U.S. DEPARTMENT OF ENERGY
Office of Electricity

DSPx: Planning for Resilient Modern Grid

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NARUC-NASEO Webinar

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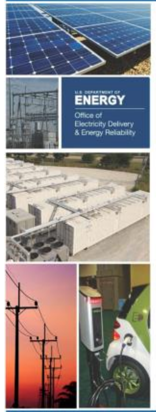
Background

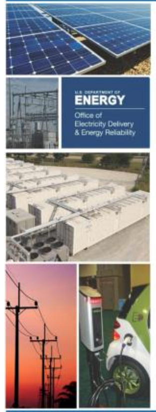
- The Next Generation of Distribution System Platform (DSPx) project was initiated in 2016 to produce reference materials to facilitate development of grid modernization strategies and implementation plans and their evaluation in any US regulatory jurisdiction or utility.
- The Modern Distribution Grid Reports, Volumes I-III, were released in 2017, and have been used in over 20 states/territories by commissions and/or utilities as well as EPRI and leading consulting firms.
- The DSPx Phase 2 updated Volumes I & II to simplify the taxonomy and created a new volume (Volume IV) to update the decision process in Vol III and expand upon the planning and cost-effectiveness frameworks based on feedback from users.

Modern Grid Report Structure



Summary & Users Guide

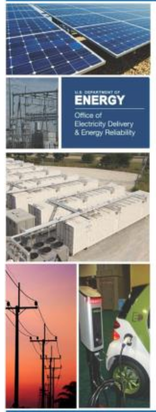
In Development by RAP



Strategy & Planning Guidebook

v.1.0

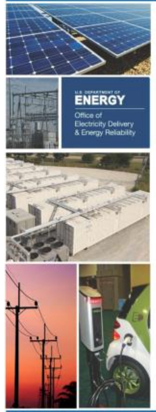
- **Strategic & Implementation Planning framework**
- **IDP Planning summary**
- **Strategic Planning Steps**
- **Grid Architecture & Architectural Strategies**
- **Implementation Planning Steps**
- **Cost-effectiveness framework**



Volume 1:
DSPx Taxonomy

v.2.0

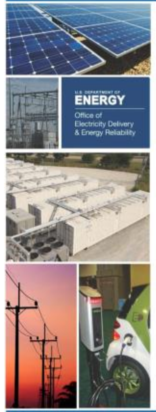
- **Overview of DSPx methodology**
- **Taxonomy Details & Maps**



Volume 2:
Technologies

v.2.0

- **Function-Technology Maps**
- **Technology Definitions & Maturity**
- **Technology Gap Identification**



Volume 3:
Strategic Planning

v.1.0

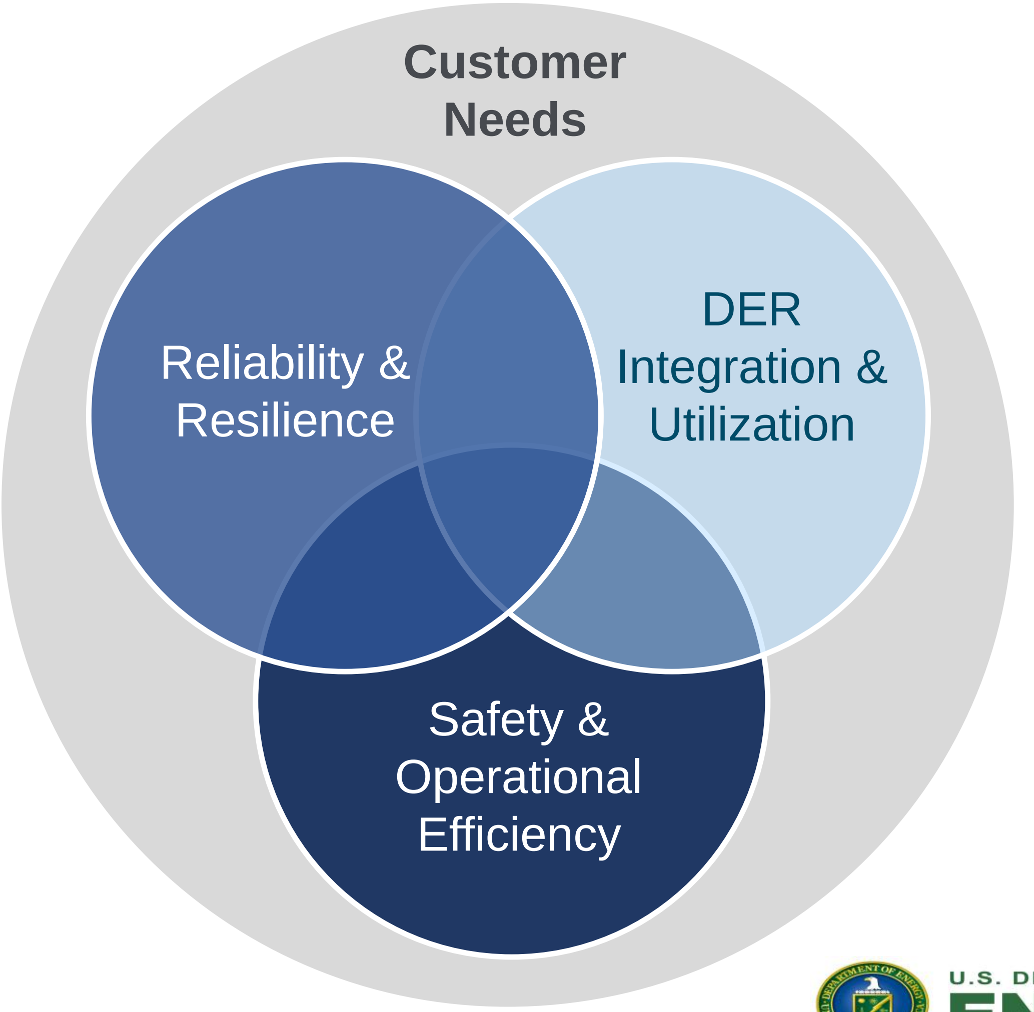
- **Strategic & Implementation Planning framework***
- **Grid Architecture & Architectural Strategies**
- **Implementation Considerations**
- **Cost-effectiveness Framework***

*Updated in Guidebook

Grid Modernization
Strategy & Planning Guidebook

Scope of Distribution Grid Modernization

"Grid Modernization" has different definitions & scope across the U.S.
Most include various aspects of these three areas to meet customer needs



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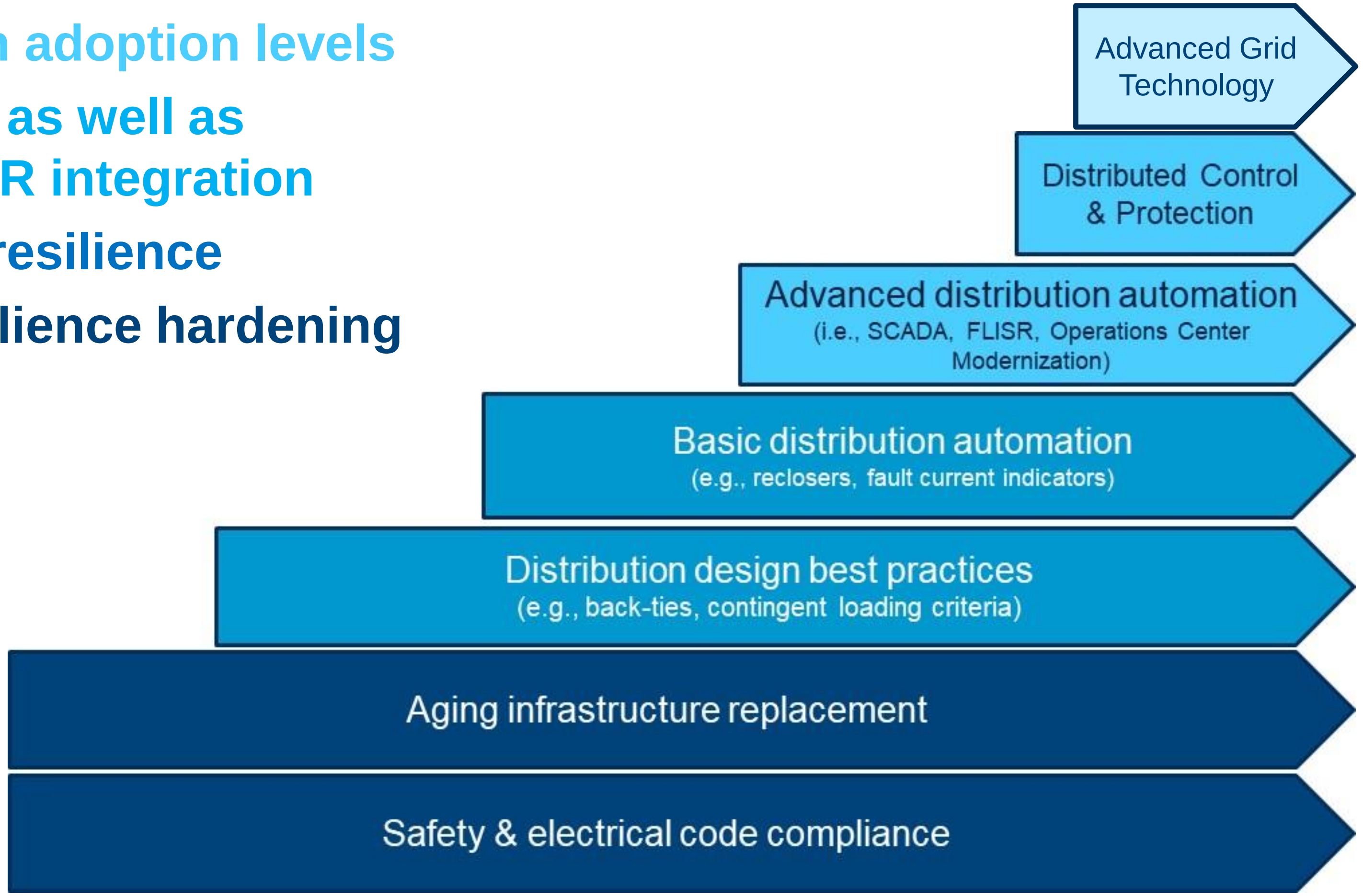
Distribution Investment Objectives & Categories

