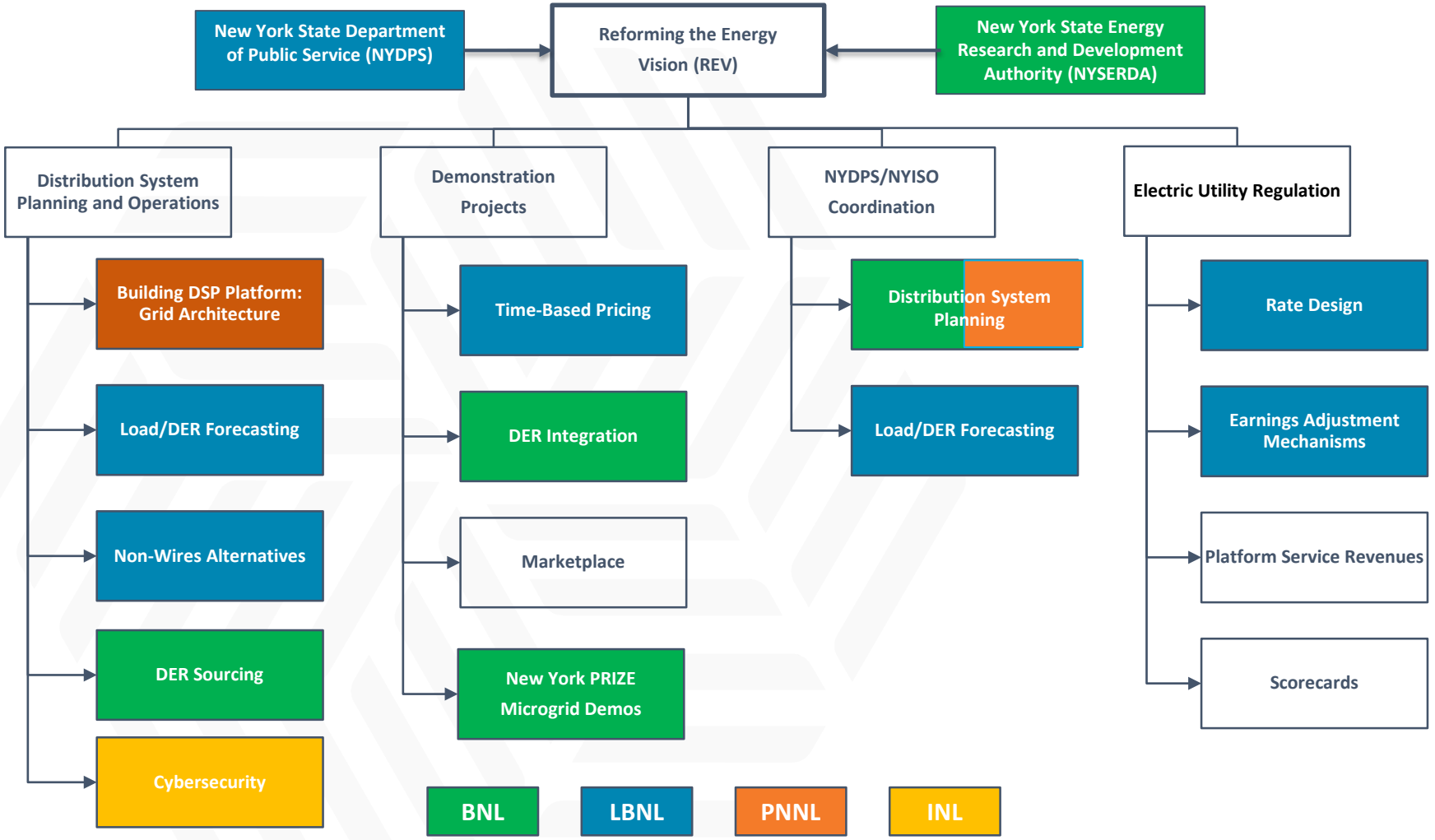
MYPP vision for the Institutional Support

- Leverage existing technical expertise, analytical tools, models, and data
- Directly address high priority grid modernization challenges and needs for NY stakeholders
- Convene key grid stakeholders as an honest-broker for collaborative dialogues
- Create an over-arching ongoing suite of grid-related "institutional" analysis, workshops, and dialogues

Technical Support to the New York State REV Initiative

Project Team & Approach

GRID MODERNIZATION INITIATIVE
U.S. Department of Energy



Technical Support to the New York State REV Initiative

Key Project Milestones

GRID MODERNIZATION INITIATIVE
U.S. Department of Energy

Milestone (FY16-FY18)	Status	Due Date
Identify high priority TA tasks by NYS agencies.	Completed	7/15/16
Annual progress report and lessons learned from REV.	Completed	12/31/16
Midterm progress report and lessons learned from REV.	On schedule	5/1/17
Final Annual progress report	On schedule	10/1/17
Summary report with insights and lessons learned from REV	On schedule	10/1/17

Technical Support to the New York State REV Initiative

Highlights of Accomplishments to Date

GRID MODERNIZATION INITIATIVE
U.S. Department of Energy

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

Technical Support to the New York State REV Initiative

Response to December 2016 Program Review

Recommendation	Response
1. Coordinate and contribute more directly to valuation project (1.2.4).	Will more directly engage with GMLC 1.2.4 project PI to identify specific areas where synergies exist and results can be shared and integrated.
2. Provide detail of accomplishments	TA for REV frequently takes the form of technical memos, presentations, and/or conversations. Provided list of expected upcoming accomplishments.
3. Clarify coordination with Projects 1.2.1 and 1.4.25	Project 1.2.1 "Grid Architecture" led by Jeff Taft, who also participates on the REV project. REV Team will inform Project 1.4.25 (Distribution System Decision Support Tool) of work ongoing in NY REV. REV Team will also coordinate with the DSPx project.
4. Highlight and document specific accomplishments	Will develop a summary report of lessons learned from the project's TA efforts that will be applicable to other state's considering similar issues.

Technical Support to the New York State REV Initiative

Project Integration and Collaboration

- **1.1: Foundational Analysis for GMLC Establishment** –Validate and demonstrate grid performance metrics
- **1.4.29: Future Electricity Utility Regulation** – Contribute design and implementation options, issues and concerns associated with NYDPS regulatory reforms
- **1.4.25: Distribution System Decision Support Tools** – Provide lessons learned from participation in DSIP review process
- **1.2.1: Grid Architecture** – Apply compatible process with the architecture defined in this project when reviewing and commenting on NY utilities' distribution system investment plans (DSIPs)
- **1.2.4: Grid Services and Technology Valuation Framework** – Identify insights on the challenges and best practices for siting DER at the distribution level
- **1.3.5 DER Siting and Optimization Tool for CA** – NY and CA regulators are coordinating on tool development and demonstration
- **Next Generation Distribution System Platform** (DSPx)

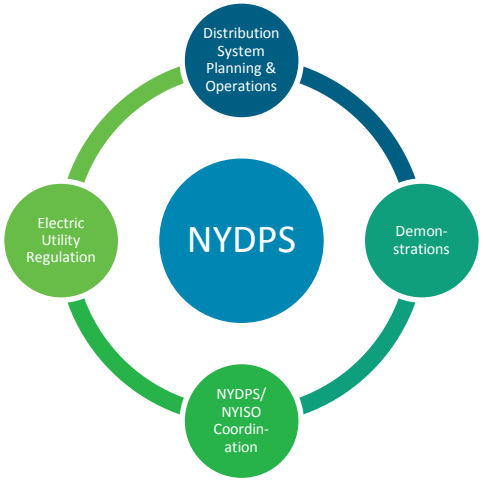
Technical Support to the New York State REV Initiative

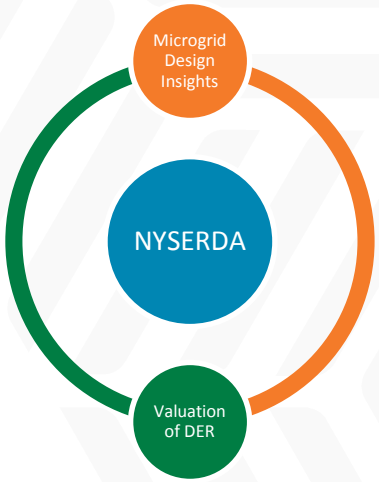
Next Steps and Future Plans

GRID MODERNIZATION INITIATIVE
U.S. Department of Energy

Continue Support to NYDPS

- Work with Staff to review and improve utility's proposed changes to business models and metrics that support REV goals
- Host a workshop for NY utilities on Grid architecture
- Report on selected communication network issues
- Individual meetings with PSC & utilities to review & discuss their approaches to adhering to the REV Cybersecurity Framework





