Integrated Resilient Distribution Planning & Grid Modernization

Paul De Martini

Newport Consulting

Training Webinars on Electricity System Planning
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Grid Modernization Laboratory Consortium.

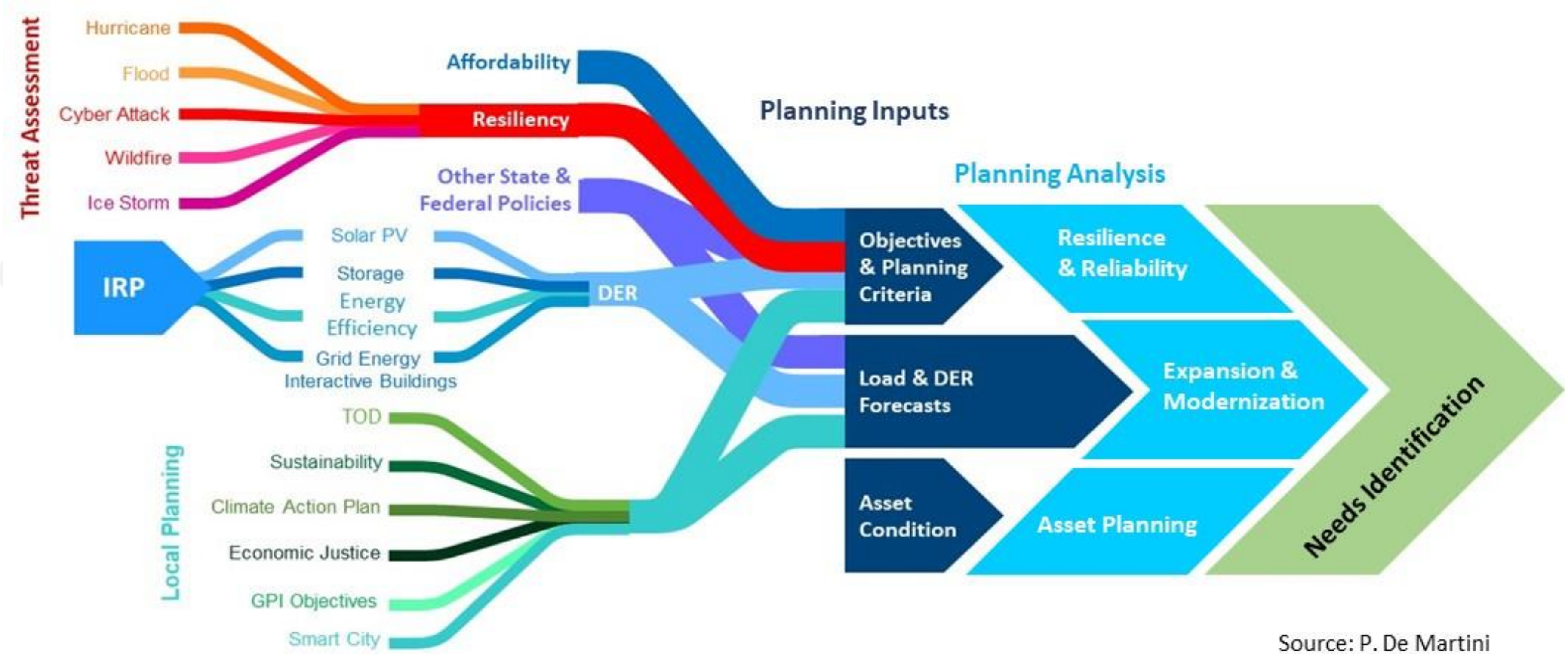
Planning for the Next 10+ Years

Distribution systems are becoming exceedingly complex, compounded by climate change impacts

	Yesterday	Today	Tomorrow
Power Flow	One-way flow	Inadvertent 2-way	Scheduled reverse flow
Distributed Solar+Storage	Load modifying resource	Grid services	Grid resource capacity & energy
Electrification	Load growth	Managed load	Grid storage & home resilience
Microgrids	Customer BTM back-up generation	Customer BTM microgrids	Community microgrids & minigrids
Grid Edge	Customer meter	BTM DER	BTM DER & Building Technologies
Ecosystem	ISO, LSE, DistCo & Customer	ISO, LSE, DistCo, Aggregator, DER Service Provider, Community & Customer	ISO, LSE, DistCo, Aggregator, DER Service Provider, MG Operator, EV Charging/Vehicle Mfg, Bldg Automation provider, Community & Customer
Climate & Weather	Predicable patterns of weather and related effects on generation and energy consumption	Uncertainty given increasing storm severity, weather variability trending warmer	Increasing climate and related weather severity and variability incl. warming, droughts, sea rise, etc.

Integrated Distribution Planning Inputs

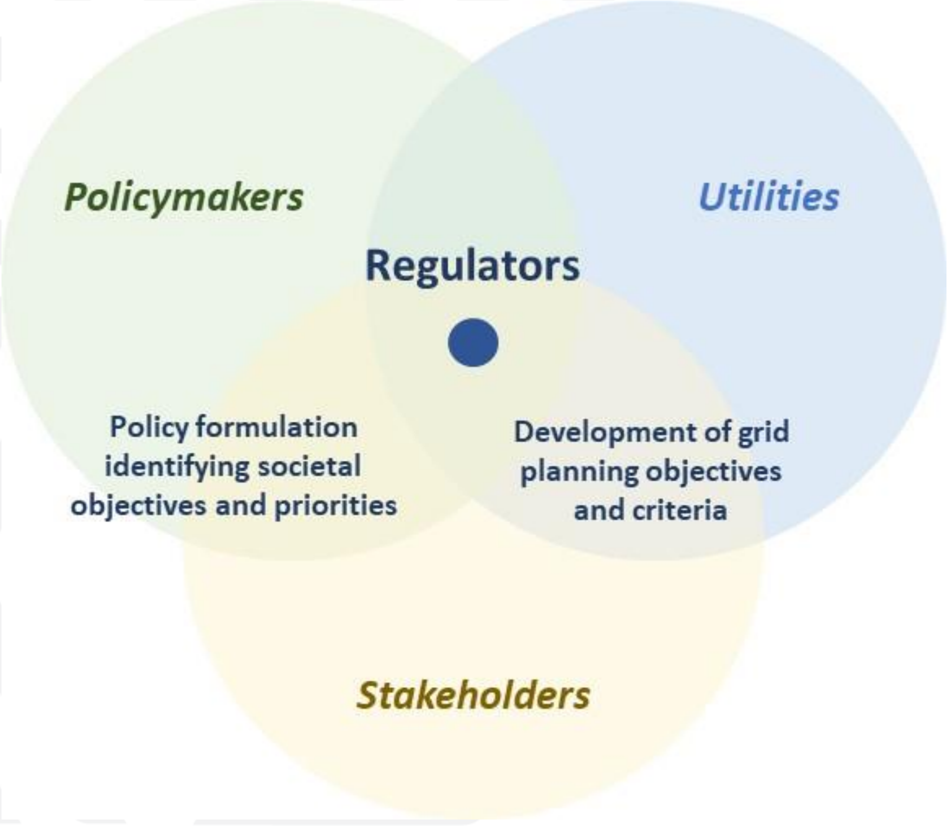
System planning is increasingly dependent upon Integrated Resource Planning (IRP)/bulk power use of distributed energy resources (DER) and local sustainability and resilience plans.



Source: P. De Martini

Need for Shared Understanding

Creating a shared understanding among stakeholders of strategies for grid transformation needed to meet resilience, decarbonization, and equity objectives



Policymakers

Utilities

Regulators

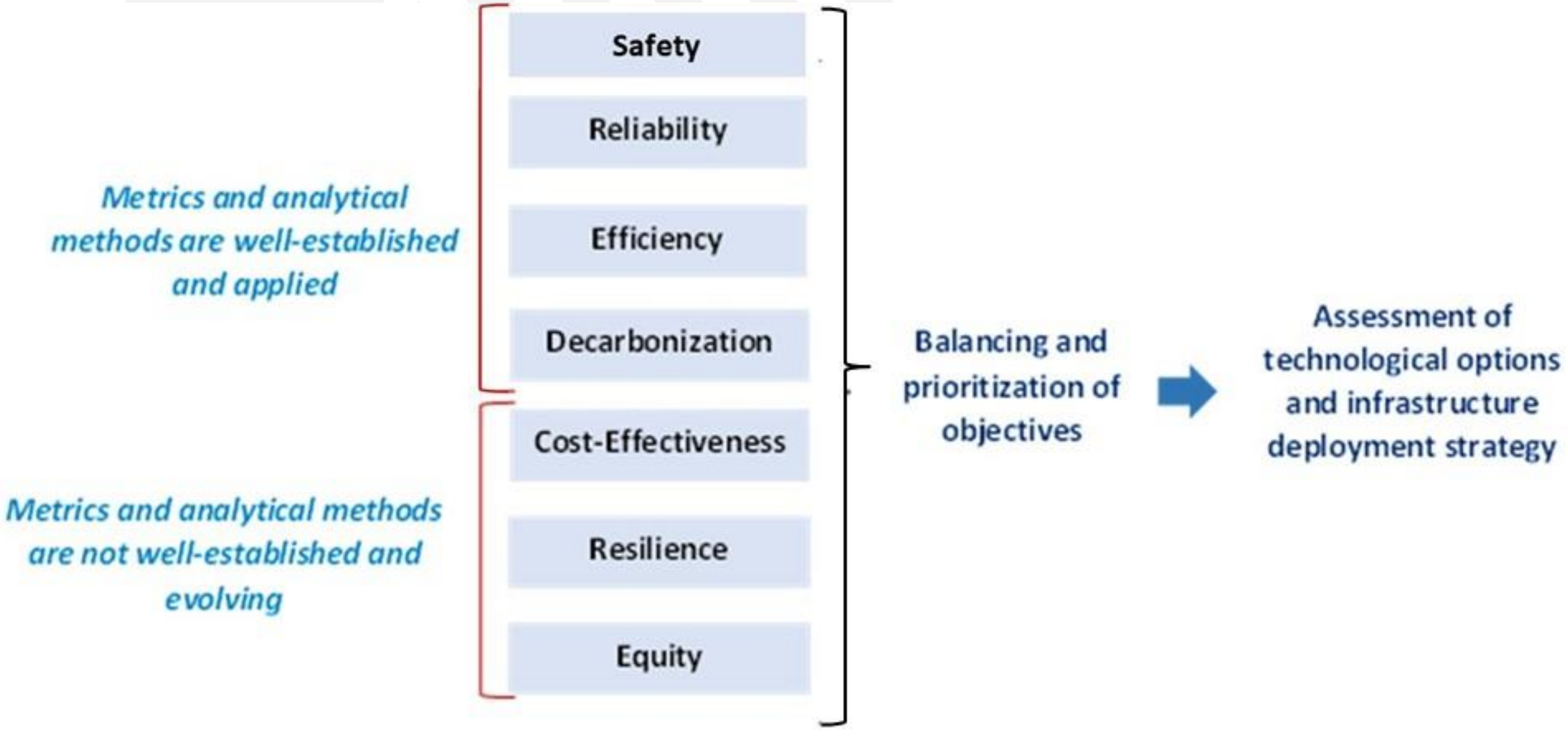
Policy formulation identifying societal objectives and priorities

Development of grid planning objectives and criteria

Stakeholders

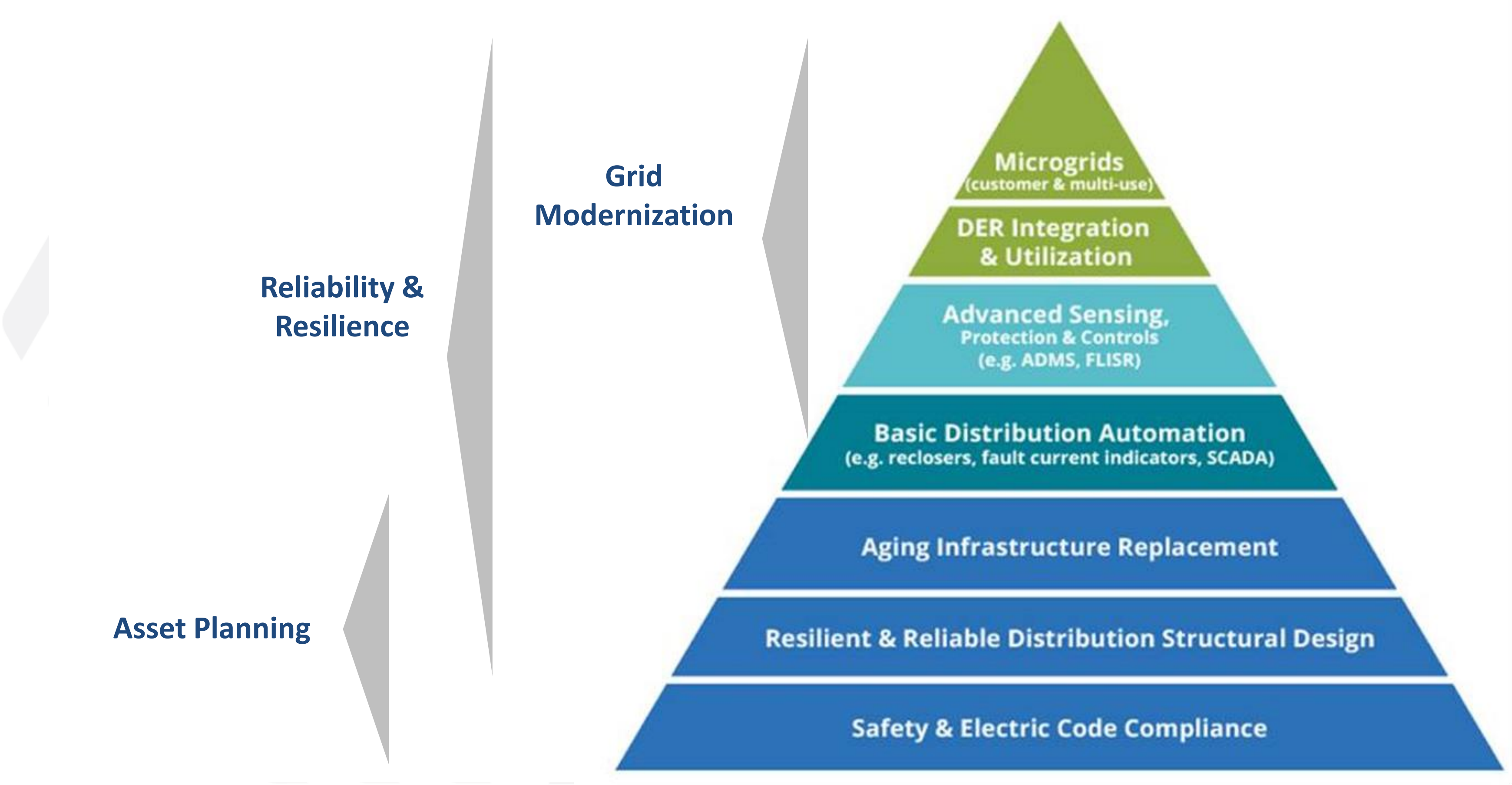
Planning Objectives

A well-designed integrated distribution system planning process provides a framework for translating policy objectives into holistic infrastructure investment strategies.



Distribution and Modernization Investment Categories

Grid modernization technologies layer on top of and integrate with foundational physical grid infrastructure.



Grid Modernization

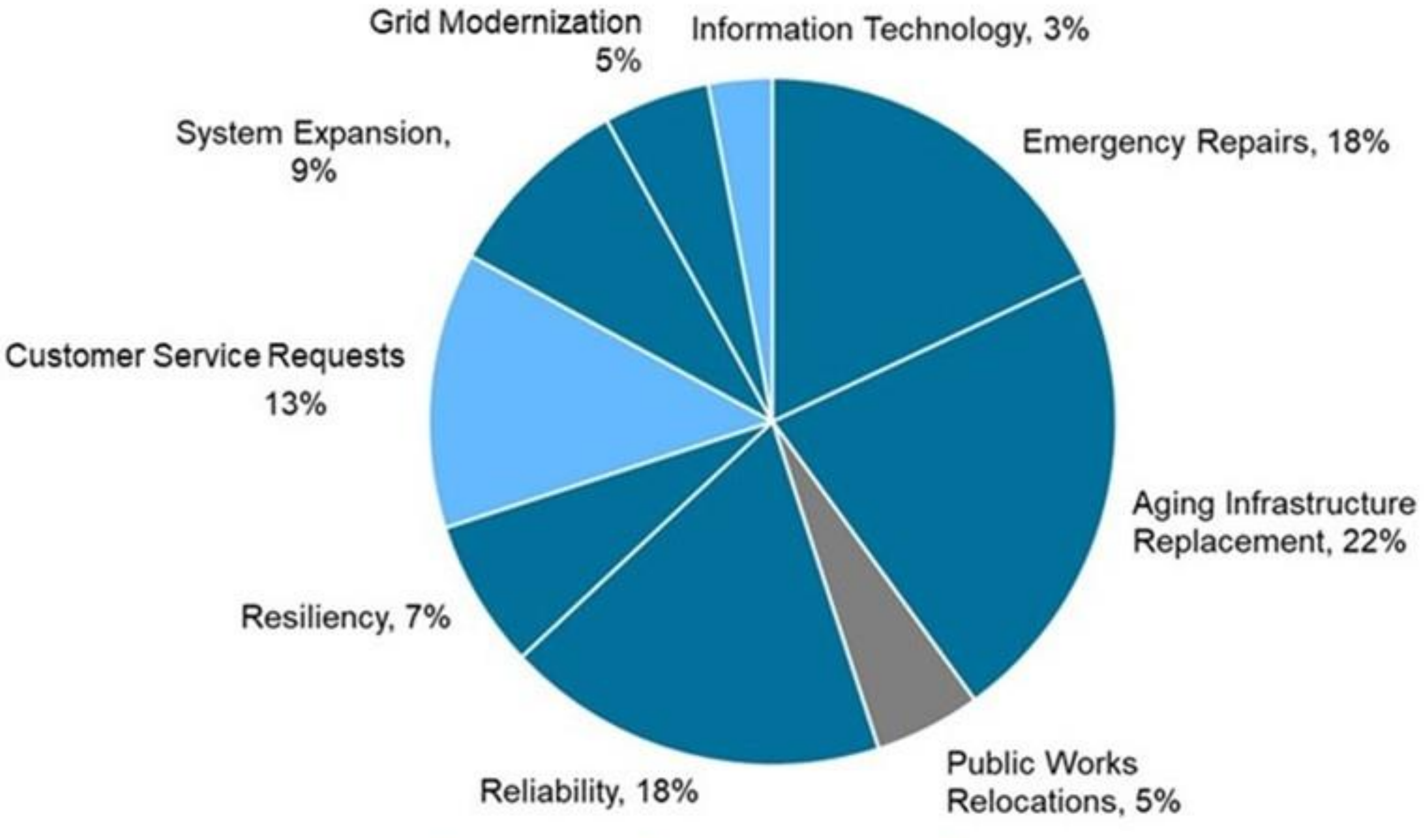
Reliability & Resilience

Asset Planning

Source: De Martini

Distribution Investments Are Interdependent

Most distribution capital investments contribute to achieving multiple objectives.

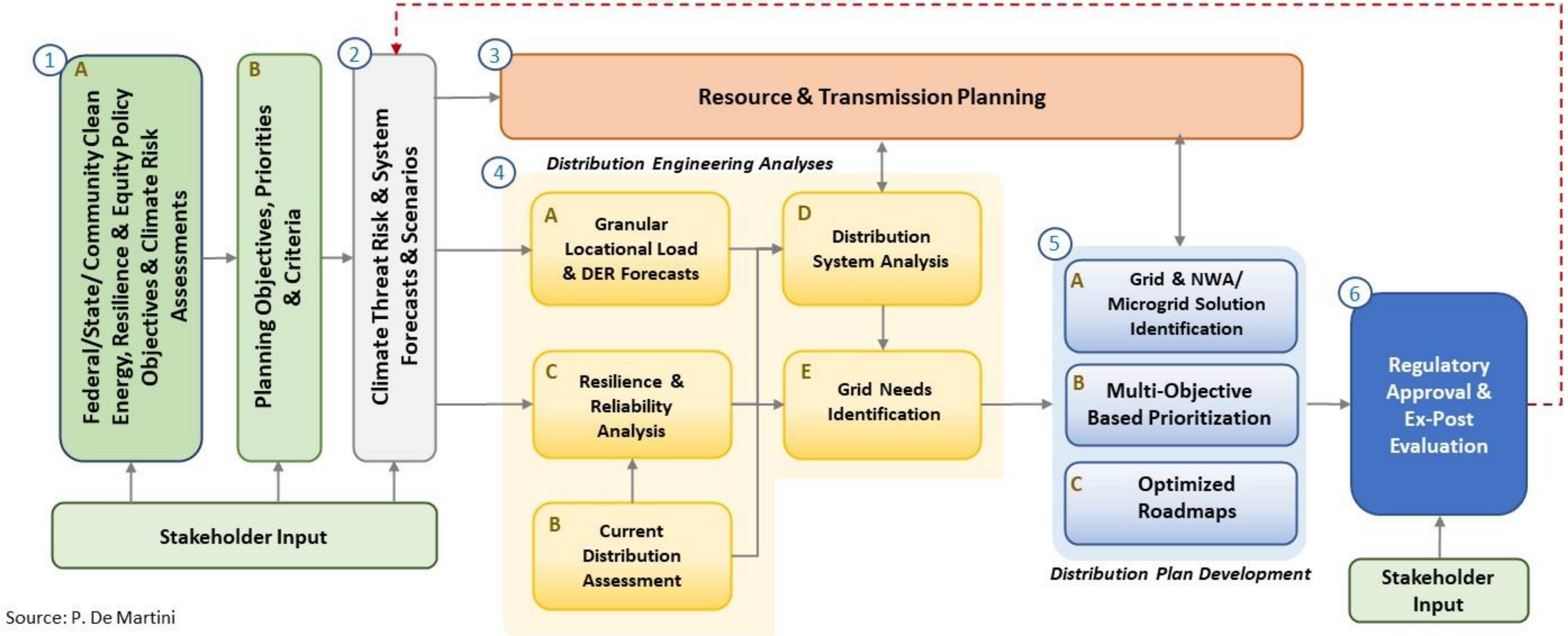


Conceptual Budget Allocation Example

Integrated Resilient Distribution Planning Process Elements

(based on emergent best practices)

Updated process flow to reflect emergent best practices regarding stakeholder engagement, resilience integration and multi-objective investment portfolio development



Source: P. De Martini

Source: P. De Martini, J. Taft and A. De Martini, Integrated Resilient Distribution Planning, Pacific Northwest National Laboratory, 2022

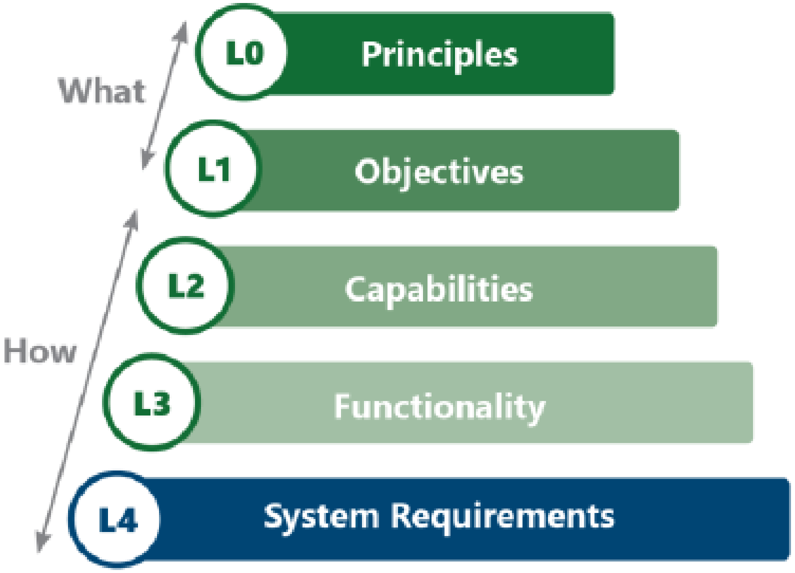
Questions Public Utility Commissions Can Ask

Multi-objective planning requirements and significantly different uses of the distribution system are driving an increasingly complex planning process.