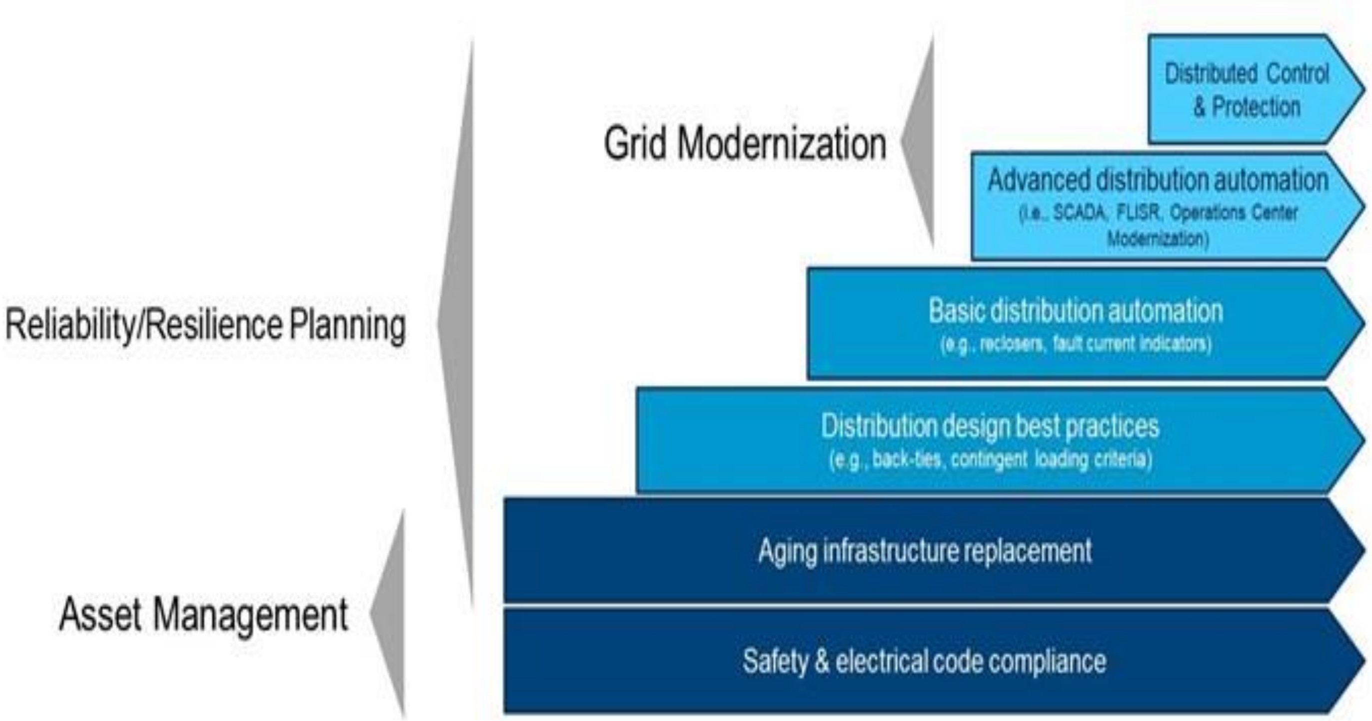
Typical investment objectives:

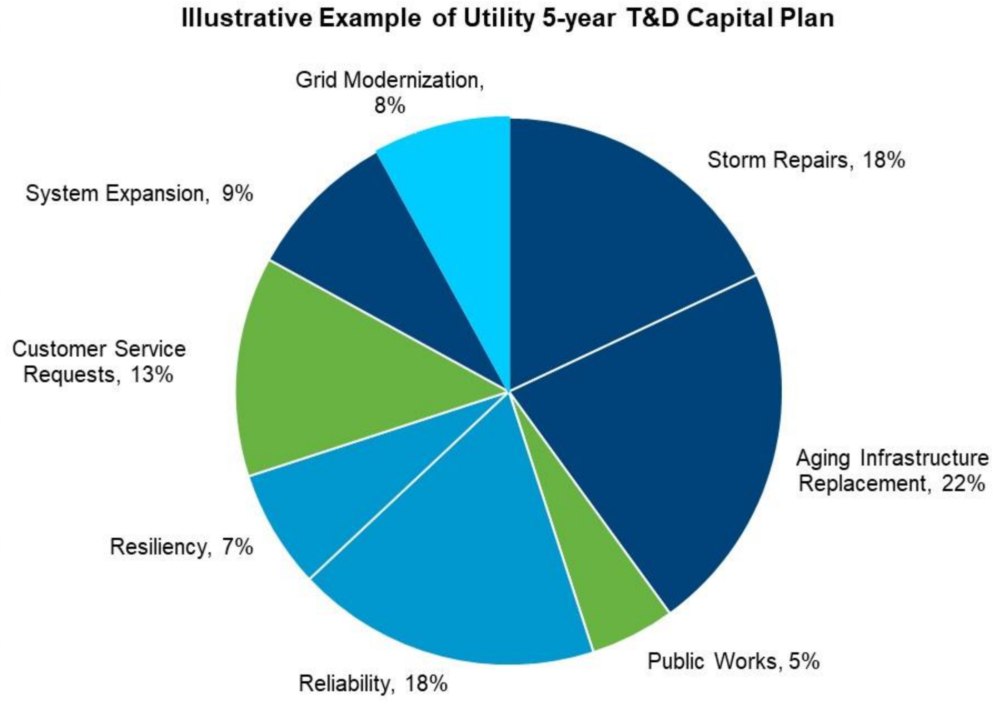
- Enable DER utilization and high adoption levels
- Enhance reliability & resilience as well as foundational investment for DER integration
- Improve customer reliability & resilience
- Basic safety, reliability and resilience hardening requirements