Continue Support to NYSERDA

- Study on NY PRIZE microgrid designs-insights and lessons learned
- TA to address issues with design, development and operation of the Distributed System Platform
- TA on a study of the Value of DER

Prepare Summary Report with Insights and Lessons-Learned from REV

Technical Support to the New York State REV Initiative

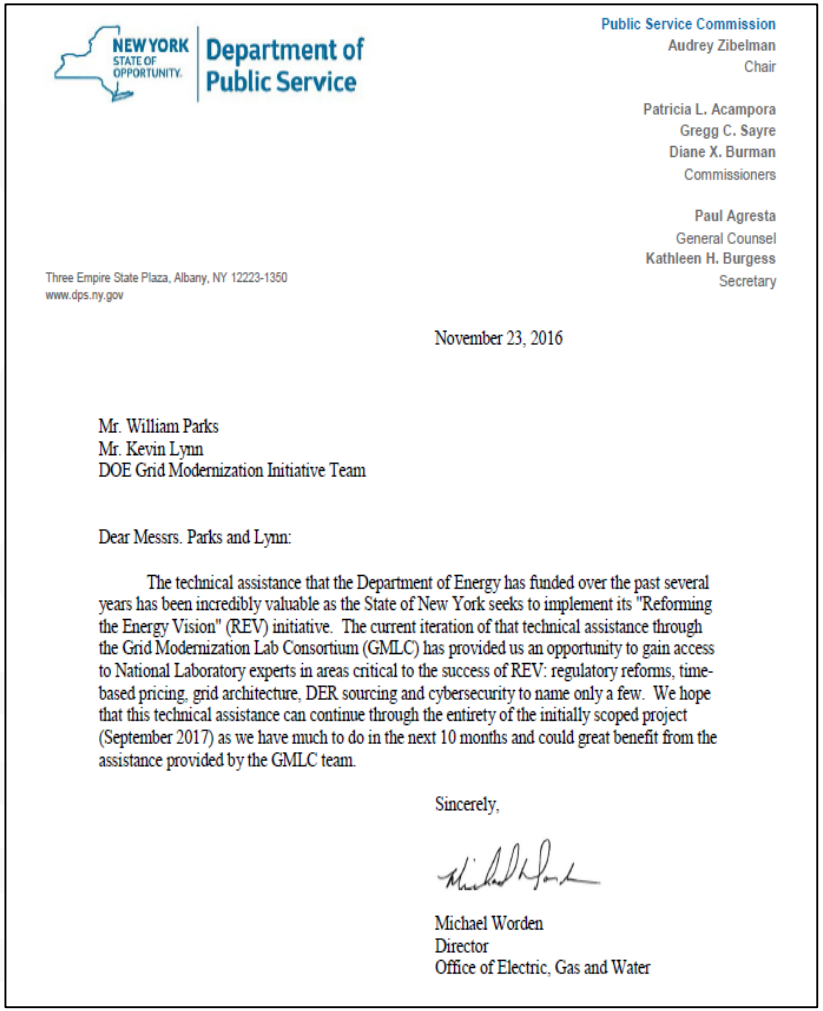
Technical Details

- Backup Slides

Technical Support to the New York State REV Initiative

Support from NY DPS

- This project has been very successful and customer response to the TA provided has been very positive
- The current project will expire this year (FY 2017); however, REV implementation is expected to continue for the next 5 or more years
- There is still much work to be done and many more challenges to be overcome, so there is a continuing need for TA



NEW YORK STATE OF OPPORTUNITY. Department of Public Service

Public Service Commission
Audrey Zibelman
Chair

Patricia L. Acampora
Gregg C. Sayre
Diane X. Burman
Commissioners

Paul Agresta
General Counsel
Kathleen H. Burgess
Secretary

Three Empire State Plaza, Albany, NY 12223-1350
www.dps.ny.gov

November 23, 2016

Mr. William Parks
Mr. Kevin Lynn
DOE Grid Modernization Initiative Team

Dear Messrs. Parks and Lynn:

The technical assistance that the Department of Energy has funded over the past several years has been incredibly valuable as the State of New York seeks to implement its "Reforming the Energy Vision" (REV) initiative. The current iteration of that technical assistance through the Grid Modernization Lab Consortium (GMLC) has provided us an opportunity to gain access to National Laboratory experts in areas critical to the success of REV: regulatory reforms, time-based pricing, grid architecture, DER sourcing and cybersecurity to name only a few. We hope that this technical assistance can continue through the entirety of the initially scoped project (September 2017) as we have much to do in the next 10 months and could great benefit from the assistance provided by the GMLC team.

Sincerely,

Michael Worden
Director
Office of Electric, Gas and Water

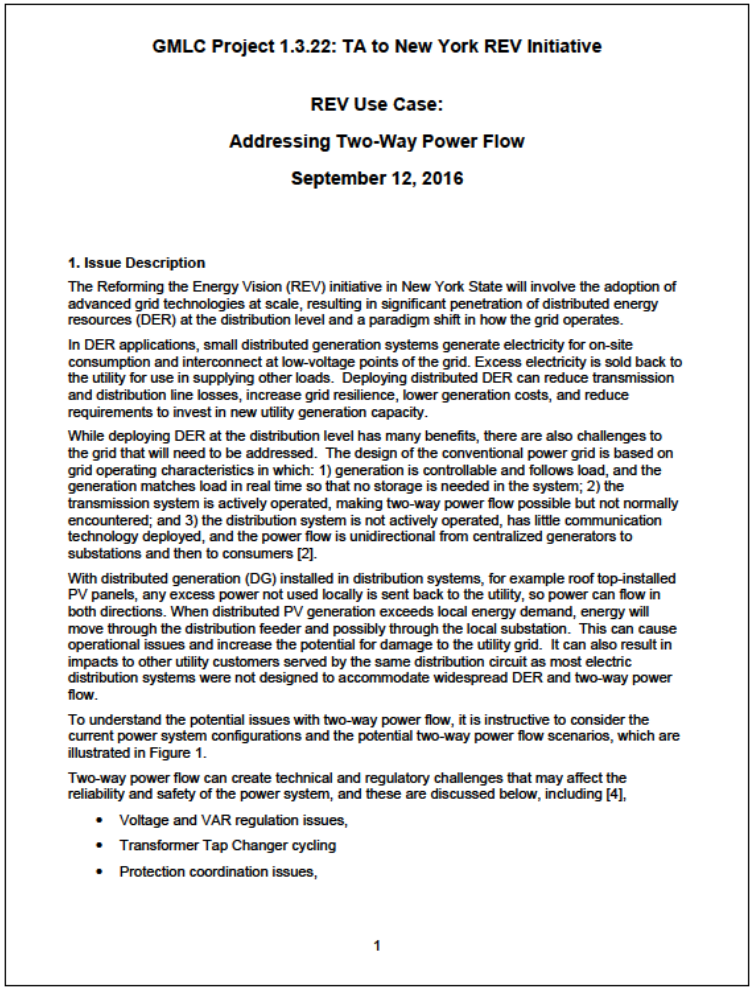
Technical Support to the New York State REV Initiative

Sample Deliverable

GRID MODERNIZATION INITIATIVE
U.S. Department of Energy

Use Case on Two-way Power Flow

- REV will involve significant use of DER at the distribution level
- Deploying DER can improve grid performance, but can also result in two-way power flow
- The GMLC REV Team developed a use case to assist in understanding the challenges of two-way power flow and how to address it



GMLC Project 1.3.22: TA to New York REV Initiative

REV Use Case:

Addressing Two-Way Power Flow

September 12, 2016

1. Issue Description

The Reforming the Energy Vision (REV) initiative in New York State will involve the adoption of advanced grid technologies at scale, resulting in significant penetration of distributed energy resources (DER) at the distribution level and a paradigm shift in how the grid operates.