- What are the appropriate planning objectives and criteria for your distribution systems?
- How should the uncertainty of the pace and scope of change be addressed?
- What is the appropriate investment prioritization model recognizing multiple objectives and multiple benefits?
- What level of collaboration is required to ensure we can achieve the desired objectives with a resilient and safe electric grid?
- What level of oversight and transparency is required to ensure objectives are achieved and stakeholder buy-in?

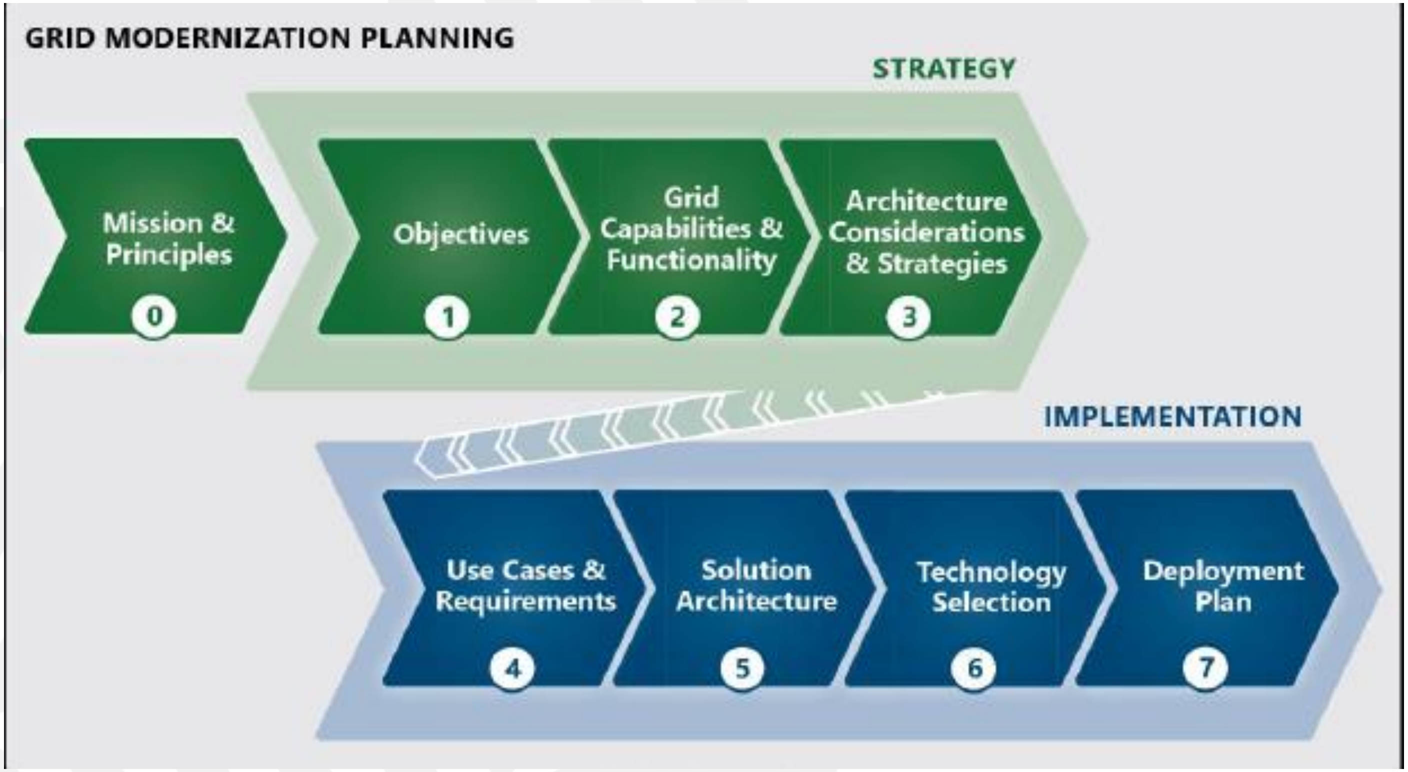
Grid Architecture Approach

- Grid modernization planning starts with objectives and capabilities needed.
- Scale and scope of needs require a holistic architectural approach.
- Resist temptation to start with technology choices.



Grid Mod Strategy & Planning Process

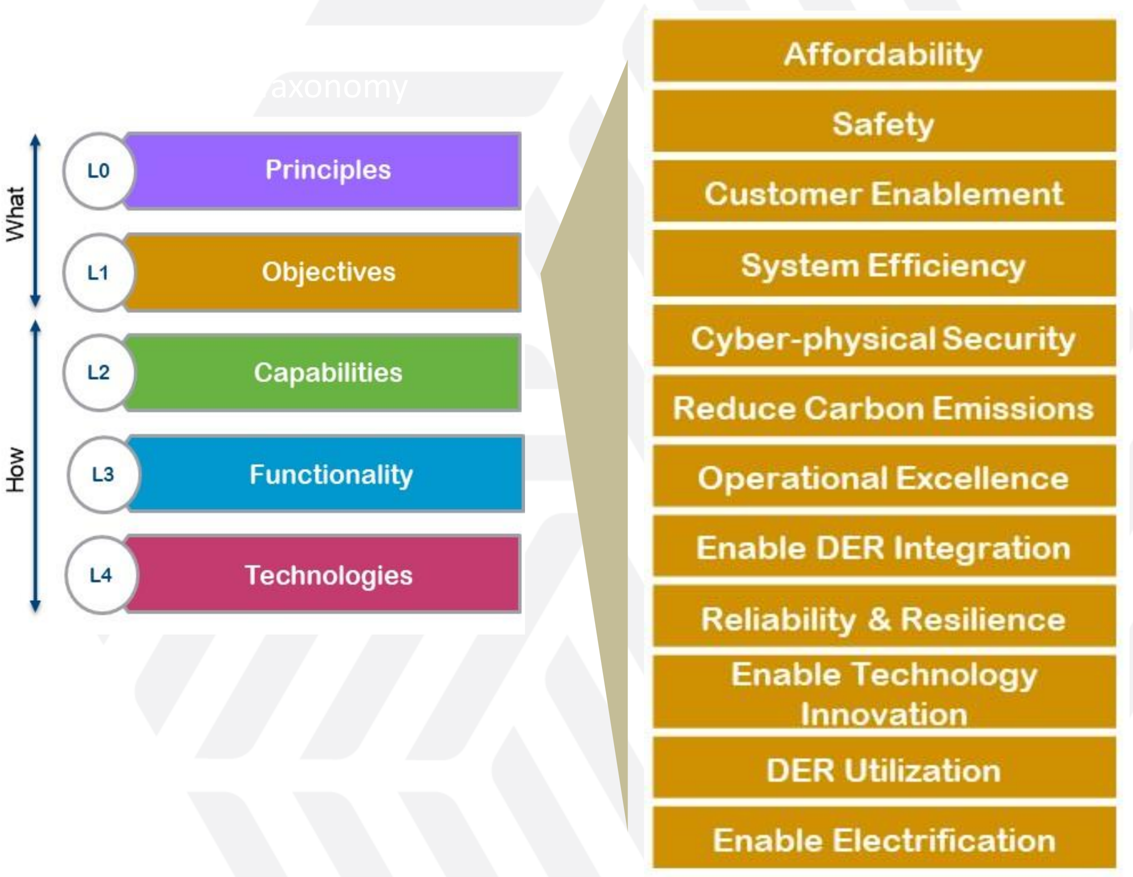
What, Why, How, When and How Much



DSPx Guidebook, Vol. 4, 2020

While encouraged, it is not essential to start with a grid mod strategy. But a clear set of objectives is necessary to develop and assess implementation plans.

Objectives Drive Grid Mod Planning


What

How

L0 Principles

L1 Objectives

L2 Capabilities

L3 Functionality

L4 Technologies

Affordability

Safety

Customer Enablement

System Efficiency

Cyber-physical Security

Reduce Carbon Emissions

Operational Excellence

Enable DER Integration

Reliability & Resilience

Enable Technology Innovation

DER Utilization

Enable Electrification

PUC Ohio example:

- **A Strong Grid: A distribution grid that is reliable and resilient, optimized and efficient and planned in a manner that recognizes the necessity of a changing architectural paradigm.**
- **The Grid as a Platform: A modern grid that serves as a secure open access platform—firm in concept and as uniform across our utilities as possible—that allows for varied and constantly evolving applications to seamlessly interface with the platform.**
- **A Robust Marketplace: A marketplace that allows for innovative products and services to arise organically and be delivered seamlessly to customers by the entities of their choosing.**
- **The Customer's Way: An enhanced experience of the customer's choosing on the application side, whether for reasons arising from financial, convenience, control, environmental, or any other chosen consideration.**

Note: The 'safe, reliable, and affordable' components were included in the mission statement, which was incorporated into the principles of the PowerForward Roadmap.

Grid Modernization Capabilities

Customer needs and policy drive grid capabilities and corresponding enabling business functionality and technology

🔵 **New**
⚫ **Existing**

		Objectives		
		Safety & Operational Efficiency	**Reliability & Resilience**	**DER Integration & Utilization**
Capabilities	**Market Operations**	🔵	🔵	🔵
	Grid Operations	⚫	◐	🔵
	Planning	⚫	◐	🔵

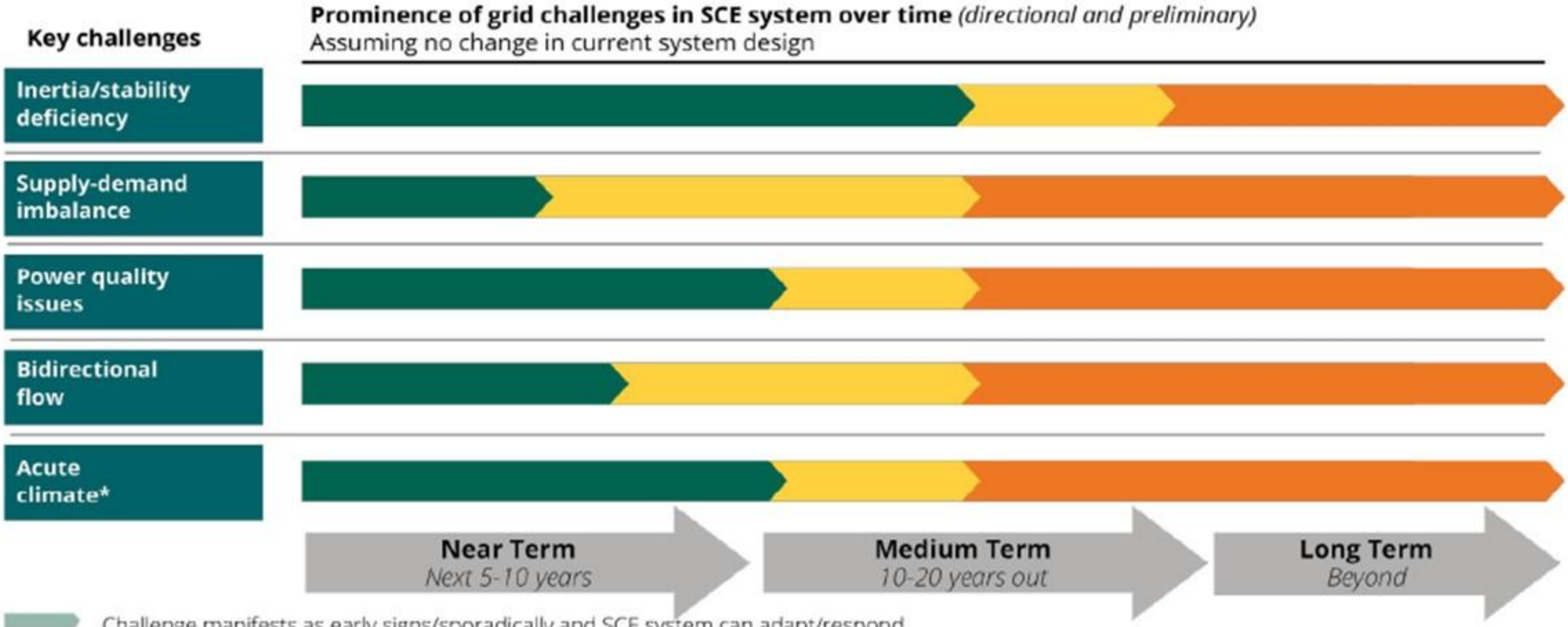
This analysis helps to identify the core platform functions and related technologies as well as the applications linked to specific policies/customer needs/locational value realization.

Taxonomy Example

Objective	Capability	Function	Technology
Reliability improvement by reducing customer unplanned outage durations Achieve 2nd quartile CAIDI performance by 2025	Improve outage identification and customer service restoration	Fault Identification Fault Location Fault Isolation Service Restoration	Fault Current Indicators Outage Notification from Meters Outage Management System Geospatial Information System Distribution Management System and/or SCADA Automated Switches Work Management System

When Are Functions Needed?

Grid modernization functionality and related technologies are largely driven by changes in resource mix, use of the distribution grid, and climate impacts.



🟩 Challenge manifests as early signs/sporadically and SCE system can adapt/respond

🟨 Challenge reaching level of consistent pattern where SCE system becomes stressed

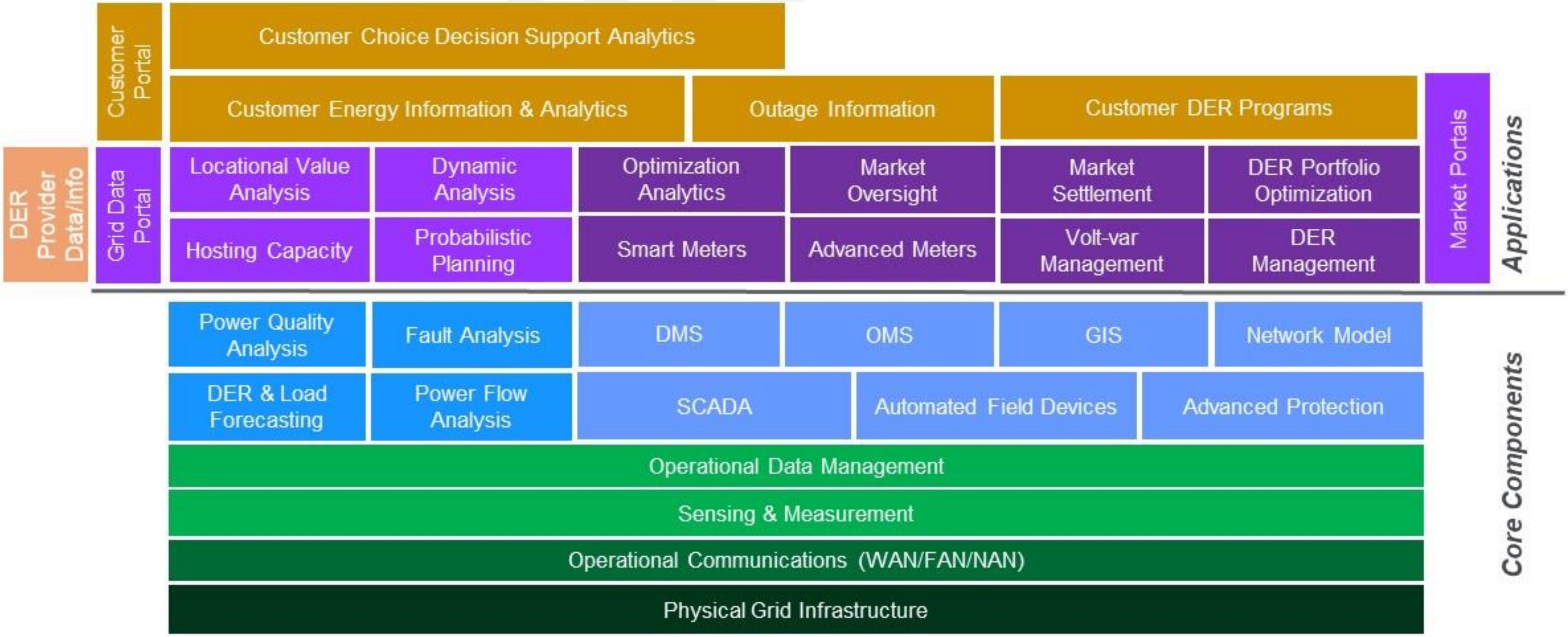
🟥 Challenge reaches systemwide scale that is beyond current system breaking point and new capabilities must be in place

** Excludes wildfires, which appear as discrete events in time*

Source: Southern California Edison

Distribution System Platform

Logical layering of core components that enable specific applications

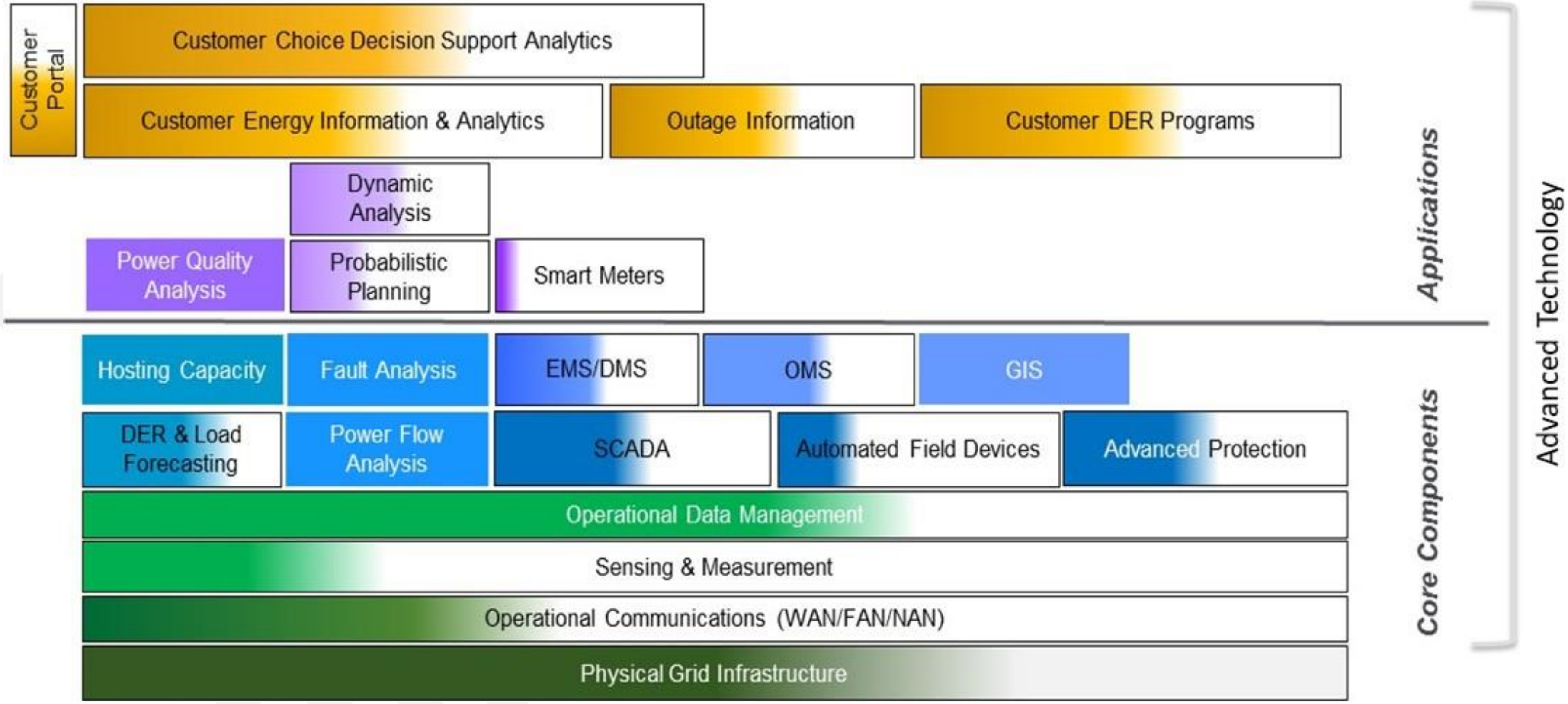


Green - Core Cyber-physical layer
Blue - Core Planning & Operational systems
Purple - Applications for Planning, Grid & Market Operations
Gold - Applications for Customer Engagement with Grid Technologies
Orange - DER Provider Application

Source: U.S. Department of Energy-Office of Electricity Delivery and Energy Reliability, 2017. *Modern Distribution Grid, Volume III: Decision Guide*.

Identify Starting Point for Grid Investment

Summary illustration of a more complete assessment (documented in narrative and tables) to enable a gap analysis against objectives and identified capabilities and functionalities



Source: Hawaiian Electric 2017

Technology Decision Criteria

General framework for technology assessment within a stage gate sequence where the evaluation begins with conceptual screening on a set of these criteria and increasingly becomes more detailed and definitive in terms of the quantitative and qualitative assessment.

Customer/Policy /Business Priority
- Policy Goals
- Regulatory Compliance
- Business Goals
- Business Plan Alignment

Technology Fit & Risk
- Tech Maturity
- Technology Fit
- Project Complexity
- Vendor Maturity

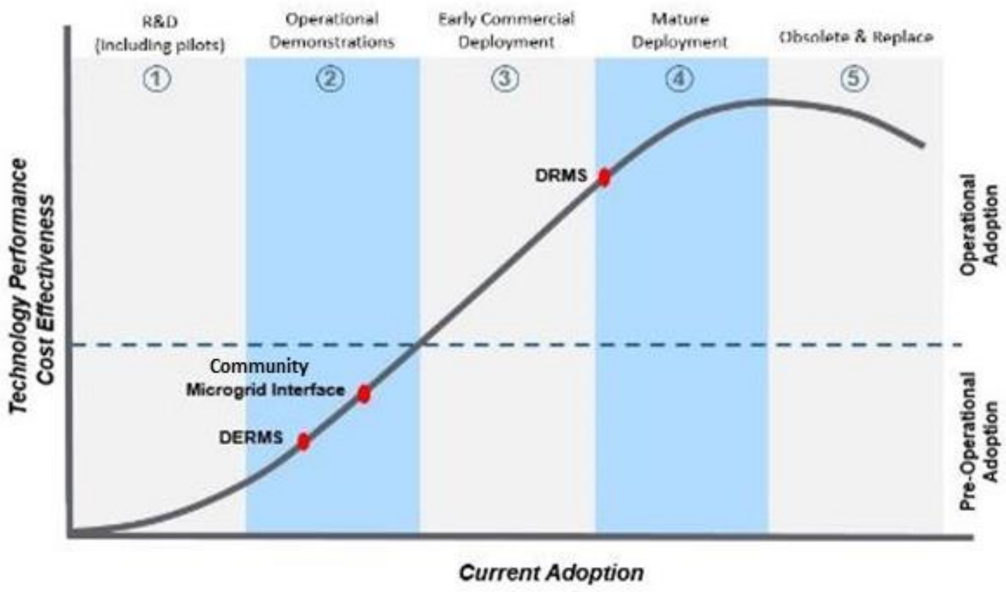
Costs
- Product Costs
- Integration Costs
- O&M Costs
- Commercial Terms

Organizational Capacity
- Business Process Impacts
- Staff Bandwidth for Project
- Organizational Change Management
- Partners – Vendor Capability

Technology Adoption Considerations

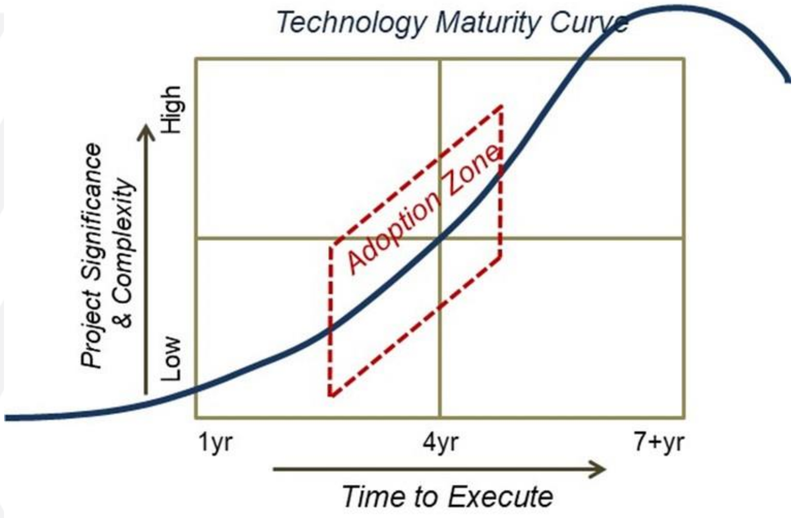
Deciding when to adopt grid technologies involves several factors: technology maturity, time to deploy, implementation complexity and functional criticality.

