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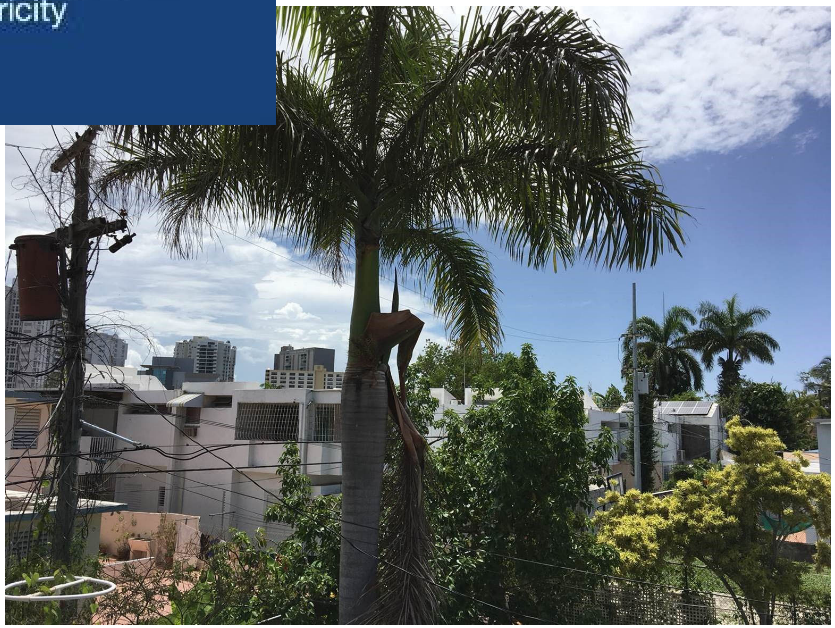

Distribution System Planning – Walk, Jog, Run

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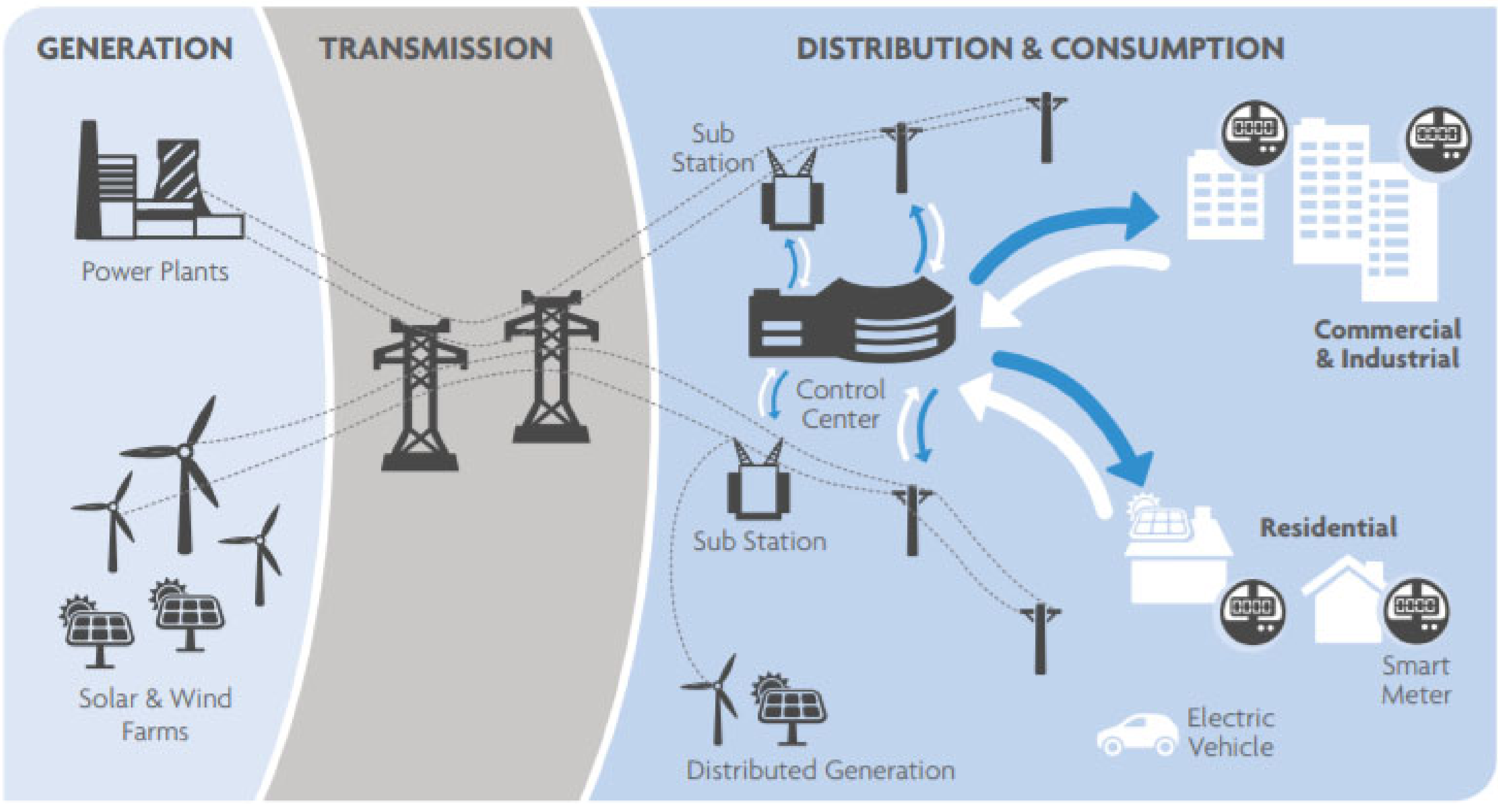
Puerto Rico Energy Bureau
Distribution System Planning Stakeholder Workshop August 16, 2019

Agenda – August 16, 2019

8:00 am	**Welcome Remarks**
8:15 am	**Introductory Discussion and Brief Introduction**
9:15 am	**Distribution Planning – Walk, Jog, Run** Introduction to Integrated System Planning
10:45 am	**Break**
11:00 am	**Deep Dive into Elements of Integrated Distribution Planning** The Core Elements of IDP Grid Modernization Strategy and Implementation Planning
12:30 am	**Lunch**
1:30 pm	**Guided Breakout Sessions**
3:30 pm	**Break**
3:45 pm	**Presentations**
4:45 pm	**Wrap-up**
5:00 pm	**Adjourn**

Increasing Complexity

We are evolving from a one-directional to multi-directional network with regard to the flow of energy, information, and financial transactions, yet need to maintain or improve reliability, resilience, and affordability



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Influencing Factors for Grid Modernization

The challenge is to manage the transition and related operational and market systems in a manner that doesn't result in an unstable or unmanageable system[1]

Federal, State and Local Policies

- Renewable Portfolio Standards
- Federal/Local Tax Credits
- Reliability and Resilience
- Integrate Distributed Energy Resources
- Enable Customer Choice

Act 17-2019:

- 100% energy production from renewable resources by 2050
- Eliminate use of coal by 2028
- Integrate PV, energy storage, microgrids and other DERs
- Consumers as "active agents"
- Reduce rates below $0.20 per kWh

Technology Availability

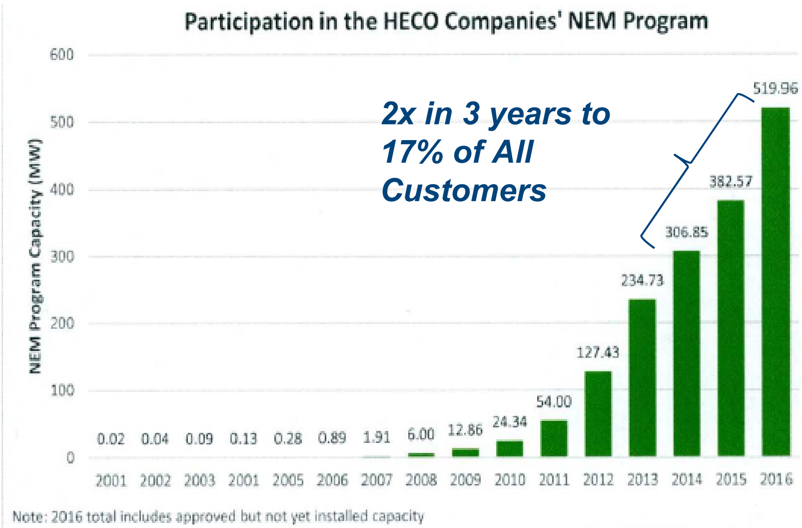
- Convergence of IT/OT
- Electric Vehicles
- Solar and Wind
- Energy Storage
- Building Energy Management Systems
- Microgrids

New Participants

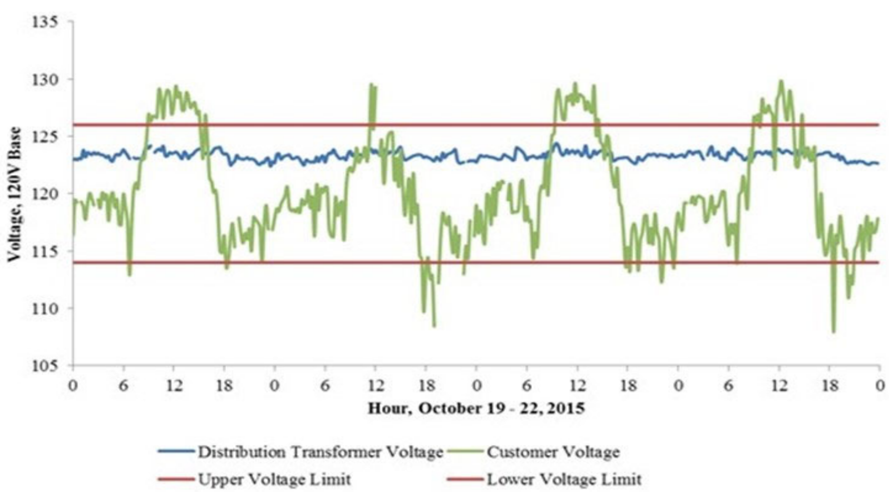
- Customers/Prosumers
- Merchants
- Technology Providers

1 - from Grid 2020, Resnick Institute Report, Sept 2012

DER Can Present Operational Challenges



Source: HECO cited in Hawaii PUC Order No. 34281



Source: Hawaiian Electric Companies

High levels of DERs will impact system design and operations

- Convergence of attractive prices, commercial offerings and favorable state policies greatly enhances adoption of PV
- High DER adoption can violate operational criteria related to voltage, thermal, and system protection requirements
- HI PUC October 12, 2015 Ruling modifies NEMS policy with “self-supply” and “grid-supply” tariffs.
  - All pay a monthly fee to cover fixed costs
  - Grid-supply compensated at the wholesale rate for electricity
- Energy storage undergoing similar trend; implications for DERs

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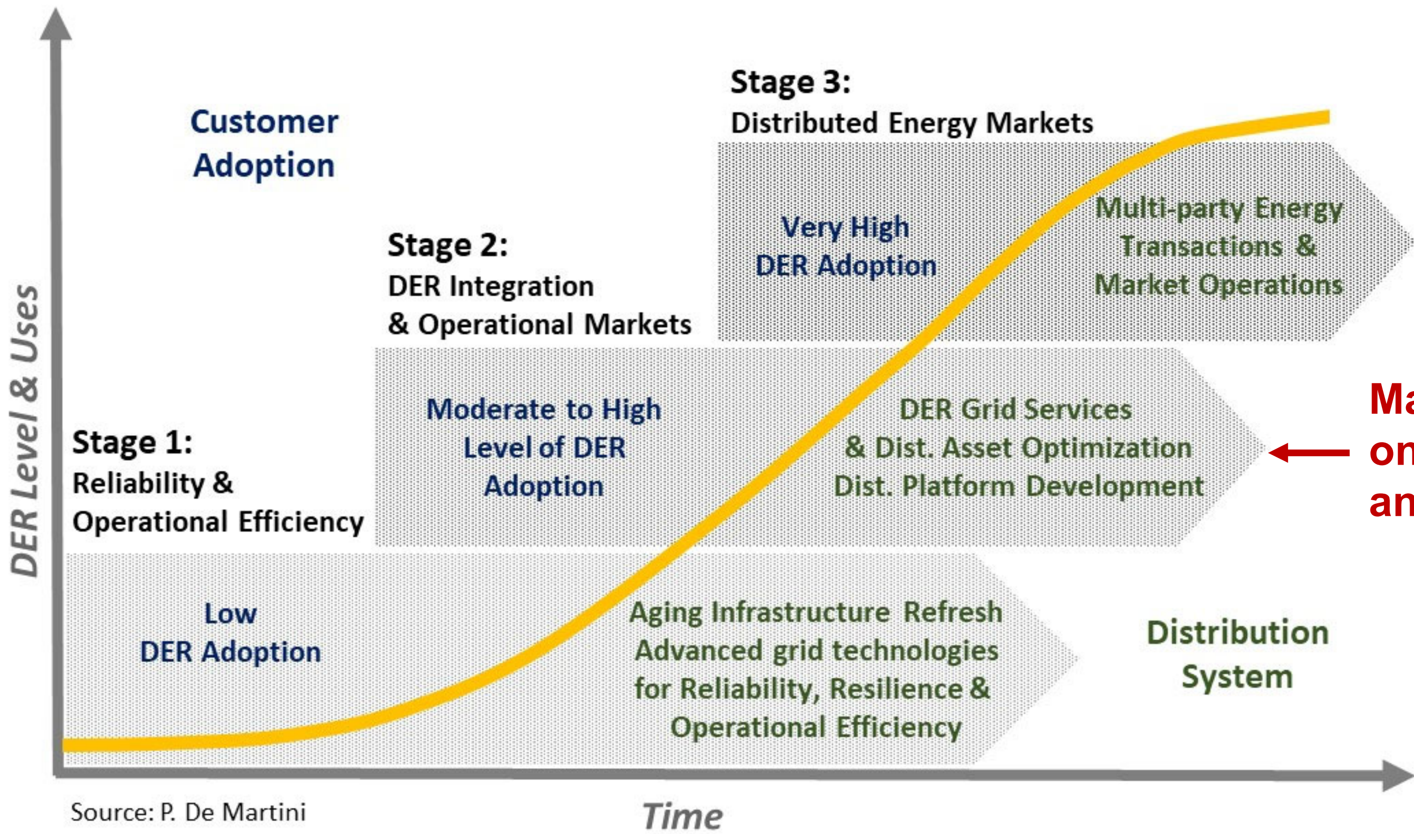
Distribution Grid Evolution

U.S. distribution systems currently have Stage 1 functionality - a key issue is *whether* and *how fast* to transition into Stage 2 functionality



Material impact on grid planning and operations

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Integrated Distribution Planning