In DER applications, small distributed generation systems generate electricity for on-site consumption and interconnect at low-voltage points of the grid. Excess electricity is sold back to the utility for use in supplying other loads. Deploying distributed DER can reduce transmission and distribution line losses, increase grid resilience, lower generation costs, and reduce requirements to invest in new utility generation capacity.

While deploying DER at the distribution level has many benefits, there are also challenges to the grid that will need to be addressed. The design of the conventional power grid is based on grid operating characteristics in which: 1) generation is controllable and follows load, and the generation matches load in real time so that no storage is needed in the system; 2) the transmission system is actively operated, making two-way power flow possible but not normally encountered; and 3) the distribution system is not actively operated, has little communication technology deployed, and the power flow is unidirectional from centralized generators to substations and then to consumers [2].

With distributed generation (DG) installed in distribution systems, for example roof top-installed PV panels, any excess power not used locally is sent back to the utility, so power can flow in both directions. When distributed PV generation exceeds local energy demand, energy will move through the distribution feeder and possibly through the local substation. This can cause operational issues and increase the potential for damage to the utility grid. It can also result in impacts to other utility customers served by the same distribution circuit as most electric distribution systems were not designed to accommodate widespread DER and two-way power flow.

To understand the potential issues with two-way power flow, it is instructive to consider the current power system configurations and the potential two-way power flow scenarios, which are illustrated in Figure 1.

Two-way power flow can create technical and regulatory challenges that may affect the reliability and safety of the power system, and these are discussed below, including [4],

- Voltage and VAR regulation issues,
- Transformer Tap Changer cycling
- Protection coordination issues,

1

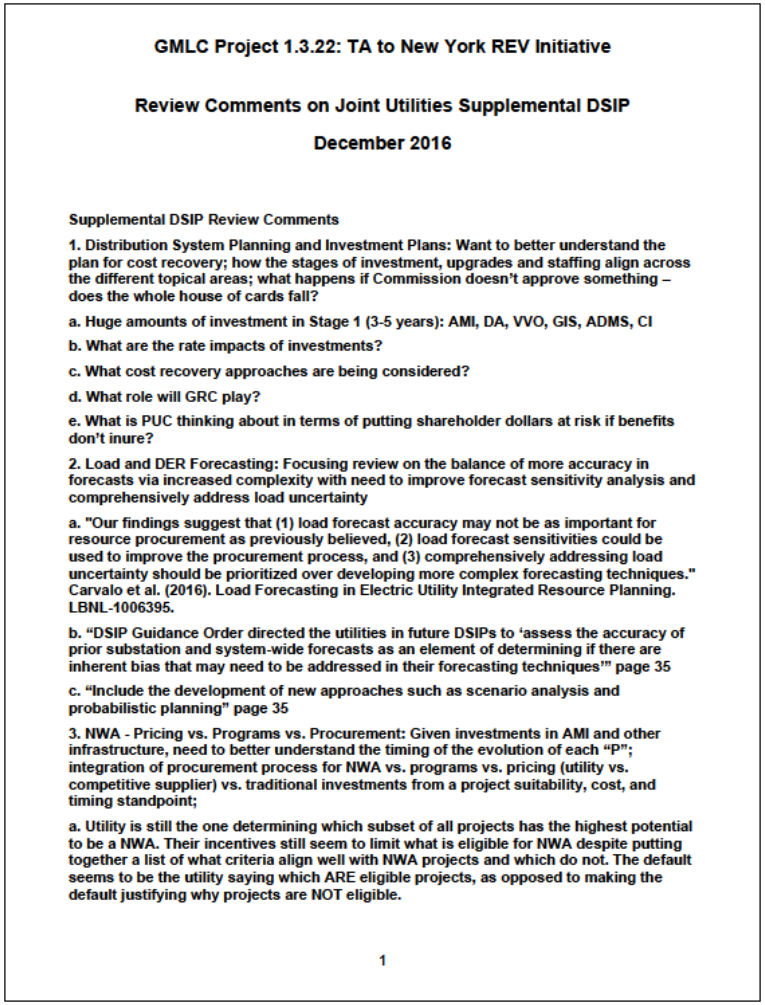
Technical Support to the New York State REV Initiative

Sample Deliverable

GRID MODERNIZATION INITIATIVE
U.S. Department of Energy

Review of Joint Utilities Supplemental DSIP

- The Joint Utilities filed a Supplemental Distributed System Implementation Plan (S-DSIP) in November 2016
- NYDPS asked the GMLC REV Team to review the S-DSIP and provide comments
- The REV Team comments directly impacted the PSC Order for the next wave of filings on DSIPs



GMLC Project 1.3.22: TA to New York REV Initiative

Review Comments on Joint Utilities Supplemental DSIP

December 2016

Supplemental DSIP Review Comments

1. Distribution System Planning and Investment Plans: Want to better understand the plan for cost recovery; how the stages of investment, upgrades and staffing align across the different topical areas; what happens if Commission doesn't approve something – does the whole house of cards fall?

a. Huge amounts of investment in Stage 1 (3-5 years): AMI, DA, VVO, GIS, ADMS, CI

b. What are the rate impacts of investments?

c. What cost recovery approaches are being considered?

d. What role will GRC play?

e. What is PUC thinking about in terms of putting shareholder dollars at risk if benefits don't inure?

2. Load and DER Forecasting: Focusing review on the balance of more accuracy in forecasts via increased complexity with need to improve forecast sensitivity analysis and comprehensively address load uncertainty

a. "Our findings suggest that (1) load forecast accuracy may not be as important for resource procurement as previously believed, (2) load forecast sensitivities could be used to improve the procurement process, and (3) comprehensively addressing load uncertainty should be prioritized over developing more complex forecasting techniques." Carvalo et al. (2016). Load Forecasting in Electric Utility Integrated Resource Planning. LBNL-1006395.

b. "DSIP Guidance Order directed the utilities in future DSIPs to 'assess the accuracy of prior substation and system-wide forecasts as an element of determining if there are inherent bias that may need to be addressed in their forecasting techniques'" page 35

c. "Include the development of new approaches such as scenario analysis and probabilistic planning" page 35

3. NWA - Pricing vs. Programs vs. Procurement: Given investments in AMI and other infrastructure, need to better understand the timing of the evolution of each "P"; integration of procurement process for NWA vs. programs vs. pricing (utility vs. competitive supplier) vs. traditional investments from a project suitability, cost, and timing standpoint;

a. Utility is still the one determining which subset of all projects has the highest potential to be a NWA. Their incentives still seem to limit what is eligible for NWA despite putting together a list of what criteria align well with NWA projects and which do not. The default seems to be the utility saying which ARE eligible projects, as opposed to making the default justifying why projects are NOT eligible.

1

GRID MODERNIZATION INITIATIVE PEER REVIEW

GMLC 1.4.25 - Distribution System Decision Support Tool Development and Application

MICHAEL H. CODDINGTON, NREL

April 18-20, 2017

Sheraton Pentagon City – Arlington, VA

Distribution System Decision Support Tool Development and Application

High-Level Project Summary

GRID MODERNIZATION INITIATIVE
U.S. Department of Energy

Project Description

Identify strategies and provide technical assistance to state regulators and utilities that focus on advanced electric distribution planning methods and tools, with a focus on incorporating emerging grid modernization technologies and the significant deployment of DER

Value Proposition

- ✓ The electric distribution systems are aging and in need of expensive upgrades
- ✓ Large amounts of DERs are being integrated to distribution systems in U.S.
- ✓ PUCs and decision makers have asked for assistance in understanding the distribution systems, and prioritizing upgrades

Project Objectives

- ✓ Provide technical assistance to state regulators in partnership with NARUC
- ✓ Identify gaps in existing and emerging planning practices & approaches
- ✓ Compile information on existing planning tools, identify gaps and necessary functions
- ✓ Provide technical assistance to electric utility industry and associated stakeholders

Project Participants and Roles

Michael Coddington – NREL (Utility Practices)