Technology Maturity Assessment



Source (above): U.S. Department of Energy-Office of Electricity, 2017. *Modern Distribution Grid, Volume II: Advanced Technology Maturity Assessment*.

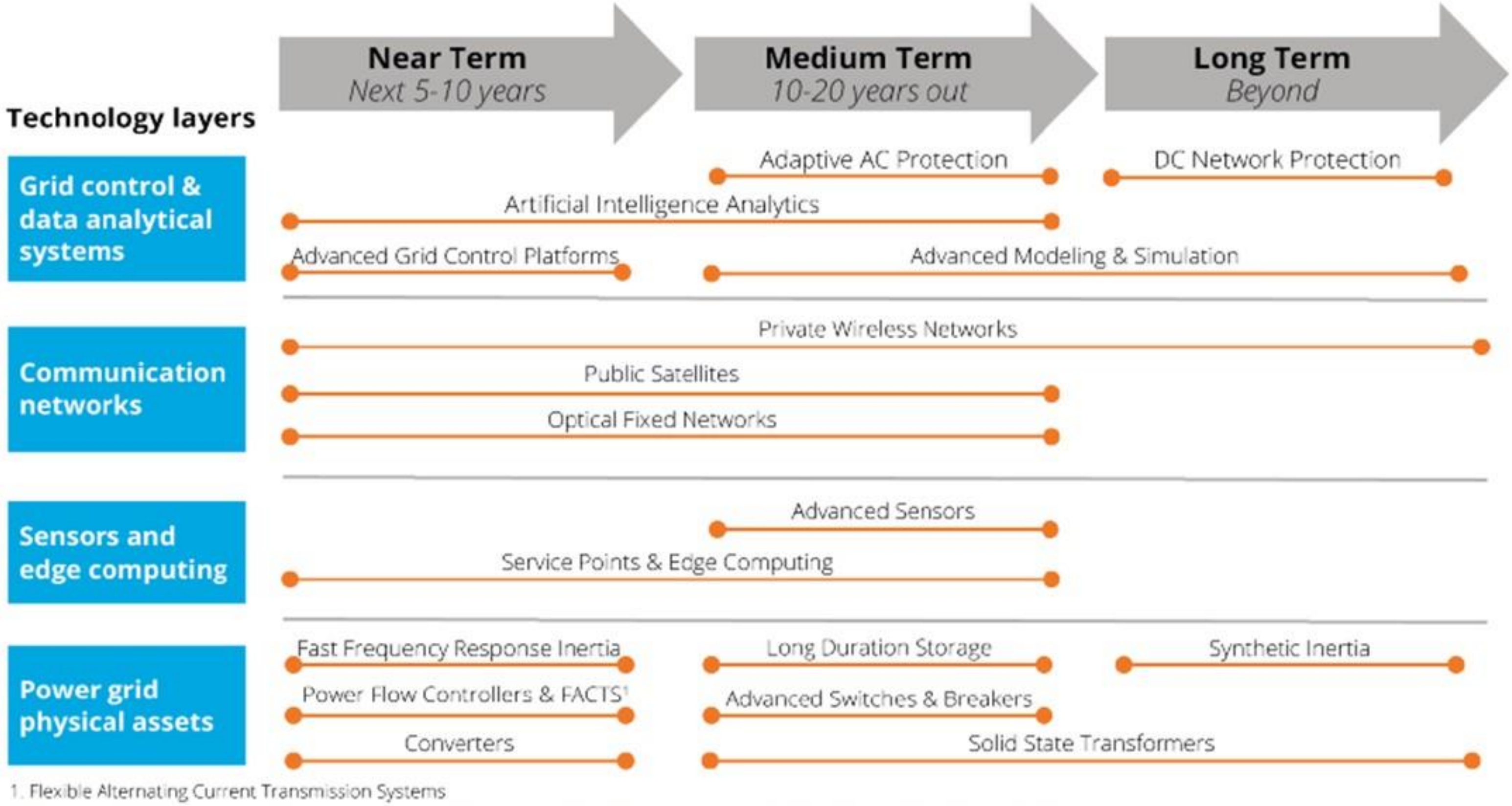
Technology Adoption Strategy



Example Technology Maturity Assessment

Grid modernization plans should consider evolution of technology innovation and commercial availability, including the underlying assessment criteria.

Estimated Commercialization Timeframes for Critical Grid Technologies

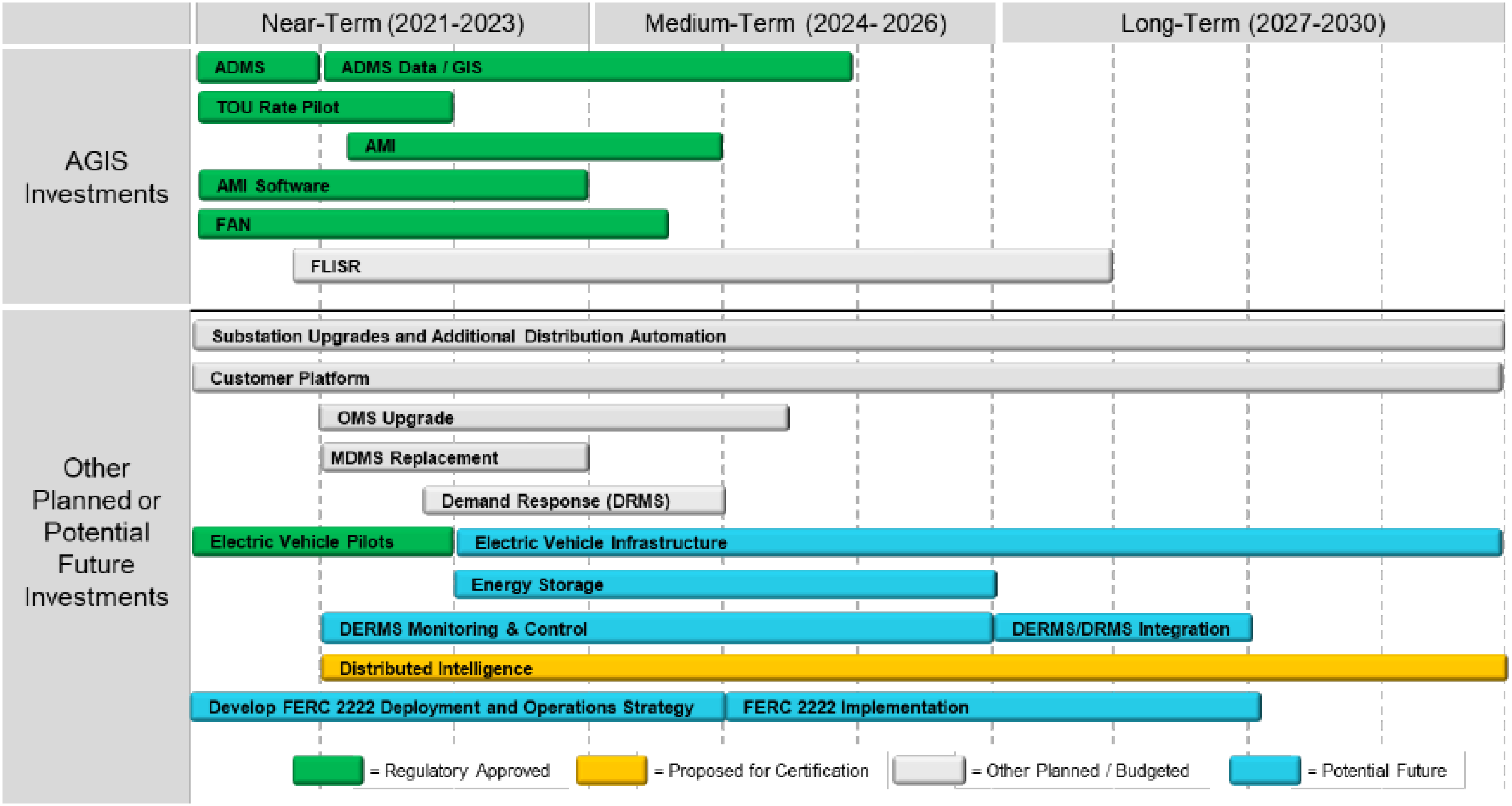


1. Flexible Alternating Current Transmission Systems

Source: Southern California Edison

Sequencing of Investments Based on Timing of Need and Technology Maturity

Long-term strategic plan of distribution grid investments



From Xcel Energy's 2021 Integrated Distribution Plan

Questions Public Utility Commissions Can Ask

- Have clear modernization objectives been established in policy or regulation, or proposed by the utility?
- Has a clear starting point for modernization been identified?
- What is the pace and scope of change expected over the planning period, and does the grid mod plan address the needs?
- Are grid mod plans aligned and integrated with asset management and resilience planning?
- Do grid mod plans incorporate flexibility needed for the uncertainty in needs and emergent grid technologies?

Resources for More Information

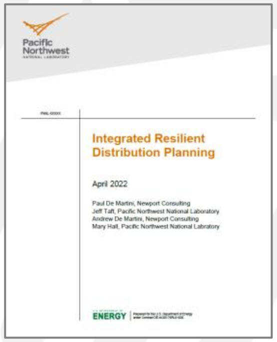
Contact:

Joe Paladino, joseph.paladino@hq.doe.gov

Paul De Martini, paul@newportcg.com

References:

Integrated Resilient Distribution Planning (forthcoming)



Pacific Northwest NATIONAL LABORATORY

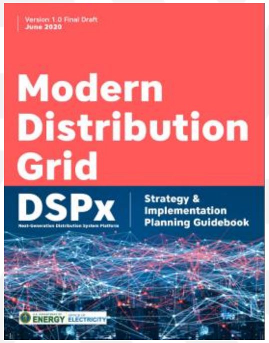
Integrated Resilient Distribution Planning

April 2022

Paul De Martini, Newport Consulting
Jeff Taft, Pacific Northwest National Laboratory
Andrew De Martini, Newport Consulting
Mary Hall, Pacific Northwest National Laboratory

ENERGY

DSPx Guidebook 2020



Version 1.0 Final Draft
June 2020

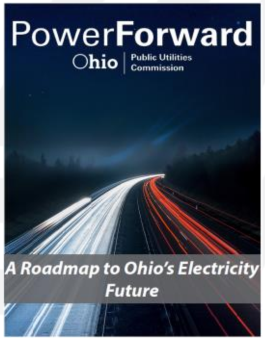
Modern Distribution Grid

DSPx Strategy & Implementation Planning Guidebook

ENERGY ELECTRICITY

https://gridarchitecture.pnnl.gov/media/Modern-Distribution-Grid_Volume_IV_v1_0_draft.pdf

PUCO Grid Mod Roadmap



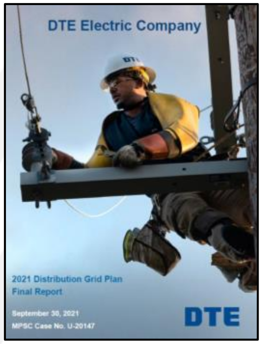
PowerForward

Ohio Public Utilities Commission

A Roadmap to Ohio's Electricity Future

https://puco.maps.arcgis.com/apps/Cascade/index.html?appid=59a9cd1f405547c89e1066e9f195b0b1

DTE's IRDP & Grid Mod Plan Using DSPx



DTE Electric Company

2021 Distribution Grid Plan
Final Report

September 30, 2021
MPSC Case No. U-20147

DTE

https://mi-psc.force.com/s/filing/a00t000000RaTD3AAN/u201470071

SCE Grid Modernization Strategy

EDISON

REIMAGINING THE GRID

EXECUTIVE SUMMARY

https://newsroom.edison.com/_gallery/get_file/?file_id=5fcfb5f62cfac23b06eb7d39&ir=1

Thank you

Economic Assessment of Grid Modernization Plans

Tim Woolf & Ben Havumaki

Synapse Energy Economics

Training Webinars on Electricity System Planning
for New England Conference of Public Utilities Commissioners
May 19, 2022

This presentation was funded by the U.S. Department of Energy's Grid Modernization Laboratory Consortium.

Overview

- Review of several utility Grid Mod Plans
- General guidance on economic evaluation of Grid Mod Plans
- Benefit-cost analysis (BCA) versus least-cost/best-fit (LCBF)
- Accounting for interdependencies between grid mod components
- Accounting for hard to quantify benefits
- Accounting for customer equity
- Based on two recent studies
  - T. Woolf, B. Havumaki, D. Bhandari, M. Whited and L. Schwartz, *Benefit-Cost Analysis for Utility-Facing Grid Modernization Investments: Trends, Challenges, and Considerations*, Berkeley Lab, 2021.
  - Minnesota Department of Commerce, *Review and Assessment of Grid Modernization Plans: Guidance for Regulators, Utilities, and Other Stakeholders*, prepared by Synapse Energy Economics, 2022. (Docket No. E002/M-21-814, available through eDockets)

Review of Benefit-Cost Analyses in Grid Modernization Plans

Review of BCAs in 21 Grid Mod Plans

Utility	State	Year	Utility	State	Year
National Grid	NY	2016	DTE Energy	MI	2018
NYSEG & RGE	NY	2016	APS	AZ	2016
Unitil	MA	2015	PSE&G	NJ	2018
National Grid	MA	2016	LGE	KY	2018
Eversource	MA	2015	Consumers Energy	MT	2018
Public Service Co.	CO	2016	Central Hudson G&E	NY	2018
SDGE	CA	2016	Hawaiian Electric Cos	HI	2017
Xcel	MN	2017	Southern CA Edison	CA	2016
FirstEnergy	OH	2017	CT Light & Power	CT	2010
Vectren	IN	2017	Entergy	AR	2016
National Grid	RI	2018			

Source: Woolf et al., *Benefit-Cost Analysis for Utility-Facing Grid Modernization Investments*, prepared for Berkeley Lab, 2021.

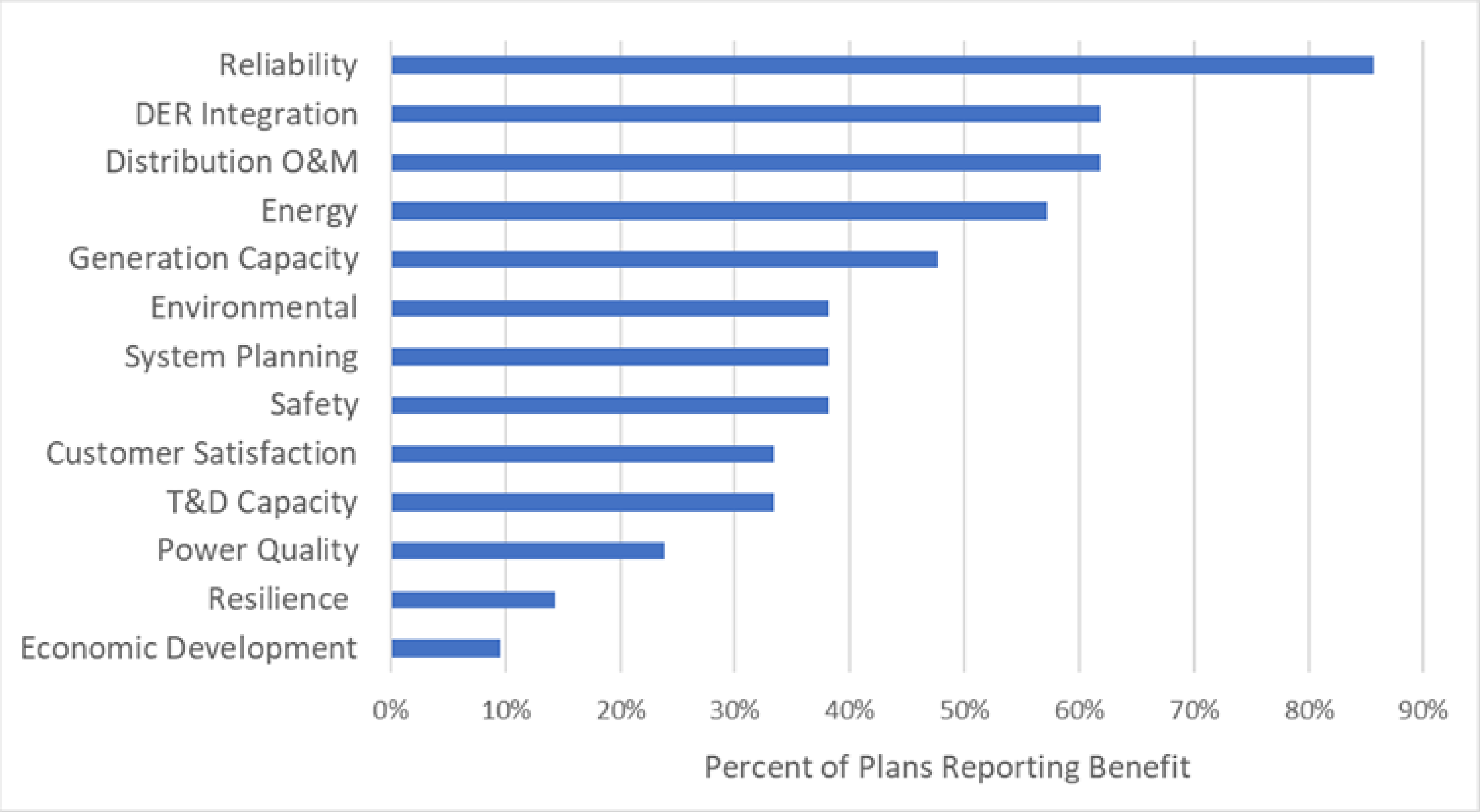
Review of Grid Mod Plans: Themes

Key items that were generally lacking:

- An overarching rationale for grid modernization investments and an explanation of how individual components will help meet overall goals
- Identification of which cost-effectiveness test was used for the BCA
- Identification of which discount rate was used to determine present values
- Methodologies to account for the interdependencies of grid modernization components
- Methodologies to account for unmonetized benefits of grid modernization components
- Robust definitions of grid modernization metrics and how they will be used to monitor grid modernization costs and benefits over time
- Methodologies and discussions for addressing customer equity issues

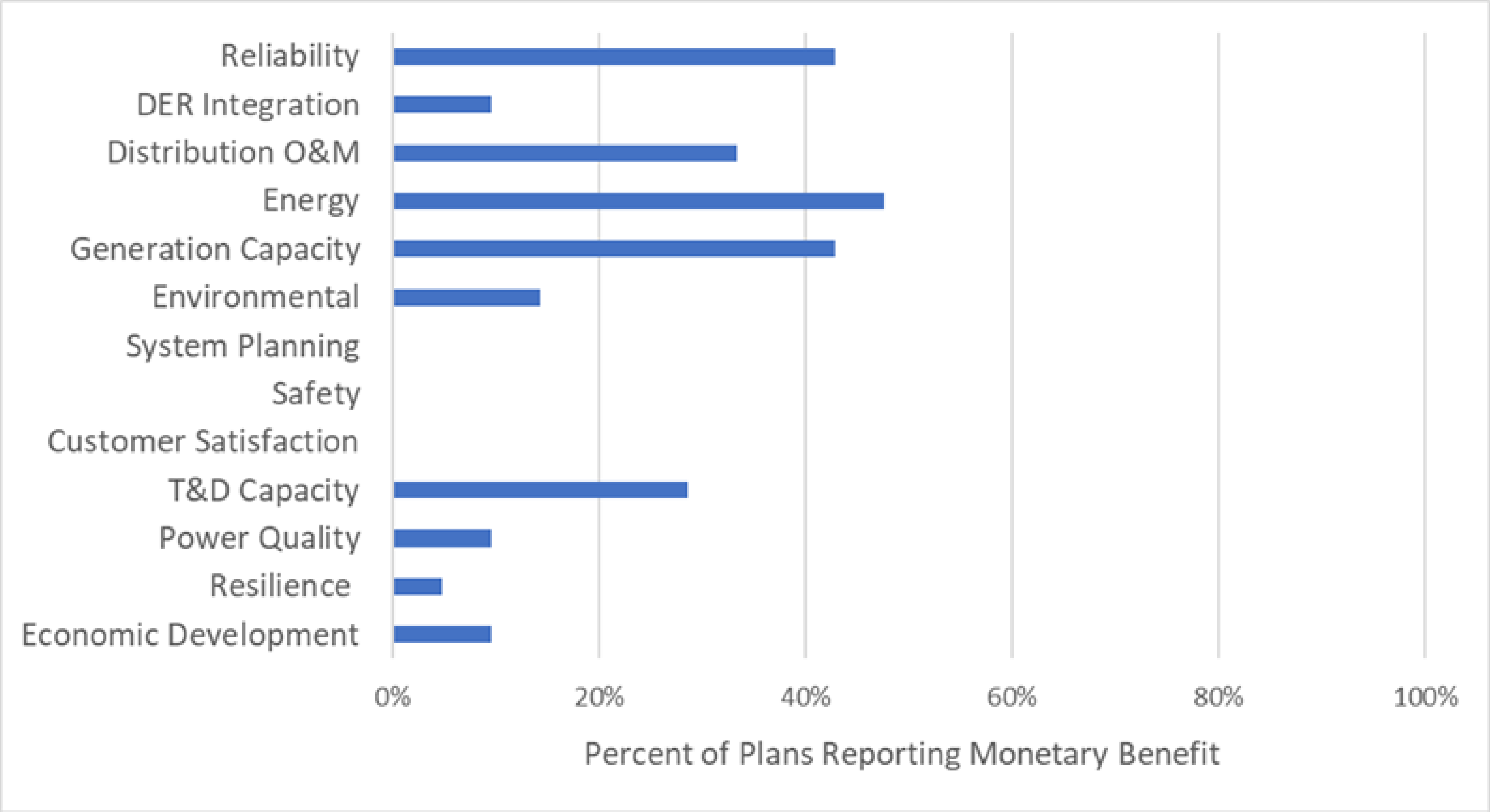
Source: Woolf et al., *Benefit-Cost Analysis for Utility-Facing Grid Modernization Investments*, prepared for Berkeley Lab, 2021.

Type and Frequency of Claimed Benefits



Source: Woolf et al., *Benefit-Cost Analysis for Utility-Facing Grid Modernization Investments*, prepared for Berkeley Lab, 2021.

Type and Frequency of Monetized Benefits



Source: Woolf et al., *Benefit-Cost Analysis for Utility-Facing Grid Modernization Investments*, prepared for Berkeley Lab, 2021.