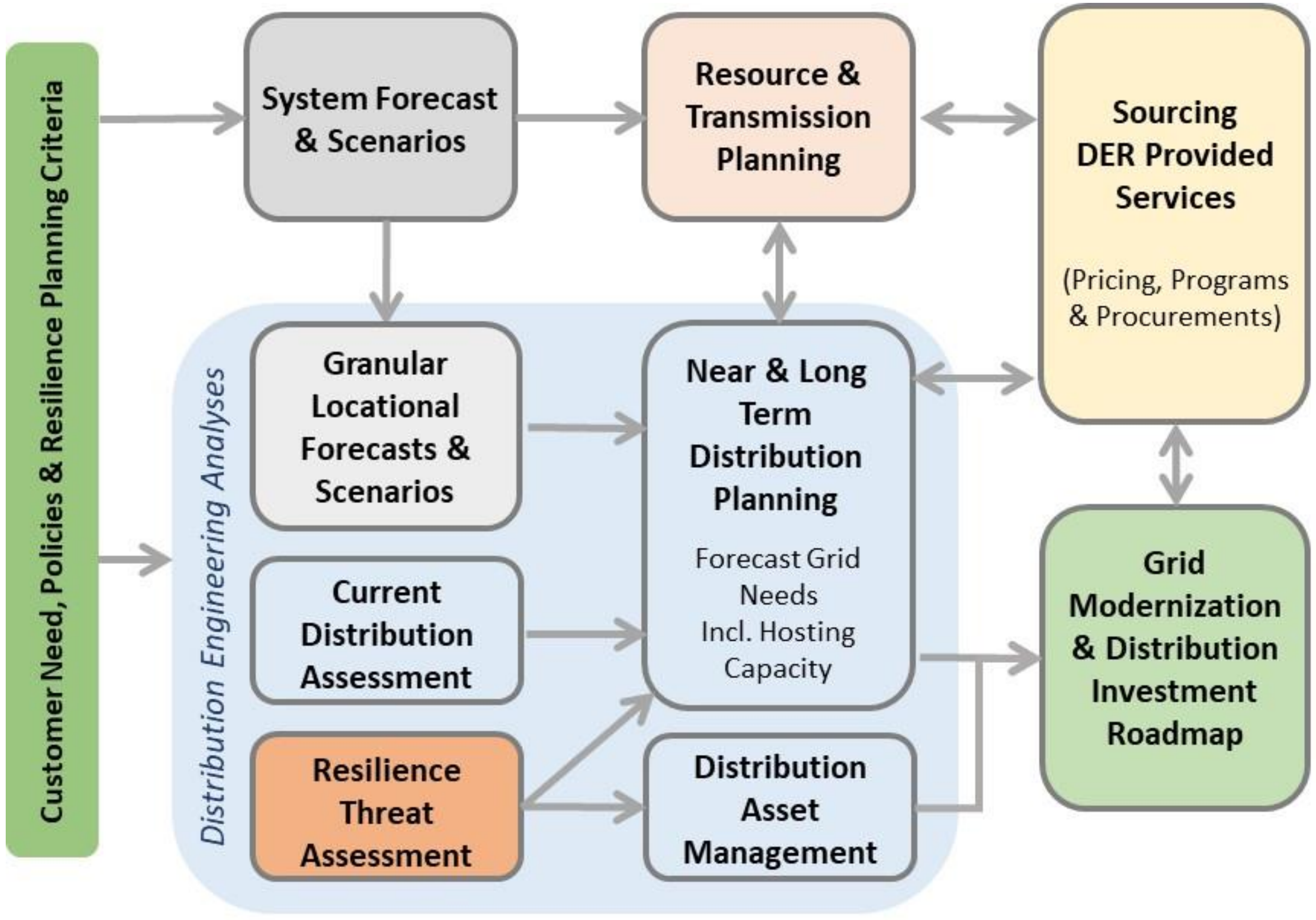
Distribution Planning

Multiple Planning Efforts Involved with Distribution Investment Planning



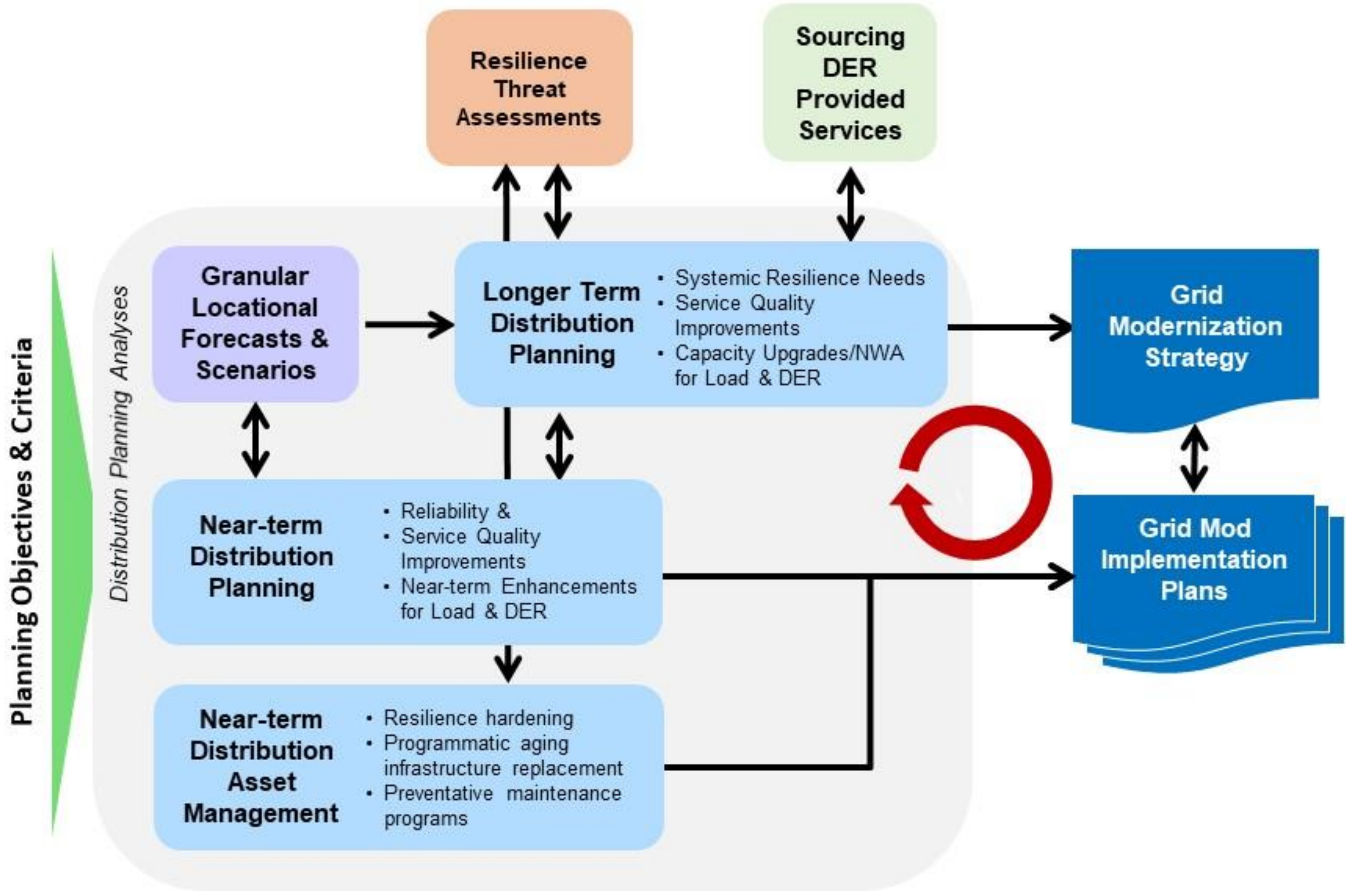


IDP – Grid Mod Planning Process



Adapted from P. De Martini, *Integrated Distribution Planning*, ICF

Planning for a Modern Distribution Grid

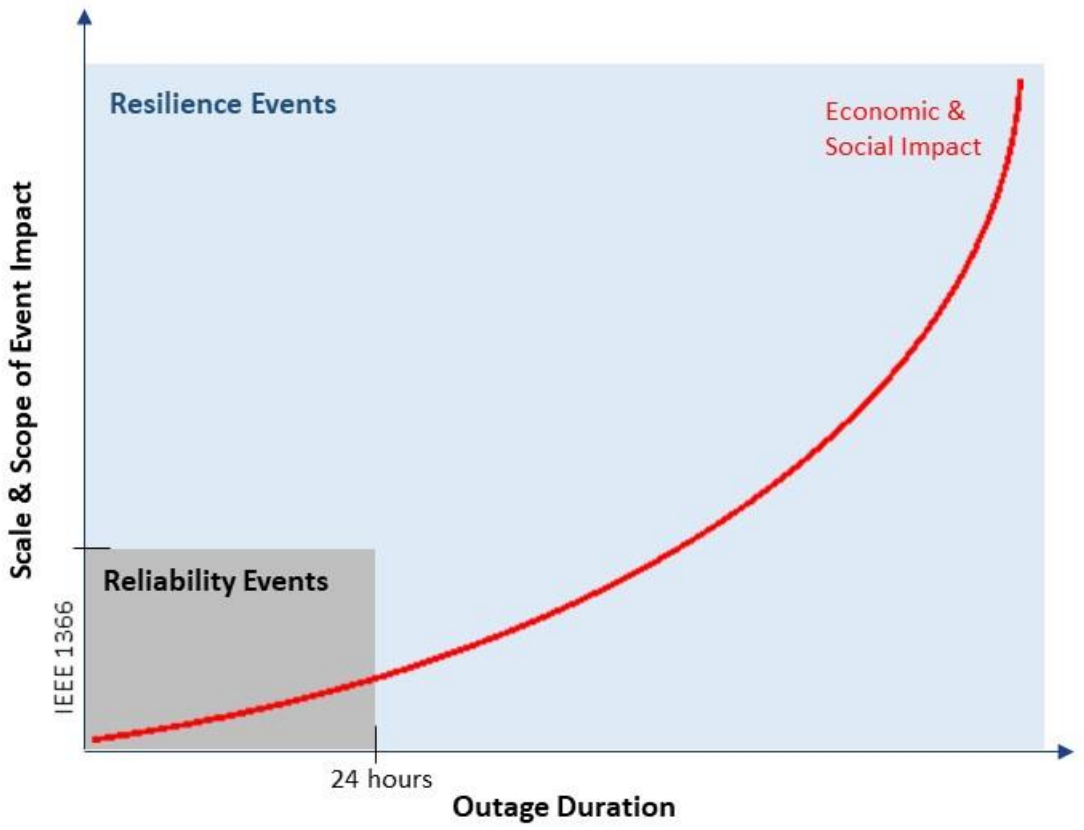


Resilience – Reliability Event Continuum

The fundamental difference is the scale and scope of an event's impact and subsequent outage duration