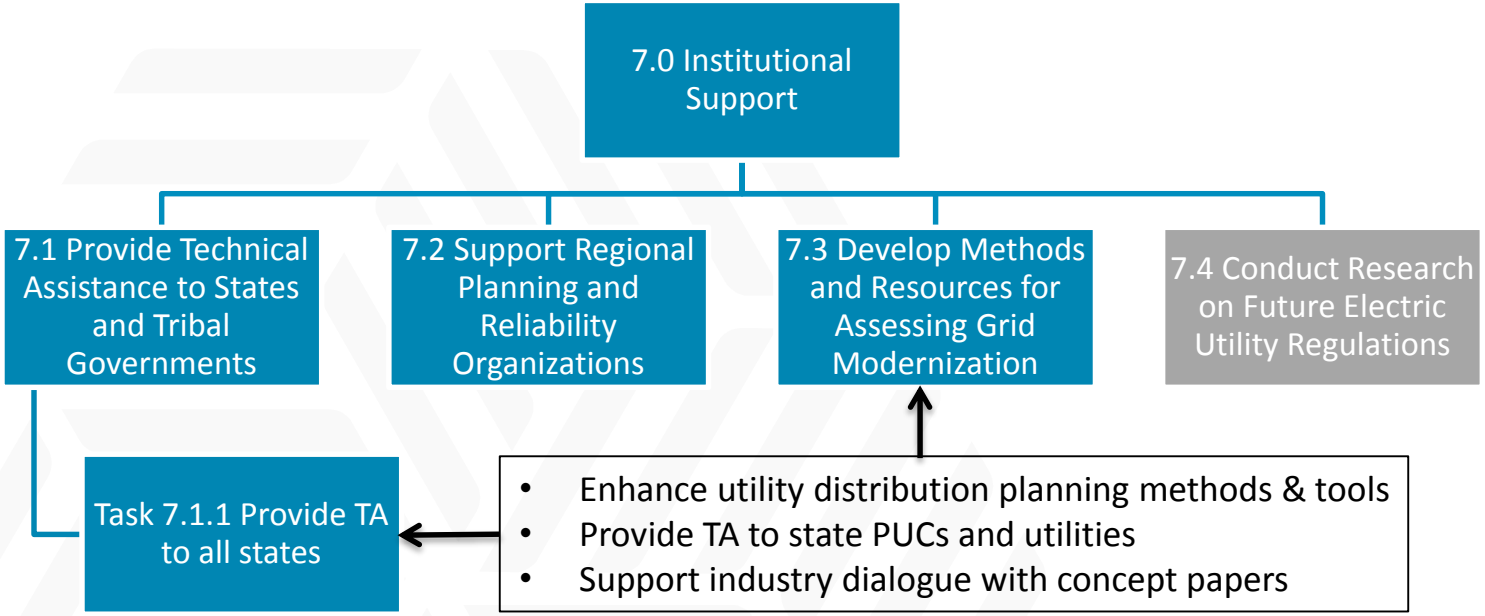
Lisa Schwartz – LBNL (Regulatory)

Juliet Homer – PNNL (Tools & Regulatory)

PROJECT FUNDING			
Lab	FY16 $	FY17 $	FY18 $
NREL	$350k	$350k	$350k
LBNL	$250k	$250k	$250k
PNNL	$234k	$233k	$233k

Distribution System Decision Support Tool Development and Application

Relationship to Grid Modernization MYPP



MYPP vision for Institutional Support area

- ✓ Leverage technical expertise, analytical tools, models and data to support and manage institutional change in a period of rapid and potentially disruptive technological innovation
- ✓ Directly address high priority grid modernization challenges and needs
- ✓ Convene key grid stakeholders as an honest-broker for collaborative dialogues on grid modernization
- ✓ Create an over-arching suite of grid-related "institutional" analysis, workshops and dialogues

GRID MODERNIZATION INITIATIVE
U.S. Department of Energy

Approach

- ✓ Support Regulatory Agencies – Deliver in-person training courses for state PUCs on emerging distribution planning practices, methods and tools, with support and guidance from NARUC and a state PUC advisory group. *Beginning summer 2017*
- ✓ Continue engagement with APPA and NRECA; Identify the highest priority TA on distribution system tools and needs that this team can provide to support coops and public power. Share information with other GMLC teams. *2017 & 2018*
- ✓ Engage with small, medium and larger-sized utility partners with the goal of assessing their needs. *2017 & 2018*
  - ✓ Goal will be to develop new methods and tools to support all sized utilities as they look to improve their distribution planning methods and how they engage their regulators.
- ✓ Provide detailed assessment of existing distribution planning tools, capabilities, gaps and recommendations for filling those gaps. *April 2017 & 2018*

Key Project Milestones

Milestone (FY16-FY18)	Status	Due Date
4.1 – Produce summary memo on the distribution system planning needs of public power and rural cooperatives and suggested approaches for working with APPA and NRECA on advancing emerging planning methods.	Completed	9/16
1.5 - Organize a planning workshop at the IEEE ISGT 2016 conference and issue workshop proceedings document that reports on advanced distribution system planning approaches, tool sets and remaining challenges discussed at the conference.	Completed	9/16
1.1 - Provide summary memo on the status of emerging distribution planning practices by states and remaining challenges for addressing high levels of DER penetration in distribution systems.	Completed	12/16

Highlights of Accomplishments to Date

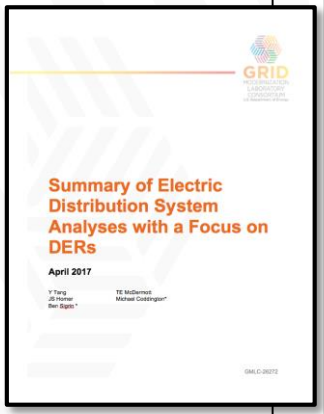
- ✓ Identified opportunities to support distribution planning activities of the American Public Power Association and National Rural Electric Cooperative Association. Shared this information with other GMLC teams.
- ✓ Organized an education program on distribution planning at the IEEE Smart Grid conference.
- ✓ Established an advisory group of state public utility commissions (PUCs) to identify distribution planning needs and a training program to help meet those needs, in partnership with the National Association of Regulatory Utility Commissioners (NARUC).
- ✓ Facilitated and presented at PUC workshops (WA, OR, MN), MGA, and NARUC winter meetings on establishing a distribution planning process integrated with resource and transmission planning and interconnection processes integrated with distribution planning.
- ✓ Summary report on status of emerging distribution planning practices when addressing high DER levels.

Highlights of Accomplishments to Date

Results from Distribution System Tools Report:

Focus on Analysis Types & Applications

- Power Flow Analysis
- Power Quality Analysis
- Fault Analysis
- Dynamic Analysis



Maturity Levels ranking:

0 – None of the DSA tools offer this function
1 – Only a small number of DSA tools offer it
2 – More than 50% of DSA tools offer it
3 – Most or all tools offer the function

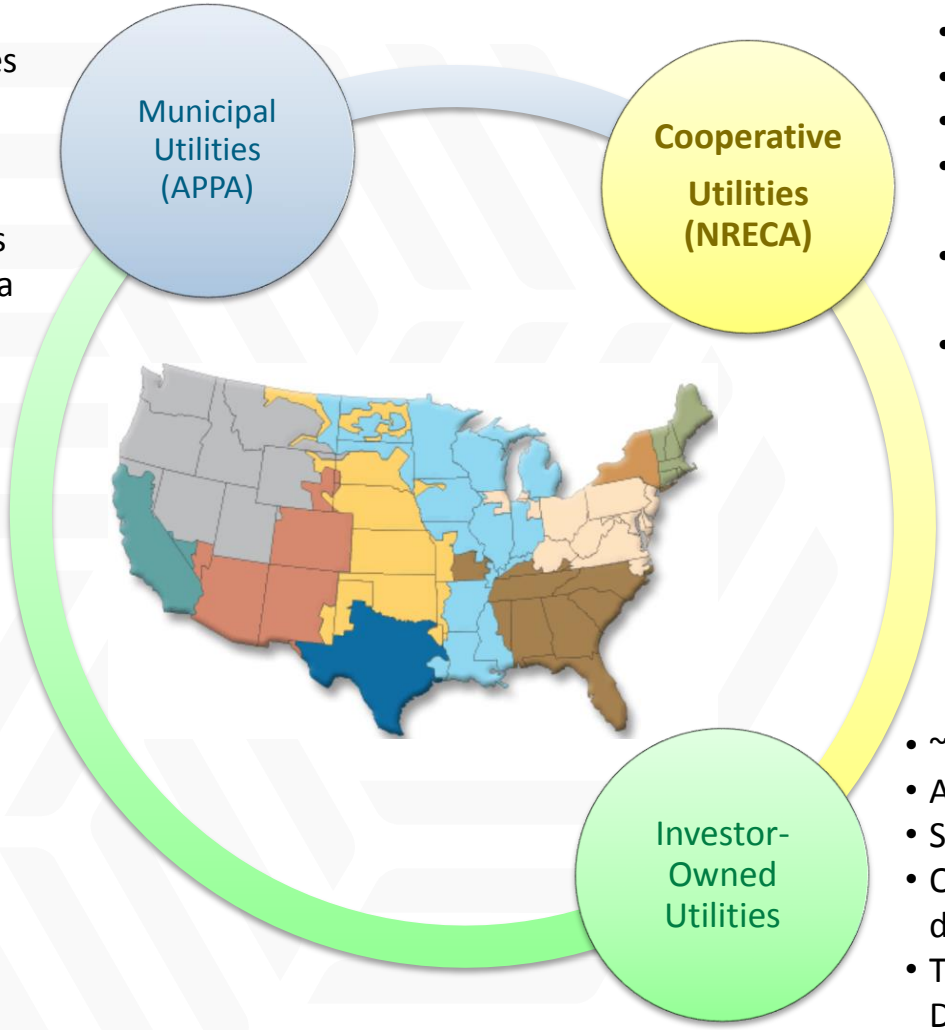
This report has provided significant input into the DSPx project