Economic Evaluation of Grid Modernization Plans

Grid Mod Regulatory Contexts

Utility seeking review of costs *before* spending

- Typically, in a case dedicated to review of proposed investments
- Allows for focused review of proposal (outside rate case)
- Sometimes initiated by commission, sometimes by the utility
- Utility often asks for some form of regulatory guidance or approval
- Implications of regulatory guidance or approval vary by state

Utility seeking recovery of costs *after* spending

- Typically, in a rate case
- Allows for retrospective prudence review
- Allows for review in context of other utility costs
- Grid modernization issues might be one of many contentious issues
- Difficult to modify, reduce, or disallow costs after they are spent

Most grid modernization plans are submitted *before* spending

Examples of Grid Mod Benefits

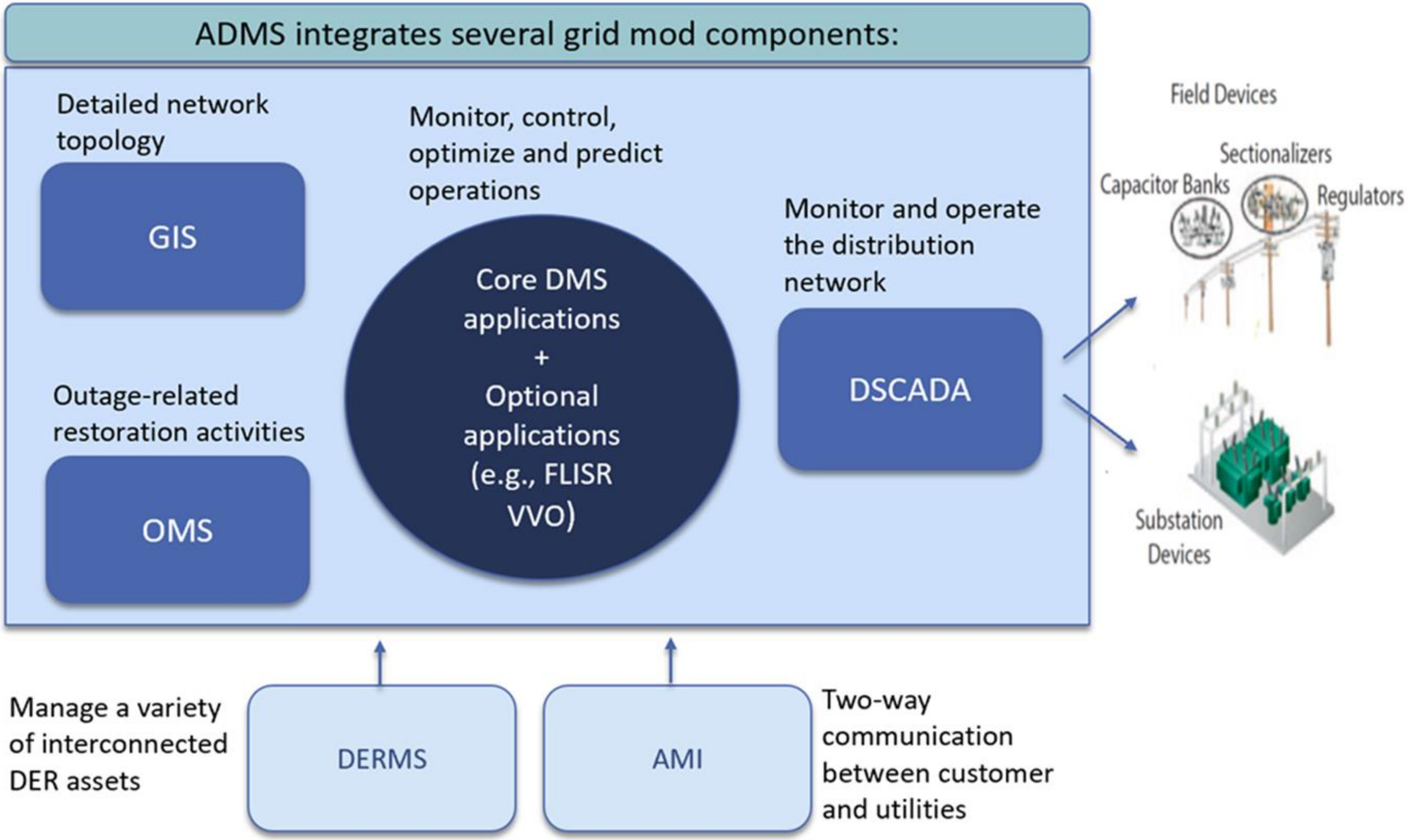
Benefit	Utility System	Society
Reduced O&M costs	✓	✓
Reduced generation capacity costs	✓	✓
Reduced energy costs	✓	✓
Reduced T&D costs and losses	✓	✓
Reduced ancillary services costs	✓	✓
Increased system reliability	✓	✓
Increased safety	✓	✓
Increased resilience	✓	✓
Increased distributed energy resource (DER) integration	✓	✓
Improved power quality	✓	✓
Reduced customer outage costs	✓	✓
Increased customer satisfaction	✓	✓
Increased customer flexibility and choice	✓	✓
Reduced environmental compliance costs	✓	✓
Environmental benefits		✓
Economic development benefits		✓

Examples of Grid Mod Costs

Cost	Utility System	Society
Incremental capital costs for grid modernization equipment	✓	-
Incremental O&M costs for grid modernization equipment	✓	-
Incremental costs for T&D upgrades needed to support the grid modernization equipment	✓	-
Program administration costs	✓	-

- Grid modernization costs are typically recovered from all customers.
    - But the benefits might not be experienced by all customers.
- Grid modernization costs are relatively easy to quantify and monetize.
    - But the benefits are sometimes hard to quantify and monetize.

Interdependence of Components



ADMS integrates several grid mod components:

Detailed network topology

GIS

Outage-related restoration activities

OMS

Monitor, control, optimize and predict operations

Core DMS applications + Optional applications (e.g., FLISR VVO)

Monitor and operate the distribution network

DSCADA

Manage a variety of interconnected DER assets

DERMS

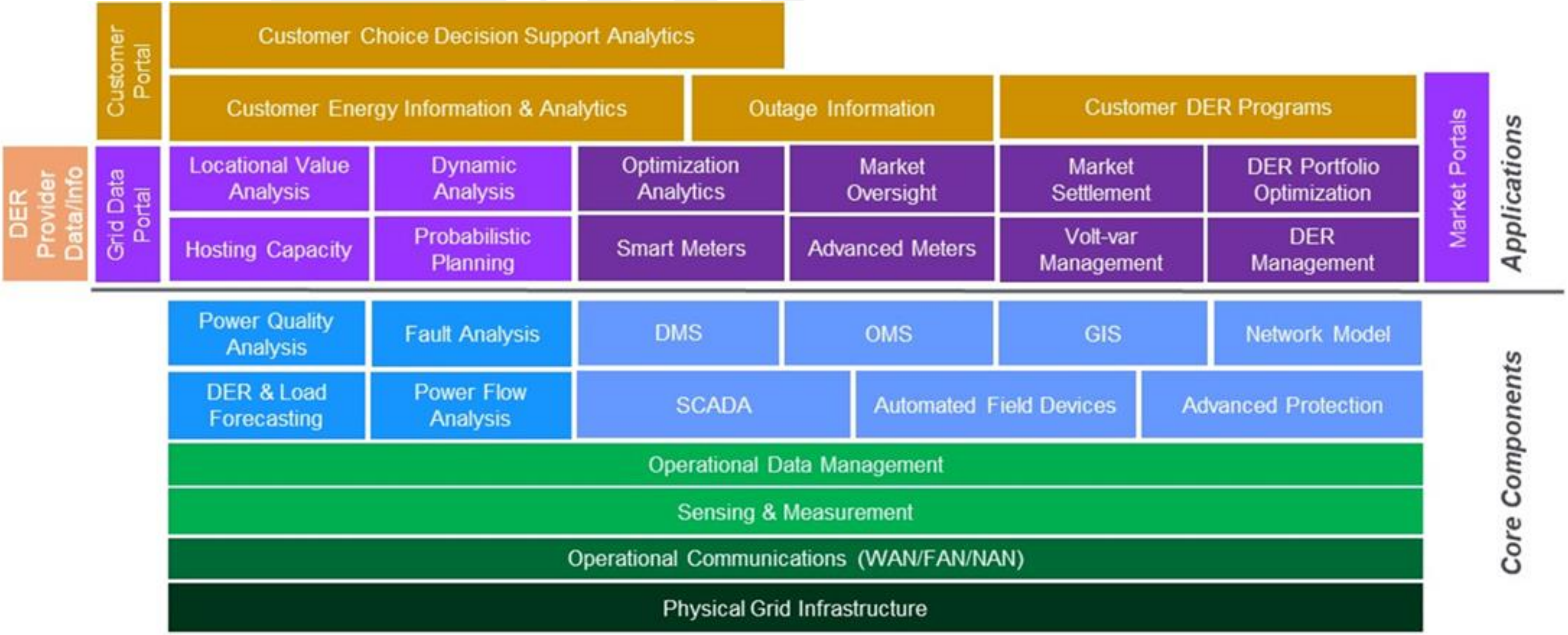
AMI

Two-way communication between customer and utilities

Source: Adapted from World Bank, *Practical Guidance for Defining a Smart Grid Modernization Strategy: The Case of Distribution*, 2017.

For definition of terms, see glossary in US DOE, *Modern Distribution Grid: Strategy & Implementation Guidebook*, 2020

Core Components Versus Applications



Source: US DOE, *Modern Distribution Grid: Strategy & Implementation Guidebook*, 2020, page 59.

Principles for Grid Mod Economic Analysis

1. Compare consistently with traditional resources or technologies
2. Clearly account for state regulatory and policy goals
3. Account for all relevant costs and benefits, including those difficult to monetize
4. Consider interdependencies between components where feasible
5. Consider customer equity issues
6. Provide symmetry across relevant costs and benefits
7. Apply a full life-cycle analysis
8. Provide a sufficient incremental and forward-looking view
9. Ensure transparency
10. Avoid combining or conflating different costs and benefits
11. Address locational and temporal values

Source: Minnesota Department of Commerce, *Review and Assessment of Grid Modernization Plans: Guidance for Regulators, Utilities, and Other Stakeholders*, prepared by Synapse Energy Economics, Attachment to Department of Commerce Letter. Docket No. E002/M-21-814, February 9, 2022

Articulate Grid Modernization Goals

Sample Goal	Sample Objectives and Targets	Sample Metric and Reporting
Accommodate higher capacities of DERs	DER capacity 50% of minimum recorded load on 25% of circuits by 2025	Annual report by circuit: • DER capacity • Minimum recorded load
	DER capacity 100% of minimum recorded load on 50% of circuits by 2030	
	DER capacity 100% of maximum recorded load on 50% of circuits by 2035	Annual report by circuit: • DER capacity • Maximum recorded load
Avoid interconnection delays	Interconnection decisions rendered on systems under 10 kW within 5 business days on circuits with available distributed energy resource capacity.	Annual reports: • Interconnection requests by size • Date of each request • Date on which decision was communicated for each request
	Interconnection decisions rendered on systems between 10 and 100 kW within 30 days on circuits with available distributed energy resource capacity	
	Interconnection decisions rendered on systems over 100 kW within 90 days	

Source: Minnesota Department of Commerce, *Review and Assessment of Grid Modernization Plans: Guidance for Regulators, Utilities, and Other Stakeholders*, Attachment to Department of Commerce Letter. Docket No. E002/M-21-814, February 9, 2022

Example performance metrics

Example benefit	Example performance metrics
DER deployment	Number of DER installations
Customer satisfaction	Customer ratings, customer engagement metrics
Reliability	System-wide or targeted SAIDI, SAIFI, CAIDI, CAIFI
Resilience	Restoration time after extreme weather events
Safety	Number of safety events, injuries, deaths
Network and data access	Interconnection times, data access times, developer satisfaction
Retail competition	Number of customers choosing a competitive option

Performance metrics can be used to indicate the extent to which purported benefits will be achieved.

Benefit-Cost Analysis versus Least-Cost/Best-Fit Analysis

Description of BCA and LCBF

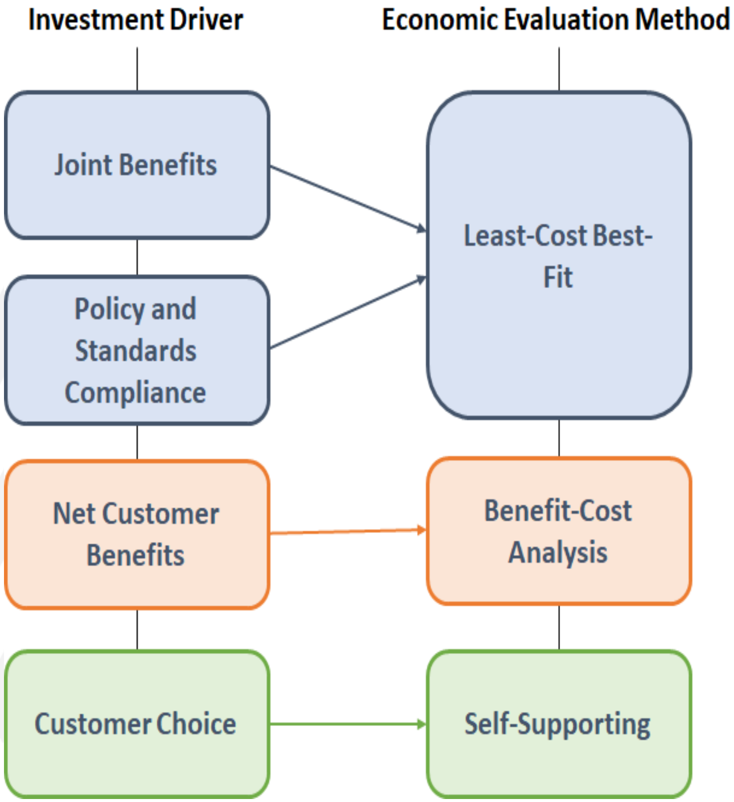
- Least-Cost/Best-Fit
  - For investments where the “need” has been established
    - Ex: A new distribution line is needed to provide service to a new residential development.
  - Different options might be considered for how to meet the need.
    - Ex. Different paths, different combinations of transformers, substations, etc.
  - LCBF is used to determine the option that meets the need at the lowest cost
  - Does not necessarily require quantifying or monetizing the benefits
- Benefit-Cost Analysis
  - For determining whether to make an investment
  - BCA used to determine whether the investment will result in net benefits
  - Typically includes monetizing, or at least quantifying, all costs and benefits
- The line between these two approaches is not always clear.

BCA Versus Least-Cost/Best-Fit

	Need	Purpose	Application	Costs	Benefits
Least-Cost/ Best-Fit	Need for the investment has been established	To identify the investment that meets the need at lowest cost	Which option is the lowest-cost way to meet the need?	Included Typically includes only utility system costs	Not Required Benefits are not necessarily accounted for; presumed to be worth the costs
BCA	Need for the investment has not been established	To determine whether to make the proposed investment	Do the benefits of the investment outweigh the costs?	Included Extent of costs depends upon BCA test chosen	Included Extent of benefits depends upon BCA test chosen

Economic Evaluation Options (from DOE)

- **Joint and interdependent benefits** — core platform investments needed to enable new capabilities and functions
- **Standards compliance and policy mandates** — utility investments needed to comply with safety and reliability standards or to meet policy mandates
- **Net customer benefits** — utility investments from which some or all customers receive net benefits in the form of bill savings
- **Customer choice** — customer-driven projects paid for by individual customers



Source: US DOE, *Modern Distribution Grid: Strategy & Implementation Guidebook*, 2020, page 113.

BCA Versus Least-Cost/Best-Fit

- The main difference
  - LCBF presumes that the utility investment is needed.
    - Therefore, the benefits of the investment are not necessarily monetized.
  - BCA is used to justify the investment.
    - Benefits are monetized to demonstrate that the investment will have net benefits.
- LCBF has been used for distribution planning for many years.
  - Because it was applied to investments that were clearly needed to maintain reliability
  - Ex: A new substation needs to be upgraded to serve an increasing customer demand.
    - What is the least-cost technology for upgrading the substation?
- Now, there are more options to consider.
  - Ex: A non-wires alternative could be implemented instead of a substation upgrade
    - A BCA should be conducted to determine which has greater net benefits.

Is There a “Need” for the Investment?

- For grid mod investments, the need is often not clear
  - Is an automated distribution management system (ADMS) necessary?
  - Is advanced metering infrastructure (AMI) necessary?
  - Is Volt-Var Optimization (VVO) necessary?
  - Grid modernization is sometimes described as necessary, but some components might not be, and some components might have costs that exceed the benefits.
- A better question to ask:
  - Will the grid mod investment result in net benefits?
  - This is the key question for Commissions, Commission staff, and consumer advocates
- This question can be answered only by a BCA
  - Therefore, BCA should be given priority over LCBF for grid mod evaluations
- BCAs provide value even if the need for grid mod investment seems clear
  - The BCA information on benefits is helpful (a) at the time of the investment decision, and (b) after the investment has been made, to monitor performance over time.

When Should BCA Be Used Instead of LCBF?

Reasons Not to Conduct a BCA	Responses
Some benefits are too hard to monetize.	There are ways to account for benefits without monetizing them.
Some grid mod components are necessary to support other elements, and it is difficult to isolate, quantify, or monetize the benefits.	BCAs can be used to assess interdependencies between components.
Some grid mod components work jointly with other components, and it is difficult to isolate, quantify, or monetize the benefits.	BCAs can be used to assess interdependencies between components.
A BCA might be expensive and burdensome.	This reason is not sufficient to justify LCBF, given the utility is proposing to spend millions of dollars on grid modernization.

Answer: BCA should be the default approach. An LCBF may be appropriate in certain situations.

BCA Provides More Information than LCBF

BCAs provide more transparency, even if all the benefits are not quantified.

Costs / Benefits (mil PV$)	Type of Cost or Benefit	LCBF	BCA #1	BCA #2
Costs	Capital, O&M, administration	20	20	20
Benefits monetized	Energy, capacity, O&M, T&D	?	18	12
Benefits not monetized	Reliability & resilience	?	?	?
Net benefits	---	?	-2	-8
Benefit-cost ratio	---	?	0.9	0.6

Result #1: This component might be deemed to be cost-effective because the reliability and resilience benefits are worth the $2 million net cost.

Result #2: This component might be deemed to be not cost-effective because the reliability and resilience benefits are not worth the $8 million net cost.

Accounting for Interdependencies, Hard to Quantify Benefits, and Customer Equity

Accounting for Interdependences

- Apply LCBF if necessary.
  - The use of LCBF must be justified in the Grid Mod Plan.
- Apply BCA tests for each component in isolation.
  - Using a BCA test appropriate for your state
- Apply BCA to several scenarios where components are bundled in different ways.
  - Start with just platform components
  - Add layers of application components on top of platform components
  - Assess how the BCA results change with different combinations of components

Accounting for Interdependences: Example

	Scenario 1: Platform Components Only	Scenario 2: Platform Plus FLISR and VVO	Scenario 3: Scenario 2 Plus AMI and DERMS
Costs (Mil PV$)	24	28	32
Benefits (Mil PV$)	22	36	38
Net Benefits (Mil PV$)	-2	8	6
Benefit-Cost Ratio	0.9	1.3	1.2
Findings	not cost-effective	cost-effective	potentially cost-effective

Scenario 3 has two potential interpretations:

- AMI and DERMS are deemed cost-effective, because the portfolio is cost-effective.
- AMI and DERMS are deemed not cost-effective, because they reduce the net benefits relative to scenario 2.

Accounting for Non-Monetized Benefits

- Put as many benefits as possible in monetary terms.
  - Define benefits in such a way that they can be monetized.
- Provide as much quantitative data as possible.
    - Ex: For reliability use SAIDI, SAIFI, MAIFI, CAIDI values
- Provide as much qualitative description as possible.
  - Can be used to inform the economic decision
- Establish metrics to report benefits.
  - Monitor metrics (benefits) over time
- Use quantitative methods to address non-monetized benefits.
  - Assign proxy values for significant non-monetized benefits
  - Use a point system to assign value to non-monetized benefits

Source: Woolf et al., *Benefit-Cost Analysis for Utility-Facing Grid Modernization Investments*, prepared for Berkeley Lab, 2021.

Accounting for Non-Monetized Benefits: Example

	Scenario 1: Platform Components Only	Scenario 2: Platform Plus FLISR and VVO	Scenario 3: Scenario 2 Plus AMI and DERMS
Monetary Impacts	--	--	--
Costs (Mil PV$)	24	28	32
Benefits (Mil PV$)	22	36	38
Net Benefits (Mil PV$)	-2	8	6
Benefit-Cost Ratio	0.9	1.3	1.2
Non-Monetized Benefits	--	--	--
Resilience	1	1	3
Customer choice & flexibility	1	2	3
Findings	not cost-effective	cost-effective	cost-effective

Scenario 3 is deemed to be cost-effective because of the high value of non-monetized benefits.

Addressing Customer Equity

- Fully document the purpose and role of each grid mod component
  - Traditional, Platform, Application
- Articulate the beneficiaries of grid modernization components
  - Which types of customers?
  - How many of those types of customers?
  - Over what time period?
- Consider results of the Utility Cost test
  - Provides the best indication of impacts on customer bills
- Present estimates of long-term customer bill impacts
  - Helps to put the grid modernization costs in context
- Consider implications for target populations

Ensuring Net Benefits to Customers

Regulators can use cost recovery approaches to ensure that customers experience net benefits from grid modernization proposals.

- Limit the amount of grid modernization costs that the utility can recover to the costs proposed in the grid modernization plan.
  - Utilities required to absorb cost over-runs
  - With allowances for contingencies
- Limit the amount of grid modernization costs that the utility can recover over time based on achievement of purported grid mod benefits.
  - Require utilities to absorb a portion of costs if benefits are not achieved
  - Use metrics to assess achievement of benefits
  - Provide allowances for contingencies

Questions Public Utility Commissions Can Ask (1)

Initial Grid Mod Plan filing requirements:

- Are grid mod goals clearly articulated, and is their relationship to policy goals clear?
  - Are there metrics with concrete measurable outcomes?
- Does the Grid Mod Plan demonstrate consistency with the utility’s distribution, transmission, and resource plans?
- Are the roles and relationships of each grid mod component identified?
- Is the scope of the economic analysis identified?
  - Utility Cost test, Societal Cost test, Jurisdiction Specific test?
- Does the plan indicate the cost-effectiveness approach used — BCA or LCBF?
  - Is any use of LCBF justified?
- Is there a thorough evaluation of alternatives to utility distribution investments?
- Does the plan clearly document how non-monetary impacts are accounted for?
- Does the plan clearly document how interrelated impacts are accounted for?
- Does the plan clearly present results of all economic analyses?

Source: Minnesota Department of Commerce, *Review and Assessment of Grid Modernization Plans: Guidance for Regulators, Utilities, and Other Stakeholders*, 2022.

Questions Public Utility Commissions Can Ask (2)

Ongoing annual Grid Mod Plan reporting requirements:

- Does the plan specify what updates will be filed to project scope, functions, or outcomes?
- How will the utility regularly report on progress on implementation and integration of grid mod components?
- How and when will the utility provide updates on capital costs and operating expenses?
  - Total to date, percent of total budgeted costs, potential budget over-runs
- How will the utility document performance of grid mod projects?
  - Using actual data from previous year
  - Using all metrics established in Grid Mod Plan
  - Comparing actual performance to metrics established in the Grid Mod Plan
- Did the utility include a well-defined action plan?
  - To describe whether and how the next year’s grid mod implementation might be modified to account for information from the previous year

Source: Minnesota Department of Commerce, *Review and Assessment of Grid Modernization Plans: Guidance for Regulators, Utilities, and Other Stakeholders*, 2022.

Resources for more information

US DOE Grid Modernization Laboratory Consortium website:
https://www.energy.gov/gmi/grid-modernization-lab-consortium

US DOE, *Modern Distribution Grid: Strategy & Implementation Guidebook*, Volume IV, 2020

US DOE Grid Mod Laboratory Consortium, *A Valuation Framework for Informing Grid Modernization Decisions: Guidelines on the Principles and Process of Valuing Grid Services and Technologies*, prepared for the National Association of Regulatory Utility Commissioners, 2019

US DOE, *Modern Distribution Grid: Decision Guide,* Volume III, 2017

T. Woolf, B. Havumaki, D. Bhandari, M. Whited and L. Schwartz, *Benefit-Cost Analysis for Utility-Facing Grid Modernization Investments: Trends, Challenges and Considerations*, Berkeley Lab, 2021

Minnesota Department of Commerce, *Review and Assessment of Grid Modernization Plans: Guidance for Regulators, Utilities, and Other Stakeholders*, prepared by Synapse Energy Economics, 2022. (Docket No. E002/M-21-814, available through eDockets)

National Energy Screening Project, *National Standard Practice Manual for Benefit-Cost Analysis of Distributed Energy Resources*, 2020

Contact

Synapse Energy Economics
is a research and consulting firm specializing in technical analyses of energy, economic, and environmental topics. Since 1996 Synapse been a leader in providing rigorous analysis of the electric power and natural gas sectors for public interest and governmental clients.