Integrated Distribution Planning's purpose is to identify the needed changes to the grid to support customer needs and public policies

- Planning is informed by defined set of objectives derived from customer needs and public policy
- Planning is also driven by a set of criteria that provide the safety, reliability and resilience parameters
- These inputs, along with associated forecasts, shape the analysis to determine the incremental changes needed on the grid
- These changes may include enabling the effective integration of distributed assets, as well establishing opportunities to utilize non-wires alternatives in lieu of conventional grid investment

Planning a Modern Grid

The scope of planning has expanded from past practices focused primarily on deterministic load growth, reliability, safety and asset management to…

- Improving Reliability, Resilience
- Maintaining Safety, and Operational Efficiency (incl. microgrids)
- Enabling DER Integration (incl. electrification)
- Utilizing DER services for grid operations (e.g., non-wires alternatives)

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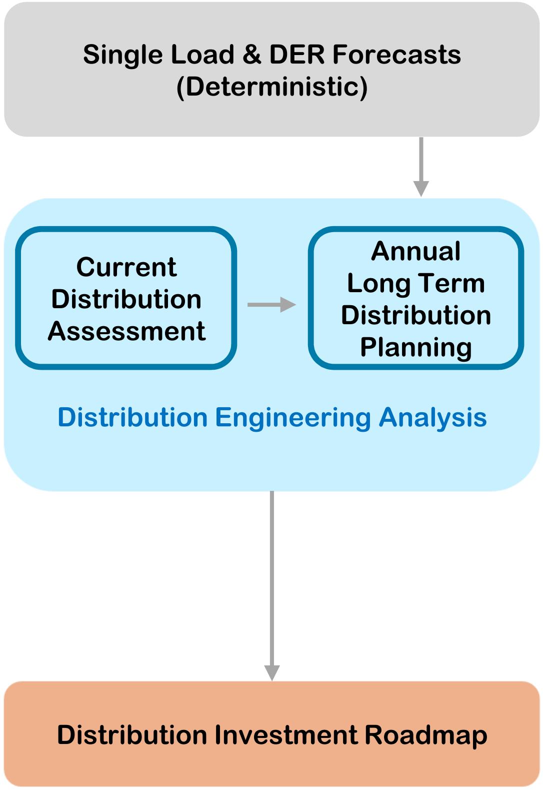
Traditional Distribution Planning

Required engineering analysis that provides foundation for enhancements

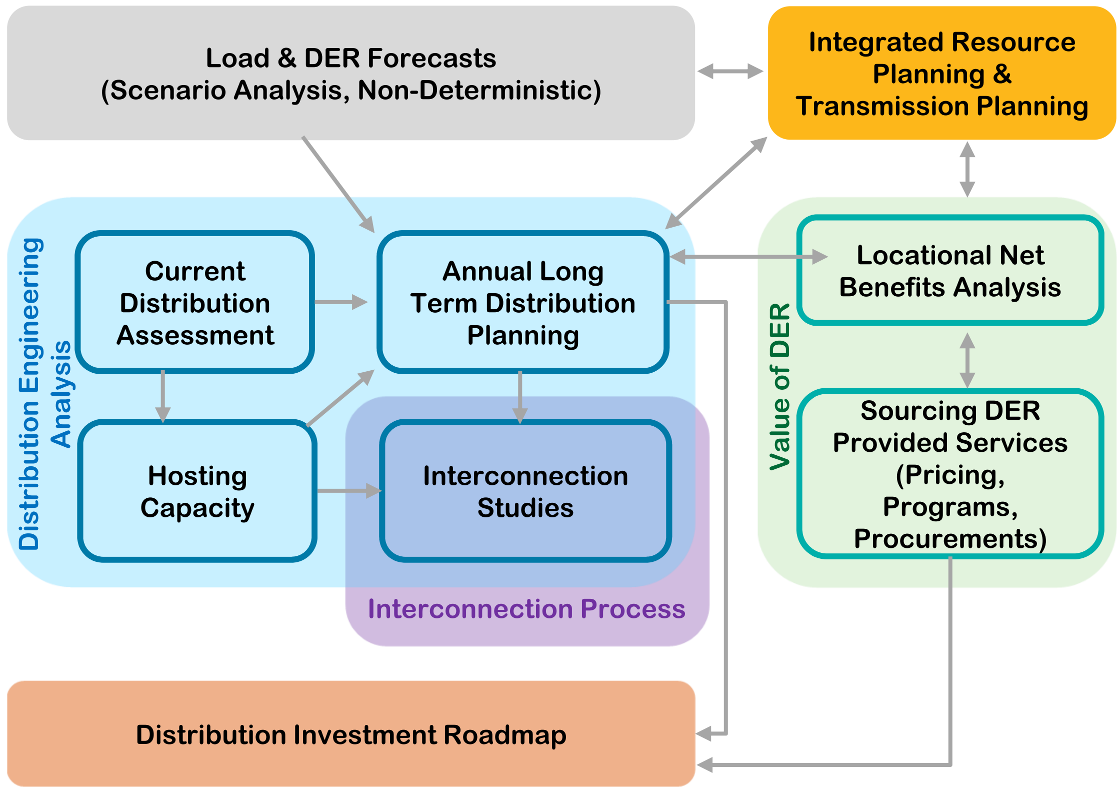
1. **Forecasts**: Develop single, long-term deterministic forecast of load and DER adoption
2. **System Needs Assessment and Solution Identification:** Assess current feeder and substation reliability, condition of grid assets, asset loading and operations;
   - Assess current operating conditions and perform power flow analysis to assess short-term (1-2) year and longer-term (5-10) changes/upgrades that may be required.
   - Evaluate solutions to grid needs identified including operational changes; short-term minor capital investment and longer-term grid upgrades and modernization investments
3. **Finalize Solutions:** Establish final distribution system investment roadmap



Integrated Distribution Planning

New elements for distribution planning to create a holistic, integrated process

1. Forecasting
2. System Needs Assessment and Solution Identification / Evaluation
3. Finalize Solutions



These elements can be phased in based on pace of value to customers

Illustrative Internal Touchpoints

IDP requires increased coordination and collaboration across the utility

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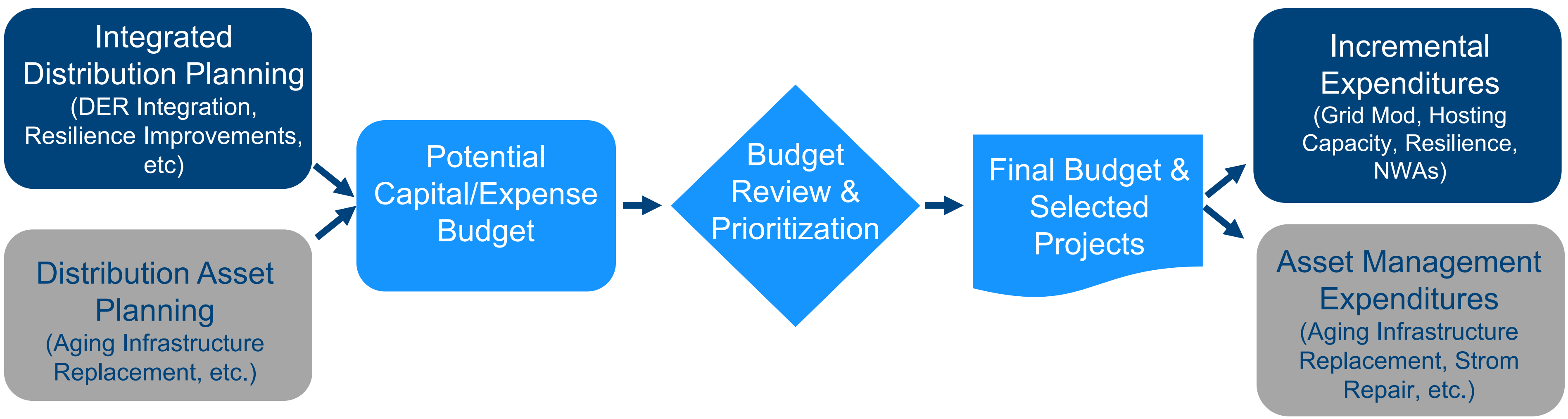
Distribution Planning & Prioritization

Annual distribution planning involves two elements: identifying incremental needs and maintaining safe, reliable existing infrastructure. This is done in two complementary activities:

- **Integrated Distribution Planning** for incremental needs, and
- **Asset management/Planning** to assess existing infrastructure condition and break/fix equipment replacements, and address other routine business needs, like customer service connections.

Identified projects/expenses are reviewed and prioritized before a final budget and selection is made – the resulting incremental expenditures list informs the potential NWA opportunities.



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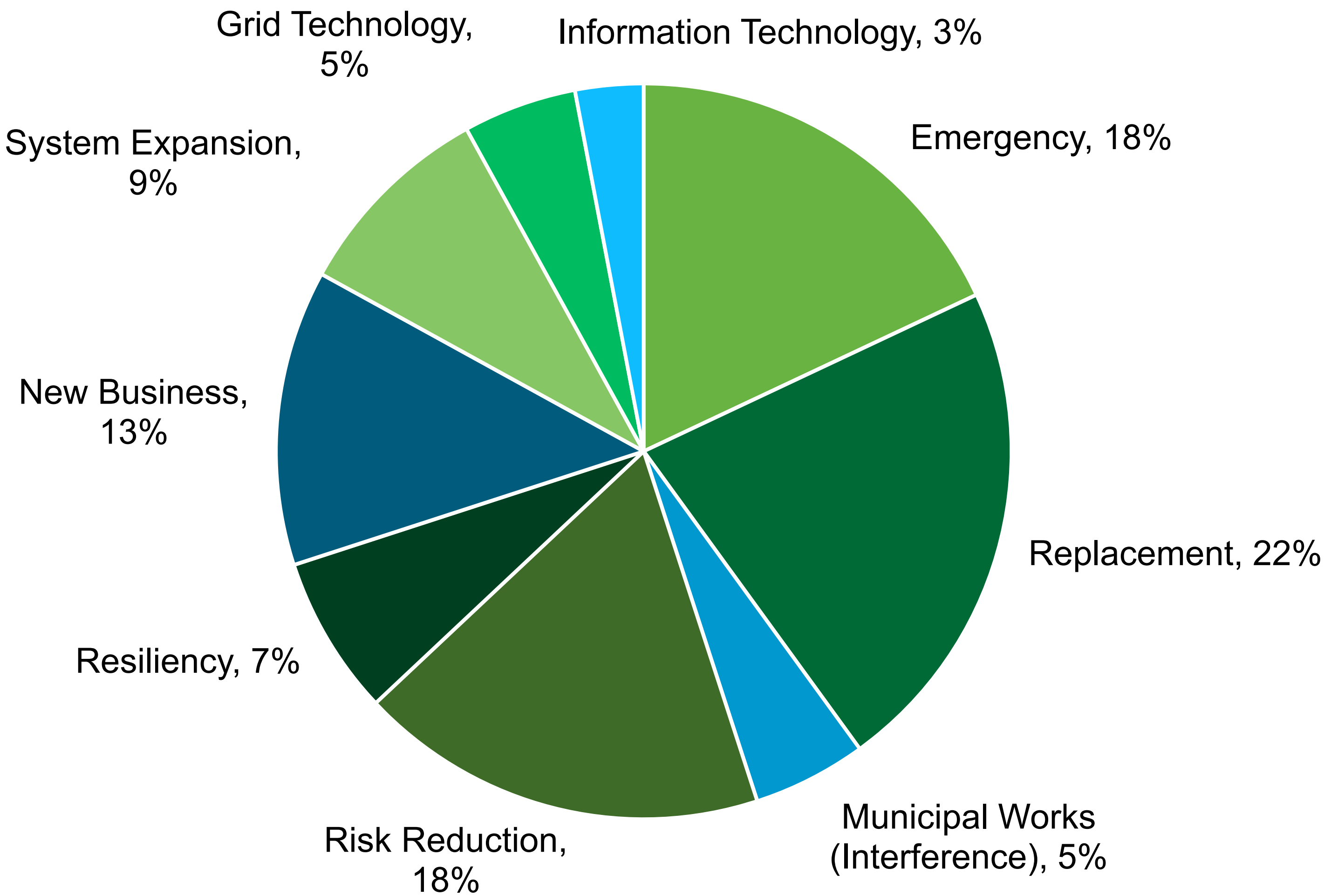
Utility Investments (CapEx)



Illustrative Example of Utility 5-year T&D Capital Plan

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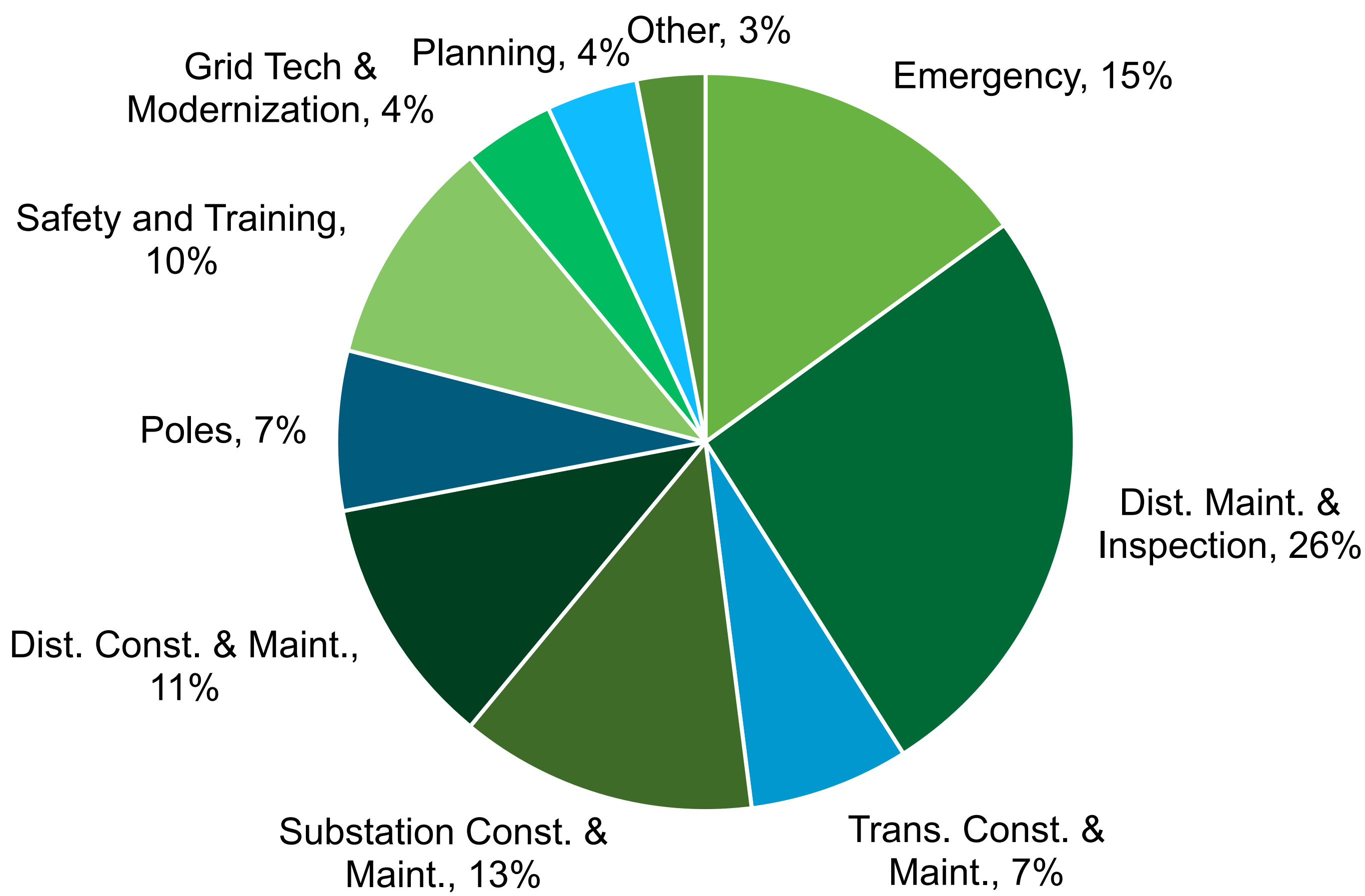
Utility Investments (O&M)