Distribution System Analysis Types and Applications	Maturity Level
Power Flow Analysis	
Peak Capacity Planning Study	3
Voltage Drop Study	3
Ampacity Study	3
Contingency and Restoration Study	3
Reliability Study	3
Load Profile Study	3
Stochastic Power Flow Study	2
Volt/var Study	2
Real-Time Performance	2
Power Quality Analysis	
Voltage Sag and Swell Study	3
Harmonics Study	2
Fault Analysis	
Arc Flash Hazard Analysis	3
Protection Coordination Study	3
Fault Location Identification	1
Dynamic Analysis	
Long-Term Dynamics	1
Electromechanical Dynamics	2
Electromagnetic Dynamics	3

GRID MODERNIZATION INITIATIVE
U.S. Department of Energy

Major Utility Types & Possible Needs

- ~2000 municipal Utilities
- Average 2200 meters
- Serve 15% of market
- Own & maintain 7% of U.S. distribution feeders
- ~1300 municipals have a single substation!
- Most municipal utilities are very small, and distribution planning is less demanding

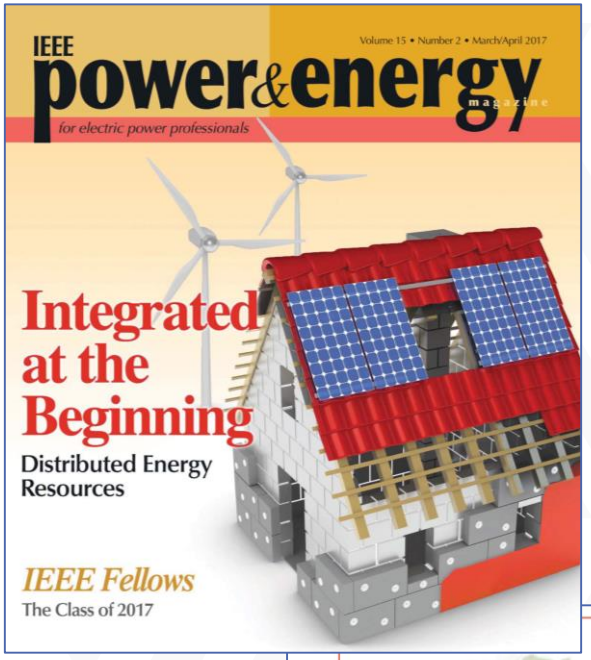


- ~900 cooperative utilities
- Average 13,000 meters
- Serve 12% of market
- Own & maintain 42% of U.S. distribution Feeders
- Many cooperatives leverage external partners for planning
- May be opportunities to assist NRECA and members with planning

- ~210 investor-owned utilities (IOU)
- Average 400,000 meters per IOU
- Serve 73% of market
- Own & maintain 50% of U.S. distribution feeders
- Typically have large Electric Distribution Planning departments
- Regulated utilities, under new scrutiny in distribution planning

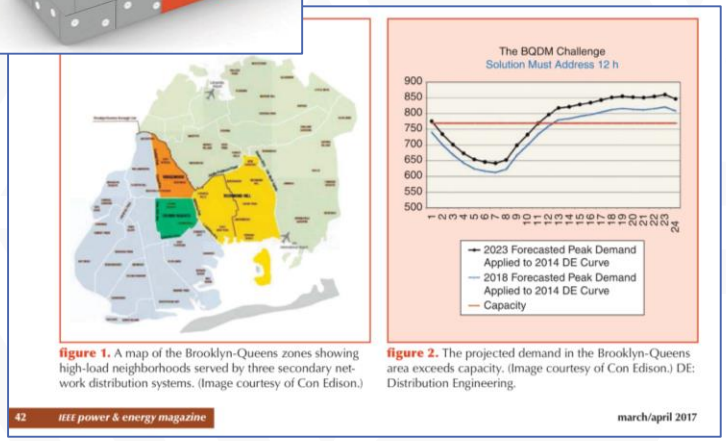
Data from EIA, NRECA, APPA, EEI

Highlights of Accomplishments to Date (cont.)



NREL-led IEEE Report on Alternatives to Traditional Distribution System Planning with Con Edison:

- Long-term Forecast showed Brooklyn Queens networks would see overloads on peak days
- Traditional approach was to build out distribution circuits, add substation transformers & switchgear, and new transmission upgrades (all underground)
- Cost estimate to serve all of this new load >$1Billion
- NY DPU via NY REV seeks alternatives from Con Edison rather than traditional investments



Many solutions were employed, including Energy Efficiency measures, Fuel Cells, Solar PV systems, Volt-VAR Optimization, Demand Response, Gas-Fired Distributed Generation, Battery Energy Storage Systems (BESS), and more…..

Response to December 2016 Program Review

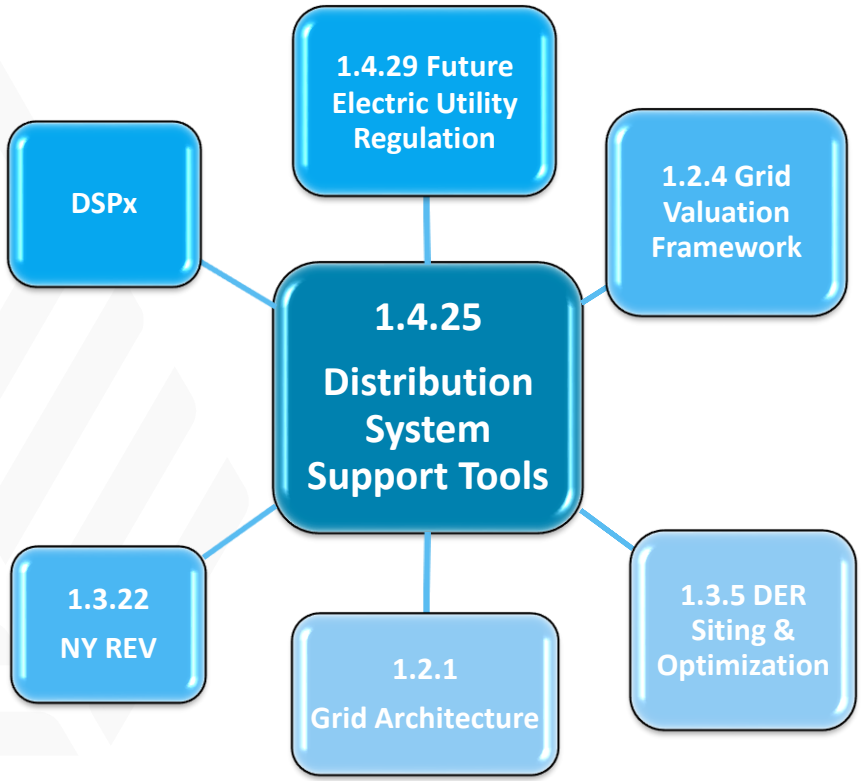
Recommendation	Response
There are a number of similar projects providing technical assistance to regulators including DSPx and 1.3.22 (NY REV).	Coordination efforts have continued throughout the project, and meetings are planned with DSPx team for May, 2017.
A description of coordination across TA projects would be very helpful at the Annual Peer Review.	Coordination among various TA projects is critical, and is discussed in upcoming slide