Tim Woolf
Senior Vice-President
Synapse Energy Economics
617-453-7031
twoolf@synapse-energy.com
www.synapse-energy.com

Considerations for Planning for Resilience and Equity

Rebecca O'Neil

Pacific Northwest National Laboratory

Training Webinars on Electricity System Planning
for New England Conference of Public Utilities Commissioners
May 19, 2022

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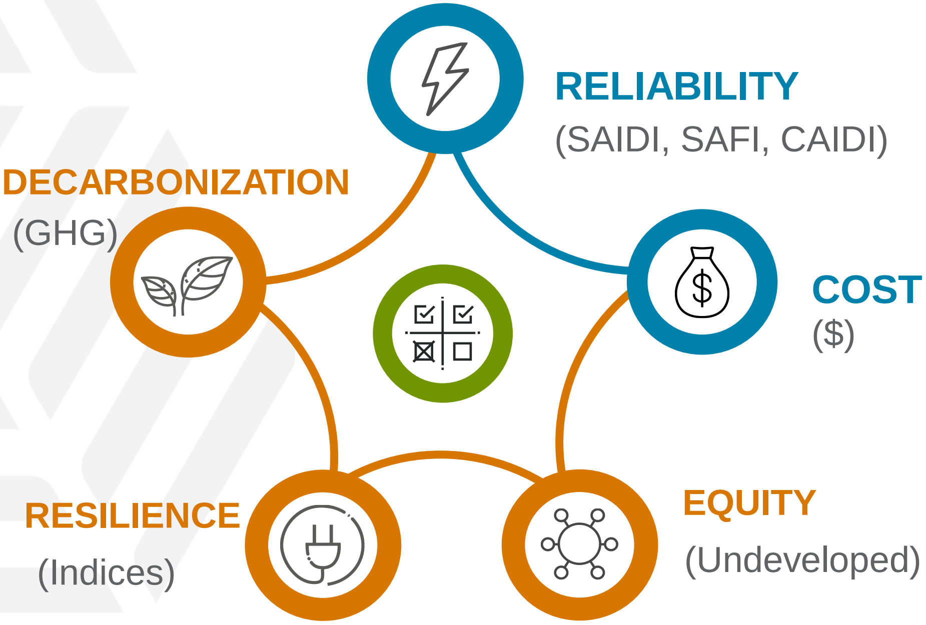
DISCUSSION TODAY

- Resilience and equity are emerging objectives for the electric grid, but to date, most utilities have not applied rigorous criteria for these objectives to electricity system planning.
- Emerging objectives require assessing new technologies, interactions, and data and integrating stakeholders into planning processes. This presentation discusses pathways to build rigor around the emerging objectives of resilience and equity.
- Optimizing for individual objectives will not lead to the same results. For example, the most aggressively decarbonized system is not the most reliable or affordable. Multi-objective decisionmaking involves tradeoffs. We present initial methods to balance disparate objectives.

Credit to Imre Gyuk and Joe Paladino in U.S. Department of Energy’s Office of Electricity for sponsorship, and Sandia National Laboratories in partnership for the suite of research in which this work is rooted.

Emerging Objectives in Grid Planning

- Traditionally, electric grid planning strives to maintain **safe, reliable, efficient, and affordable** service for current and future customers.
- As policies, social preferences, and the threat landscape evolve, additional considerations for power system planners are emerging, including **decarbonization, resilience, and energy equity**.
- Relative to traditional objectives, these emerging objectives are not well integrated into grid planning paradigms.


RELIABILITY

(SAIDI, SAFI, CAIDI)

DECARBONIZATION

(GHG)

COST

($)

RESILIENCE

(Indices)

EQUITY

(Undeveloped)

Dimensions & Approaches of Energy Equity

Distributive Justice (where?)

- The unequal allocation of benefits and burdens and unequal distribution of the consequences

Recognition Justice (who?)

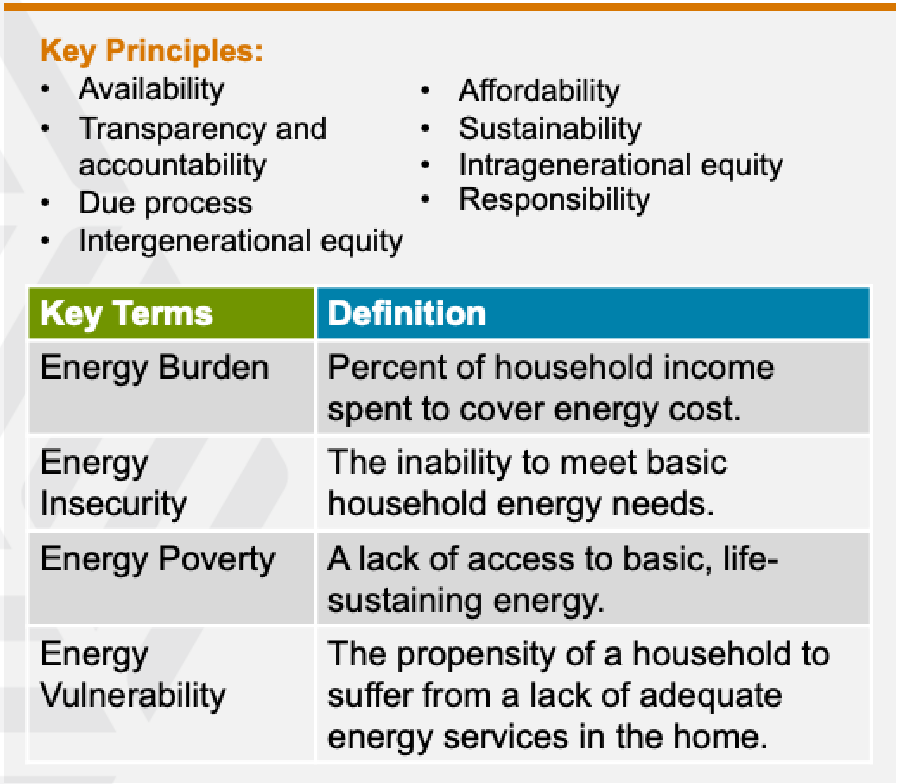
- The practice of cultural domination, disregard of people and their concerns, and misrecognition

Procedural Justice (how?)

- The fairness of the decision-making process

Restorative Justice

- The response to those impacted by the burdens of energy projects



Key Principles:

- Availability
- Transparency and accountability
- Due process
- Intergenerational equity
- Affordability
- Sustainability
- Intragenerational equity
- Responsibility

Key Terms	**Definition**
Energy Burden	Percent of household income spent to cover energy cost.
Energy Insecurity	The inability to meet basic household energy needs.
Energy Poverty	A lack of access to basic, life-sustaining energy.
Energy Vulnerability	The propensity of a household to suffer from a lack of adequate energy services in the home.

Observations from Utility Engagements

- **Utilities lack the mechanisms to successfully communicate infrastructure needs.** It may be difficult for utility planners to communicate resilience needs to utility customers, regulators, and even to their own utility executives.
- **Utilities lack reliable funding sources for resilience investments.** When competing for limited capital funding, long-term investments in system hardening and resilience are frequently crowded out by more immediate needs.
- **Making long-term resilience investments today is challenging.** Growing and changing risk profiles make long-term forecasting difficult. Future-proofing and least-regrets investments are needed.
- **Utilities' perception of non-wires alternatives is evolving.** They may view non-wires alternatives less as long-term solutions and more as temporary stopgaps to assist in managing and spreading out capital expenditures on large infrastructure upgrades.
- **Distribution planning standards vary by utility.** While some states have established distribution planning requirements for regulated utilities, there are very limited universal standards or scenario-based planning applications like there are for generation and transmission.

State of Current Practice

- Policy Translation to Grid Investment Strategy
- Objective Formulation
- Planning Practice
- Balancing Multiple Objectives
- Implementation and Performance Metrics

Planning Paradigms	**Traditional Objectives**				**Emerging Objectives**		
	Safety	*Reliability*	*Efficiency*	*Affordability*	*Decarbonization*	*Resilience*	*Equity*
Integrated Resource Planning	Connected	Robust	Robust	Robust	Robust	Limited	Limited
Transmission Planning	Robust	Robust	Connected	Connected	Limited	Connected	None
Distribution System Planning	Robust	Robust	Robust	Connected	Limited	Connected	Limited
Reliability Planning	Robust	Robust	Robust	Connected	Robust	Connected	None
EE & DSM Planning	Connected	Robust	Robust	Robust	Robust	Connected	Limited
Integrated Distribution Planning	Robust	Robust	Robust	Robust	Limited	Connected	Limited

Equity in Grid Planning: Current Practice

Remain tied to decarbonization goals and/or environmental justice

- **Michigan**: 2020 Executive Order (EO) requires PUC to expand its environmental review of integrated resource plans (IRPs) to evaluate whether utilities are meeting state decarbonization goals
    - Also requires PUC to assess whether IRPs consider environmental justice and health impacts
- **Washington**: 2019 Clean Energy Transformation Act requires IRPs to include an assessment of energy and non-energy benefits and reductions of burdens to vulnerable populations
- **Connecticut**: 2019 EO requires the Public Utilities Regulatory Authority (PURA) to analyze decarbonization pathways consistent with the state's goal of 100% carbon-free electricity by 2040
    - EO also calls for PURA oversight to ensure energy affordability and equity for all ratepayers during the resource planning process (but this is loosely outlined)
- **California**: 2018 CPUC decision requires IRPs with LSEs to assess their impacts on disadvantaged communities
    - CA defines disadvantaged communities as those with the highest pollution burden (top 25% statewide)

Planning Paradigm	**Treatment of Equity Within Paradigm**
Integrated Resource Planning	**Limited**
Transmission Planning	**None**
Distribution System Planning	**Limited**
Reliability Planning	**None**
EE & DSM Planning	**Limited**
Integrated Distribution Planning	**Limited**

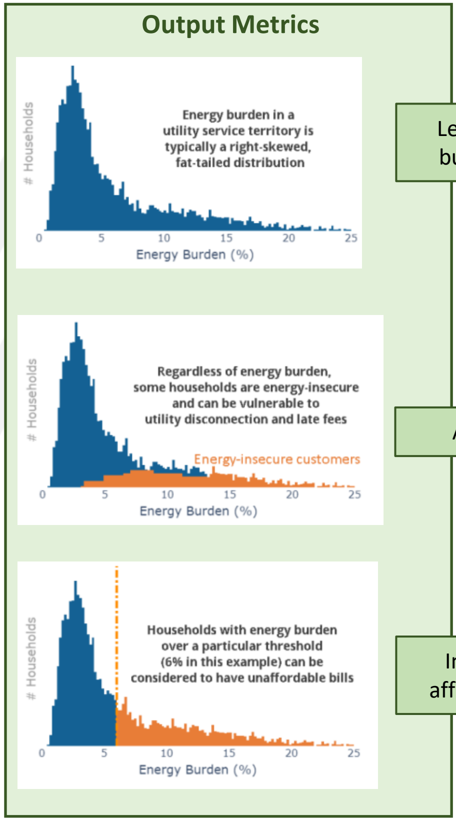
Dimensions of Energy Justice Reflected into State Policies for Incorporating Equity into Grid Planning

Jurisdiction & Policy	Dimensions of Energy Justice Included			
	Procedural	Recognition	Restorative	Distributive
Oregon (HB 2021)	X	X		X
Washington (SB 5116, 2019)		X		X
Connecticut (EO.3, 2019)		X		
Illinois (SB 2408, 2021)		X		X
California (SB 350, 2015)	X		X	X
Hawaii (Decision/Order NO. 37787, 2021)				X
Massachusetts (Chapter 8 of the Acts of 2021)				X
Michigan (ED 2020-10, 2020)		X		

Kazimierczuk K., M. DeMenno, and R.S. O'Neil. 2022. *Equitable Electric Grid: Defining, Measuring, & Integrating Equity into Electricity Sector Policy & Planning*. PNNL-32887. Richland, WA: Pacific Northwest National Laboratory

Creating Comparable Objectives

- **New Analytical Framework Required:** Different from siting a facility or a discrete decision under environmental justice framework
- **Grid Planning Scales:** Distribution system planning is useful starting point – spatial in nature, closely connected to community experience
- **Missing Insights on Investments to Effects:** No one single attribute of the grid is sufficient for energy equity – may be composite or index until clearer insights about which are the most meaningful in practice
- **Tradeoffs and Co-Optimization:** Strong relationships, including tradeoffs, with other objectives



Levelling burden?

Addressing insecurity?

Improving affordability?

Example:
Energy Storage and Community Objectives

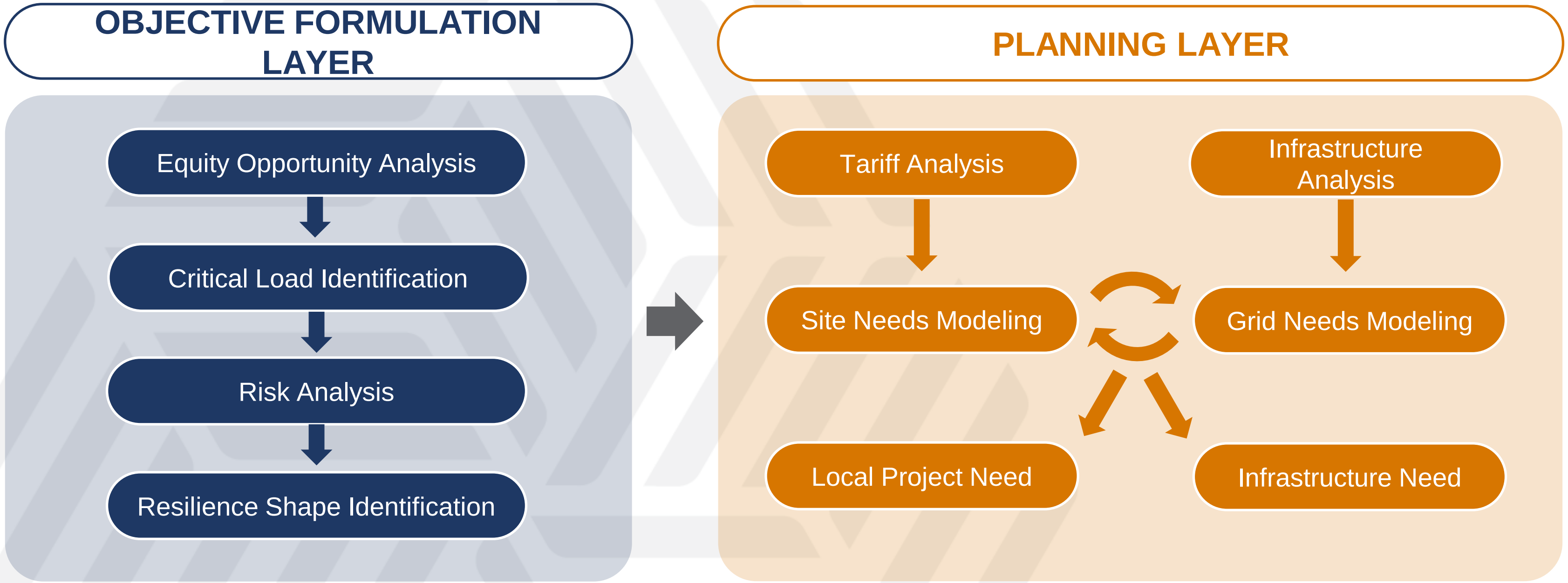
WHY **ENERGY STORAGE**?

- **Locational flexibility**
- **Wide applications**
- **Broad uses for storage**

HOW CAN ENERGY STORAGE SUPPORT **COMMUNITY GOALS** AND ADDRESS **NEEDS?**

- **Access**
- **Affordability**
- **Environmental Impact**
- **Social Impact**
- **Decarbonization**
- **Resiliency**

Formulating Resilience Objectives as Part of Planning Practices



OBJECTIVE FORMULATION LAYER

Equity Opportunity Analysis

Critical Load Identification

Risk Analysis

Resilience Shape Identification

PLANNING LAYER

Tariff Analysis

Infrastructure Analysis

Site Needs Modeling

Grid Needs Modeling

Local Project Need

Infrastructure Need

Objectives:

- Cross-sectoral evaluation of critical loads
- Inclusive approach captures current inequities
- Model-grade needs identification

Objectives:

- Identify a *portfolio* that meets resilience needs and offers other strategic benefits such as reliability services and equity
- Identify communication and control needs to enable project functionality

Stakeholder Roles and Responsibilities

Policy Translation to Grid Investment Strategy

Objective Formulation

Planning Practice

Balancing Multiple Objectives

Implementation and Performance Metrics

Policy Makers

Government Agencies (FEMA, Cities, Counties, Emergency Response, HUD,etc.)

Regulators

Stakeholders

Steering Committees, Advisory Groups

Utilities

Advocates, Coalitions, Communities

Stakeholders

Near & Long Term Plans

Climate & System Forecasts

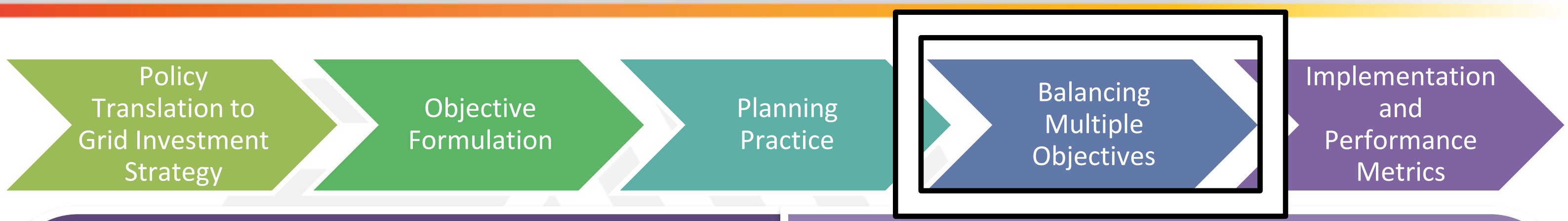
Integrated Distribution Planning (IDP)

Resiliency & Reliability Assessments, Asset Management

Data gathering & updates (ex: GIS, CIS, OMS, EMS, etc.)

Resource & Transmission Planning

Multiple Objectives and Tradeoffs



Cost:

- Bounding cost with investment outcome
- Relationship between public/ratepayer costs
- Relationship between ratepayer and resilience benefit
- Least cost individual measures vs. best fit portfolio standard

Decarbonization:

- Reliable backup power alternatives to diesel
- Central vs. distributed resources
- Role of clean energy transition in resilience drivers
- Reduce health harms to vulnerable and disadvantaged communities

Multi-Objective Tradeoffs with Resilience

Equity

- Recognition of most impacted communities
- Remedial strategies and prioritization for acute or long-term conditions
- Cost pressure and affordability (energy burden, insecurity, poverty, democracy)
- Transitional effects

Reliability

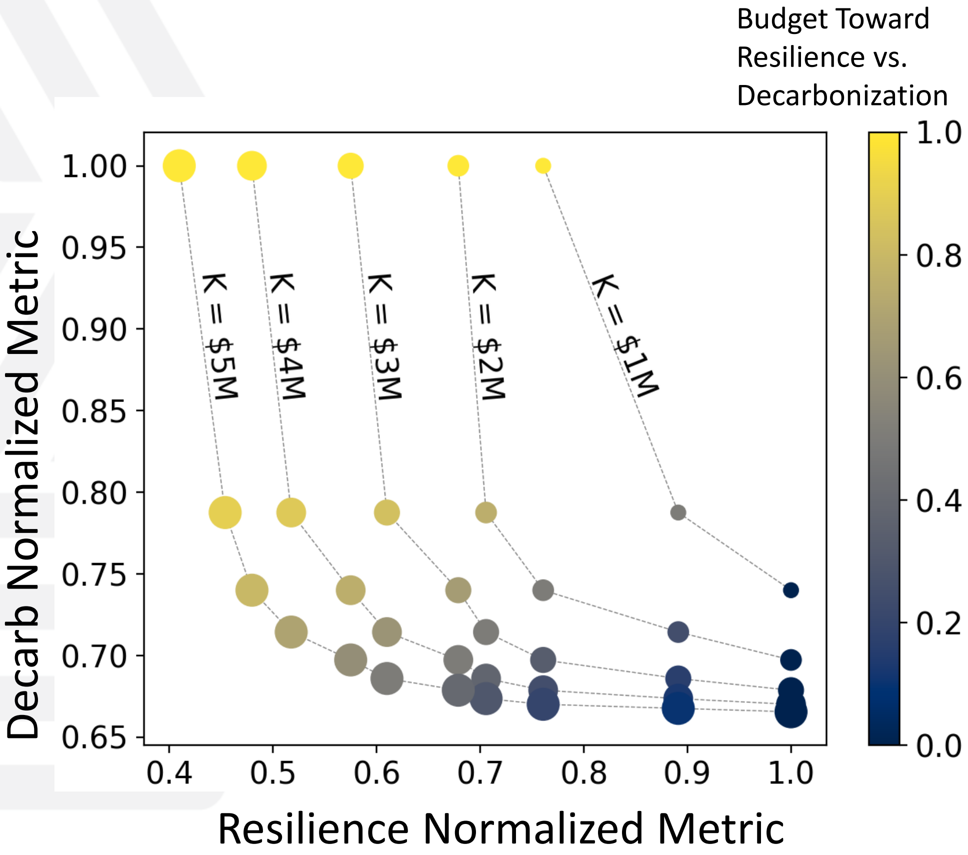
- SAIDI, SAIFI, CAIDI improvements
- Improvement in daily disruptions
- Asset Management Portfolio
- Reliability project prioritization

Pathways to Evaluating Tradeoffs: Multi-Objective Decision Analysis

- Priorities among objectives
  - Determine “must haves” which can be represented as constraints (e.g., fixed investment, minimum reliability performance in identified disadvantaged communities)
  - Requires understanding relationship between investment and effect

- Analytical process to show trade-offs in achieving objectives between investment decisions and portfolios
  - Fixed hierarchy
  - Optimization
  - Multi-criteria decisionmaking analysis (subjective weighting)

- A portfolio approach with performance metrics supports planning decisions as well as post-investment validation.



CREDIT: Brian Pierre, Sandia National Laboratories

Performance Metrics

- *Metrics* for new objectives lack national standardization and quantification practice.
- Grid performance metrics can support evaluating in a planning context and also validating cause-effect relationships between plans and outcomes.