Illustrative Example of Utility 5-year T&D O&M Plan

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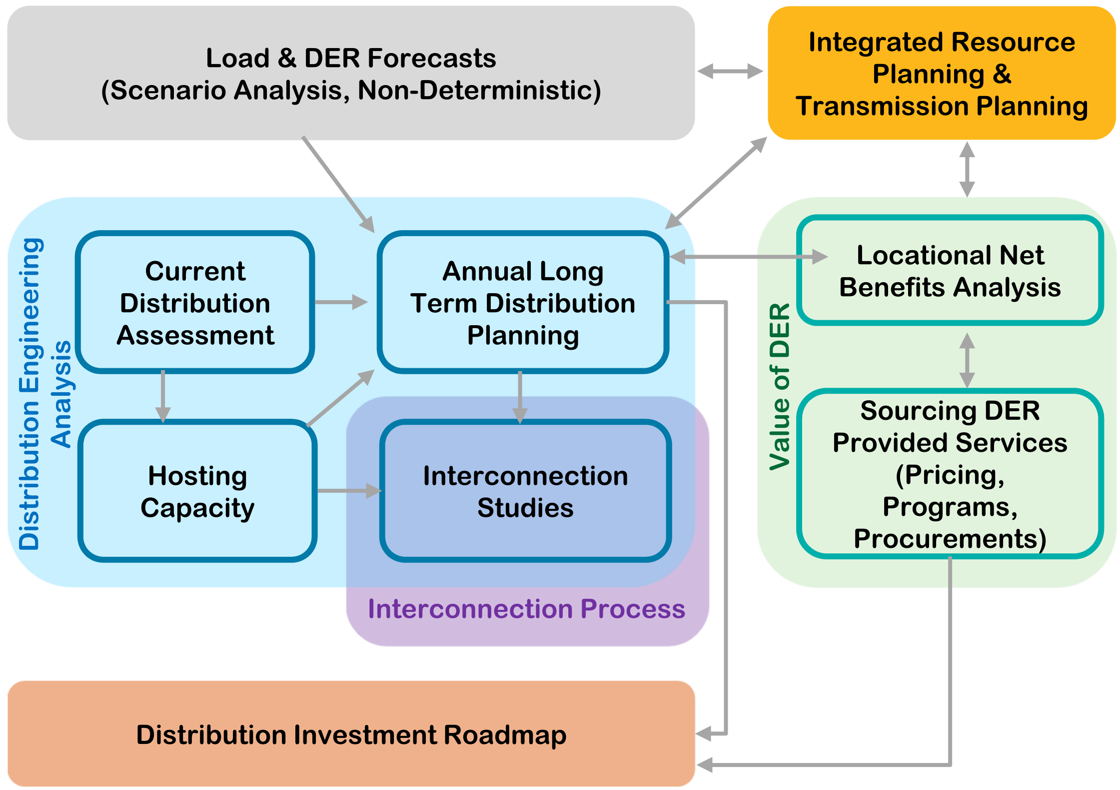
Integrated Distribution Planning Revisited

1. Forecasting
2. System Needs Assessment and Solution Identification / Evaluation
3. Finalize Solutions

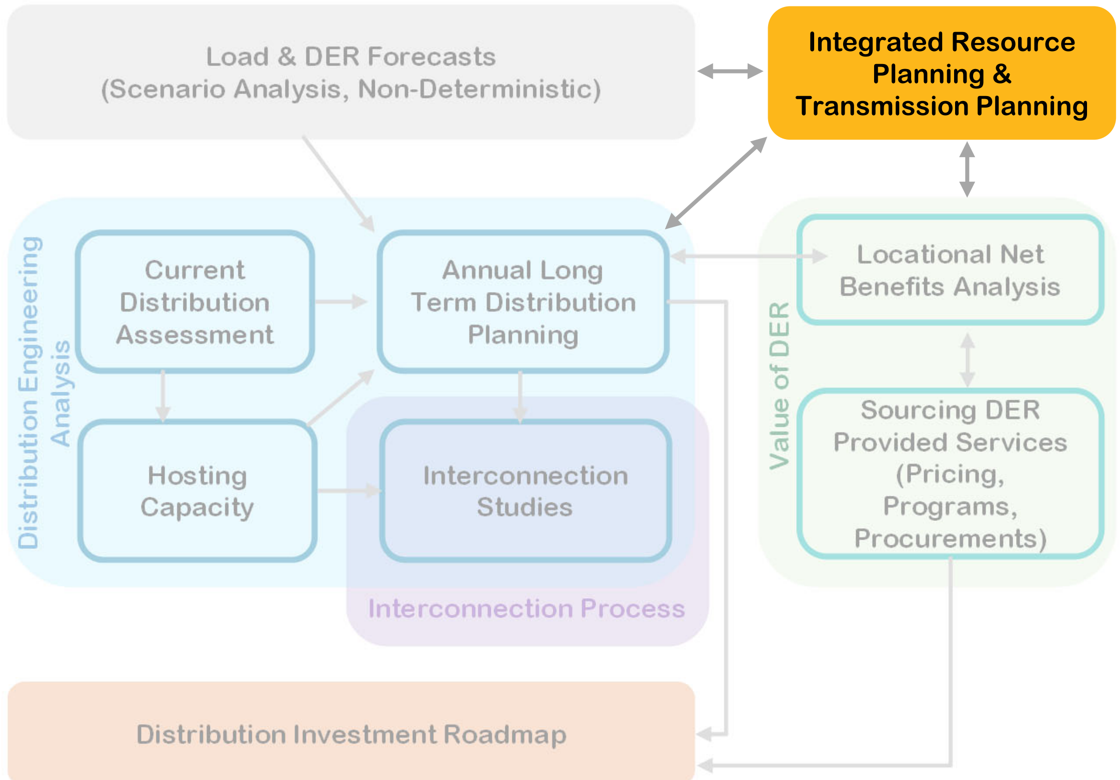


Coordination Across Planning Processes

1. **Forecasting**

2. **System Needs Assessment and Solution Identification / Evaluation**

3. **Finalize Solutions**



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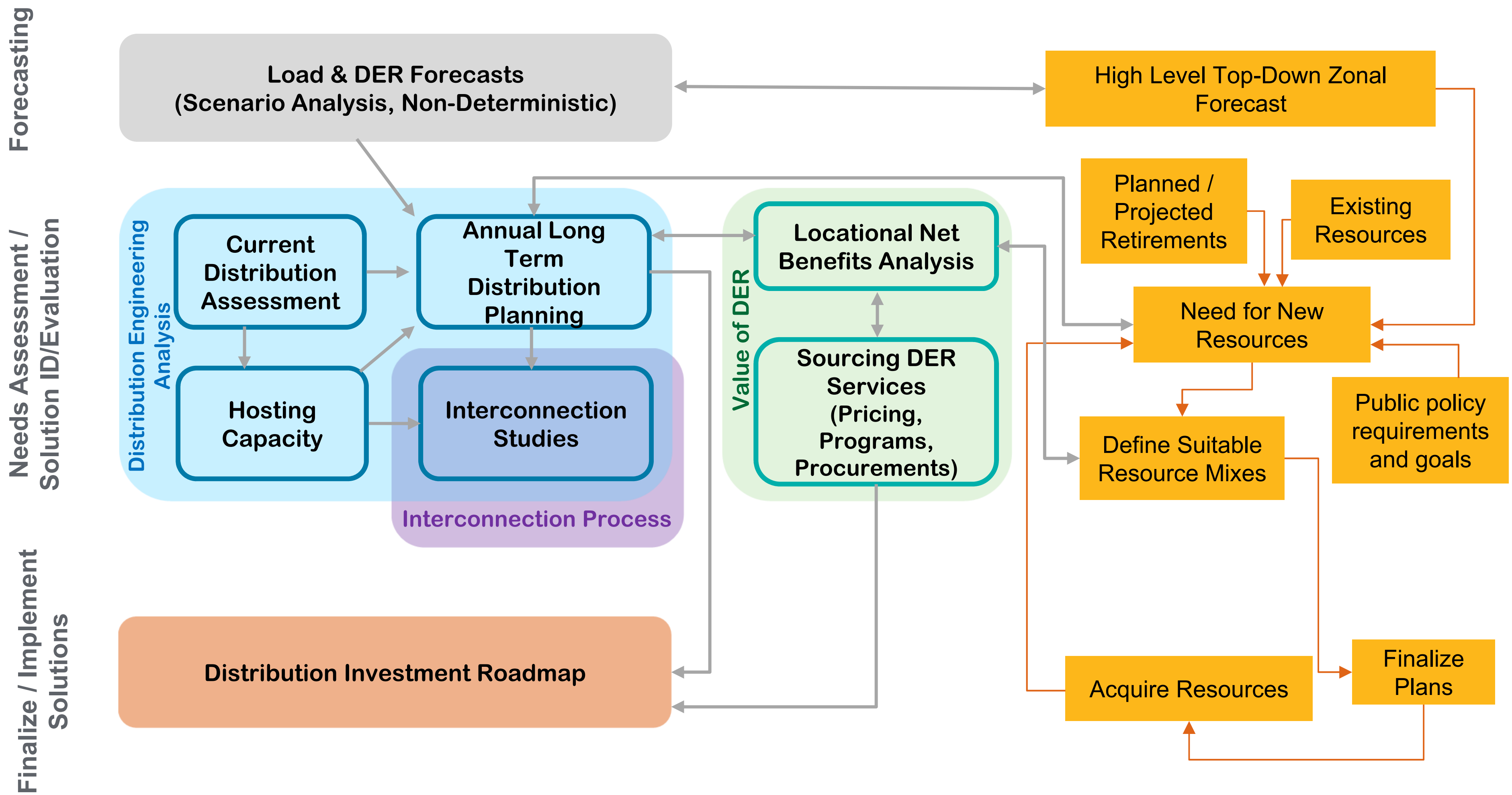
Expanded View of Coordination



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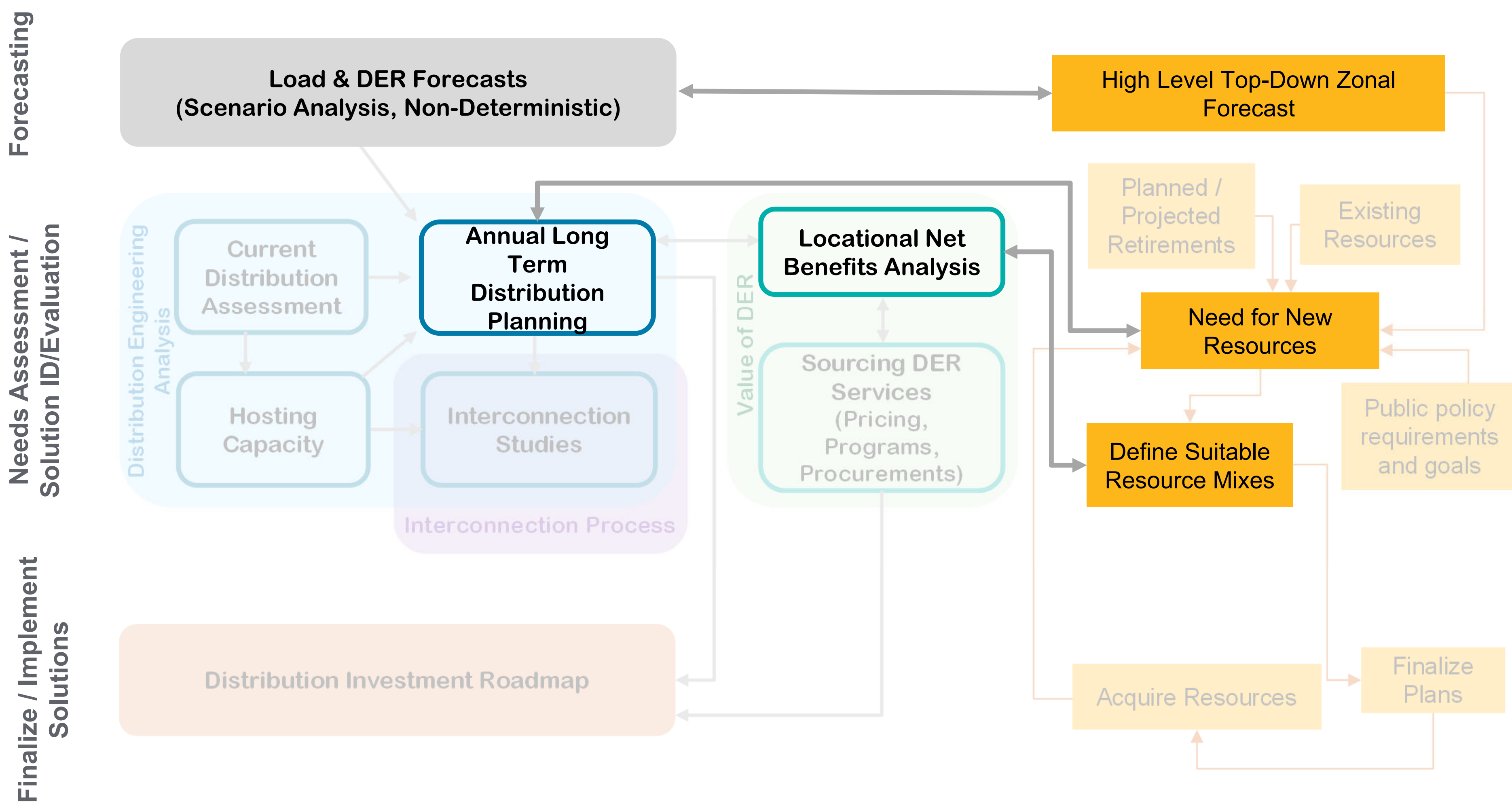
Key Focal Points for Coordination