Project 1.4.25 received a “Green Light” in the Go/No-Go review

Distribution System Decision Support Tool Development and Application

Project Integration and Collaboration

- ✓ **1.4.29: Future Electricity Utility Regulation** – Contribute design and implementation options. Electric utility regulation is a key aspect of this project as this team works to educate regulators on existing and emerging planning methods and tools.
- ✓ **1.3.5 DER Siting and Optimization Tool for CA** – NY and CA regulators are coordinating on tool development and demonstration
- ✓ **1.2.1: Grid Architecture** – Apply evolving grid architecture with distribution planning tools and methods.
- ✓ **1.3.22: Technical Support to the NYS REV Initiative** – Partner with NY utilities and BNL team to understand advanced approached in distribution system upgrades, planning, non-wires alternatives. Continue evaluation of alternative distribution planning methods used by Con Edison in the Brooklyn-Queens Demand Management project.
- ✓ **1.1: Foundational Analysis for GMLC Establishment** – Validate and demonstrate grid performance metrics
- ✓ **Next Generation Distribution System Platform (DSPx)** – Coordinate with DSPx and provide inputs as requested. E.g., the distribution planning tools report.



Next Steps and Future Plans

- ✓ Training for PUC commissioners & staff starting summer of 2017, with additional training locations in 2018. Training agendas will reflect PUC Advisory Group and NARUC feedback.
- ✓ Continue engaging with APPA and NRECA to seek opportunities for joint collaboration with respect to planning and tools
- ✓ Focus on larger utility industry participants and evaluate gaps and needs for those larger entities
- ✓ Continue the development of the Next Phase Electric Distribution System Tools and Gaps Report for 2017-2018
- ✓ Publish a technical report that summarizes major distribution system analyses, applications and tools - April 2017
- ✓ Publish a technical report that identifies remaining gaps, development requirements, and lessons learned on distribution system planning tools - April 2018

GRID MODERNIZATION INITIATIVE PEER REVIEW

GMLC 1.4.29 - Future Electric Utility Regulation

LISA SCHWARTZ, BERKELEY LAB

April 18-20, 2017

Sheraton Pentagon City – Arlington, VA

Future Electric Utility Regulation
High Level Summary

GRID MODERNIZATION INITIATIVE
U.S. Department of Energy

Project Description

Provide technical assistance and analysis for public utility commissions (PUCs) 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 utility shareholders and customers
- Engaging consumers
- Addressing utility incentives to achieve grid modernization goals

Value Proposition

- ✓ Modernizing grids requires utilities to make large investments in the face of rapid change and increasing risk and uncertainty.
- ✓ This project helps PUCs and utilities explore regulatory changes to deploy needed capital.

Project Objectives

- ✓ 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.

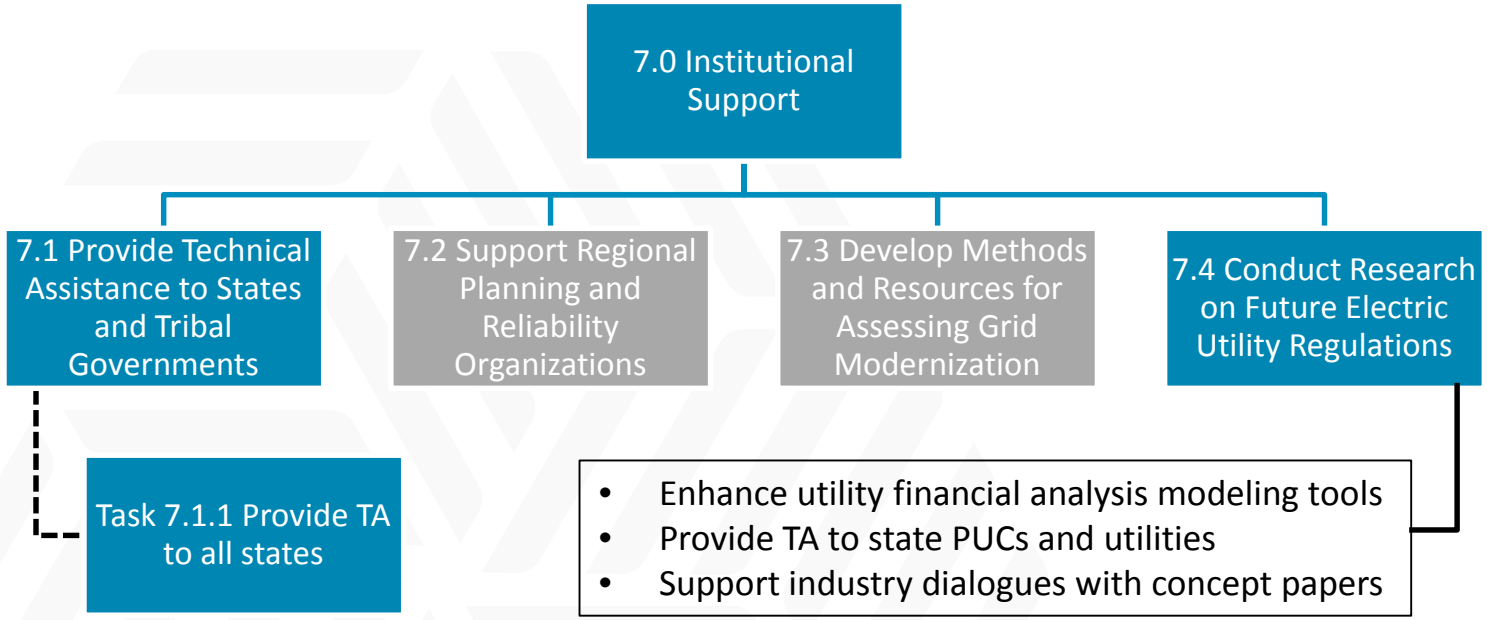
Future Electric Utility Regulation
Project Team

Project Participants and Roles

- LBNL – Project manager; modeling and state technical assistance (TA); Future Electric Utility Regulation report series; performance-based regulation technical report
- NREL – Plus one; modeling and state TA
- NETL – Modeling and state TA
- SNL – State TA
- PNNL – State TA
- National Association of Regulatory Utility Commissioners – Outreach

PROJECT FUNDING			
Lab	**FY16 $**	**FY17 $**	**FY18 $**
LBNL	$810	$795	$725
NREL	$71	$117	$47
NETL	$75	$25	$25
SNL	$34	$33	$33
PNNL	$10	$30	$30
TBD (Task 1 modeling FY18)	—	—	$140
TOTAL	**$1M**	**$1M**	**$1M**