RESILIENCE	**Attribute-Based**	**Performance-Based**			
		Power System Performance	Economic Consequence	Social Consequence	National Security Consequence

EQUITY	**Procedural and Recognition** *(due process and accountability)*	**Distributive** *(affordability and availability)*	**Restorative** *(intra- and inter-generational sustainability and responsibility)*

DECARBONIZATION	**Emissions**	**Resources**

Grid Performance Metrics for Emerging Objectives: Resilience

Attribute-Based	Performance-Based			
	Power System Performance	Economic Consequence	Social Consequence	National Security Consequence
• Absorptiveness • Adaptiveness • Robustness • Resourcefulness • Recoverability • Resilience indices (e.g., Resilience Measurement Index)	• Cumulative electricity demand not served (e.g., MWh load unserved) • Average number/ percentage of customers experiencing outage • Duration of load curtailment • Recovery duration • Frequency of outages exceeding a given duration	• Unserved load for key production facilities • Utility outage costs (e.g., revenue loss, restoration, repair, and recovery costs) • Customer outage costs or damage functions (e.g., business interruption costs, value of lost load) • Outage impact on economic production (e.g., gross regional product)	• Unserved load for critical services (e.g., hospitals) • Vulnerable populations experiencing outages • Loss of life and health impacts • Labor market impacts • Effort to access critical services (e.g., social burden metric)	• Unserved load for key military facilities • Degradation of mission readiness, assurance, or performance

Measuring Energy Equity

Target Population Identification

- Program equity index
- Program accessibility
- Energy cost index
- Energy burden index
- Late payment index
- Appliance performance
- Household-human development index

Investment Decision Making

- Community acceptance rating
- Program funding impact
- Energy use impacts
- Energy quality
- Workforce impact

Program Impact Assessment

- Profits
- Program acceptance rate
- Energy savings (MWh)
- Energy cost savings ($)
- Energy burden change
- Change in household-human development index score

See *Review of Energy Equity Metrics*
https://www.pnnl.gov/main/publications/external/technical_reports/PNNL-32179.pdf

Effects from Equitable Outcomes

Recognition

- Ending disconnections (e.g., commitment to reduce or end disconnections, moratorium on shutoffs for customers with severe or extreme energy burdens)
- Maximizing resilience, minimizing vulnerabilities (e.g., targeted program investments for communities and households facing severe climate and health risks)

Distributive

- Maximizing co-enrollments in affordable rates, payment plans, and clean energy programs (e.g., notify disadvantaged customers of the programs they qualify for)
- Enabling energy affordability (e.g., commitment for reducing the distribution of high energy burdens)

Restorative

- Integration in cross-sector and long-term planning (e.g., quantitative and qualitative treatment of equity in long term plans and models)
- Wealth building (e.g., on-bill financing with special terms for disadvantaged customers, effective caps on DERs and storage)

Procedural

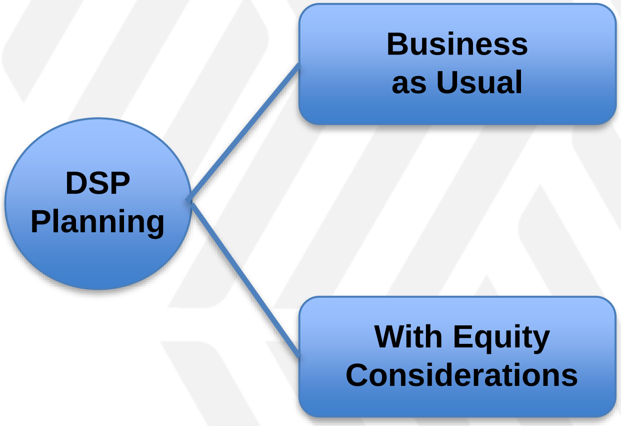
- Enabling participation (e.g., participation stipends, intervenor funding for disadvantaged community engagement)
- Unbiased evaluation (e.g., no conflict-of-interest w/ third party evaluators, evaluation open for public input, access to original data)

Extending Energy Equity Metrics

Procedural and Recognition (due process and accountability)	**Distributive** (affordability and availability)	**Restorative** (intra- and inter-generational sustainability and responsibility
• Representativeness and inclusiveness of planning processes for all affected stakeholders • Responsiveness of planning processes to public participation and fairness of decisions • Transparency of planning processes and decisions	• Electricity cost burden (i.e., household electricity bills/income) • Electricity affordability gap • Electricity quality (e.g., geographic disaggregation of outage frequency/severity; restoration efficiency) • Electricity program (e.g., tax credits; energy efficiency) and technology (e.g., BTM solar and storage) accessibility and performance (e.g., participation/investment demographics; distribution of savings/costs, reliability/resilience, or other benefits/burdens) • Social burden (i.e., effort and ability to access critical services)	• Economic (e.g., job training/job quality; energy resource ownership/governance; reparation of electricity cost burden shouldered by energy burdened communities) • Environmental (e.g., natural resource replenishment; generation/storage resource siting) • Social (e.g., improvements in household-human development index; establishment of safeguard/grievance redress mechanisms)

The Need for Energy Equity Simulation Analysis

- Inclusion of ***energy equity*** within planning models is a complex process and is not yet well explored by utilities or existing literature.
- Most utilities are not likely to have sufficient data and approaches to model energy equity effects. Unclear where to stop when collecting data related to communities (education, health, medical condition).
- Purpose of laboratory analysis is to provide insights into trade-offs among emerging objectives such as equity/resiliency and traditional objectives such as affordability/efficiency etc.



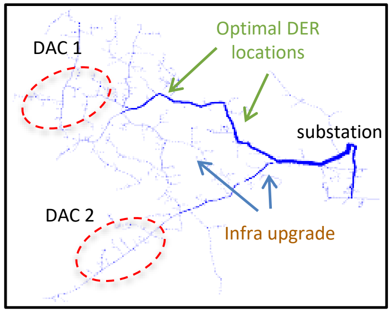
DSP Planning

Business as Usual

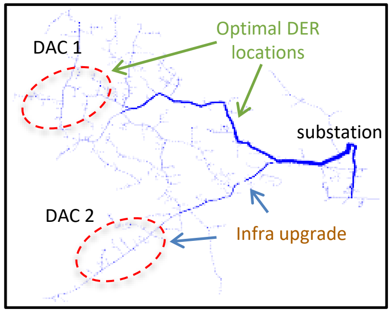
With Equity Considerations

Impact on Outcome

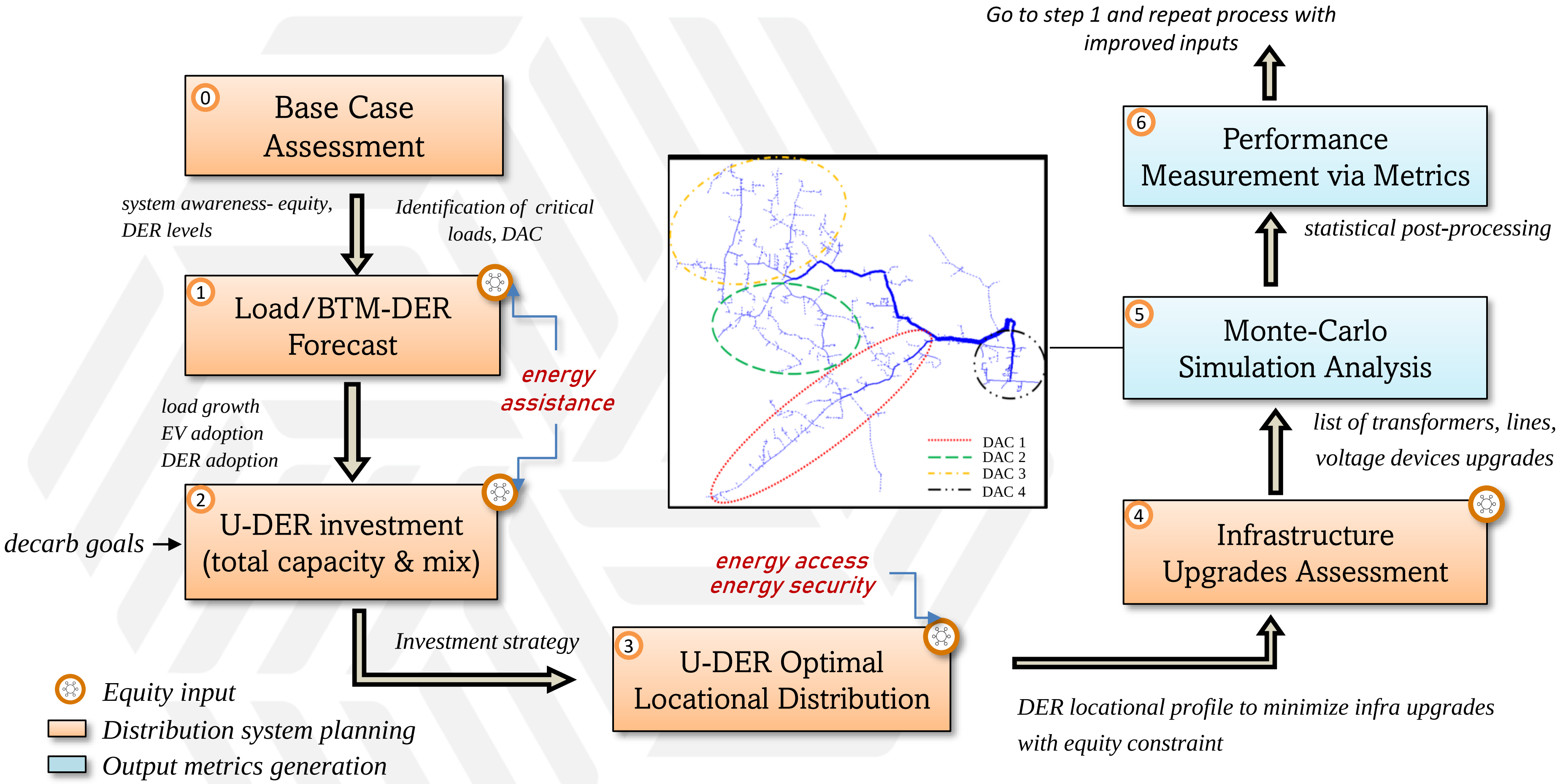
- Major focus on cost and reliability



- Potentially different investment strategy
- Insights into what part of the feeder needs to be prioritized
- Insights into how to reduce energy burden and increase resiliency of disadvantaged communities (DAC)



DSP Plan and Modeling Equity



⓪ Base Case Assessment

system awareness- equity, DER levels

Identification of critical loads, DAC

① Load/BTM-DER Forecast

energy assistance

load growth
EV adoption
DER adoption

decarb goals →

② U-DER investment (total capacity & mix)

Investment strategy

③ U-DER Optimal Locational Distribution

energy access energy security

DER locational profile to minimize infra upgrades with equity constraint

④ Infrastructure Upgrades Assessment

list of transformers, lines, voltage devices upgrades

⑤ Monte-Carlo Simulation Analysis

statistical post-processing

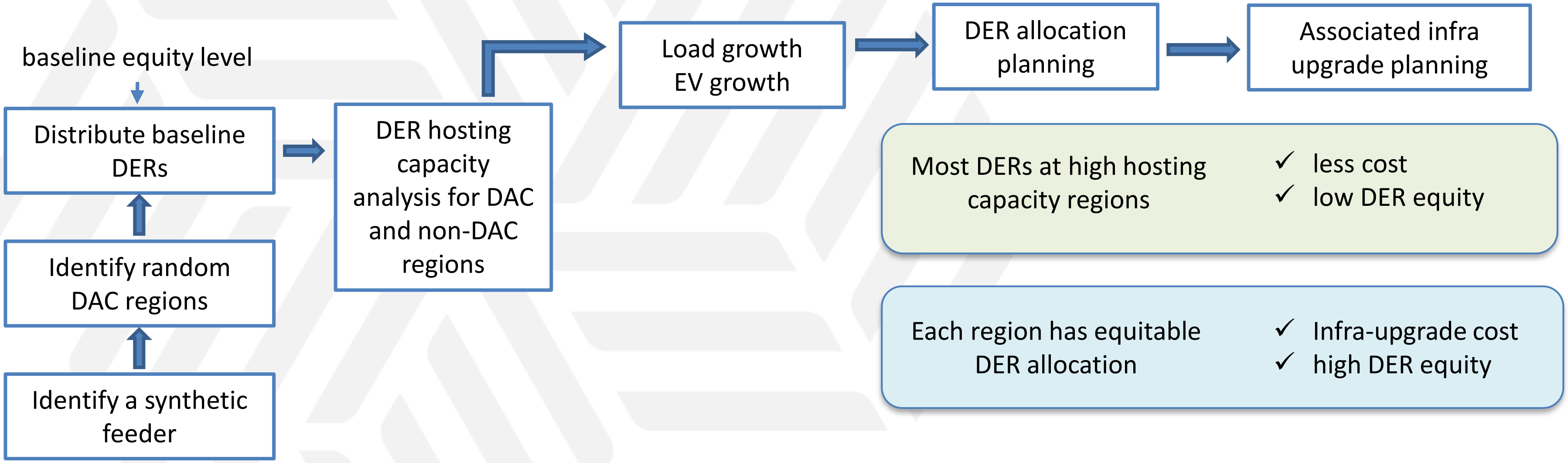
⑥ Performance Measurement via Metrics

Go to step 1 and repeat process with improved inputs

Equity input
🟧 *Distribution system planning*
🟦 *Output metrics generation*

Equity in Planning Simulation

To analyze the impact of equity considerations on DER allocation and asset upgrade planning through hosting capacity analysis



baseline equity level

Identify a synthetic feeder

Identify random DAC regions

Distribute baseline DERs

DER hosting capacity analysis for DAC and non-DAC regions

Load growth EV growth

DER allocation planning

Associated infra upgrade planning

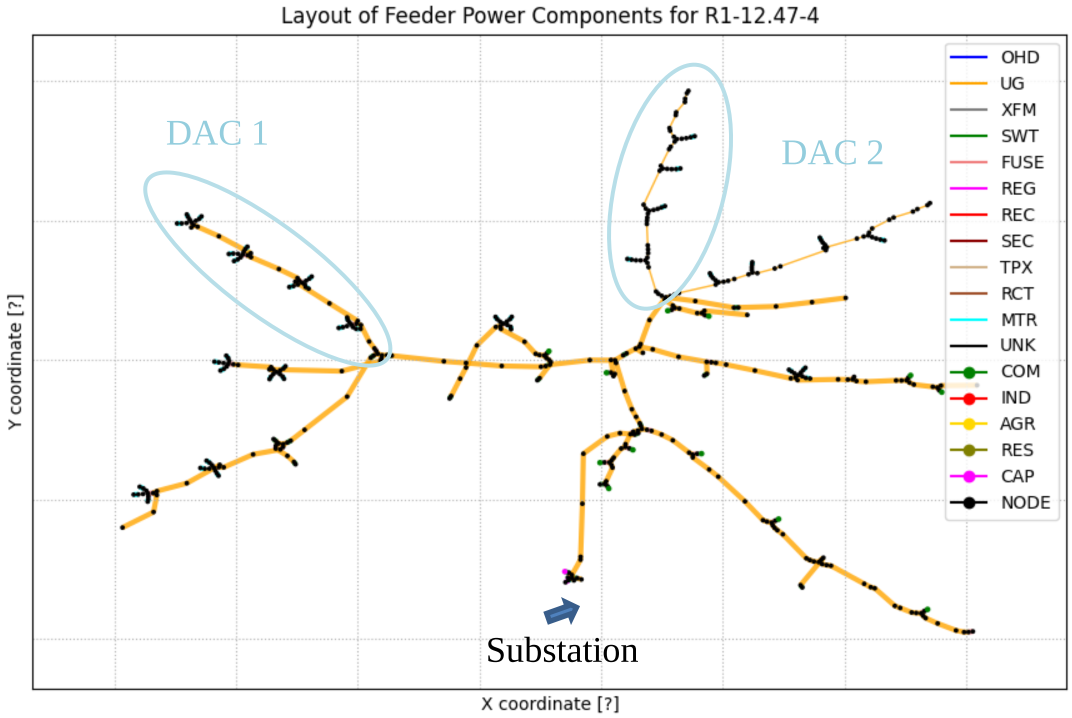
Most DERs at high hosting capacity regions

- ✓ less cost
- ✓ low DER equity

Each region has equitable DER allocation

- ✓ Infra-upgrade cost
- ✓ high DER equity

PNNL Prototype Feeder

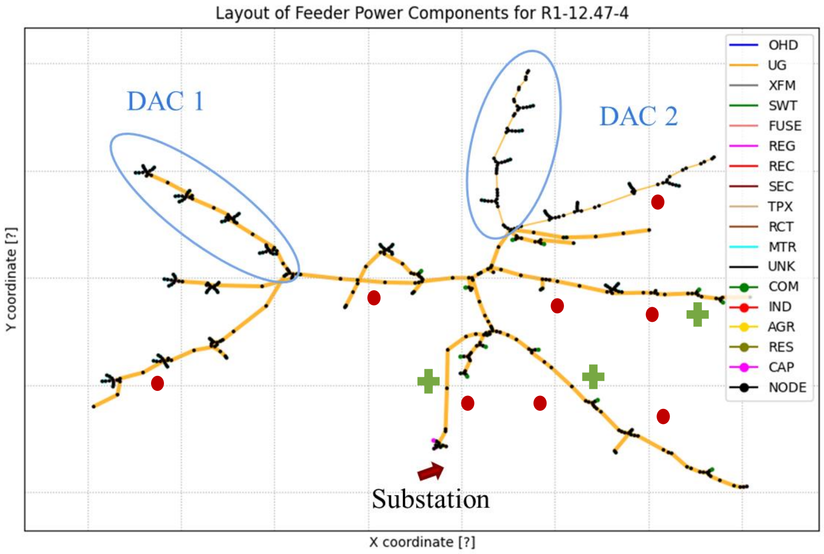


- A 300-node taxonomy feeder representing west-coast heavy sub-urban area

Service transformers	50
Residential customers	380
Commercial customers	12
Total load	5.3 MW

- Randomly identified DAC regions
  - Average DAC customer load: 1.8 kW
  - Non-DAC: 5 kW
  - DAC: 70 customers
  - Non-DAC: 310 customers

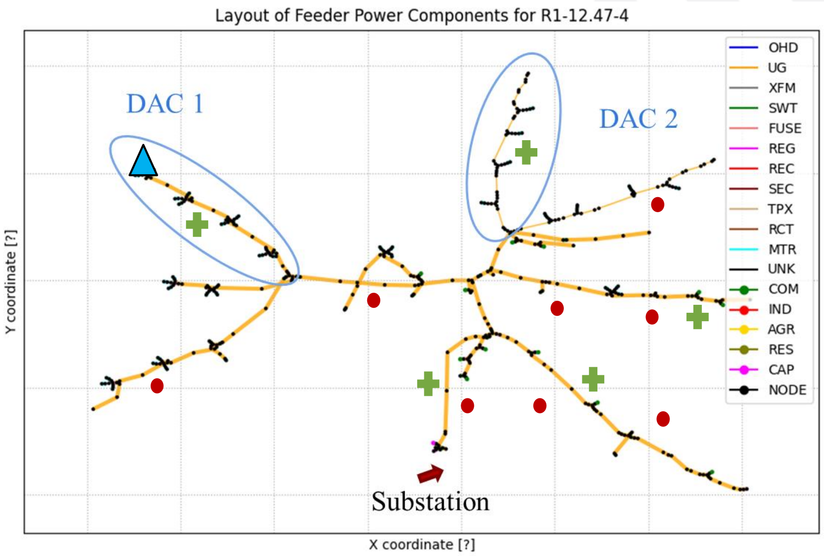
Planning: BAU



- ● Transformer and line upgrade
- ✚ Utility-level DER allocation

- Utility-level DER allocation - Most DERs should be located:
  - Closer to high EV load locations to avoid asset upgrade
  - In high hosting capacity locations without voltage violations to avoid voltage mitigation solutions
- Asset Upgrade - Transformer upgrades at locations obtained from the analysis in non-DAC region
- DAC regions are not likely to be part of asset upgrades and DER allocation in this case, making them vulnerable to resiliency events.

Planning with Equity



● Transformer and line upgrade

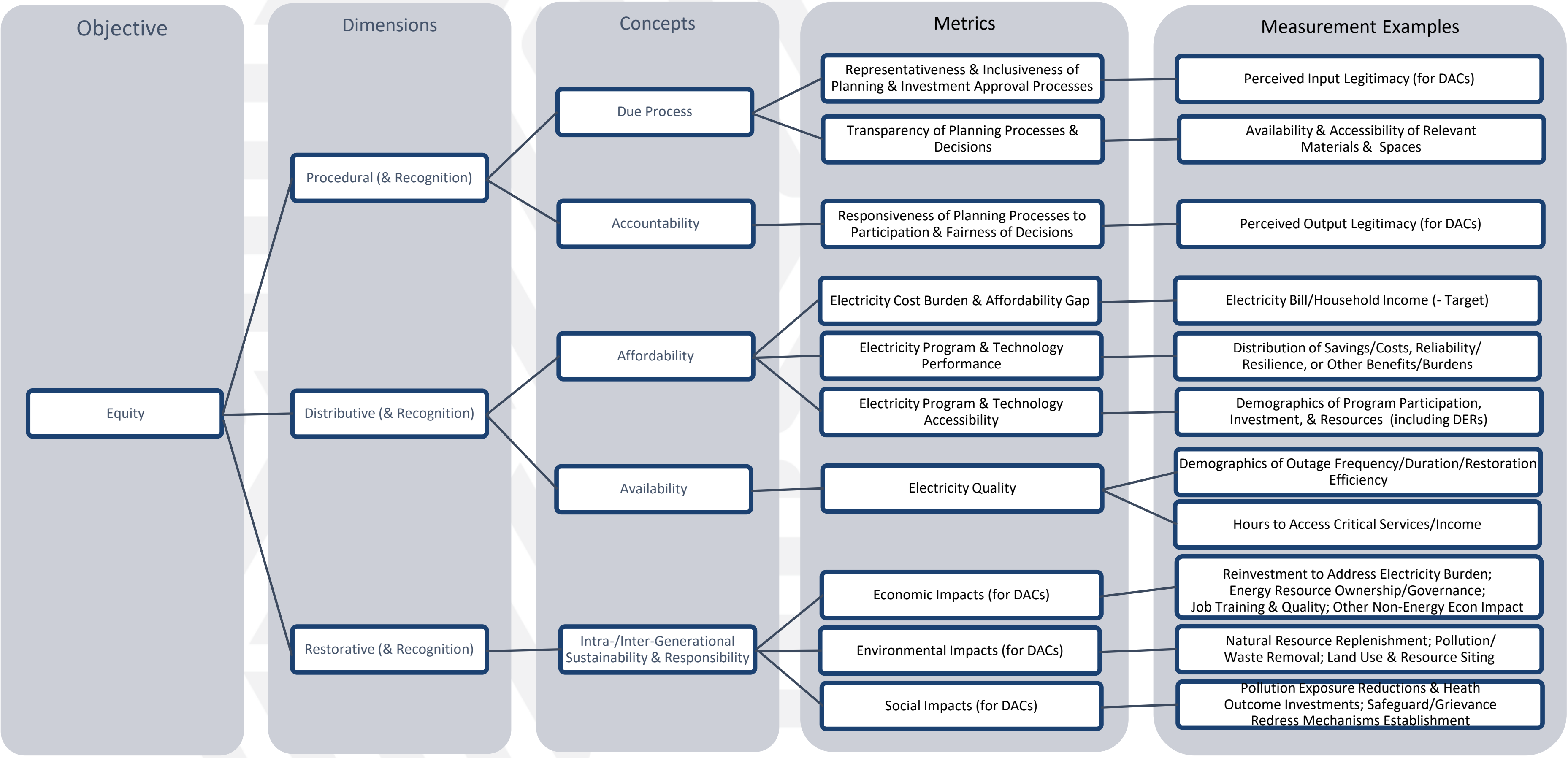
✚ Utility-level DER allocation

▲ Voltage regulator installation

- DAC regions should have equitable PV hosting capacity
  - Requires solutions such as voltage regulator installation in DAC-region
  - TODO: simulation analysis to demonstrate increased hosting capacity in DAC-1 region with voltage regulator device
  - TODO: cost analysis
- Asset upgrades in non-DAC region due to high EV load also improve resiliency of these regions compared to DAC
  - TODO: observe the impact of high EV and asset upgrades on resiliency

Equity Objective, Dimensions, Concepts, Metrics, and Measurement Approaches

GRID
MODERNIZATION
LABORATORY
CONSORTIUM
U.S. Department of Energy



Objective

Equity

Dimensions

Procedural (& Recognition)

Distributive (& Recognition)

Restorative (& Recognition)

Concepts

Due Process

Accountability

Affordability

Availability

Intra-/Inter-Generational Sustainability & Responsibility

Metrics

Representativeness & Inclusiveness of Planning & Investment Approval Processes

Transparency of Planning Processes & Decisions

Responsiveness of Planning Processes to Participation & Fairness of Decisions

Electricity Cost Burden & Affordability Gap

Electricity Program & Technology Performance

Electricity Program & Technology Accessibility

Electricity Quality

Economic Impacts (for DACs)

Environmental Impacts (for DACs)

Social Impacts (for DACs)

Measurement Examples

Perceived Input Legitimacy (for DACs)

Availability & Accessibility of Relevant Materials & Spaces

Perceived Output Legitimacy (for DACs)

Electricity Bill/Household Income (- Target)

Distribution of Savings/Costs, Reliability/ Resilience, or Other Benefits/Burdens

Demographics of Program Participation, Investment, & Resources (including DERs)

Demographics of Outage Frequency/Duration/Restoration Efficiency

Hours to Access Critical Services/Income

Reinvestment to Address Electricity Burden; Energy Resource Ownership/Governance; Job Training & Quality; Other Non-Energy Econ Impact

Natural Resource Replenishment; Pollution/ Waste Removal; Land Use & Resource Siting

Pollution Exposure Reductions & Heath Outcome Investments; Safeguard/Grievance Redress Mechanisms Establishment

Equity Metrics and Measurement Approaches

Metrics	Measurement Examples
Representativeness & Inclusiveness of Planning & Investment Approval Processes	Perceived Input Legitimacy (for DACs)
Transparency of Planning Processes & Decisions	Availability & Accessibility of Relevant Materials & Spaces
Responsiveness of Planning Processes to Participation & Fairness of Decisions	Perceived Output Legitimacy (for DACs)
Electricity Cost Burden & Affordability Gap	Electricity Bill/Household Income (- Target)
Electricity Program & Technology Performance	Distribution of Savings/Costs, Reliability/ Resilience, or Other Benefits/Burdens
Electricity Program & Technology Accessibility	Demographics of Program Participation, Investment, & Resources (including DERs)
Electricity Quality	Demographics of Outage Frequency/Duration/Restoration
	Hours to Access Critical Services/Income
Economic Impacts (for DACs)	Reinvestment to Address Electricity Burden; Energy Resource Ownership/Governance
Environmental Impacts (for DACs)	Natural Resource Replenishment; Pollution/ Waste Removal; Land Use & Resource Siting
Social Impacts (for DACs)	Pollution Exposure Reductions & Health Outcome Investments; Safeguard/Grievance Redress Mechanisms Establishment

Questions public utility commissions can ask

- How should a grid planning process handle a large, conflicting, and variable amount of social information? Once I start, where do I stop?
- How do modeling strategies vary between planning processes? For example, how does a transmission planning process use highly local information?
- What are the tradeoffs between resilience and equity? Shouldn’t some of those objectives be standard requirements, like cost and reliability?
- What are some of the most innovative practices from utilities and commissions in energy equity and resilience?
- What about technology mandates, such as legislative requirements for energy storage solutions?
- What are some of the ways that business models can affect whether a set of solutions shows up in grid performance metrics as more or less resilient or equitable?