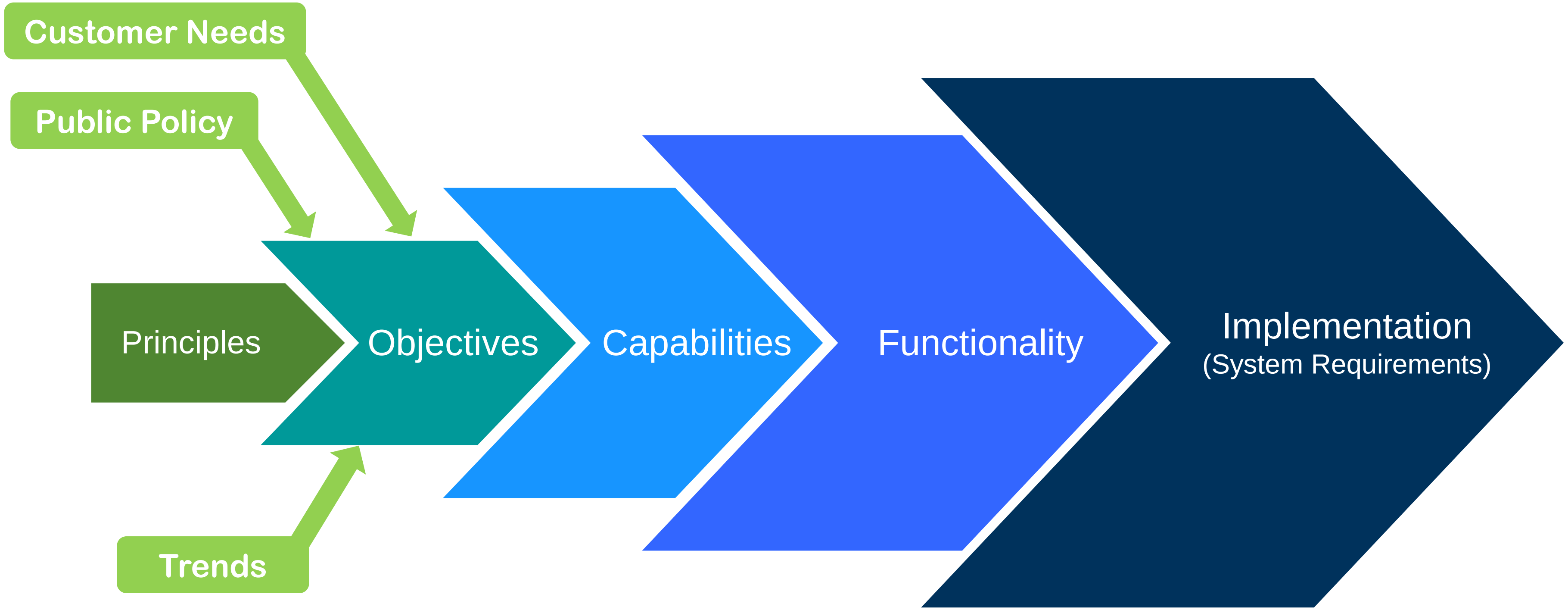
Resilience Events: Large geographic impact on distribution and/or bulk power system with long duration outage (typically greater than 24 hours & excluded from IEEE)

Reliability Events: Local impact with short duration outage (generally less than 24 hours measured by IEEE metrics)



DSPx Taxonomy Flow

Customer needs, public policy & trends shape grid mod objectives that align to organizational mission & grid mod principles



Grid Modernization

Customer Needs & Policy drive grid capabilities and corresponding enabling business functionality and technology

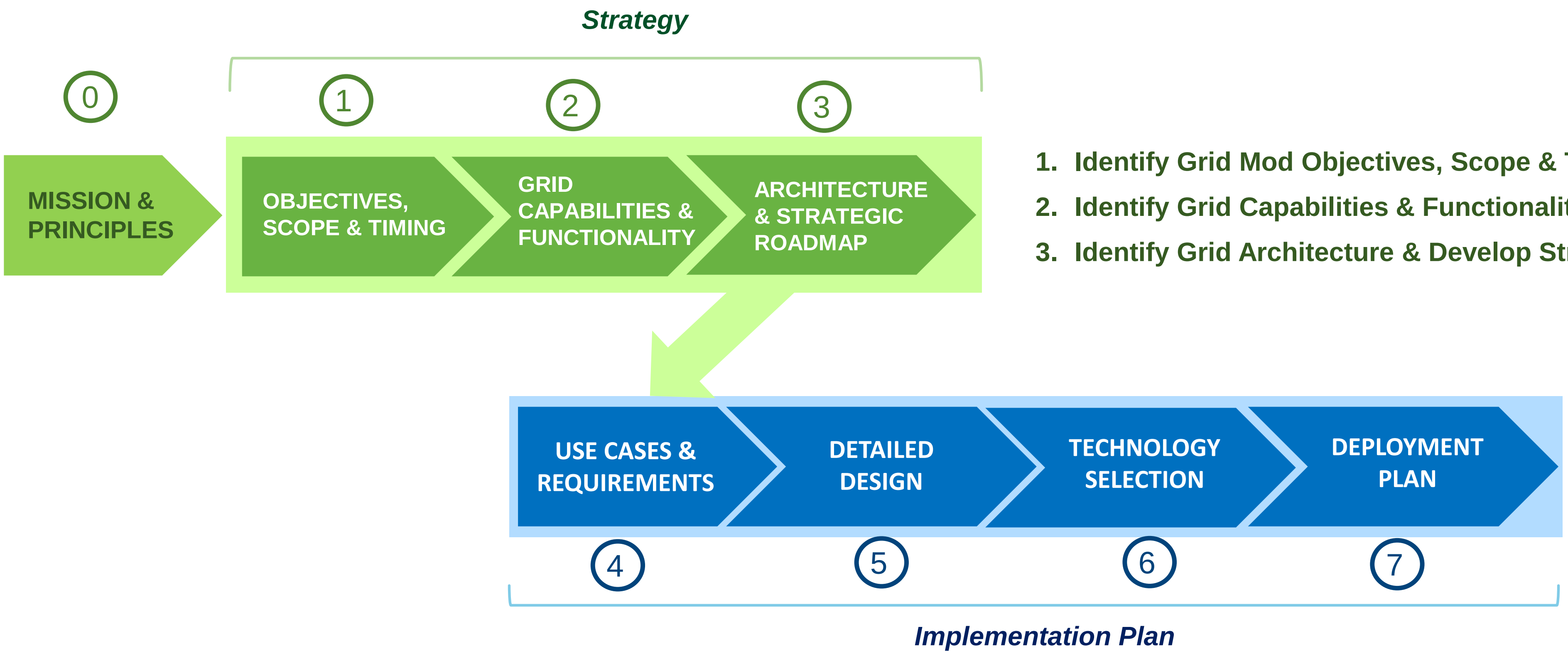
● New
● Existing

		Objectives		
		Safety & Operational Efficiency	Reliability & Resilience	DER Integration & Utilization
Capabilities	Market Operations	New	New	New
	Grid Operations	Existing	Existing / New	New
	Planning	Existing	Existing / New	New

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

Grid Mod Strategy & Planning Process

What, Why, How, When & How Much



1. **Identify Grid Mod Objectives, Scope & Timing**
2. **Identify Grid Capabilities & Functionality Needed**
3. **Identify Grid Architecture & Develop Strategic Roadmap**

4. **Develop Functional Use Cases to Identify Detailed Business & Technical Requirements**
5. **Develop Detailed Architecture & Design**
6. **Technology Assessment & Selection**
7. **Develop Deployment Plan & Cost Effectiveness Assessment**

Mission & Principles

Mission Examples:

Ohio

"The PUCO was created to assure Ohioans adequate, safe and reliable public utility services at a fair price. More recently, the PUCO gained responsibility for facilitating competitive utility choices for Ohio consumers."

Missouri

"We will:

- *ensure that Missourians receive safe and reliable utility services at just, reasonable and affordable rates;*
- *support economic development through either traditional rate of return regulation or competition, as required by law;*
- *establish standards so that competition will maintain or improve the quality of services provided to Missourians;*
- *provide the public the information they need to make educated utility choices;*
- *provide an efficient regulatory process that is responsive to all parties, and perform our duties ethically and professionally."*

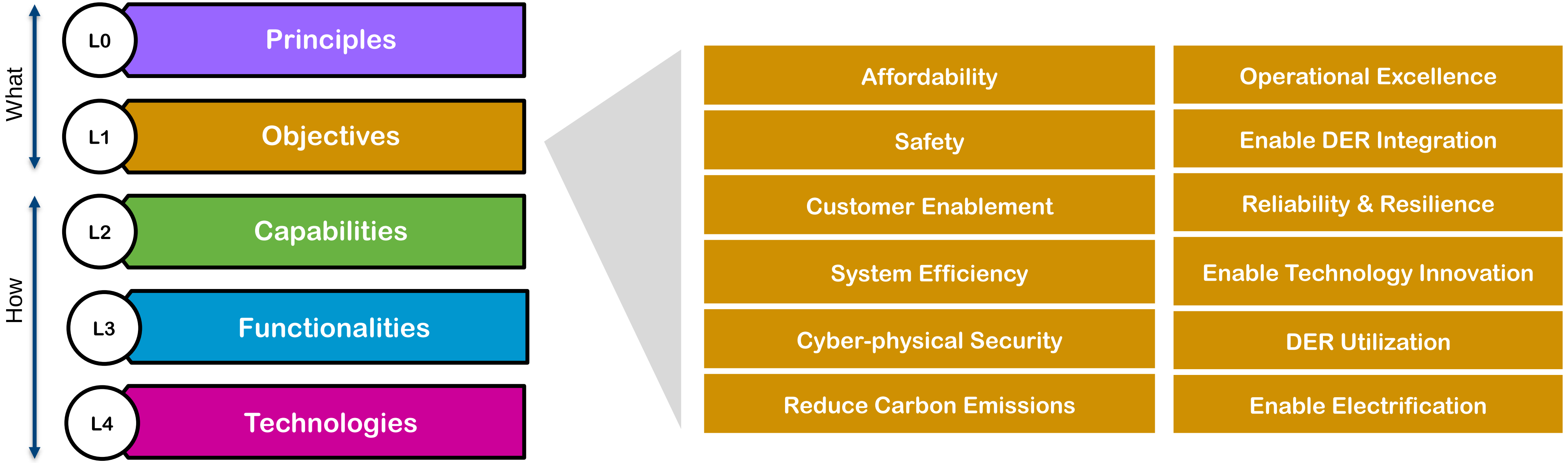
Grid Mod Principles Example:

Hawaii *(Adopted by HECO & PUC)*

- *Enable greater customer engagement, empowerment, and options for utilizing and providing energy services.*
- *Maintain and enhance the safety, security, reliability, and resiliency of the electric grid, at fair and reasonable costs, consistent with the state's energy policy goals.*
- *Facilitate comprehensive, coordinated, transparent, and integrated grid planning across distribution, transmission, and resource planning.*
- *Move toward the creation of efficient, cost-effective, accessible grid platforms for new products, new services, and opportunities for adoption of new distributed technologies.*
- *Ensure optimized utilization of resources and electricity grid assets to minimize total system costs for the benefit of all customers.*
- *Determine fair cost allocation and fair compensation for electric grid services and benefits provided to and by customers and other non-utility service providers.*

Revised DSPx Taxonomy & Objectives

Taxonomy Provides a Structured Method to Trace Objectives to Functionality



Sample Relationship Maps

OBJECTIVES

CAPABILITIES		Safety	Affordability	Reliability	Resilience	Technology Innovation	Customer Enablement	System Efficiency	Cyber-physical Security	Emissions Reduction	Operational Excellence	DER Integration	DER Utilization
2.1.1	Scalability		●	●	●	●	●	●			●	●	
2.1.2	Impact Resistance and Impact Resiliency	●		●	●				●				
2.1.3	Open and Interoperable		●	●		●	●	●			●	●	●
2.1.4	Accommodate Tech Innovation	●	●	●	●	●	●	●	●	●	●	●	●
2.1.5	Convergence with other Critical Infrastructure		●	●	●		●	●			●		
2.1.6	Accommodate New Business Models		●			●	●			●	●	●	●
2.1.7	Transparency	●	●	●		●	●	●				●	●
2.2.1	Operational Risk Management	●	●	●	●			●	●		●		
2.2.2	Situational Awareness	●	●	●	●			●	●		●	●	●
2.2.3	Controllability and Dynamic Stability			●				●		●			
2.2.4	Management of DER and Load Stochasticity		●		●			●		●	●	●	

FUNCTIONALITIES

CAPABILITIES		3.1 DISTRIBUTION SYSTEM PLANNING										
		1	2	3	4	5	6	7	8	9	10	11
		Short and Long-term Demand and DER Forecasting	Short-term Distribution Planning	Long-term Distribution Planning	Interconnection Process	Reliability and Resiliency Criteria	Locational Value Analysis	Integrated Resource, Transmission, and Distribution Planning	Distribution System Information Sharing	Planning Analytics	Hosting Capacity Analysis	EV Readiness
2.1.1	Scalability	●		●	●	●		●	●			
2.1.2	Impact Resistance and Impact Resiliency	●	●	●	●	●					●	●
2.1.3	Open and Interoperable				●				●			●
2.1.4	Accommodate Tech Innovation	●	●	●	●		●	●	●	●	●	●
2.1.5	Convergence with other Critical Infrastructure	●	●	●		●	●	●	●	●		●
2.1.6	Accommodate New Business Models	●	●	●			●	●	●		●	
2.1.7	Transparency	●	●	●	●	●	●	●	●		●	
2.2.1	Operational Risk Management	●	●	●	●	●	●	●		●	●	●
2.2.2	Situational Awareness	●	●	●	●	●	●	●		●	●	●
2.2.3	Controllability and Dynamic Stability	●			●	●	●			●		●
2.2.4	Management of DER and Load Stochasticity	●	●	●	●		●	●		●	●	
2.2.5	Contingency Management		●	●	●	●	●	●		●		
2.2.6	Security		●	●	●	●						
2.2.7	Public and Workforce Safety		●	●	●	●						

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Taxonomy Example

Objective	Capability	Function	Technology
Customer Choice through information access for small business & residential customers to support decision making by 2020	Provide online customer access to relevant & timely information	Remote meter data collection & verification Customer data management Energy management & DER purchase analysis	Customer Portal Customer Analytic Tools Greenbutton Smart Meter Telecommunications Meter Data Management System Customer Info System Data Warehouse

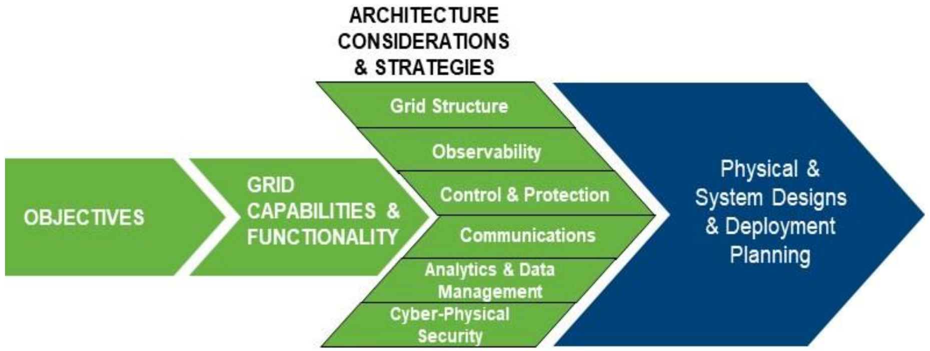
Taxonomy Example

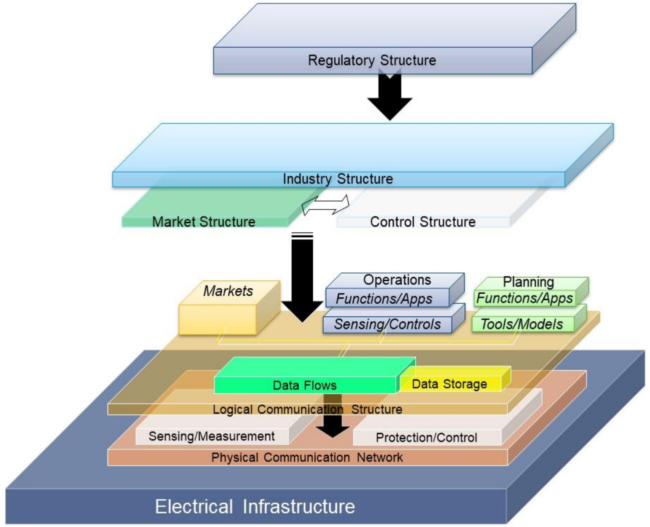
Objective	Capability	Function	Technology
Reliability improvement by reducing customer unplanned outage durations Achieve 1st Quartile CAIDI Performance by 2020	Improve outage identification and customer service restoration	Fault Identification Fault Location Fault Isolation Service restoration	Fault Current Indicators Outage Notification from Meters Outage Management System Geospatial Information System Distribution Management System and/or SCADA Automated Switches Work Management System

Architectural Strategy

The engineering issues associated with the scale and scope of dynamic resources envisioned in policy objectives for grid modernization requires a holistic architectural approach

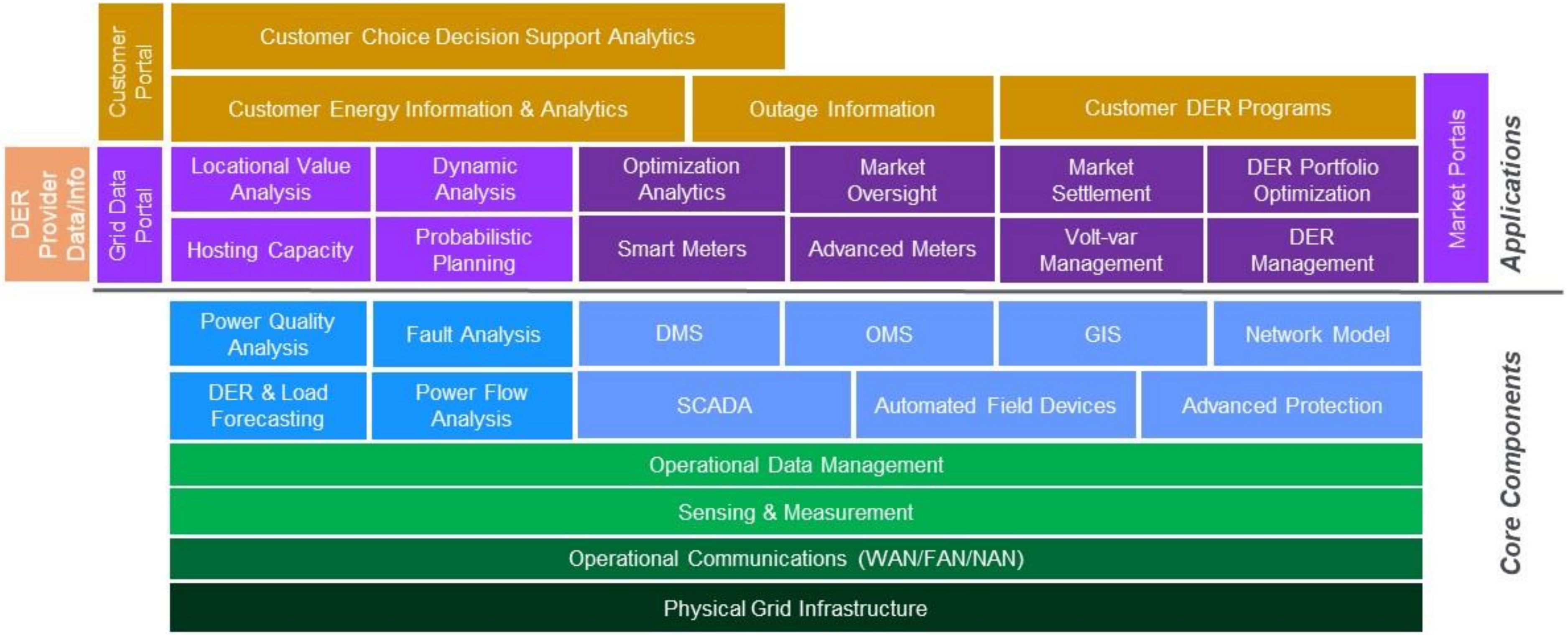
1. Outline key system considerations that come from an understanding of grid technology, emerging trends and systemic issues
2. Define architectural strategies that derive from an understanding of grid structure concepts
3. Apply the strategies to key considerations in the design of new and modified grid systems