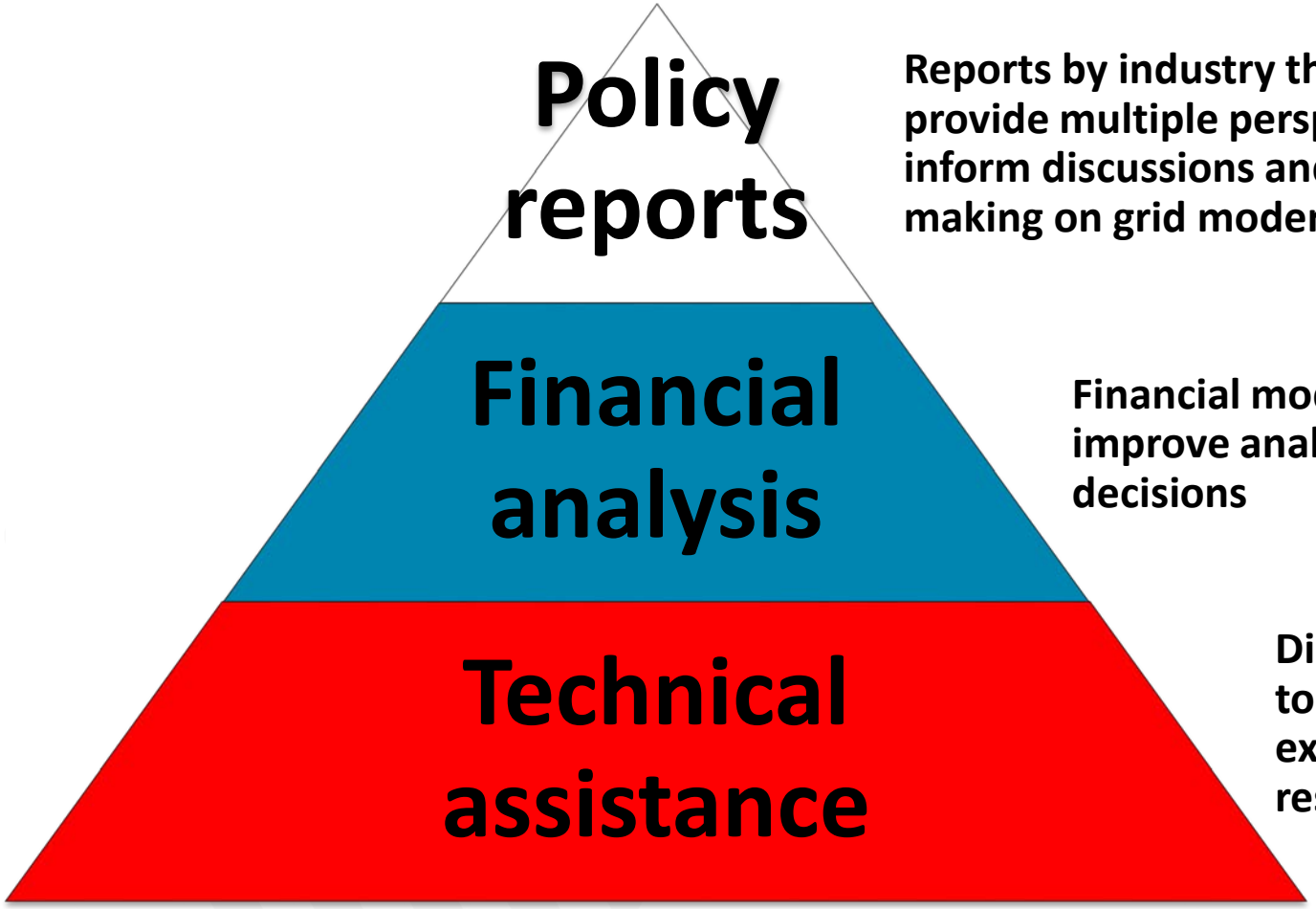
Future Electric Utility Regulation
Relationship to Grid Modernization MYPP



MYPP vision for Institutional Support area

- Leverage technical expertise, analytical tools, models and data to support and manage institutional change in a period of rapid and potentially disruptive technological innovation
- Directly address high priority grid modernization challenges and needs
- Convene key grid stakeholders as an honest-broker for collaborative dialogues on grid modernization
- Create an over-arching suite of grid-related "institutional" analysis, workshops and dialogues

Future Electric Utility Regulation
Approach



Reports by industry thought-leaders provide multiple perspectives to inform discussions and decision-making on grid modernization

Financial modeling tools to improve analyses and decisions

Direct TA to state PUCs to provide requested expertise and resources

Future Electric Utility Regulation

Key Project Milestones

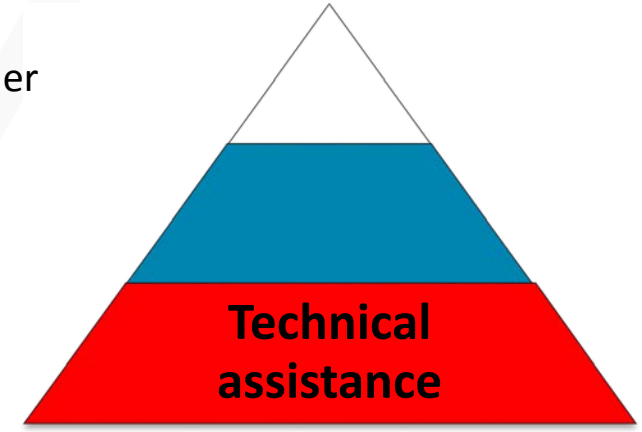
GRID MODERNIZATION INITIATIVE
U.S. Department of Energy

Milestone (FY16-FY18)	Status	Due Date
Upgrade financial modeling tools (FY16 & FY17); characterize utility in region targeted for state TA using FINDER model	Complete/on schedule	10/1/16, 10/1/17
Develop list of targeted states and topics for state TA	Complete	10/1/16
Provide status report on value of modeling for state TA	Complete	12/31/16
Complete 2 reports in Future Electric Utility Regulation series	1st complete; 2nd on schedule	4/1/17, 5/15/17
Publish technical report on performance-based regulation (PBR) with case studies and results of productivity and incentive power research	On schedule	5/15/17
Provide TA on financial impacts to 3-4 states each year	On schedule	10/1/17, 10/1/18
Provide TA on PBR, distribution markets, and energy services pricing to 2-4 states each year	On schedule	10/1/17, 10/1/18
Complete 4 additional reports in Future Electric Utility Regulation series	On schedule	4/1/18, 10/1/18

Future Electric Utility Regulation
Highlights of Accomplishments to Date

GRID MODERNIZATION INITIATIVE
U.S. Department of Energy

1. **Technical assistance (TA) to state PUCs**
   - Two types of TA
     - Incremental changes to cost of service regulation
     - Broader visionary questions about alternative forms of regulation
   - Focus on financial impacts to utility shareholders and utility customers
   - State TA plan identifies approaches for targeting TA
   - TA to date on the following topics:
     - 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 shareholder incentives (CA)

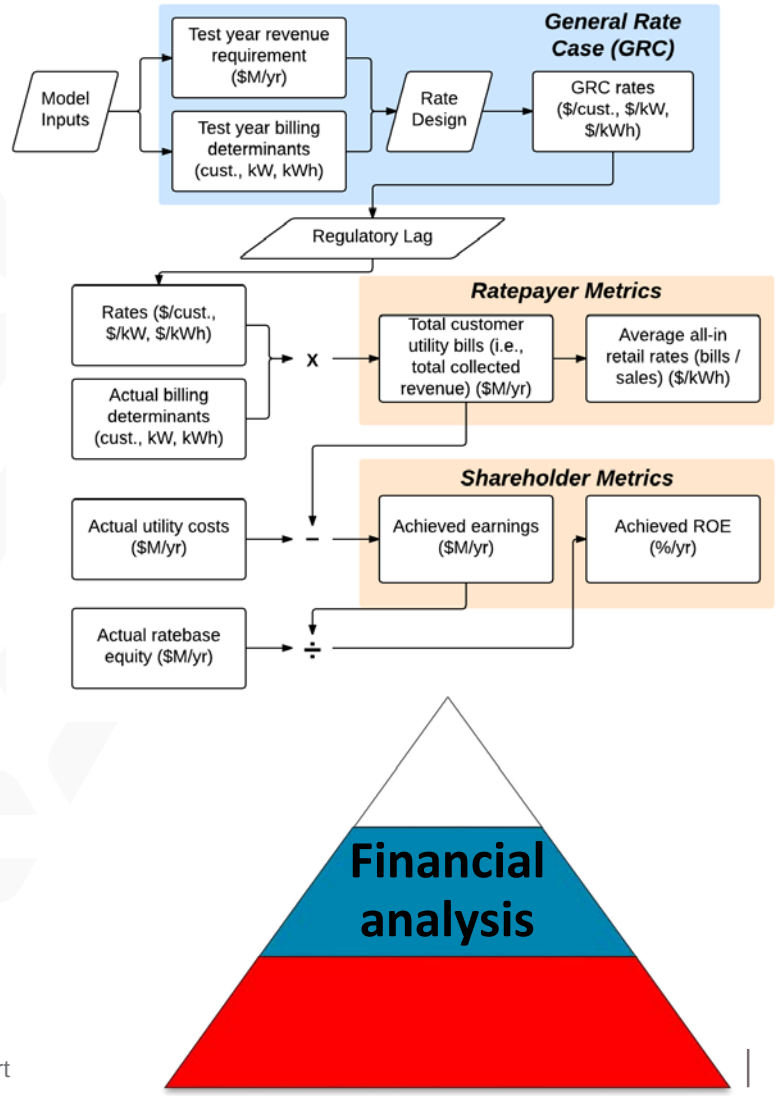


Future Electric Utility Regulation
Highlights of Accomplishments to Date

GRID MODERNIZATION INITIATIVE
U.S. Department of Energy

2. Financial analysis of impacts to utility shareholders and ratepayers

- LBNL's FINancial impacts of Distributed Energy Resources (FINDER) model quantifies financial impacts of DERs
- FY16 model enhancements & analysis quantified:
  - Combined effects of aggressive 10-yr ramp-up of energy efficiency and distributed solar PV
  - Financial impacts for utility and customers — by class, participants vs. non-participants
- Final report on findings for prototypical NE utility
  - Hourly impacts and shifts in timing of utility system peak
  - Impacts on utility costs, revenues, earnings, return on equity and customer rates
  - Impact of mitigation approaches — e.g., alternative revenue collection mechanisms such as demand charges and increased fixed customer charges