Resources for more information

- **Energy Storage as an Equity Asset. *Current Sustainable Renewable Energy Reports* 8, 149–155 (2021).** https://doi.org/10.1007/s40518-021-00184-6
- **Review of Energy Equity Metrics, 2021.** https://www.pnnl.gov/sites/default/files/media/file/Metrics%20for%20Energy%20Equity_0.pdf
- **Multi-Objective Grid Planning** https://energy.sandia.gov/programs/electric-grid/mod-plan
- **Energy Equity Publications** https://www.pnnl.gov/projects/energy-equity/publications, (ex: Community Energy Storage and Energy Equity, FERC Public Participation Workshop, Business Models for Decommissioning)
- **Advancing Equity in Utility Regulation, 2021.** https://emp.lbl.gov/publications/advancing-equity-utility-regulation

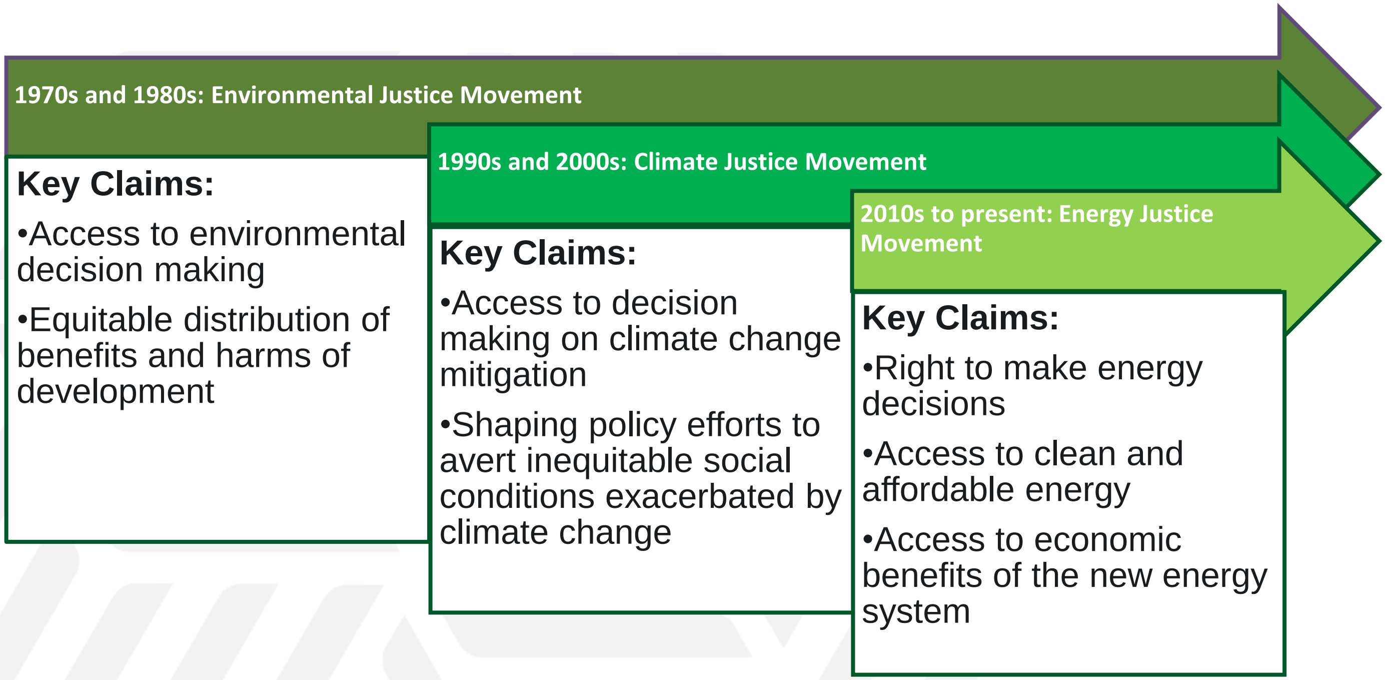
Contact

Rebecca O’Neil
Advisor, Electricity Infrastructure
Pacific Northwest National Laboratory
971/940-7098
Rebecca.ONeil@pnnl.gov

Brian Pierre, PhD
Electric Power Systems Research Department
Sandia National Laboratories
bjpierr@sandia.gov

BACKUP

Movements of Environmental, Climate, and Energy Justice



1970s and 1980s: Environmental Justice Movement

Key Claims:

- Access to environmental decision making
- Equitable distribution of benefits and harms of development

1990s and 2000s: Climate Justice Movement

Key Claims:

- Access to decision making on climate change mitigation
- Shaping policy efforts to avert inequitable social conditions exacerbated by climate change

2010s to present: Energy Justice Movement

Key Claims:

- Right to make energy decisions
- Access to clean and affordable energy
- Access to economic benefits of the new energy system

Energy justice refers to the goal of achieving **equity** in both the **social** and **economic** participation in the energy system, while also **remediating** social, economic, and health **burdens** on those historically harmed by the energy system (“frontline communities”). Energy justice explicitly centers the concerns of marginalized communities and aims to make energy more accessible, affordable, and clean and democratically managed for all communities.

https://iejusa.org/section-1-defining-energy-justice/

Dimensions and Approaches of Energy Justice

Distributive Justice: Where?

- Addressing the unequal allocation of benefits and burdens and unequal distribution of the consequences
- Increasing affordability and availability

Procedural Justice: How?

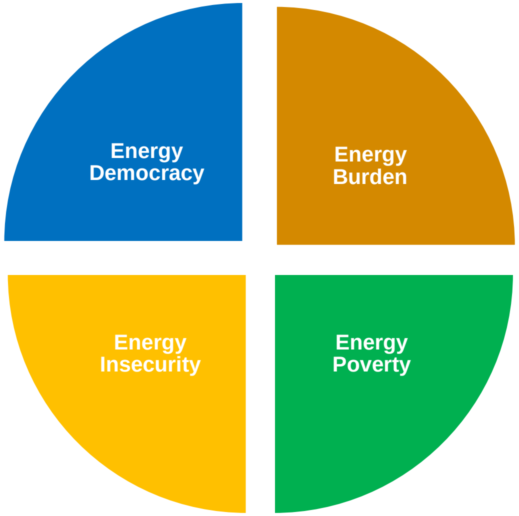
- The fairness of the decision-making process
- Allowing for due process, transparency, and accountability

Recognition Justice: Who?

- Addressing the practice of cultural domination, disregard of people and their concerns, and misrecognition

Restorative Justice

- The response to those impacted by the burdens of energy projects
- Addressing intra- and inter-generational inequities
- Creating sustainability
- Establishing responsibility



Energy Democracy

Energy Burden

Energy Insecurity

Energy Poverty

https://iejusa.org/section-1-defining-energy-justice/

Performance Metrics

► Energy Burden	*Equity*
► Energy Vulnerability to Outages	*Resiliency, Equity*
► Access to black-start DERs	*Resiliency, Equity*
► Loss of load (SAIFI/SAIDI)	*Reliability, Equity*
► Energy Served from DERs	*Decarb, Equity*
► Cost of Assets Upgrade	*Cost, Equity*
► Impact on Energy Consumption due to Energy Assistance Program	*Efficiency, Equity*

Example Metrics	
Energy Burden	$\frac{Annual\ utility\ bills}{Annual\ household\ income}$
SAIFI	$\frac{Total\ \#\ of\ customers\ interrupted}{Total\ \#\ of\ customers\ served}$
E3B Investment*	$\%\ of\ low\ income\ population\ \times$ $Total\ residential\ EE\ investment\ (\$)$

*Energy Efficiency Equity Baseline (E3B)

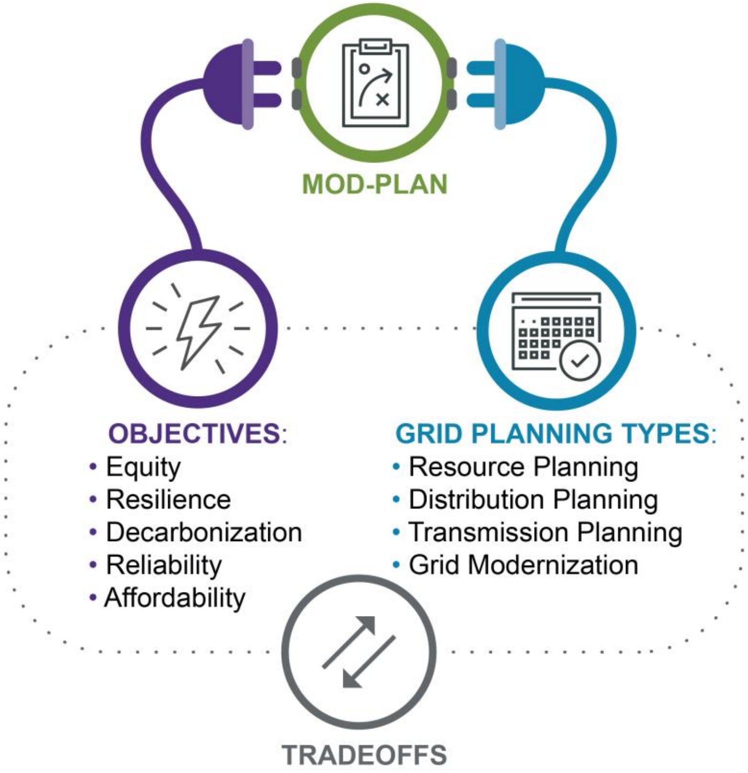
Stakeholder Roles for Resilience Planning within IDP

	Set Planning Goals and Define Metrics and Targets	Forecast Load and DER Adoption, EVs, and Scenarios	Baseline Analysis and Identify Critical Gaps	Systems Analysis to Design Alternative Portfolios to Fill Gaps	Evaluate Tradeoffs and Prioritize Solutions	Implement and Track Performance
Utility	Identify current requirements and foundational needs	Localized threat forecasts, customer and grid vulnerability analysis	Calculate baseline consequence with defined metrics	Identify DER-inclusive resilience investment alternatives	Evaluate improvement in resilience metrics for each alternative	Execute distribution investment plan across asset categories
PUC	Convene stakeholders. Resilience goals, metrics, screening requirements, targets	Define forecasting requirements	Identify resilience gaps versus targets using defined metrics	Ensure candidate alternatives meet screening requirements	Ensure preferred alternative meets resilience goals, and are feasible and equitable	
Other Stakeholders	*DOE:* Work across industry to collect data, standardize resilience metrics, and support goal-setting	*FEMA Regional Offices:* Regional threat forecast and multi-infrastructure vulnerability analysis	*Local Govts:* Provide weighting of human services for social burden, provide economic i-o model	*Local Govts:* Identify and connect initiatives and stakeholders	*Local Govts:* Integrate improved grid resilience into local resilience plan, identify public investments	

MOD-Plan: Multi-Objective Decision Making

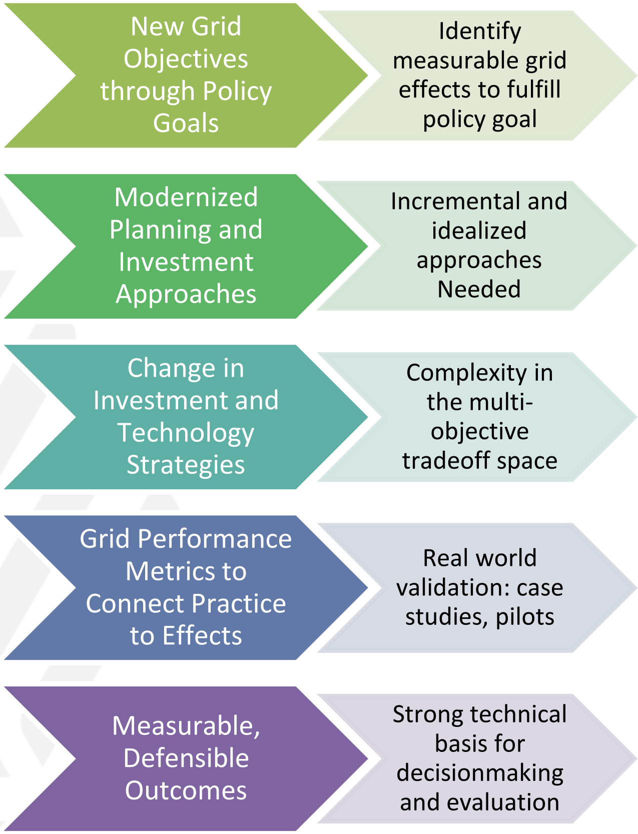
Funded by the Office of Electricity

- **Planning frameworks with stakeholder roles.** Develop a framework that applies multiple emerging objectives in electric grid planning processes with stakeholder roles throughout.
- **Emerging objectives and trade-offs.** Advance innovative and practical methods for formulating planning objectives for decarbonization, resilience, and energy equity to indicate trade-offs.
- **Metrics for success.** Develop and report on metrics that can measure the performance of the grid with respect to these emerging objectives.



MOD-Plan Strategic Purpose

- Identify measurable effects to underserved communities, connected to operational change that can occur within a grid planning and investment context.
- Incremental and idealized approaches needed: address low-data-quality/simpler distribution system plans as well as integrated planning paradigms.
- Complexity in the multi-objective tradeoffs space: where laboratory contribution and insights can be strong
- Case studies, pilots, and other external partnerships for validation will be material to project outcomes



New Grid Objectives through Policy Goals

Identify measurable grid effects to fulfill policy goal

Modernized Planning and Investment Approaches

Incremental and idealized approaches Needed

Change in Investment and Technology Strategies

Complexity in the multi-objective tradeoff space

Grid Performance Metrics to Connect Practice to Effects

Real world validation: case studies, pilots

Measurable, Defensible Outcomes

Strong technical basis for decisionmaking and evaluation

Creating Transparent Process with Stakeholders

Identify Stakeholders

- Community members
- Disadvantaged Communities
- National Agencies
- Regional Agencies
- State Agencies
- Local Agencies
- Policy Makers
- Regulators
- Utilities
- Industry Experts

Roles & Responsibilities

- Meet with stakeholders to:
  - Define roles for each stakeholder
  - Identify responsibilities for stakeholders in relation to timing in IDSP process

Iterative Feedback Process

- Incorporate stakeholder feedback in creation of iterative process
- Include policy and regulation schedules
- Address accessibility of community members in feedback process (ex: transportation, technology, language, etc.)
- Incorporate feedback into policies

Implementation into Planning Objectives & Criteria

- Transparency and communication of the following:
  - Final policies and regulations
  - Planning Objectives and timing of implementation
  - Criteria, metrics, and reporting
  - Performance and feedback to stakeholders

Emerging Trends in Utility Cost Allocation

Dan Boff

Pacific Northwest National Laboratory

Training Webinars on Electricity System Planning
for New England Conference of Public Utilities Commissioners
May 19, 2022

This presentation was funded by the U.S. Department of Energy's
Grid Modernization Laboratory Consortium.

Agenda

- Traditional cost allocation methods
- A changing landscape
- Time-based cost allocation
- Multi-use assets
- Electric vehicle (EV) charging
- Summary and key takeaways

What is cost allocation and why is it important?

- Cost allocation studies determine which customers are responsible for certain costs associated with operating the electricity system.
- The objective of cost allocation is to ensure that costs are allocated fairly and equitably.
  - Attribute costs to customers based on how utility costs are incurred or who benefits from the investment
- It is one part of the utility regulatory process.
  - It typically occurs after a cost-of-service study, which determines the utility's revenue requirement, and
  - Before a rate design study, which determines what and how customers will be charged.
- Together these studies ensure that customers are charged fairly, and utilities receive enough revenue to reliably operate the system.

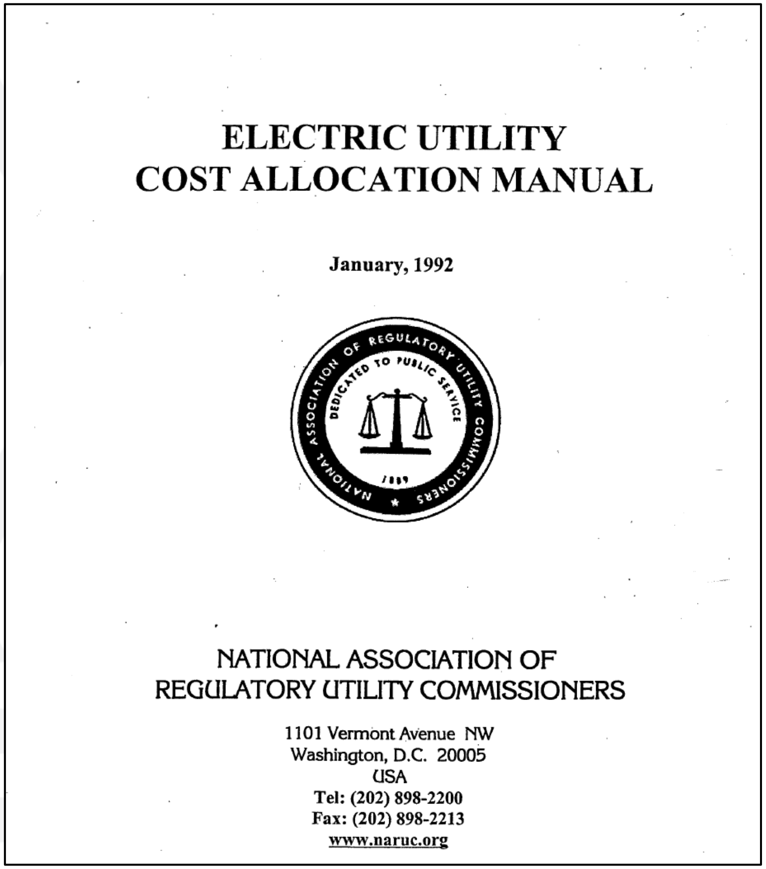
Cost of service study

Cost allocation study

Rate design study

Traditional methods of cost allocation

- The traditional cost allocation process is outlined in NARUC’s Electric Utility Cost Allocation Manual (1992), which instructs utilities to:
  1. Decide on an embedded or marginal cost allocation process
  2. Assign costs to different utility functions (e.g., generation, transmission, distribution, administrative)
  3. Classify costs based on the rate structure (i.e., as a unit of energy, demand, or customer)
  4. Allocate costs to customer classes



ELECTRIC UTILITY
COST ALLOCATION MANUAL

January, 1992

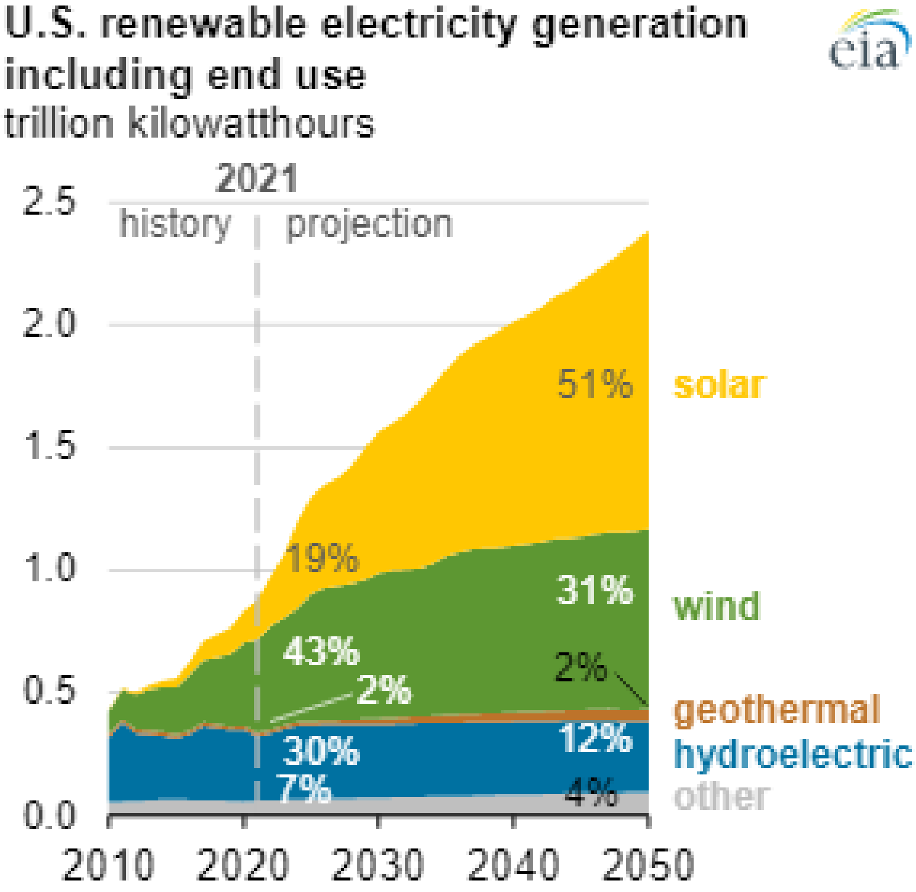
1889

NATIONAL ASSOCIATION OF
REGULATORY UTILITY COMMISSIONERS

1101 Vermont Avenue NW
Washington, D.C. 20005
USA
Tel: (202) 898-2200
Fax: (202) 898-2213
www.naruc.org

Changes in technology and regulation necessitate a change in cost allocation process

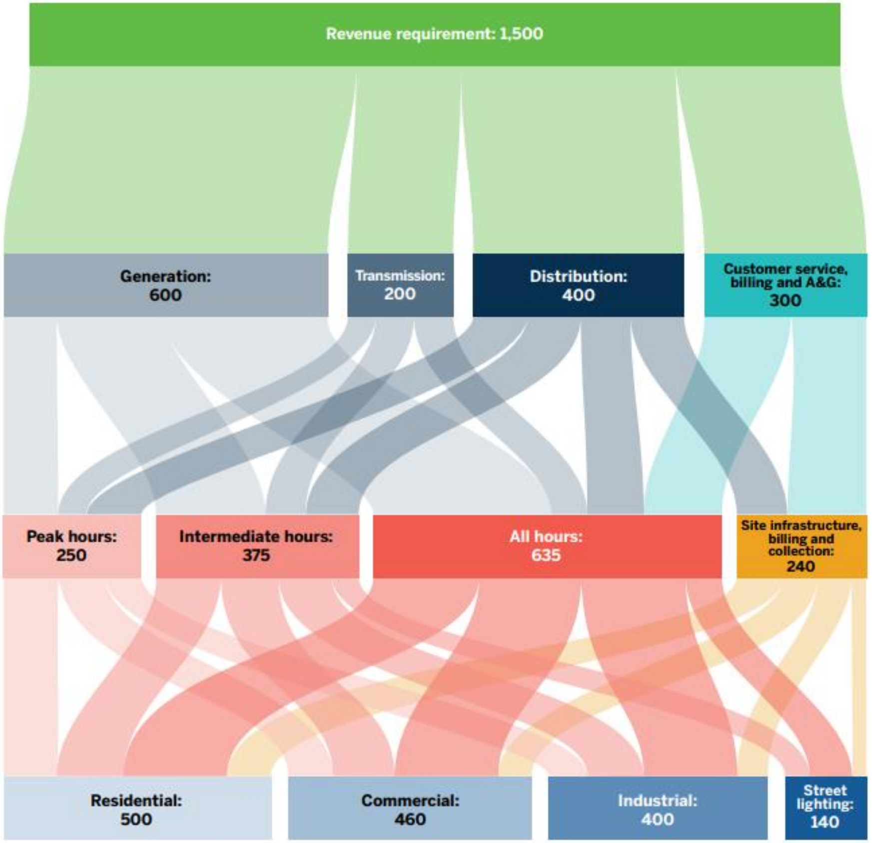
- Growth in renewables is changing how the grid is operating.
- Smart meters and distributed energy resources (DERs) provide for greater customer control and insights.
- Regulatory principles like performance-based regulation change how utilities are compensated.
- Energy storage has emerged as a flexible resource that can be used as a generating, transmission, or distribution asset.