Distribution System Platform

Logical layering of core components

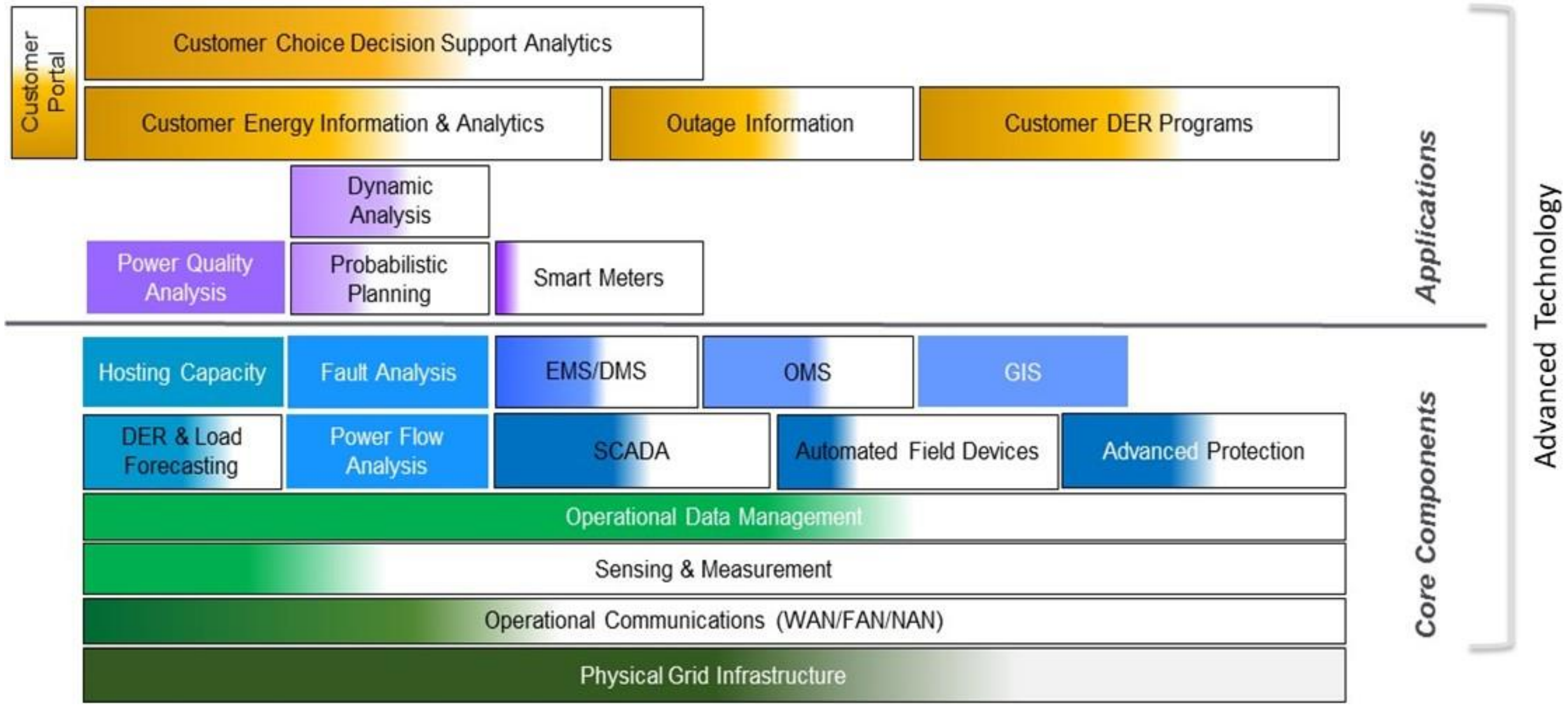


Green - Core Cyber-physical layer
Blue - Core Planning & Operational systems
Purple - Applications for Planning, Grid & Market Operations
Gold - Applications for Customer Engagement with Grid Technologies
Orange - DER Provider Application

Source: U.S. Department of Energy-Office of Electricity Delivery and Energy Reliability, 2017. *Modern Distribution Grid, Volume III: Decision Guide.* Available online at: https://gridarchitecture.pnnl.gov/media/Modern-Distribution-Grid-Volume-III.pdf

What is the Starting Point for Grid Investment ?

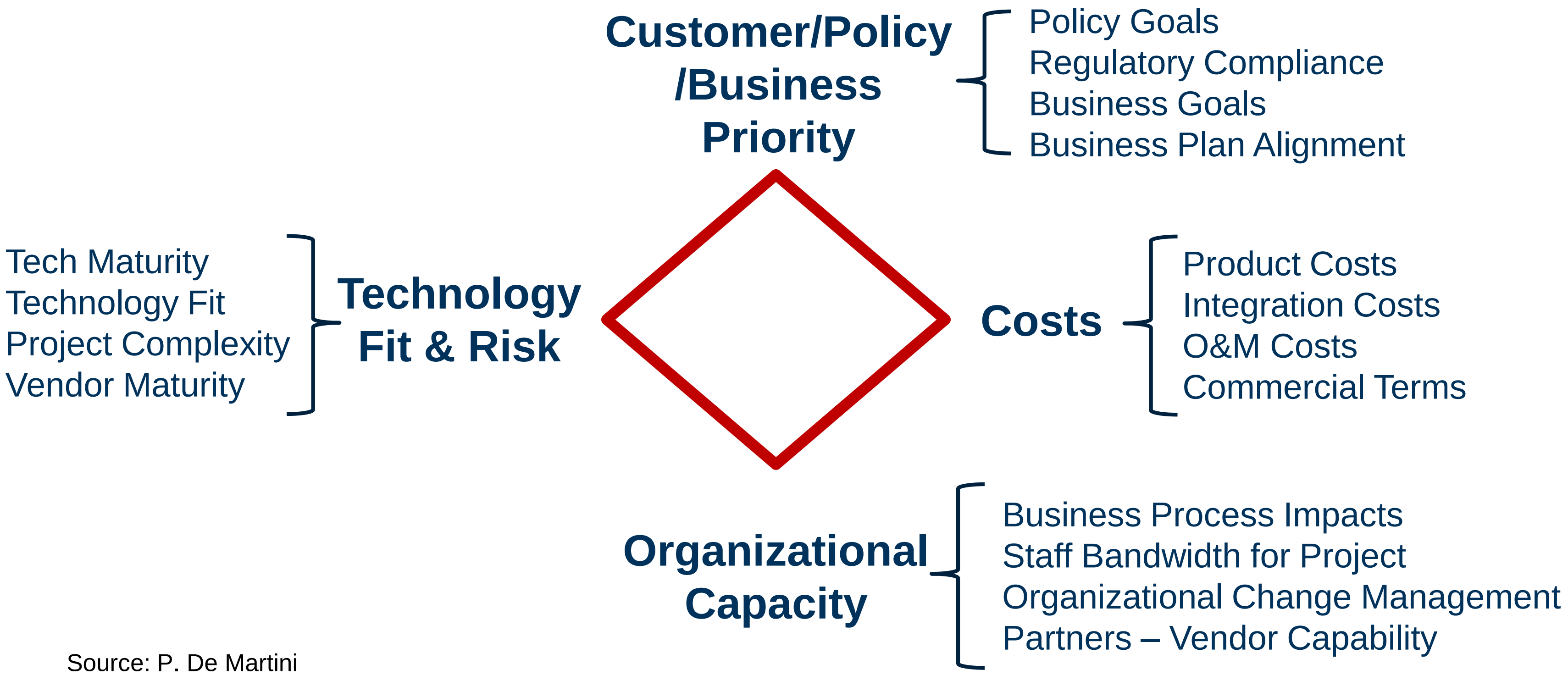
This graphic is a summary illustration of a more complete assessment documented in narrative and tables to enable a gap analysis against objectives and identified capabilities & functionalities