Future Electric Utility Regulation
Highlights of Accomplishments to Date

GRID MODERNIZATION INITIATIVE
U.S. Department of Energy

3. Future Electric Utility Regulation reports

- Innovative series of reports taps industry thought leaders to grapple with complex electricity issues
- Unique multiple-perspective approach highlights different views on the future of utility regulation and business models and achieving a reliable, affordable, and flexible power system to inform ongoing discussion and debate
- Advisory group* provides guidance
  - Recognized experts — state regulators, utilities, stakeholders and academics
  - Helps identify and prioritizes topics
  - Reviews drafts, assists with outreach

*See backup slides

feur.lbl.gov

New reports under GMI:

- *The Future of Centrally-Organized Wholesale Electricity Markets* (March 2017)
- *Regulatory Incentives for Utilities to Invest in Grid Modernization* (under peer review)
- *Value-Added Electricity Services: New Roles for Utilities and Third Parties* (underway)

Future Electric Utility Regulation
Response to December 2016 Program Review

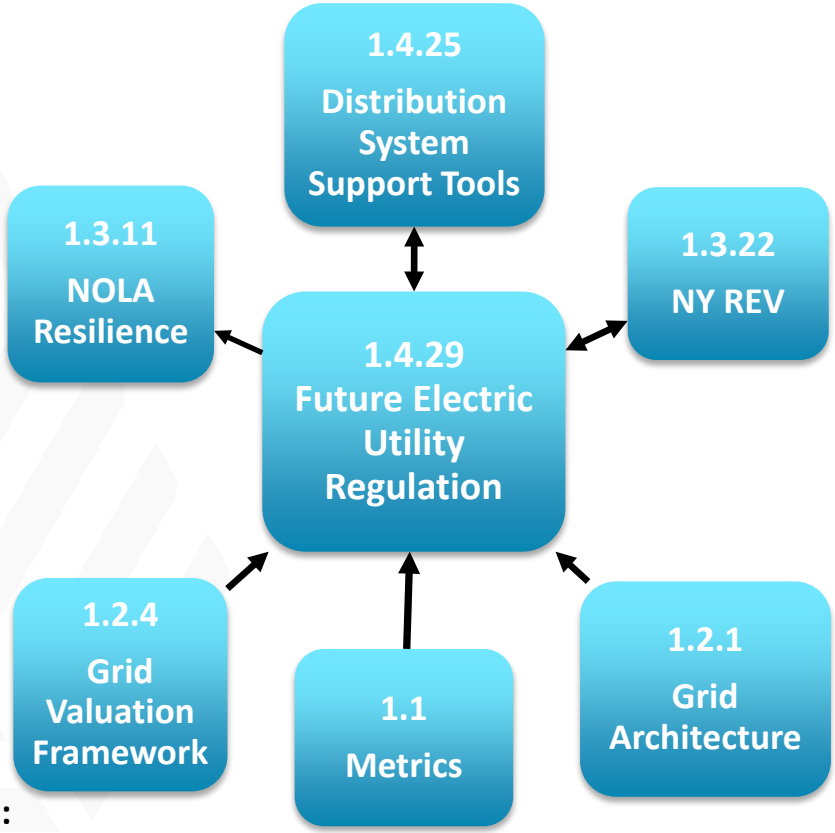
GRID MODERNIZATION INITIATIVE
U.S. Department of Energy

Recommendation:
Show how this effort is distinct from previous regulatory and analytical efforts.

Response:
- Activities are focused on DOE's *comprehensive* vision of a modern grid, rather than individual technologies or institutional components.
- We expanded modeling tools to improve financial analysis of the impacts of a suite of new technologies on utility shareholders and customers and implications for regulation and ratemaking.
- The project includes analysis and technical assistance for state PUCs on new topics, including performance-based regulation (multiyear rate plans with rewards and penalties related to target performance metrics), and markets and pricing for distribution system services.
- Under the GMI, the Future Electric Utility Regulation report series moved into new areas, such as:
  - Electricity markets
  - Incentives for utilities to make grid modernization investments under traditional and innovative forms of regulation
  - Ways states can foster competition for value-added electricity services while allowing utilities to play new roles

Future Electric Utility Regulation
Project Integration and Collaboration

- 1.1 Metrics – Metrics may inform state TA related to performance-based regulatory approaches.
- 1.2.1 Grid architecture – Used precursor work in Future Electric Utility Regulation report #2; will reference as relevant in continuing report series
- 1.2.4 Grid valuation framework - Coordinated on TA for Vermont, a potential initial user of framework; can refer to framework in relevant reports in series
- 1.3.11 New Orleans resilience – Coordinating on city's interest in performance-based regulation
- 1.3.22 NY REV – Insights from this project can be tapped for TA in other states.
- 1.4.25 Distribution system support tools - Significant penetration of DERs on the distribution system often raises utility regulatory and business model issues.



Example stakeholder communications (beyond Advisory Group):

- Western Conference of Public Service Commissioners (5/25/16)
- Clean Energy States Alliance webinar (10/11/16)
- *Public Utilities Fortnightly* article (November 2016)
- Annual meeting of National Association of State Utility Consumer Advocates (11/14/16)
- National Governors Association's Policy Academy on Power Sector Modernization (January 2017)

Future Electric Utility Regulation

Next Steps and Future Plans

- Continue **state TA** to support decision-making
- **Modeling** activities in FY17 linked to state TA
  - LBNL will assess financial impacts of distribution network investments to accommodate two-way power flows at high levels of distributed energy resources penetration and under various grid modernization scenarios.
  - NREL will address impacts of: 1) time of use rates with peak periods defined to encourage consumption mid-day and 2) two-way rates on consumer grid exports.
- **Technical report**, *Multiyear Rate Plans for U.S. Electric Utilities: Design Details and Case Studies of Performance-Based Regulation* (PBR)
- **Future Electric Utility Regulation series**
  - *Regulatory Incentives and Disincentives for Utilities to Invest in Grid Modernization*
  - *Value-Added Electricity Products and Services: New Roles for Utilities and Third Parties*
- **Upcoming presentations**
  - National Conference of Regulatory Attorneys – 5/10/17 panel on *Regulatory Incentives* report, combined impacts of high levels of energy efficiency and solar PV on utility shareholders and utility customers, and putting rate impacts of solar PV in context, *plus* presentation on PBR report
  - Western Conference of Public Service Commissioners – 5/23/17 innovation panel

Future Electric Utility Regulation
Advisory group for report series

GRID MODERNIZATION INITIATIVE
U.S. Department of Energy

State Utility Regulators

Commissioner Lorraine Akiba, Hawaii

Commissioner Travis Kavulla, Montana

Chair Nancy Lange, Minnesota

Commissioner Carla Peterman, California

Chair Audrey Zibelman, New York*

Utilities

Doug Benevento, Xcel Energy

Tim Duff, Duke Energy

Val Jensen, Commonwealth Edison

Lori Lybolt, Consolidated Edison

Sergej Mahnovski, Edison International

Jay Morrison, NRECA

Delia Patterson, APPA

Peter Zschokke, National Grid

Academics and Other Experts

Janice Beecher, MSU Institute of Public Utilities

Ashley Brown, Harvard Electricity Policy Group

Steve Corneli, consultant

Peter Fox-Penner, Boston University Questrom School of Business

Scott Hempling, attorney

Steve Kihm, Seventhwave

Kris Mayes, Arizona State University College of Law/Utility of the Future Center

Karl Rábago, Pace University School of Law

Rich Sedano, Regulatory Assistance Project

Consumer or Environmental Advocates

Paula Carmody, MD Office of People's Counsel

Ralph Cavanagh, NRDC

Sonny Popowsky, former consumer advocate (PA)

*Recently left PSC