Source: EIA, 2022

Hourly allocation

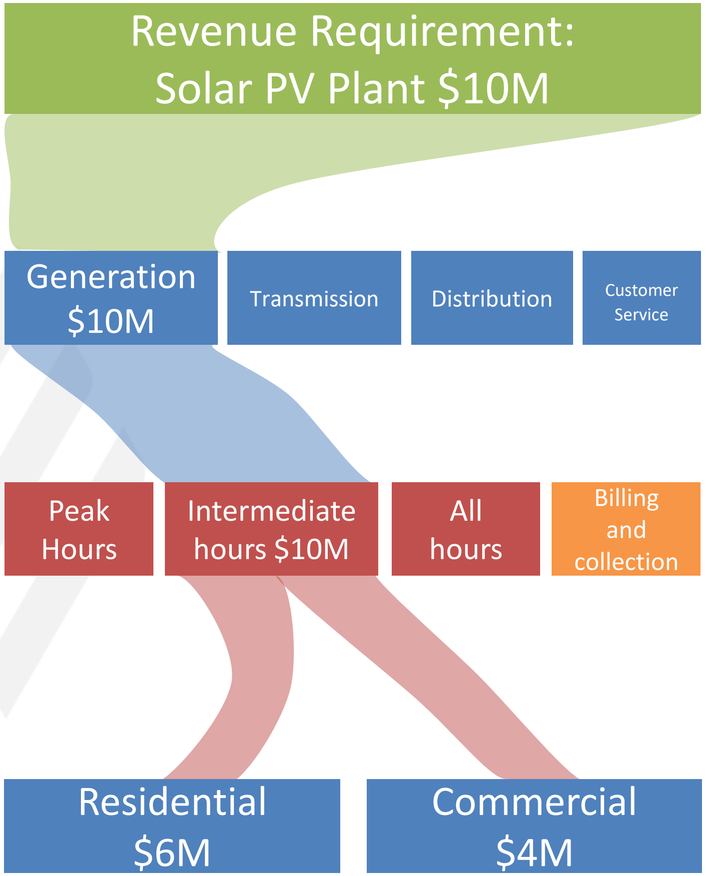
- In 2020, the Regulatory Assistance Project (RAP) published a guide to update analytical techniques for cost allocation.
- The key innovation is a focus on time assignment instead of a functional assignment.
  - Costs are assigned to operating periods where they are "used and useful."
- This helps align costs with peak usage and is more tailored to assets that serve multiple functions.
- Utility regulators should embrace a flexible approach for allocating costs.



Source: RAP, 2020

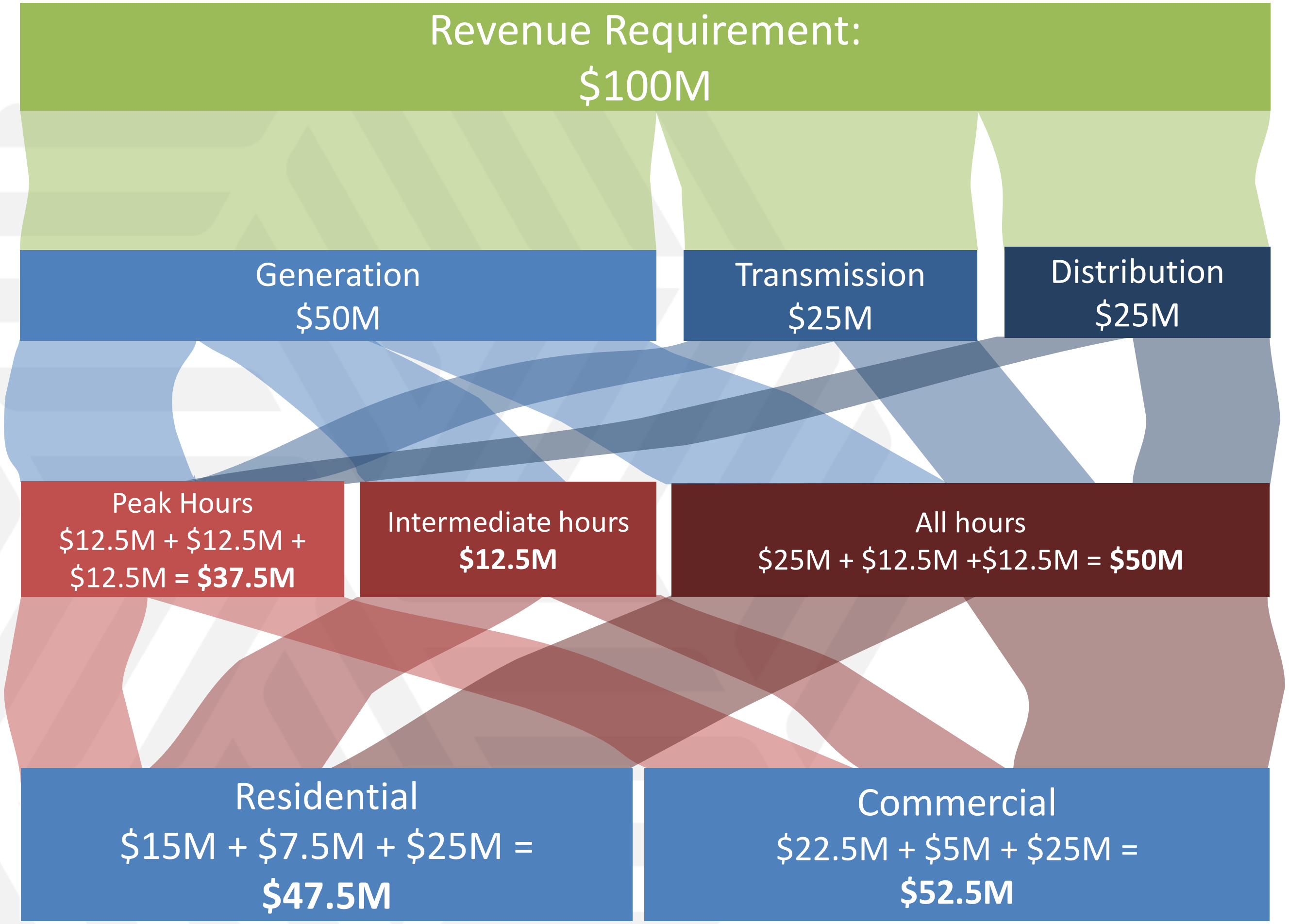
A simple example

- Consider a simplified use case with one generating asset and two customer classes.
  - Determine load requirements for customers
    - In this case, residential use accounts for 60% of intermediate hours and commercial use accounts for 40%.
  - Determine revenue requirement
    - In this case, one solar plant with $10 million in purchased power
  - Trace use of the plant through the allocation process
    - In this case, it's a generating asset, focused on intermediate hours
  - Allocate usage to each customer class



Adapted from: RAP, 2020

A more realistic example



Revenue Requirement:
$100M

Generation
$50M

Transmission
$25M

Distribution
$25M

Peak Hours
$12.5M + $12.5M + $12.5M = **$37.5M**

Intermediate hours
$12.5M

All hours
$25M + $12.5M +$12.5M = **$50M**

Residential
$15M + $7.5M + $25M = **$47.5M**

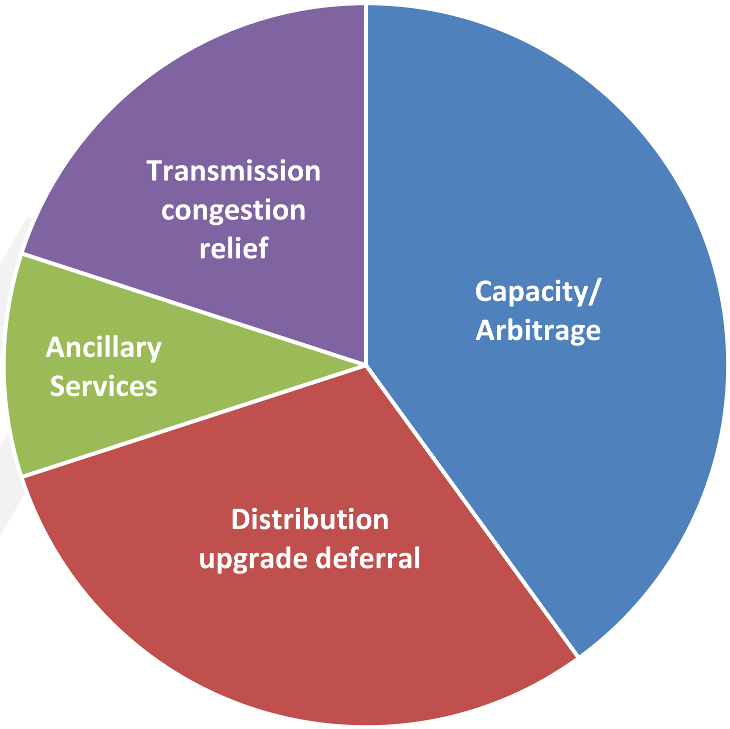
Commercial
$22.5M + $5M + $25M = **$52.5M**

Adapted from: RAP, 2020

Energy storage and other multiuse assets

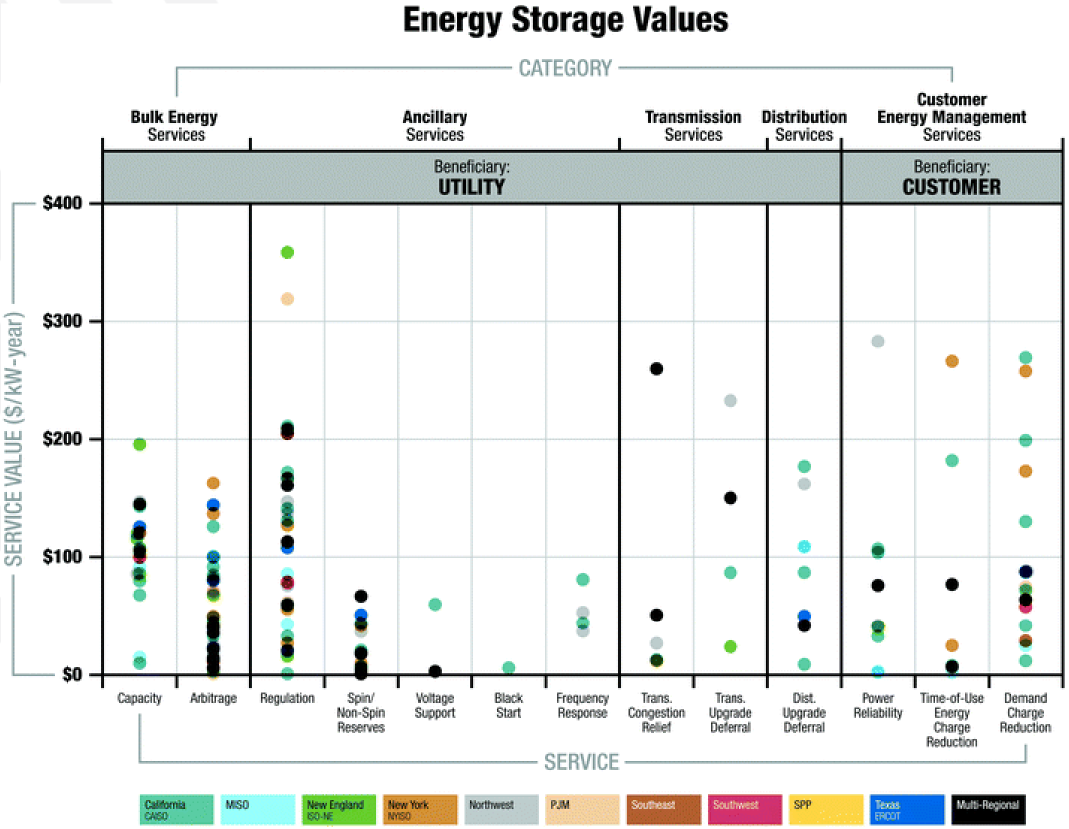
- Energy storage is more complicated to fit into a traditional allocation framework.
  - Can be energy related, demand related, or customer related depending on siting and use
- Regardless of approach, cost allocation should be dependent on how the asset will be used and who benefits from the asset.
  - Allocate multi-use assets proportionally.
  - Document the predicted uses of the asset as well as potential high value, low frequency uses of the project.
  - These uses are often more easily allocated in time of use frameworks than traditional methods.

Use of Energy Storage Asset



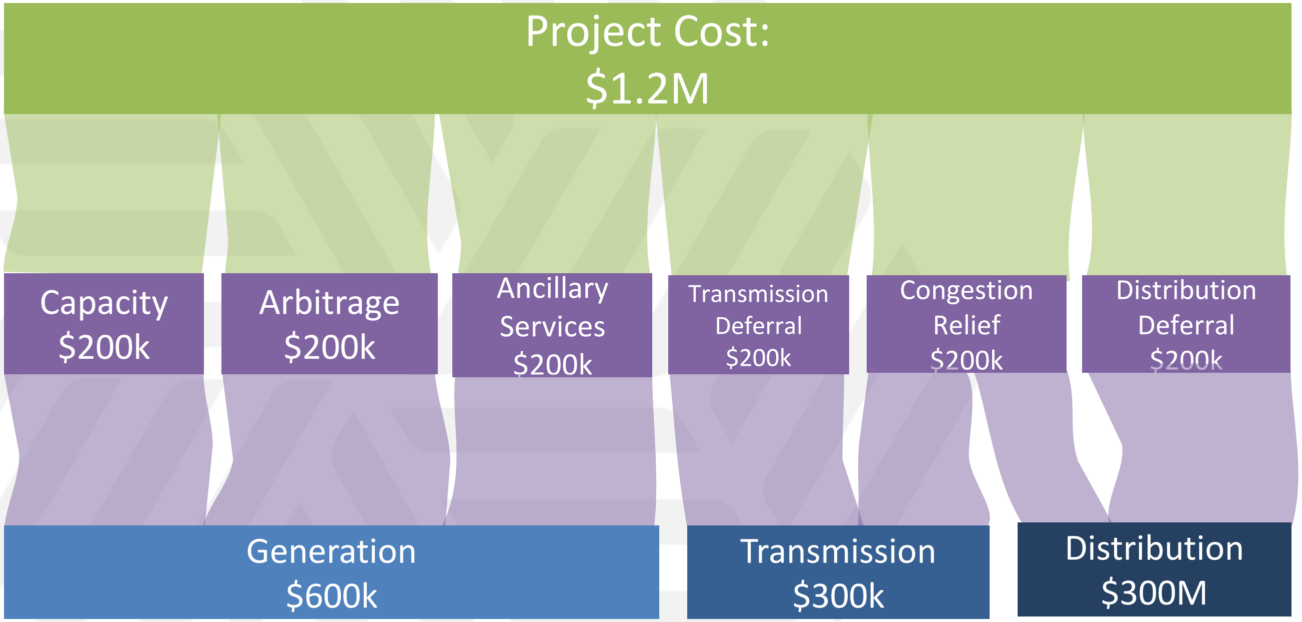
Value stacking for energy storage

- ► Value stacking exercises can help functionalize and trace the benefits of energy storage assets.
- ► PNNL provides examples and taxonomies for defining energy storage value.
- ► Analysts should consider all potential benefits (even those that may be unfamiliar) when allocating energy storage costs.



Source: Balducci, et al. 2018

From services to cost allocation



Project Cost:
$1.2M

Capacity
$200k

Arbitrage
$200k

Ancillary Services
$200k

Transmission Deferral
$200k

Congestion Relief
$200k

Distribution Deferral
$200k

Generation
$600k

Transmission
$300k

Distribution
$300M

Adapted from: RAP, 2020

EV users as a separate asset class

Home charging

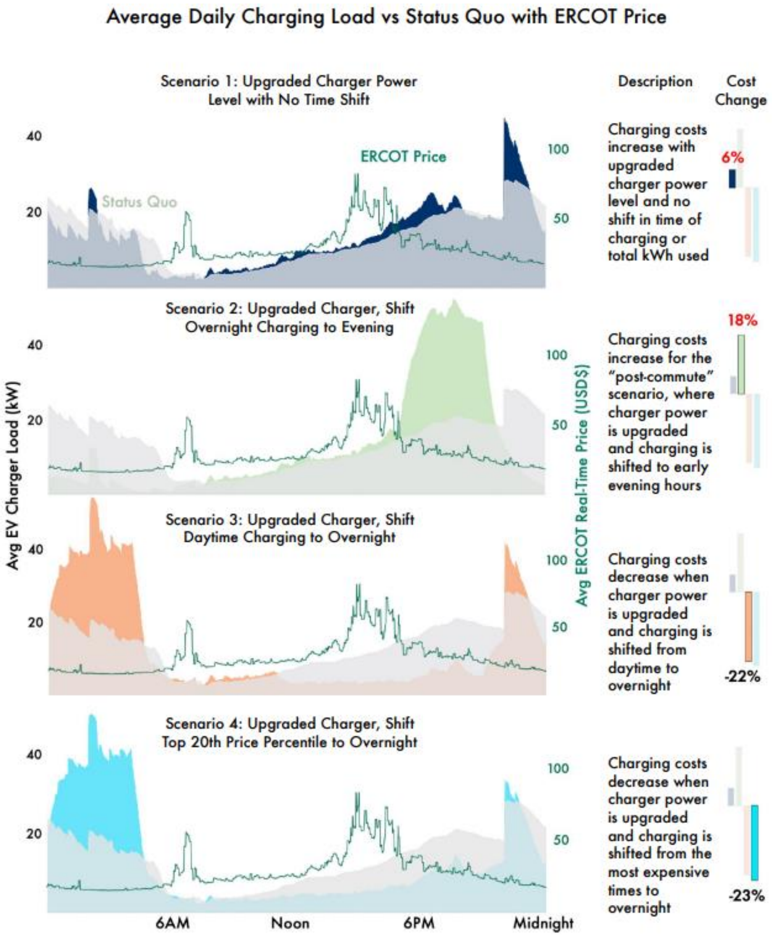
- ► Demand in line with other household appliances
- ► Load can be spread out over a broad period of time.
- ► Benefits and costs incurred by a residential user

Public charging

- ► Demand can be very high and sustained or variable.
- ► Load is less likely to be spread out or controllable.
- ► Costs are usually incurred by a commercial entity but benefit the commercial customer and EV end users.

Cost allocation and cost recovery for EVs

- Rate design is likely a better avenue to ensure equity from home charging.
  - EV chargers use less power than an electric water heater, and slightly more than an air conditioner (DOE, 2017).
  - Managed charging and time-based pricing have been effective in managing these impacts (SEPA, 2019).
- Public fast chargers are less straightforward.
  - Fast chargers sited with commercial and industrial customers on demand charges may not be substantially different than other commercial loads.
  - Dedicated public charging stations could warrant the creation of a separate customer class.


Average Daily Charging Load vs Status Quo with ERCOT Price

Description	Cost Change
Charging costs increase with upgraded charger power level and no shift in time of charging or total kWh used	6%
Charging costs increase for the "post-commute" scenario, where charger power is upgraded and charging is shifted to early evening hours	18%
Charging costs decrease when charger power is upgraded and charging is shifted from daytime to overnight	-22%
Charging costs decrease when charger power is upgraded and charging is shifted from the most expensive times to overnight	-23%

Source: Pecan Street, 2021

Questions public utility commissions can ask

- Are you allocating costs based on causes or benefits? Is there a large difference between the two?
- Is it still worthwhile to allocate costs by demand and energy, or is a new approach warranted?
- Is a proposed new rate class large and distinct, or does the creation of a new class only impact a few customers?
- What objectives can be accomplished through the cost allocation process? Which objectives are better left for the ratemaking or system planning processes?
- Are you using smart meter data to understand customer load patterns and attribute causation and benefits?

Summary and key takeaways

- Cost allocation is subjective. There is not a single correct way to conduct the analysis.
- Consider comparing multiple frameworks and seeing if results are similar.
- Modern utility assets may be easier to allocate under a time-based framework, rather than a usage-based framework.
- For assets that have multiple use cases, allocate costs proportionally to causation or benefits.
- Be careful if creating new rate classes. Ensure that they are large and distinct.
- For EV charging, consider differences between commercial charging, public fast charging and home charging.
- Note that issues can also be addressed in the cost-of-service process and ratemaking process. Cost allocation does not have to solve every issue.
- Equity is a critical component of cost allocation, but it can also be addressed in other parts of the ratemaking process.

Resources for more information

- Balducci, Patrick J., M. Jan E. Alam, Trevor D. Hardy, and Di Wu. 2018. "Assigning Value to Energy Storage Systems at Multiple Points in an Electrical Grid." *Energy & Environmental Science* 11 (8)
- Balducci, Patrick, Jan Alam, Tom McDermott, Vanshika Fotedar, Xu Ma, Di Wu, Bilal Bhatti, et al. 2019. "Nantucket Island Energy Storage System Assessment." Pacific Northwest National Laboratory.
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Contact

Thank you!

Dan Boff

Economist

Pacific Northwest National Laboratory

Daniel.Boff@PNNL.gov