Source: Hawaiian Electric 2017

Technology Implementation 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

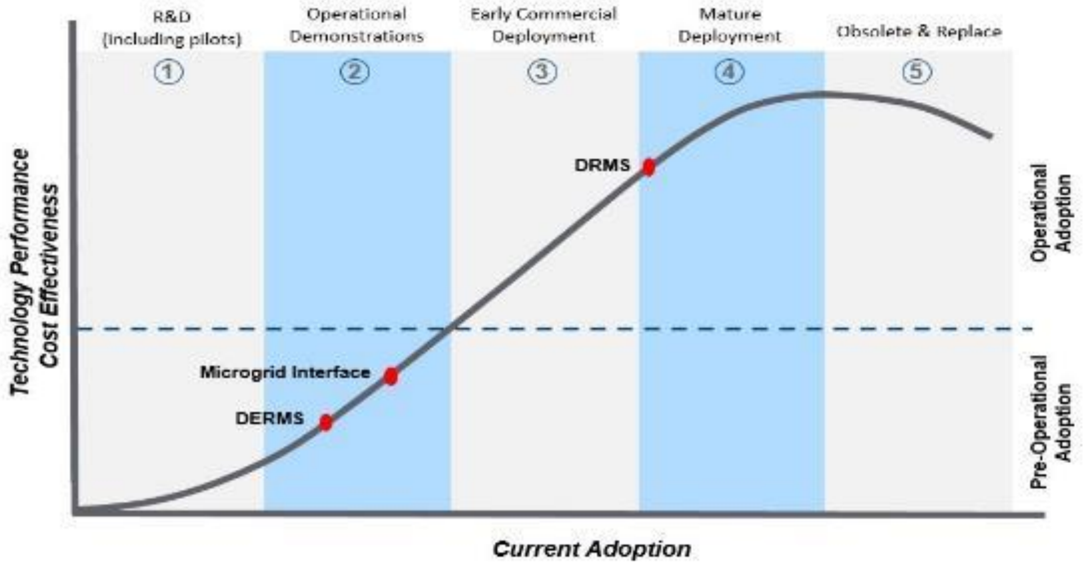


Source: P. De Martini

Technology Adoption Considerations

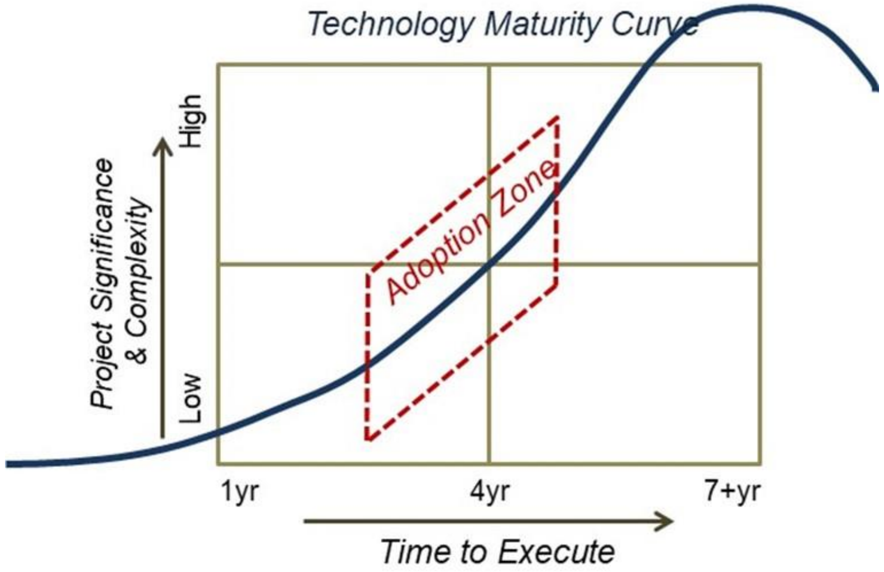
Deciding when to adopt grid technologies involves several factors: technology maturity, time to deploy, implementation complexity & functional criticality

Technology Maturity Assessment



Source (above): U.S. Department of Energy-Office of Electricity Delivery and Energy Reliability, 2017. *Modern Distribution Grid, Volume II: Advanced Technology Maturity Assessment. Link*: https://gridarchitecture.pnnl.gov/media/Modern-Distribution-Grid-Volume-II.pdf

Technology Adoption Strategy



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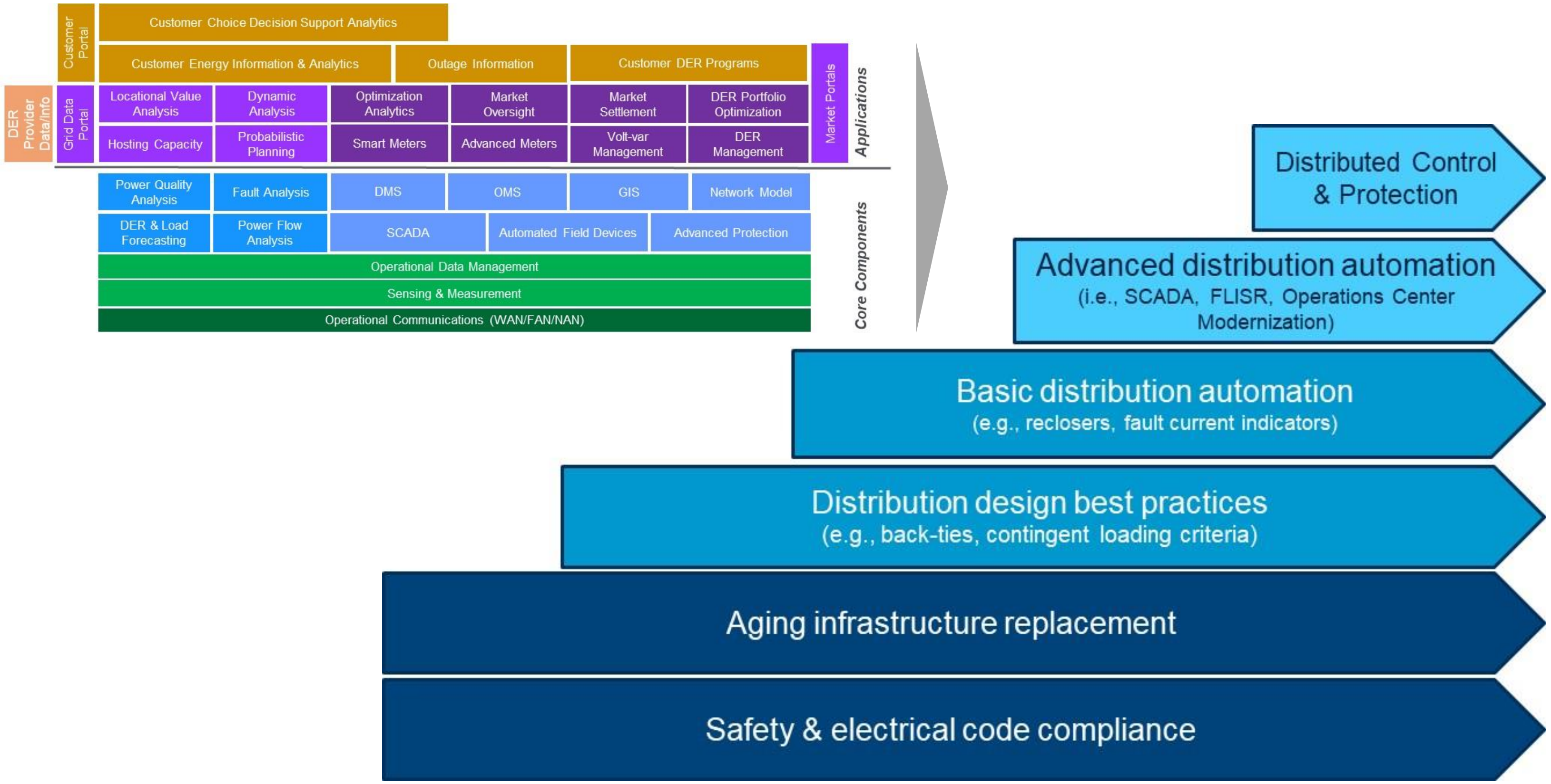
Distribution & Modernization Investment Categories

Grid Modernization technologies layer on top of & integrate with foundational physical grid infrastructure



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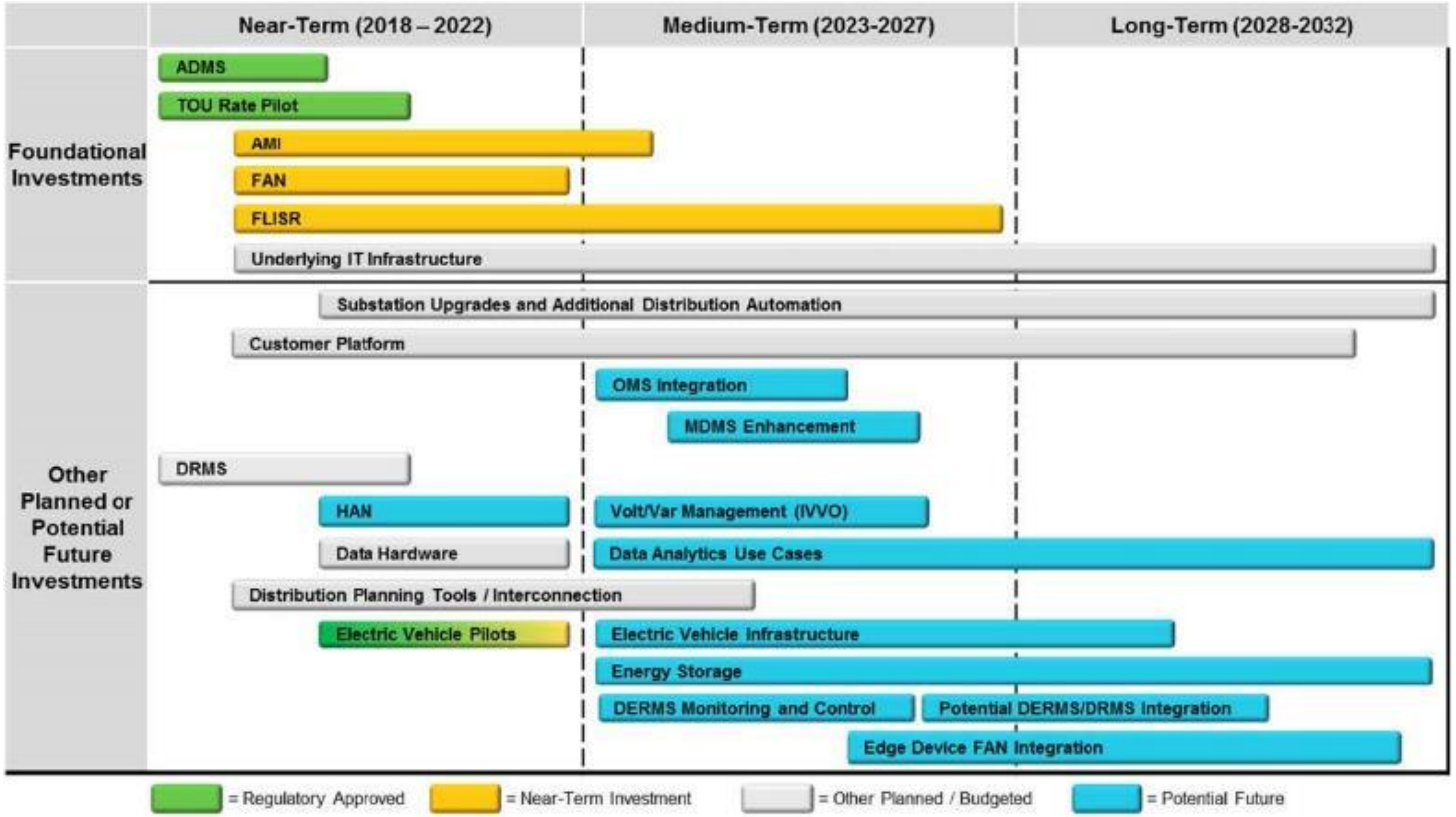
Sequencing of Investments