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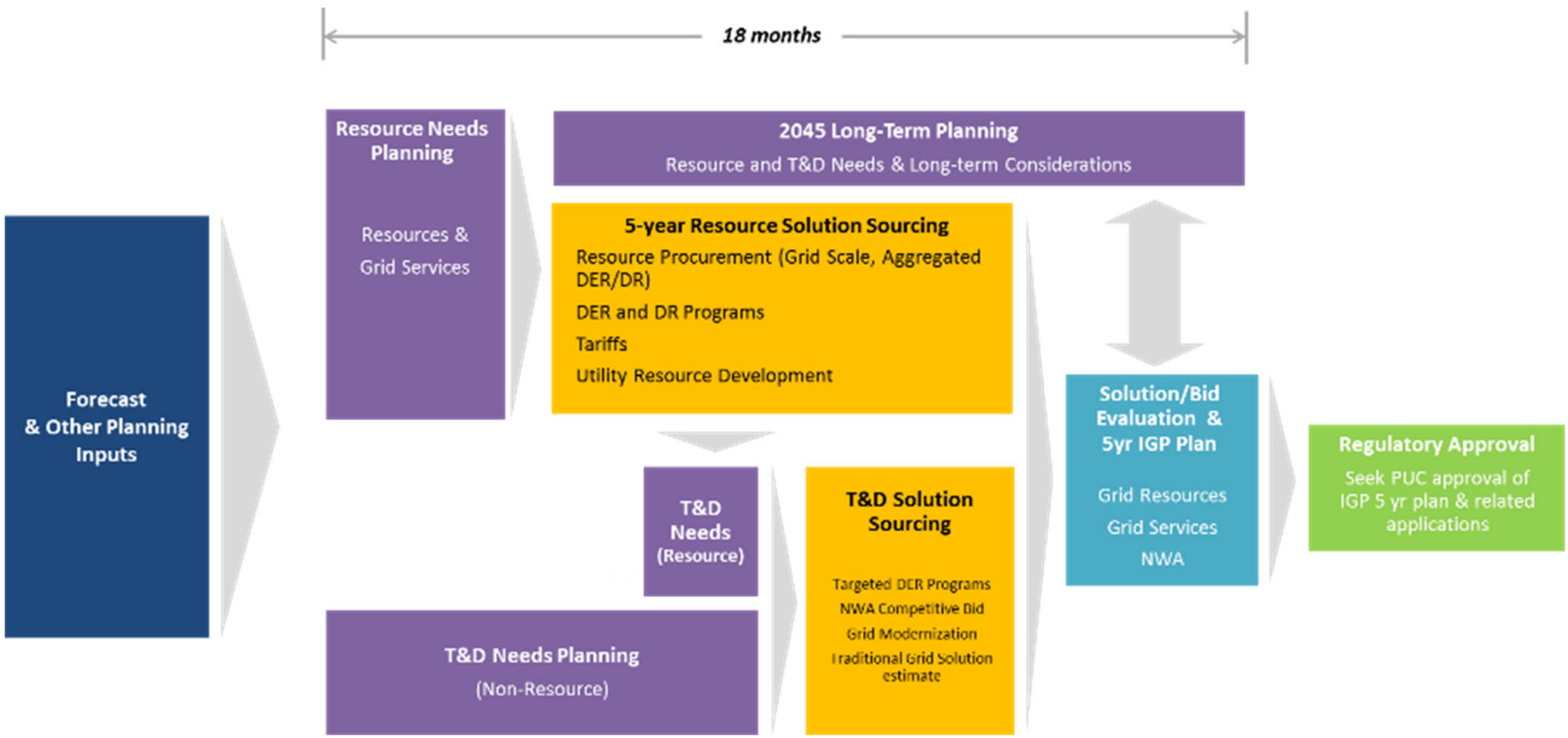
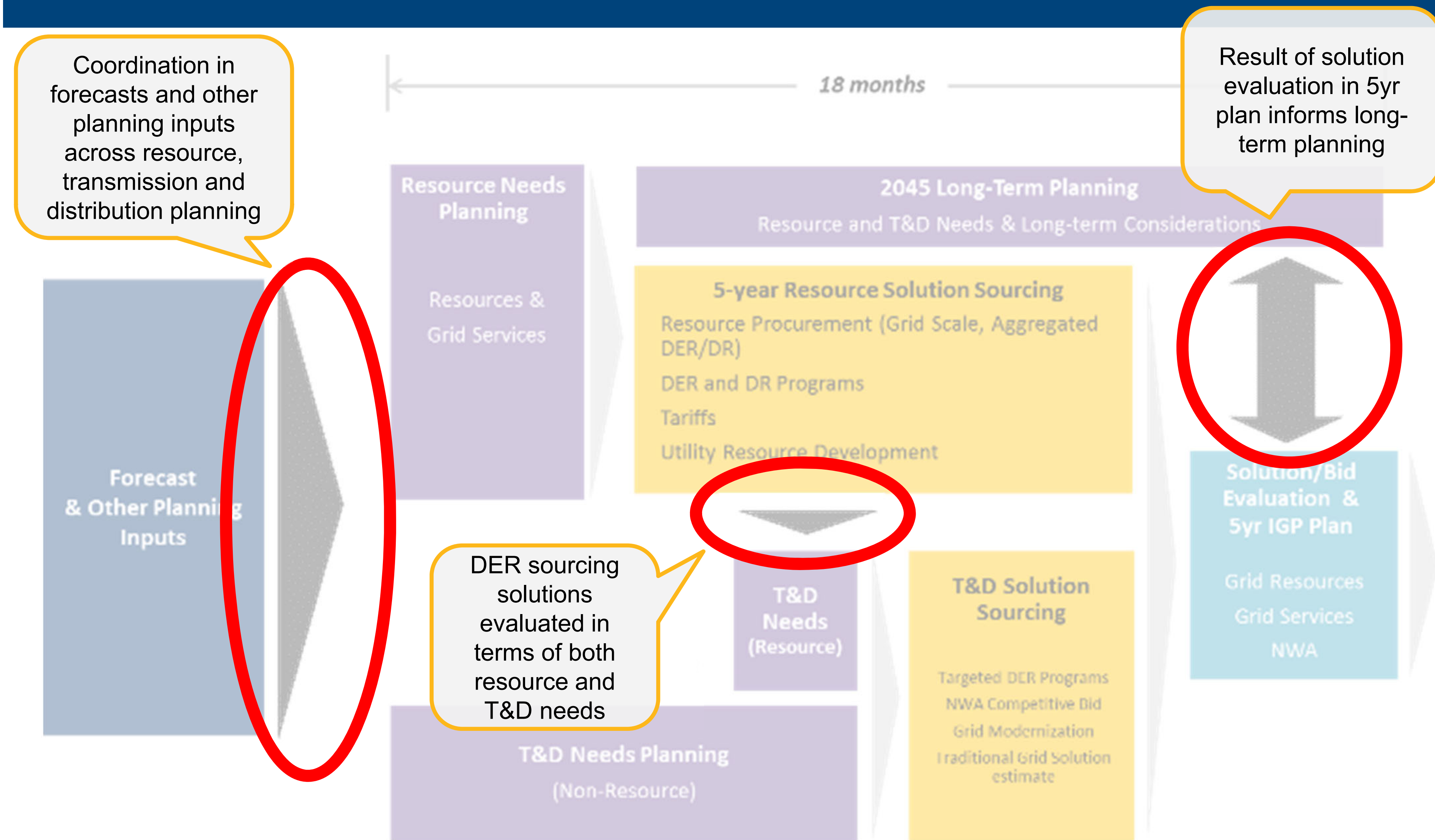
HECO - IGP & Solution Sourcing Process



Source: Hawaiian Electric

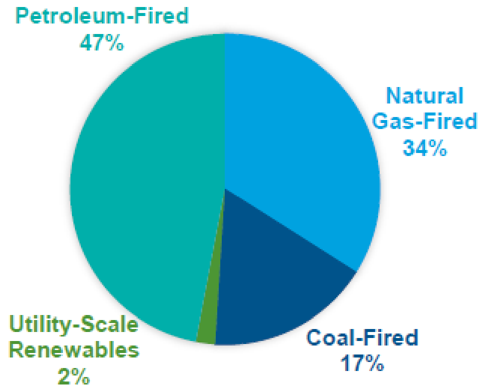
HECO - IGP & Solution Sourcing Process



Source: Hawaiian Electric

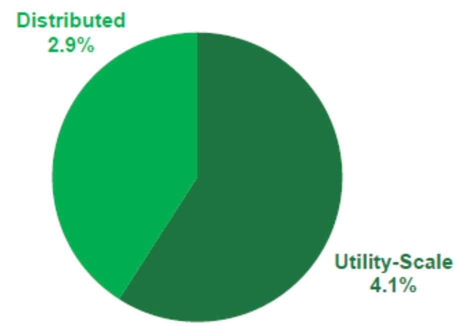
Generation Mix: Puerto Rico & Hawaii

Net Electricity Generation, 2017



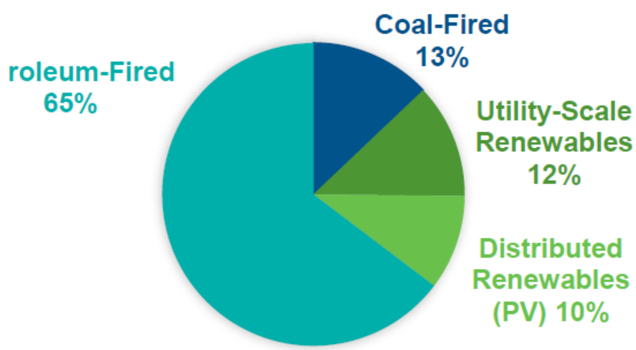
Source: EIA Puerto Rico Territory Energy Profile

Nameplate Installed PV Capacity as Percentage of Peak Load, 2017
Total: 7.0%



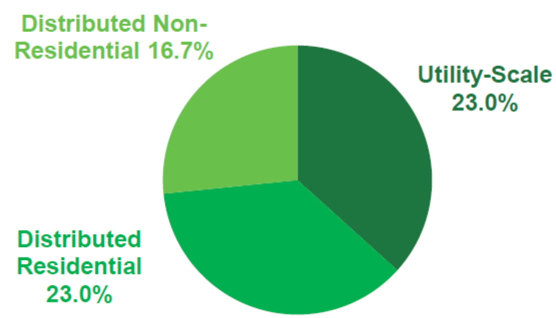
Source: ICF Analysis of EIA and Puerto Rico Electric Power Authority data

Net Electricity Generation, 2018



Source: EIA Electricity Data Browser

Nameplate Installed PV Capacity as Percentage of Peak Load, 2017
Total: 62.7%



Source: ICF Analysis of EIA and Wood Mackenzie Power & Renewables Data

Source: NARUC-NASEO Task Force Member States: Introductory Information (April 2019)

Lessons Learned

- **Changes to distribution planning should proactively align with state policy objectives and pace of customer DER adoption**
- **Define clear planning objectives, expected outcomes and regulatory oversight – avoid micromanaging the engineering methods**
- **Define the level of transparency required for distribution planning process, assumptions and results**
- **Engage utilities and stakeholders to redefine planning processes and identify needed enhancements**
- **Stage implementation in a *Walk, Jog, Run* manner to logically increase the complexity the scope and scale as desired**
- **Effective coordination and alignment between planning processes has the potential to produce better solutions**

BREAK

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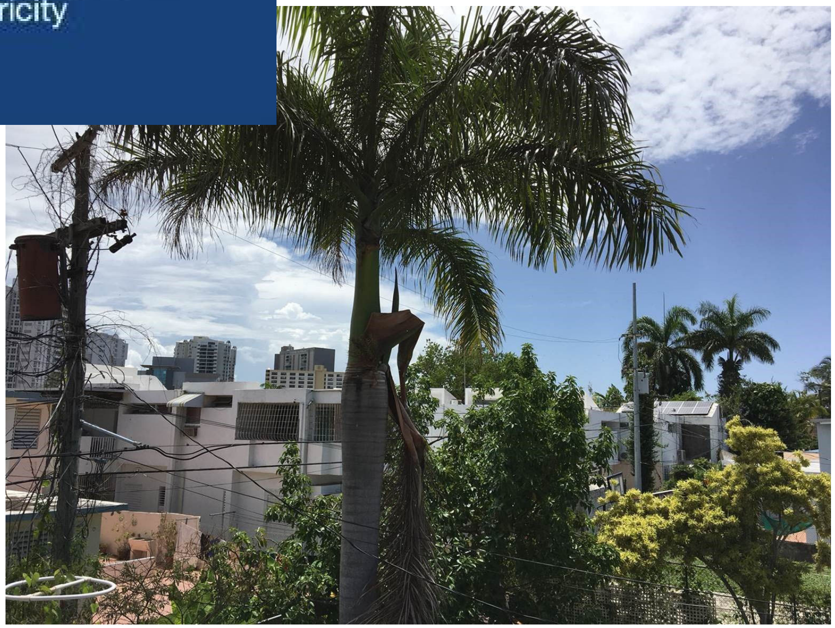