Long-term strategic plan of distribution grid investments



From the Xcel Energy 2018 Integrated Distribution Plan. Link: https://www.edockets.state.mn.us/EFiling/edockets/searchDocuments.do?method=showPoup&documentId={E098D466-0000-C319-8EF6-08D47888D999}&documentTitle=201811-14

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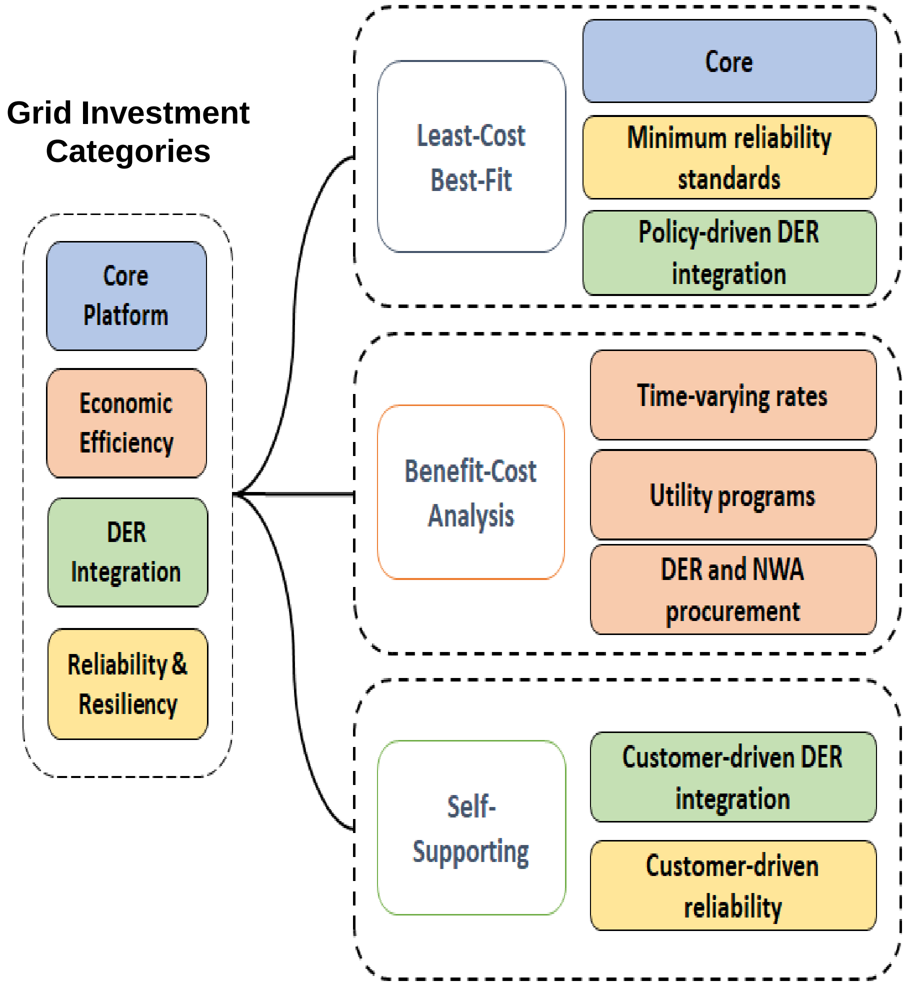
Grid Investment Cost-Effectiveness Framework

Cost-effectiveness Methods for Typical Distribution Grid Projects



Least-cost, best-fit for core grid platform and grid expenditures required to maintain safe, reliable, resilient operations as well as integrate distributed resources connected behind and in front of the customer meter that may be socialized across all customers.

Benefit-Cost Analysis for grid expenditures proposed to enable public policy and/or incremental system and societal benefits to be paid by all customers. Grid expenditures are the cost to implement the rate, program or NWA. Various methods for BCA may be used.

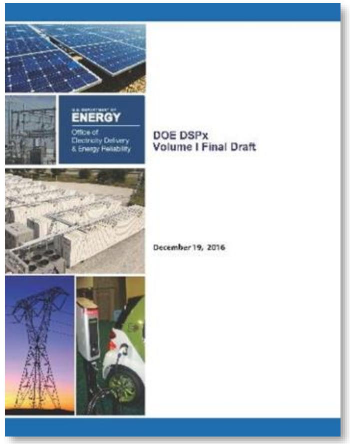
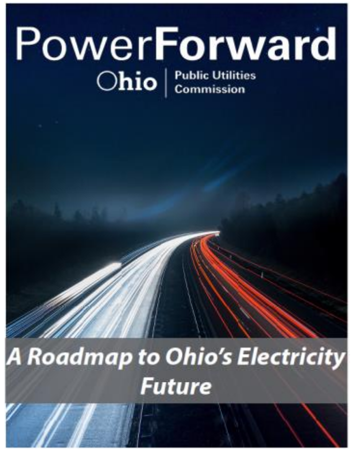
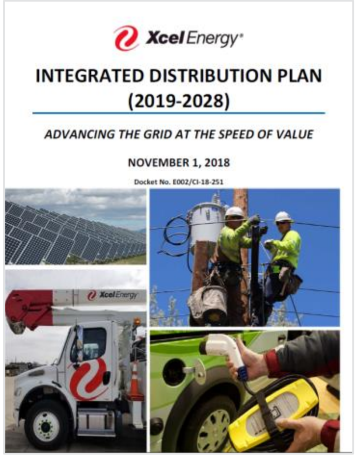
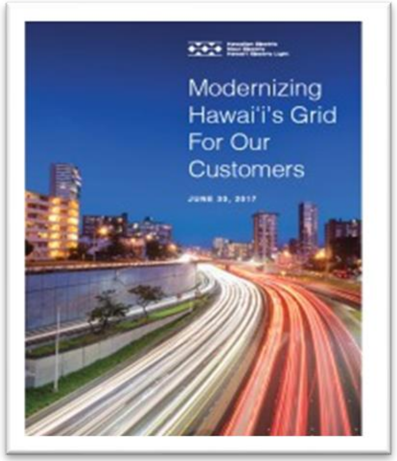
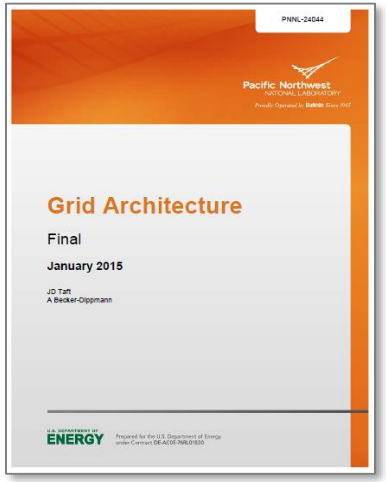
Customer Self-supporting costs for projects that only benefit a single or self-selected number of customers and do not require regulatory benefit-cost justification. For example, DER interconnection costs not socialized to all customers. Also, undergrounding wires at customers' request.

Thank You

Contact:

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

References:

Modern Distribution Grid Report	PUCO Grid Mod Roadmap	Grid Modernization Strategy Using DSPx	Grid Modernization Strategy Using DSPx	Grid Architecture
				
https://gridarchitecture.pnnl.gov/modern-grid-distribution-project.aspx	https://puco.maps.arcgis.com/apps/Cascade/index.html?appid=59a9cd1f405547c89e1066e9f195b0b1	https://www.edockets.state.mn.us/EFiling/edockets/searchDocuments.do?method=showPoup&documentId={E098D466-0000-C319-8EF6-08D47888D999}&documentTitle=201811-147534-01	www.hawaiianelectric.com/gridmod	http//gridarchitecture.pnnl.gov