Core Elements of IDP

Tom Mimnagh, ICF

Puerto Rico Energy Bureau
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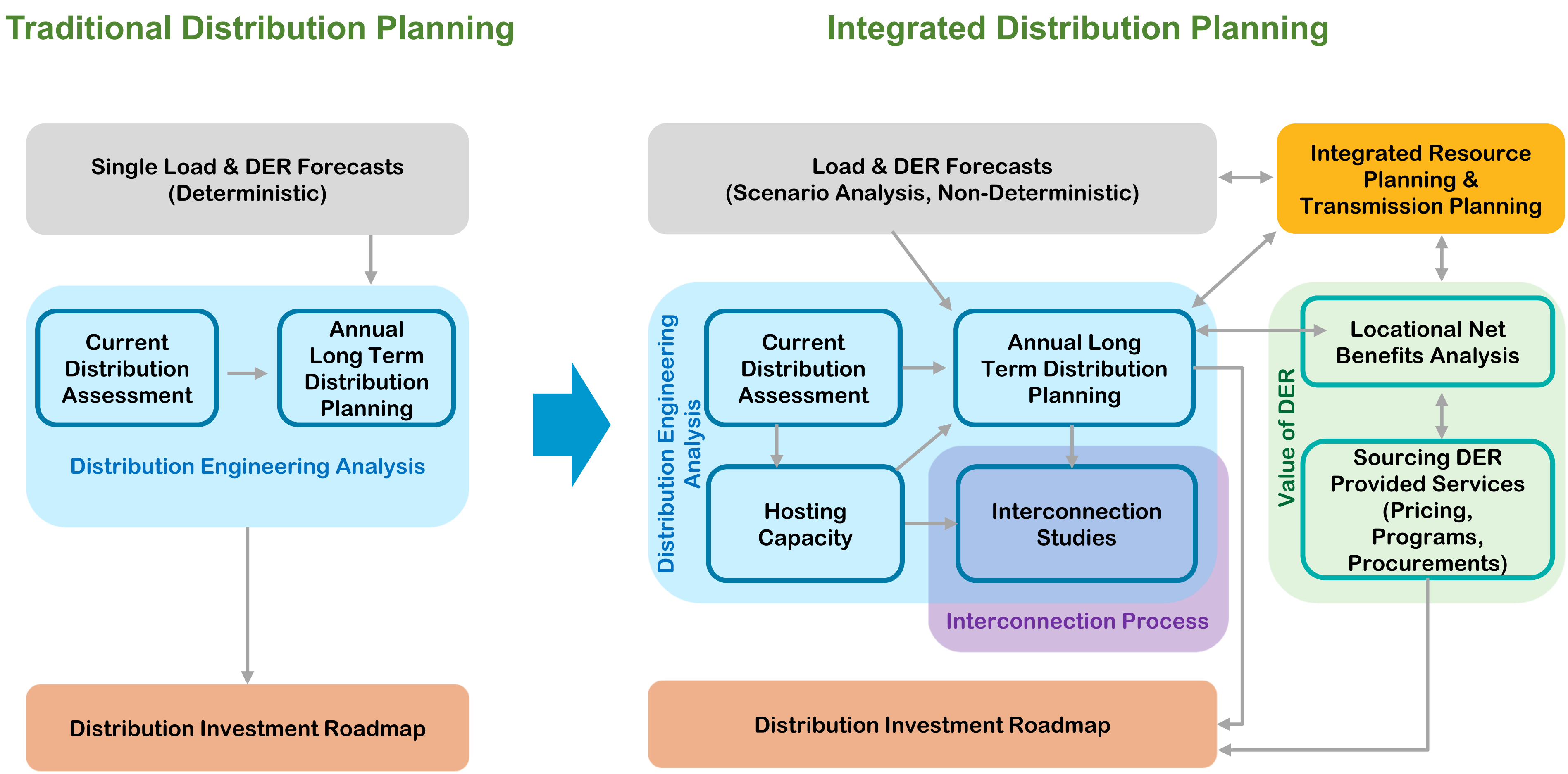
Integrated Distribution Planning



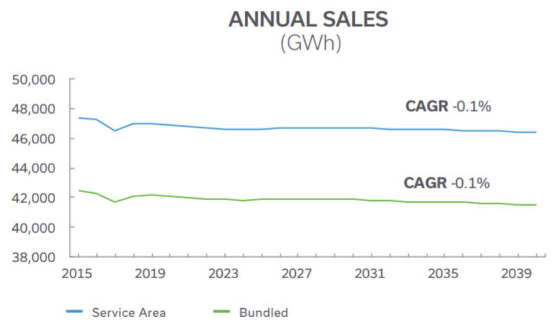
Integrated Distribution Planning Elements

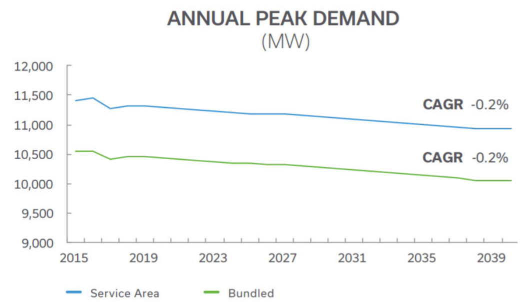
Load and DER Forecasting	Shift Toward Scenario-based Forecasting
Interconnection	Efficient and More Transparent DER Interconnection
Hosting Capacity Analysis	Improved Understanding of System Constraints
Locational Value Assessment	Improved Accuracy of Locational Value Measures and Assessment of NWA vs. capex

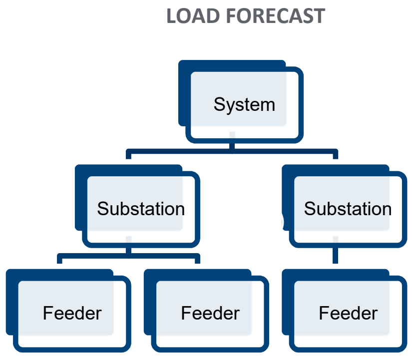
- Technology Integration
- Customer Strategy Implications
- Stakeholder Engagement

Load and DER Forecasting

What is Load Forecasting?



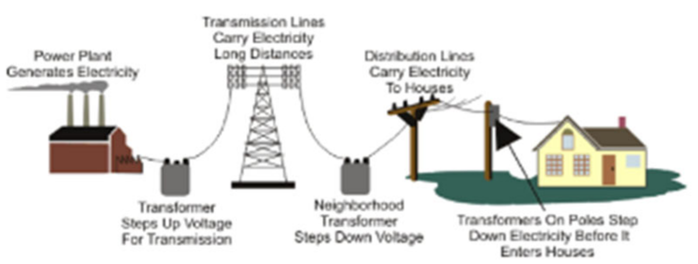




- **Maintained at multiple levels: System; Substation; Feeder**
- **Deeply detailed as load varies across location and time**
- **Allows utilities to ensure that equipment ratings and distribution system planning criteria are maintained**

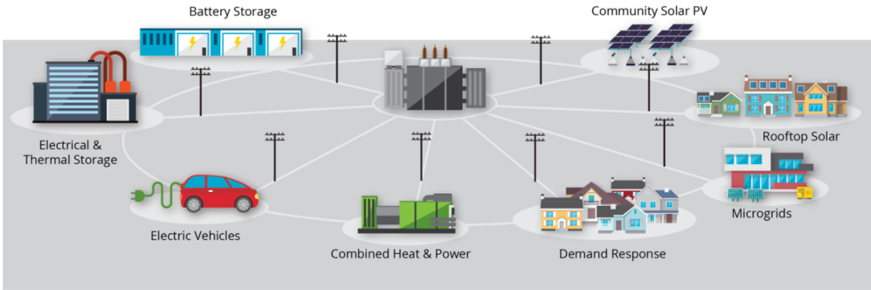
Evolution of Forecasting

Today: Load Forecasting



- Ensure customer growth is accounted for
- Capacity and reliability planning is for peak loading conditions

New: Load and DER Forecasting

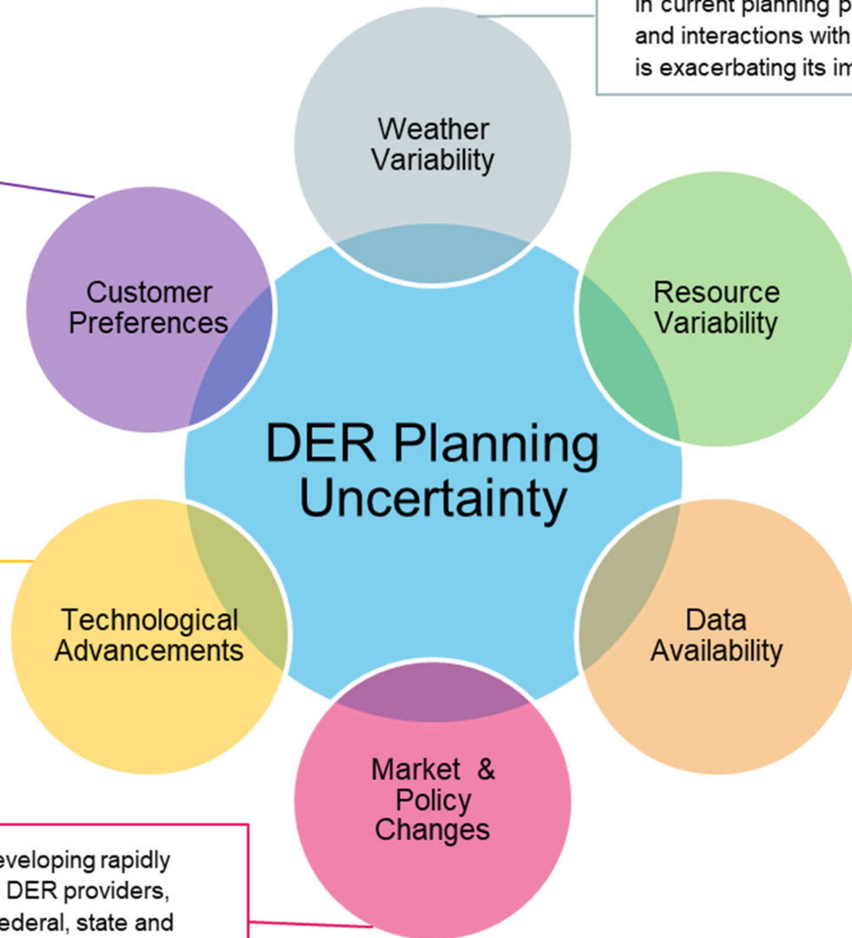


- Integrate the presence and availability of Distributed Energy Resources (DER) into forecasts and planning processes
- Capacity and reliability planning extends beyond peak load periods

DER Forecasting Challenges

Though weather variability has been included in current planning processes, its correlation and interactions with DER resource variability is exacerbating its impacts

Decreasing DER costs, incentives, environmental awareness, etc., are influencing customer preferences and creating localized DER adoption patterns which adds to the forecasting uncertainty at the granular level.



Inherent variability in DER generation profiles due to weather (PV), charging behavior(ES), tariff structures (EE,EV), etc. can impact power reliability, cause voltage and require system upgrades.

Advancements in DER technology and smart functionalities is injecting uncertainties in energy usage patterns and DER adoption.

Lack of granular, historical and behind-the-meter DER installation can severely impact utility forecasting and resource planning

Market mechanisms for DERs is developing rapidly prompted by increase in third-party DER providers, novel business models, favorable federal, state and local policy changes for DERs, etc. This is influencing DER growth temporally and spatially

DER Forecasting

Quantifying Uncertainty | DER Forecasting Process

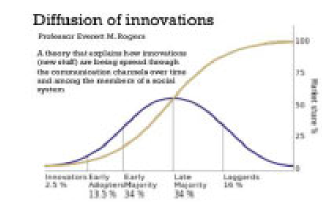
ID Drivers of Uncertainty

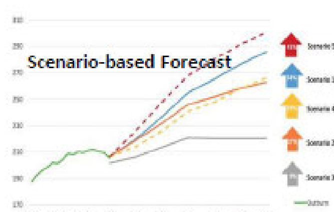
Assess Available Data

Data Availability
Data Quality
Data Vintage and Refresh Rate

Types of Data
- Historic Adoption
- Demographics
- Tech Price (Cost)
- Tech Operating characteristics
- Customer Energy Use and Load Profiles

Select Analytic Framework





Develop Assumptions

Policy
- Subsidies
- Prescribed programs
- Utility Rates/Tariffs

Technology
- Price (Cost)
- Value (Benefit)
- Operating characteristics

Consumer
- Addressable market
- Demand curve and Elasticity of demand

Develop Range of Outputs

- Technology Adoption
- Energy Impact
- Capacity Impact

Impact Analysis

- Energy Demand Impact
- Peak Capacity Impact
- Infrastructure Needs
  - Distribution
  - Transmission
- Customer Rate Impact
- Financing Needs
- Emissions Impacts

Integrating the Presence and Availability of DER into Forecasts

Stage 1
Improved accounting

Distinguishing DER in peak load forecasts at the substation and feeder level

Stage 2
Increased granularity

Improving spatial and temporal granularity of forecasts

Stage 3
Beyond deterministic methods

Introducing probabilistic and scenario planning methods to account for uncertainty

Stage 1 – Improved Accounting

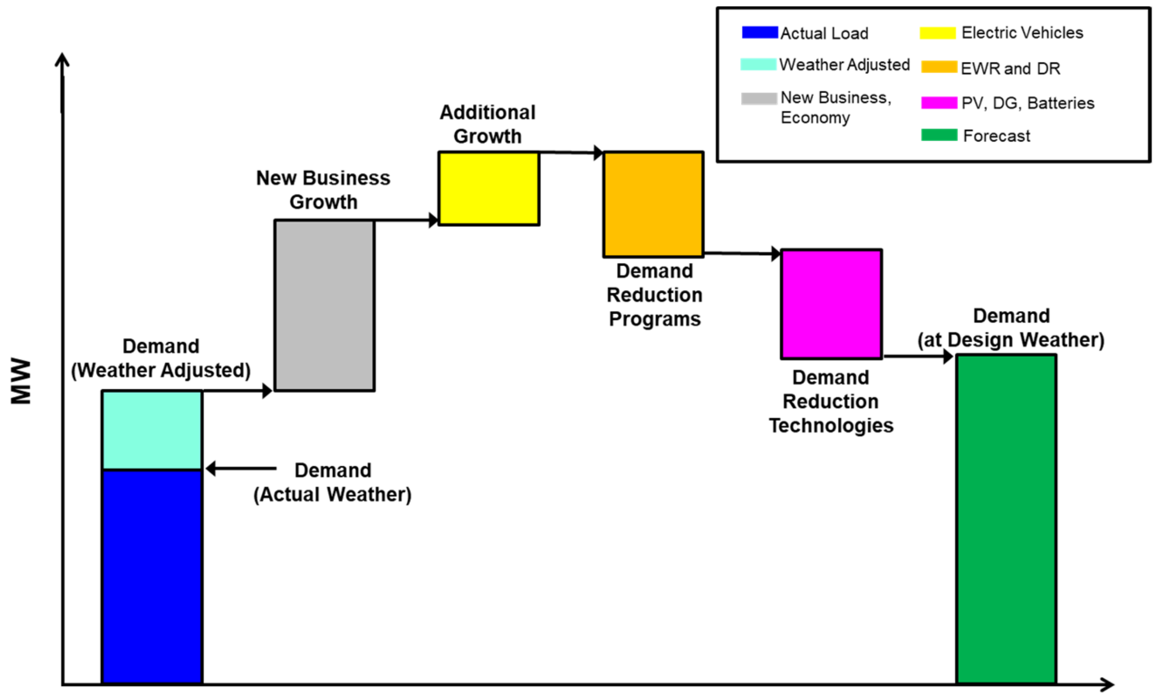
Characteristics may include:

Databases for existing and pending DG are up-to-date

Improved information flow between distribution planners and DSM program managers

DER contributions at historical peak loads are understood

Future contributions of DER are distinctly captured, reflecting their anticipated growth rates



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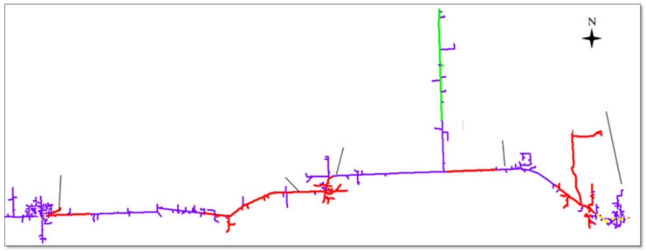
Stage 2 – Increased Granularity

Characteristics may include:

- Higher quality circuit information
- Improved load allocations through integration of AMI data with planning software
- Inclusion of DG and Energy Storage devices in circuit power flow models
- Seasonal load and resource profiles by distribution feeder
- Bottom-up compilation of distribution feeder-level forecasts inclusive of DER and EVs (gross and net load)



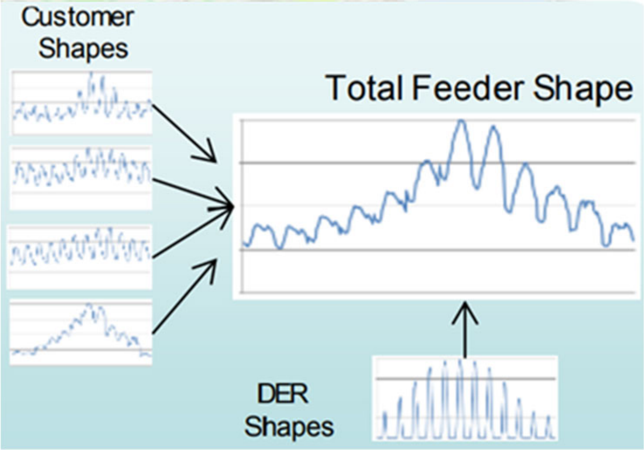


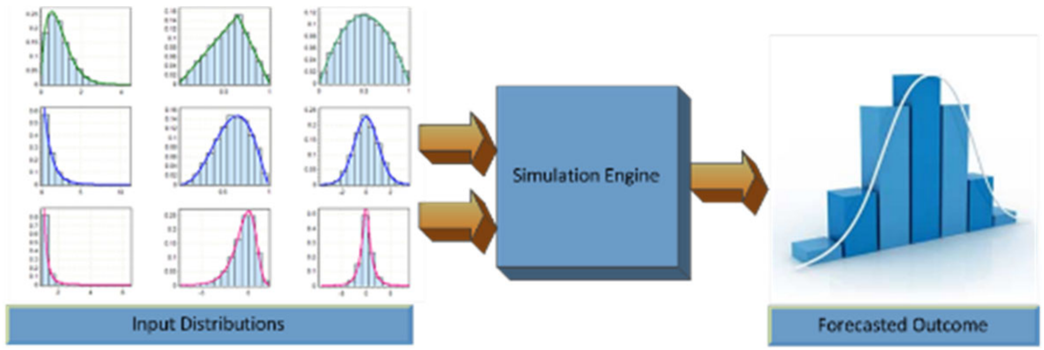
Image source: DER Growth Scenarios and Distribution Load Forecasting Working Group Discussion, May. 3th, "Distributed Generation ". http://drpwg.org/wp-content/uploads/2017/04/GSWG_Distributed_Generation-FINAL.pdf

Stage 3 – Beyond Deterministic Methods

Characteristics may include:

Scenario Planning – developing multiple possible scenarios to allow for forecasts to capture a full range of possible outcomes

Probabilistic planning – incorporates the probability distribution of multiple inputs to produce a distribution of possible circuit loads that reflect possible outcomes in probability-weighted framework



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Key Takeaways

- Increased granularity of DER and load forecasts allows for better reflection of DER impacts, supports prudent investments to maintain reliability, safety, security
- Historical DER adoption rates may not serve as effective proxies for future adoption in the case of nascent technologies such as battery storage and EV's
- Multi-Scenario planning will improve utilities' ability to identify system needs necessary to overcome long-term uncertainties regarding customer DER adoption
- Design analysis and investments based on value proposition of the intended use cases: level of granularity, time horizon, probabilistic inputs/outputs
- Increasing granularity of forecasts depends on high quality system monitoring data as well as systems that provide access to that data
- AMI and other sources of system monitoring data in the context of planning can inform system planning, hosting capacity, interconnection and short-term operational planning

Hosting Capacity

Overview - Hosting Capacity

- Hosting Capacity is the amount of DER that can be accommodated without adversely impacting power quality or reliability under current configurations and without requiring infrastructure upgrades.
- Hosting Capacity is location dependent (interconnection point on the distribution network), feeder-specific (A feeder’s hosting capacity is not a single value, but a range of value) and time-varying (change in distribution and operation configurations).
- Hosting capacity evaluations require precise models of entire distribution system

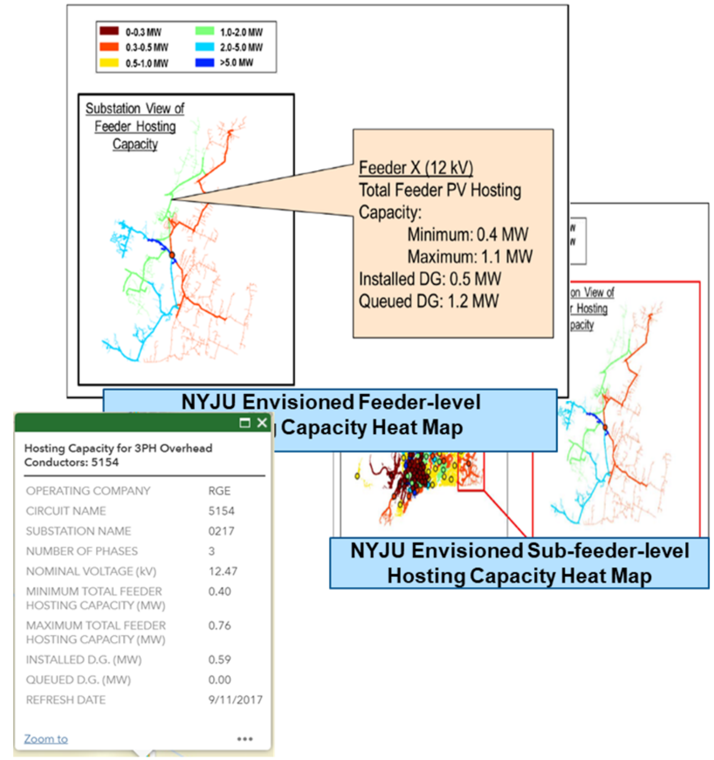


Image : Joint Utilities of New York Supplemental DSIP
http://documents.dps.ny.gov/public/Common/ViewDoc.aspx?DocRefId={3A80BFC9-CBD4-4DFD-AE62-831271013816}

Hosting Capacity – Requirements

- Measurement Data – SCADA at substation
- GIS mapping of distribution infrastructure
- Individual feeder analysis
- Peak, Off-peak, voltage class dependent
- Modelling capabilities – scale of distribution models
- Grid edge measurements – less known
- System-wide models often unavailable
- Aggregation of capacity changes at substation level
- Connected and queued DER
- Voltage regulation
- Feeder re-configuration

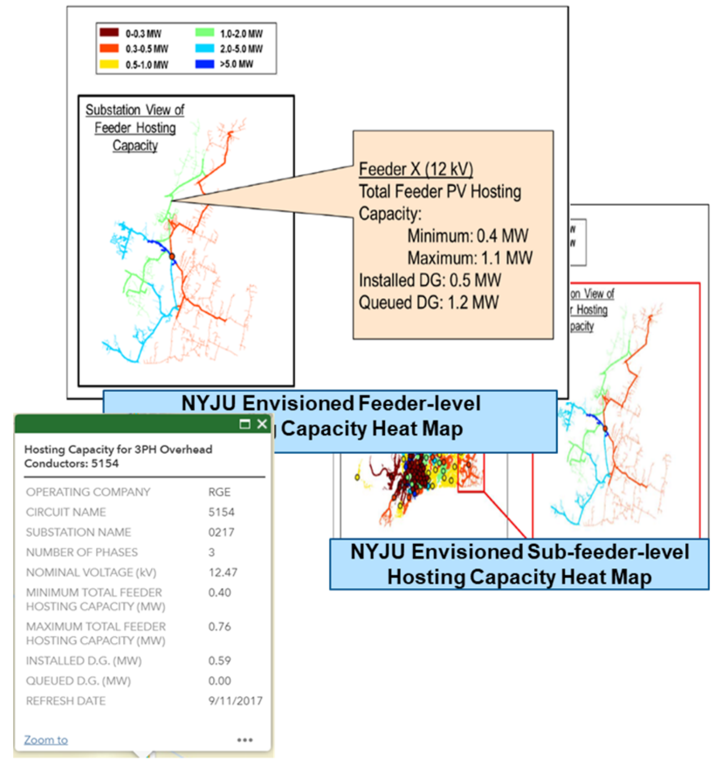
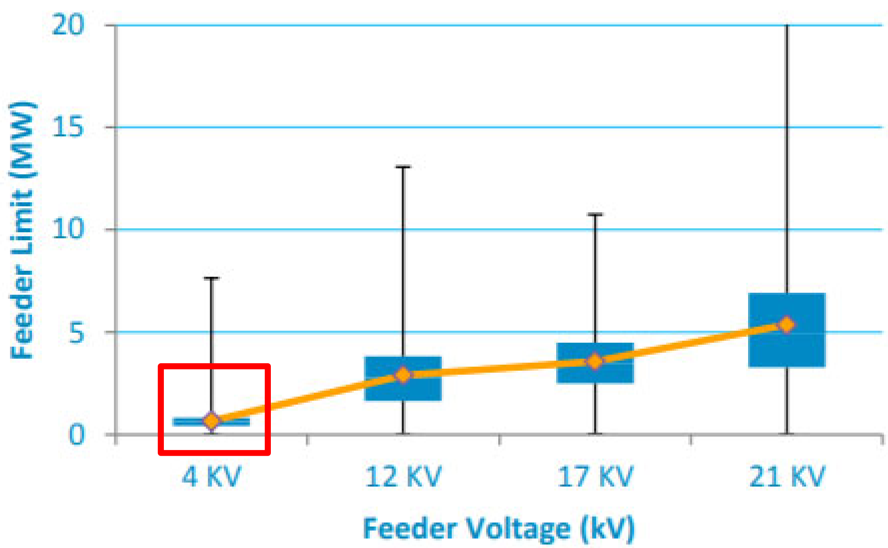


Image : Joint Utilities of New York Supplemental DSIP http://documents.dps.ny.gov/public/Common/ViewDoc.aspx?DocRefId={3A80BFC9-CBD4-4DFD-AE62-831271013816}

Case Study: California, PG&E 4kV System

- 4 kV feeders have much less capacity as compared to other feeders because of their lower voltage and age (generally older than other feeders).

Results Analysis for Solar PV Hosting Capacity Analysis (2015 ICA data)



- 4 kV systems provide limited ability to host DG (PV) as compared to higher voltage classes
- When addressing a 4 kV capacity deficiency, PG&E generally does not seek to increase the capacity of 4 kV distribution systems by installing new 4 kV transformers and feeders
- PG&E will seek to convert portions of 4 kV systems to a higher voltage class
- This approach provides an opportunity to upgrade the distribution system and gradually reduce the amount of 4 kV feeders

Source: Pacific Gas & Electric (PG&E) 2015 Distributed Resources Plan (DRP) Filing and Webinar

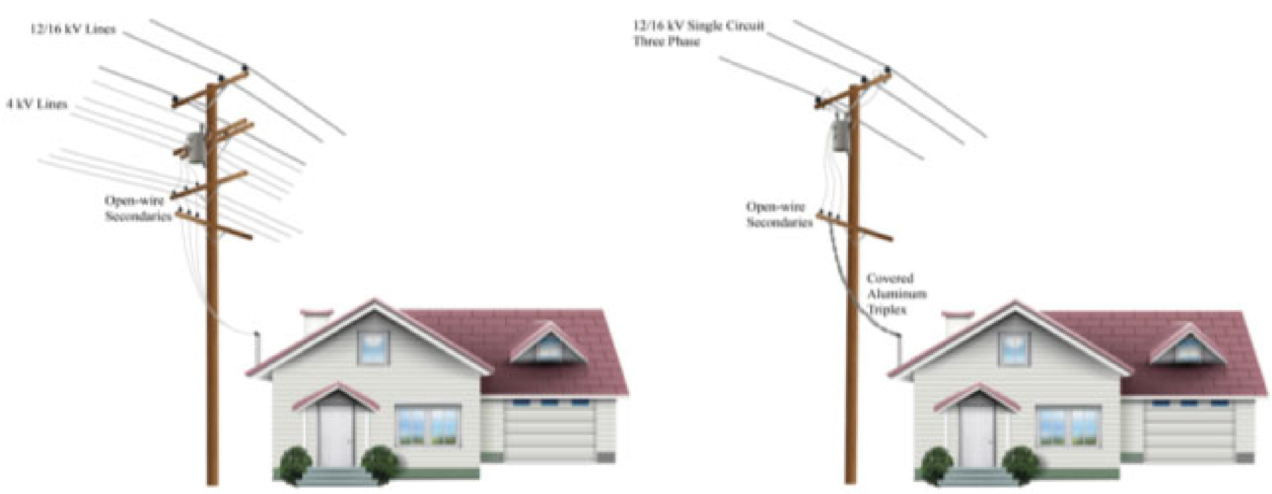
Case Study: California, SCE 4kV System

- Over 1,100 of SCE's circuits and 211 substations operated at voltages of 4 kV or lower and made up some of the oldest parts of SCE's system.
- Over time, SCE experienced challenges serving customers and system operations due to age, obsolescence, increased load, and DER growth.

Figure IV-24
4 kV Cutover - Example

Before: Customer Fed From 4kV System with Parallel 12/16 kV Circuit Constructed on the Same Pole Line

After: 4kV Lines Removed; Customer Fed From Existing 12 kV or 16 kV



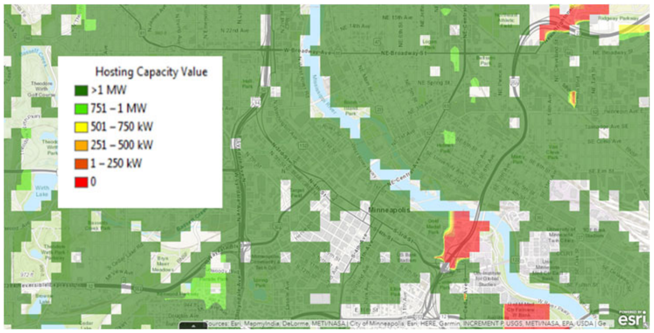
Source: Southern California Edison (SCE) 2018 GRC

Use Cases for Hosting Capacity

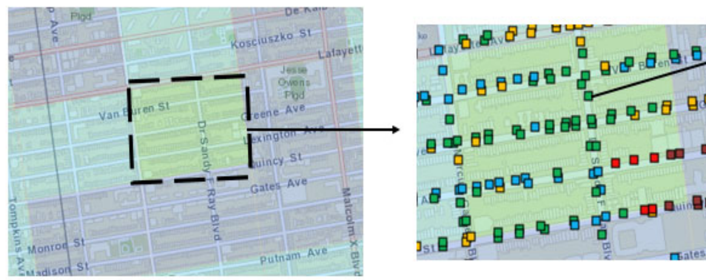
Use Case	Objective	Method	Challenges
Development Guide	Accelerate DER deployment	Focus development capital in potentially lower cost areas	Regularly updated analysis of the full system and data visualization to facilitate external use
Technical Screen	Facilitate timely, more robust interconnection screening process	Hosting capacity replaces less accurate rules of thumb in the interconnection technical screens	High granularity required, model validation, benchmarking to detailed studies
Distribution Planning Tool	Reduce future barriers to DER integration	Proactive identification of system upgrades to increase hosting capacity	Higher input data requirements and granular load and DER forecasts
Dynamic Hosting Capacity	Real time dispatch feasibility analysis for DER services	Analysis of impacts of DER output on the as-switched system	Deployment of ADMS/DERMS to facilitate implementation

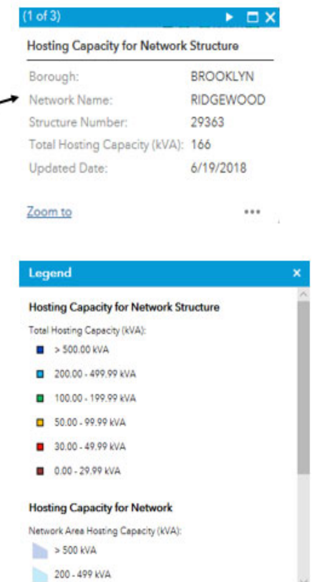
Development Guide Use Case

- Direct developers to lowest cost interconnection points
- System security and data access considerations should inform choices on data granularity
- The refresh rate and accuracy of the analysis determines the relative value to stakeholders



Xcel Energy Heat Map

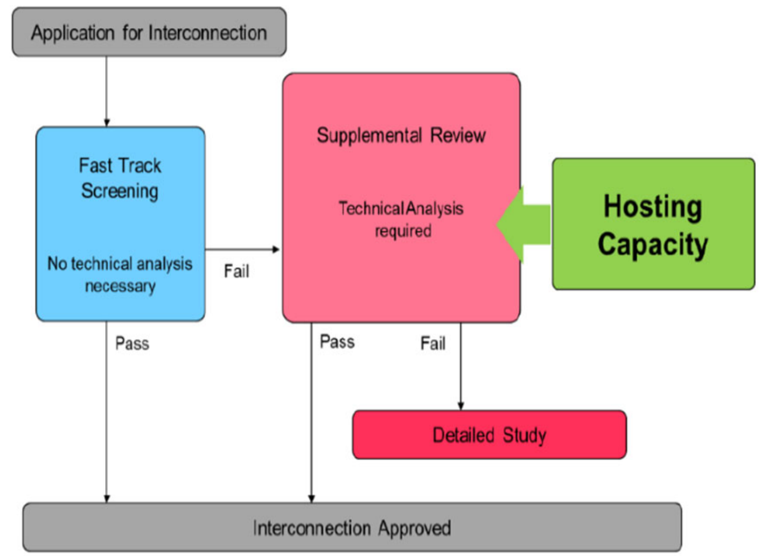




Con Edison Network Hosting Capacity Map

Interconnection Technical Screen Use Case

- Hosting Capacity can be used to inform utility interconnection screening processes and support DER developers' understanding of more favorable locations for interconnection.
- HC helps streamline DER interconnection by:
  - Identifying feeders with minimal or no hosting capacity to interconnect DERs
  - Fast-tracking interconnection requests in regions favorable for DERs and strategic for utility planning
- For many DER applications, the HC analysis and maps are a sufficient and efficient proxy for the technical screens employed by each individual utility.

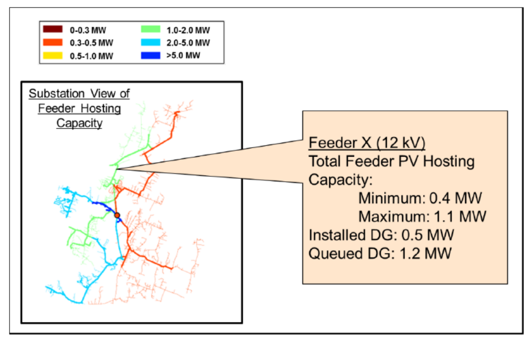


Source: Electric Power Research Institute, Impact Factors, Methods, and Considerations for Calculating and Applying Hosting Capacity, 3002011009, Feb 2018.

Distribution Planning Use Case

- Increasing spatial granularity aids DER tracking and distribution system planning.
- Increasing the granularity of HC portal can be used to track DER installations and inform distribution planning for identifying system upgrades and increasing HC.
- Improving the granularity also increases costs to process extensive information, generate maps, etc. If utilities would publish the granular views of HC, maintaining the external facing portals (refresh rate, handling queries, etc.) would need to be considered.

NYJU Envisioned Feeder-level Hosting Capacity Heat Map



NYJU Envisioned Sub-feeder-level Hosting Capacity Heat Map

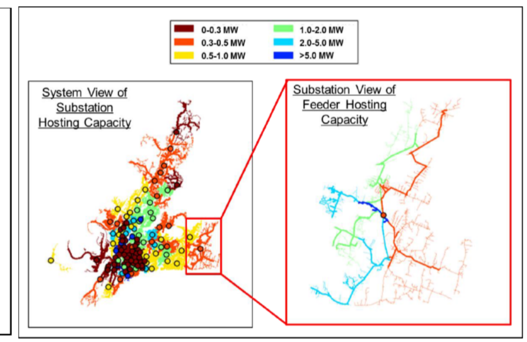


Image : Joint Utilities of New York Supplemental DSIP
http://documents.dps.ny.gov/public/Common/ViewDoc.aspx?DocRefId={3A80BFC9-CBD4-4DFD-AE62-831271013816}

National Activities on Hosting Capacity

	Hosting Capacity
Hawaii *Key Driver: Legislative Mandates & regulatory requirements from Commission*	• Locational Value Maps available online • Integrated Interconnection Queue for all areas, including those currently exceeding hosting capacity • Customers can check the status of their interconnection application online
California *Key Driver: Distribution Resource Planning Proceedings*	• Goal is to streamline the interconnection review process. • Replaces interconnection screens in some instances • Interconnection Capacity Analysis (ICA) 2.0 maps expand analysis to include output values such as alternate circuit configurations and storage ICA with high accuracy and monthly updates
New York *Key Driver: Reforming the Energy Vision*	• Hosting Capacity maps are provided to guide solar PV developers to locations with lower expected interconnection costs • Goal is to eventually build to an integrated value assessment tool
Minnesota *Key Driver: Regulatory & legislative mandates for renewable generation, emission reduction and fossil fuel reduction*	• Focus on planning and incorporating lessons learned from other jurisdictions • Xcel published visual hosting capacity maps and allow for formal request for interconnection on-site and for pre-application data request

Benchmarking Hosting Capacity

Use Case	Description	CA IOUs	NY IOUs	HI	APS	Xcel	Pepco
Utility Interconnection Analysis	HCA as a utility tool for evaluating interconnection applications (SIS), (dependency: interconnection)				●		
Distribution Planning Tool	HCA as a tool to enable greater DER integration by identifying potential future constraints and proactive upgrades (dependency: locational value, forecasting)	●		●			
Interconnection Technical Screen	Use of HCA as a means to automate technical screens as part of the state interconnection process (dependency: interconnection)	●		●			●
Development Guide	HCA to identify areas with potentially lower interconnection costs	●	●	●		●	●
Dynamic Hosting Capacity	Identify impacts to the system from DER dispatch in real time based on the as-switched system (dependency: locational value)						

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Barriers to Hosting Capacity Analysis

- **Value Proposition**: Hosting capacity application must be focused where it has the potential to provide value, based on the utility's specific planning and operating parameters.
- **Internal coordination**: For ensuring the hosting capacity use cases effectively inform the approach and methodology for carrying out hosting capacity
- **Data Privacy**: Publication of visualization platforms for hosting capacity analysis could make public some potentially sensitive system data
- **Communication**: Effective external communication of hosting capacity objectives, hosting capacity results and framing visualization around intended use cases is critical to ensure analysis results are correctly interpreted
- **Cost Allocation**: Proactive measures to increase hosting capacity could result in a cost shift from DER developers to other customers

Key Takeaways

- **Determine the use case**
  - Facilitating DER growth
  - Utility internal planning
- **Understand the data needs (near and long-term)**
  - Inputs: Utility data – metering data, asset information
  - Outputs: Data and format to be published for developers
  - Information Updates and granularity of forecasts
- **Considerations for increasing Hosting Capacity**
  - Control Systems and Smart grid technologies – Traditional utility and emerging technologies on the utility and customer side
- **Use of DER (Energy Storage, Demand Response, etc.)**
  - Solutions to look beyond hosting capacity – Flexible Interconnection and DER curtailment

Locational Value & Non-Wire Alternatives

Overview - Locational Value

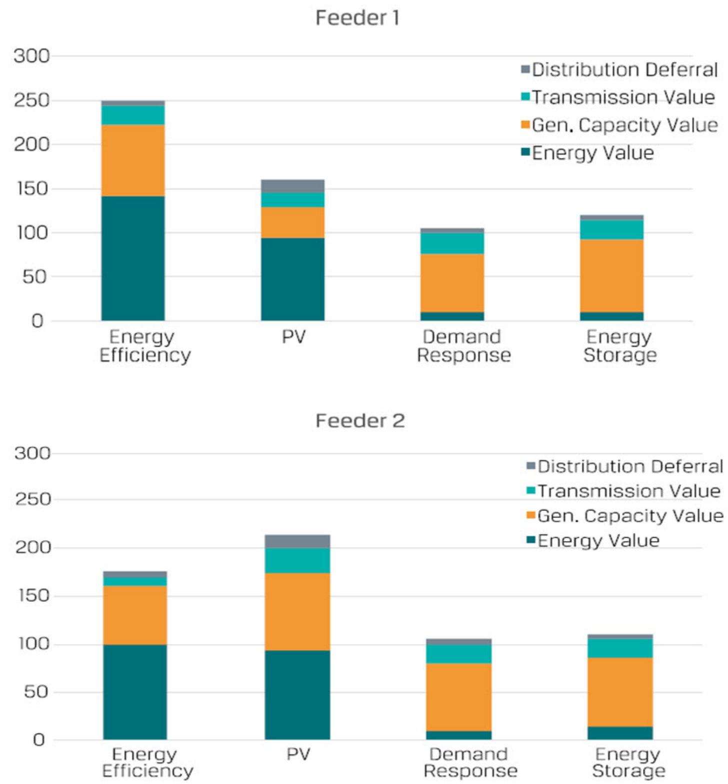
"Locational Value" refers to the value of Distributed Energy Resources (DER) on a **locational basis.**

Term arises from discussion around the inadequacies of existing DER compensation mechanisms that reward equally across a utility service territory (e.g. Net Energy Metering, Energy Efficiency rebates, etc.)

Previously limited to NY and CA, concept is spreading

Hypothesis is that a more accurate valuation is locational, recognizing other characteristics remain important (profiles, technology, etc.)

Longer-term, utilities are seeking to improve locational price signals while deploying advanced DER control strategies.



Source: ICF

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Use Cases for Locational Value Assessment

Use Case	Objective	Challenges
Non-Wires Alternatives	Utilize DER to eliminate or defer system upgrades.	Mapping quantifiable DER performance to utility planning criteria, quantification of costs and risk management.
Program Design	Pivot utility programs to geotarget customer load reductions in areas of need.	Ensuring that incentivized measures provide the anticipated value over their lifetime.
Retail Rate Design	Enable the provision of DER products and services via price signals.	The development of short-term and long-term prices that accurately and transparently reflect the value of distribution services.
Distribution Markets (theoretical)	Enable real-time transactions for grid services.	Requires major regulatory, technological, and business model changes.

Industry Emphasis is on Non-Wire Alternatives (NWA)

NWA: a portfolio of distributed energy resources (DER) such as energy efficiency (EE), demand response (DR), solar PV, battery energy storage (BES), combined heat and power (CHP) etc. that can be used to help provide grid needs.

In Puerto Rico, NWA could support enhanced resiliency.

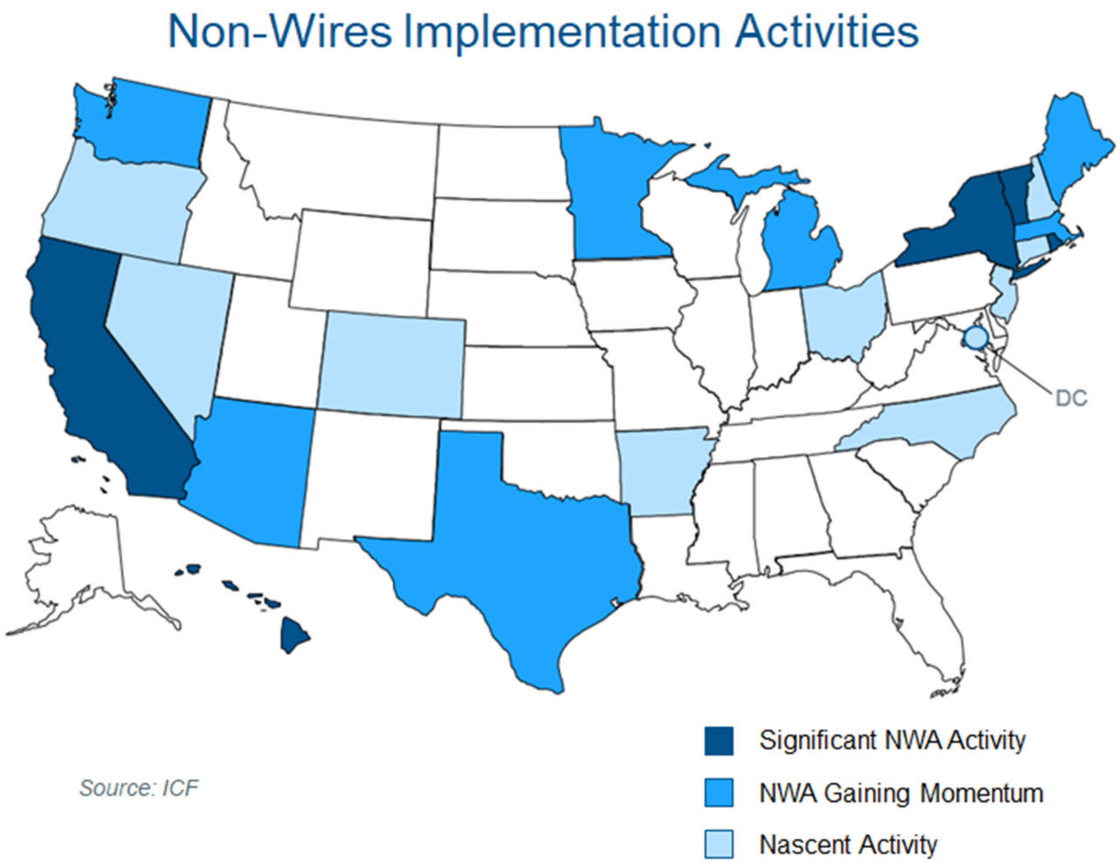
NWA Drivers

- **Regulatory Policy**
- **Environmental Goals**
- **R&D / Innovation**
- **Cost Reduction**

Source: Mountain view in Puerto Rico

NON-WIRES ALTERNATIVES TODAY

- ❖ Still in pilot phase
- ❖ Momentum is building
- ❖ Growing numbers of utilities are working on NWA projects
- ❖ Propelled by regulatory mandates, internal utility decisions, and public/stakeholder input
- ❖ Integrated Distribution Planning learnings are being generated



Source: ICF

NWA Landscape

NWA: Harder in Practice Than in Theory, Need DSM

Case study spotlight: REV CONNECT

NWA Opportunities Listed	Listed and Successful	Successful, Using Targeted DSM	No Resolution Listed	Average Size Load Reduction
47	6	6	39	5-10 MW

Case study spotlight: E4 THE FUTURE, PLMA, Smart Electric Power Alliance

NWA Case Studies	Using EE	Using DR	Using Storage	Average Size Load Reduction
10	4	7	5	1-85 MW

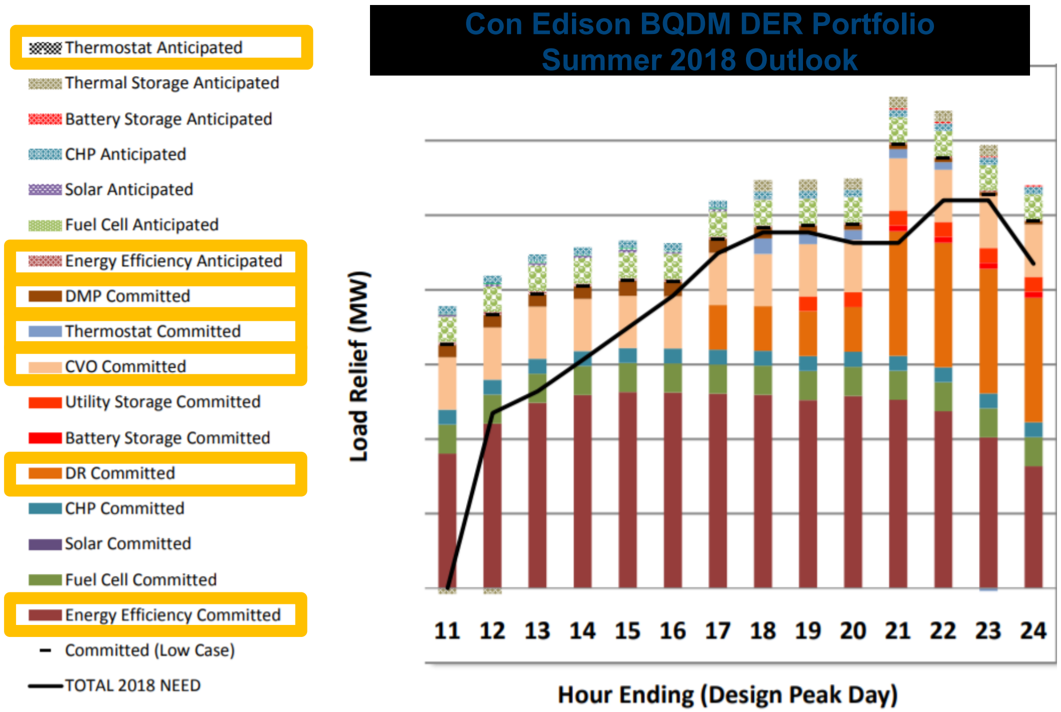
Key takeaway: *procurements need ample lead time, lots of work on contracting process*

Example: Con Edison Brooklyn Queens Demand Management Program

Goal: **$1.2 B Substation Deferral with DER portfolio**

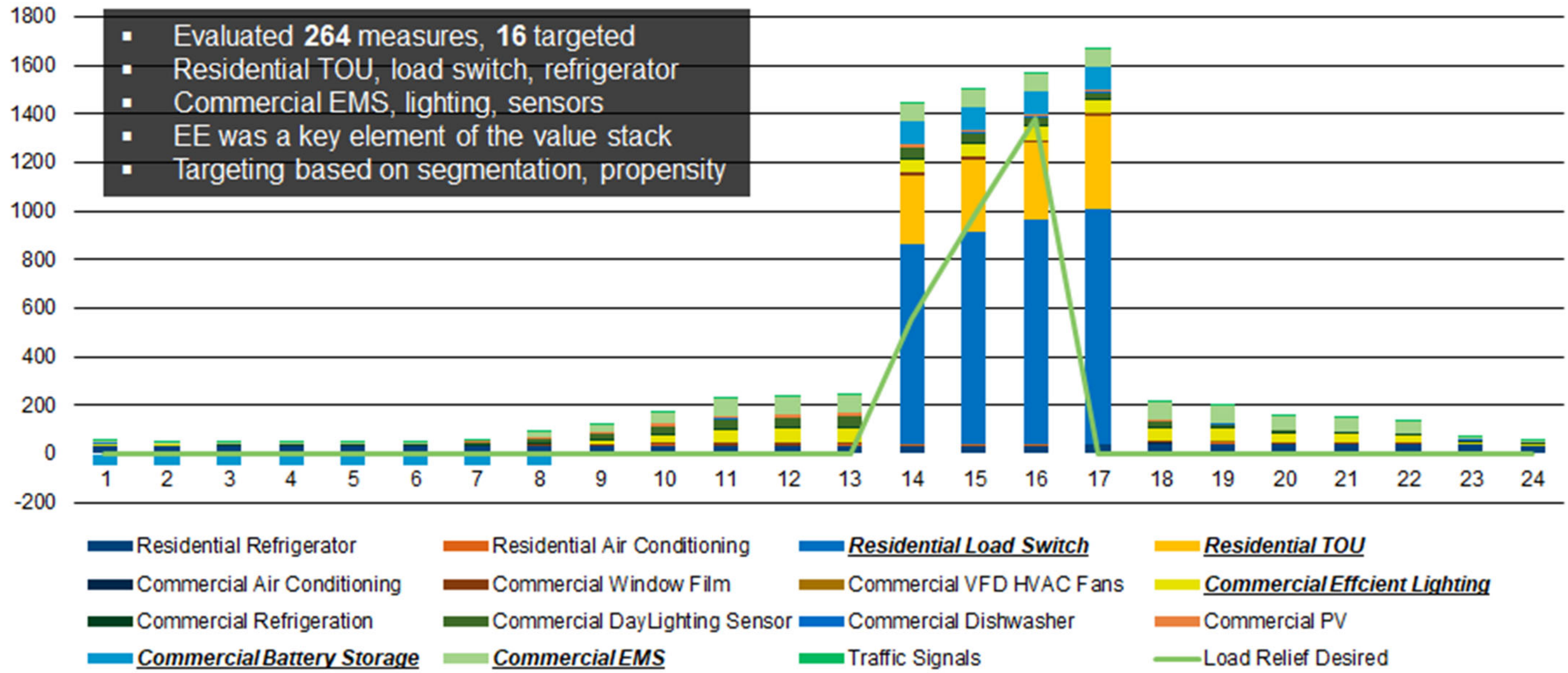
	2016	2017	2018	Total
Customer Side Solutions	9 MW	23 MW	9 MW	41 MW
Utility Side Solutions	3 MW	8 MW	-	11 MW
Total	**12 MW**	**31 MW**	**9 MW**	**52 MW**

An outlier in terms of its size, BQDM played an important role in NY REV and in propelling forward the NWA concept.



Source: Con Edison, Brooklyn-Queens Demand Management , Targeted Demand Management (April, 2017)

Case Study: NWA Consumers Energy (MI)



Source: Consumers Energy, Non-Wires Alternative Pilot, PLMA (November 2017)

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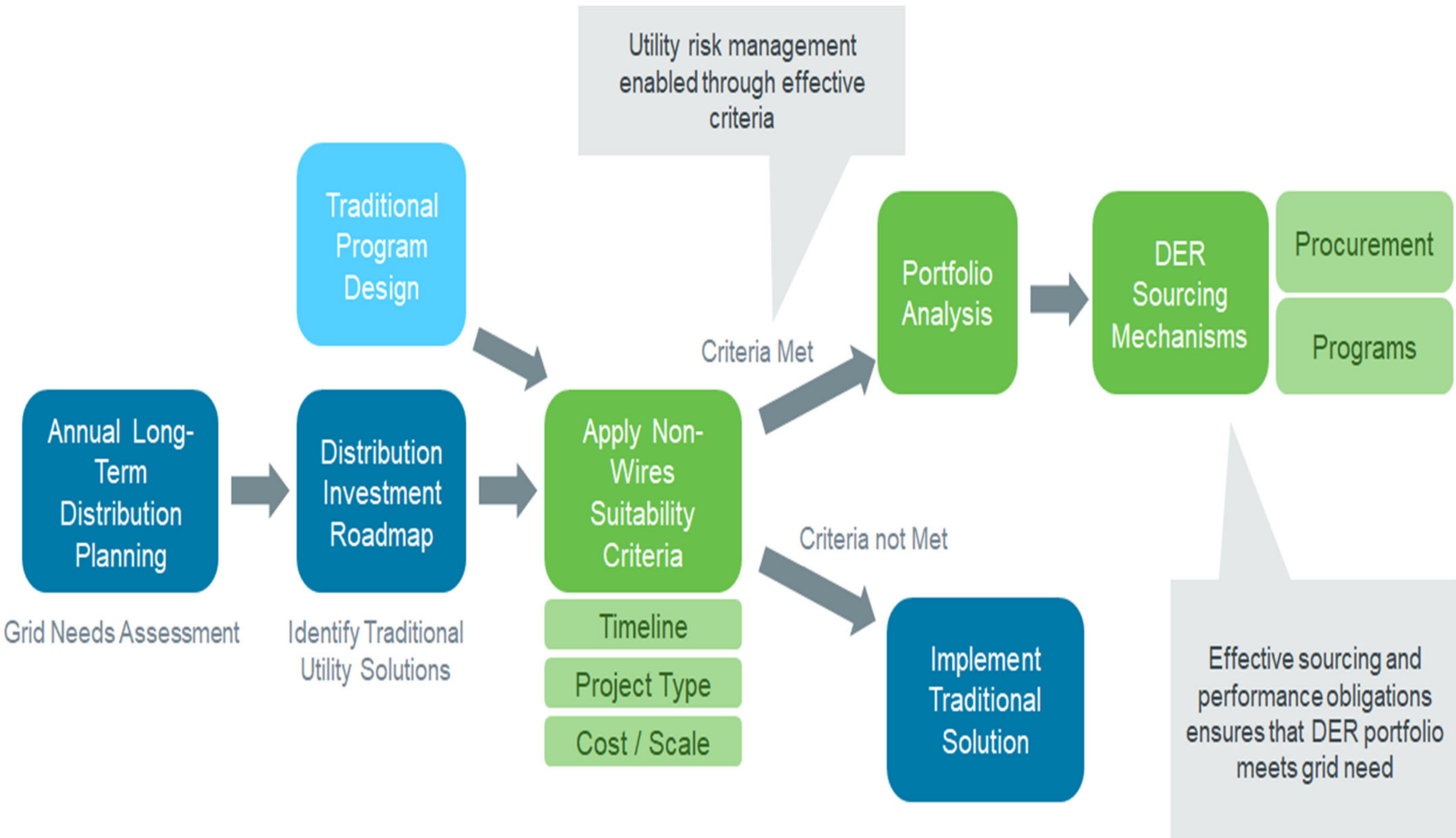
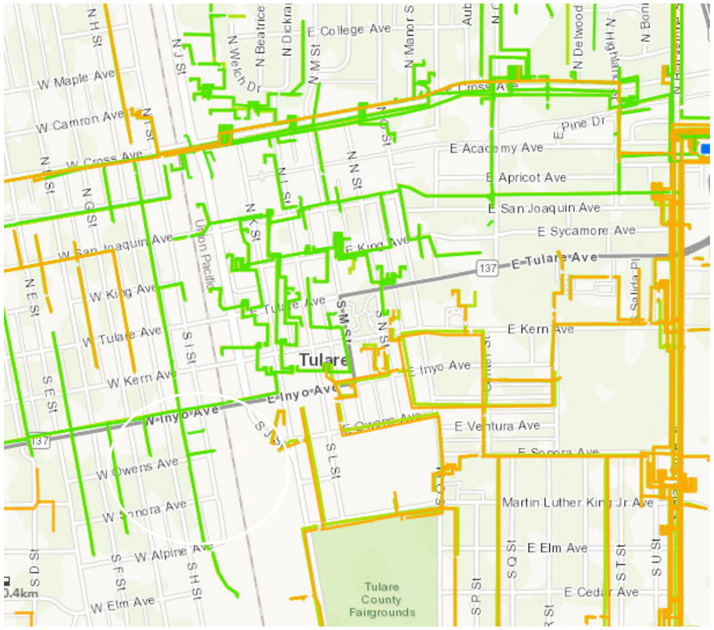
Suitability Criteria Refines NWA Opportunity



Key Takeaways

- There is a great value to empirical learning in the area of NWAs
- Utilities are increasingly implementing pilots that will yield learnings; using these to validate planning methodologies and assumptions around DER will be critical
- Some utilities are turning to a "test bed" approach to validate DER as a planning resource
- Customer programs can be locationally targeted at the right time and with the right certainty



Source: Southern California Edison DERiM Web Map

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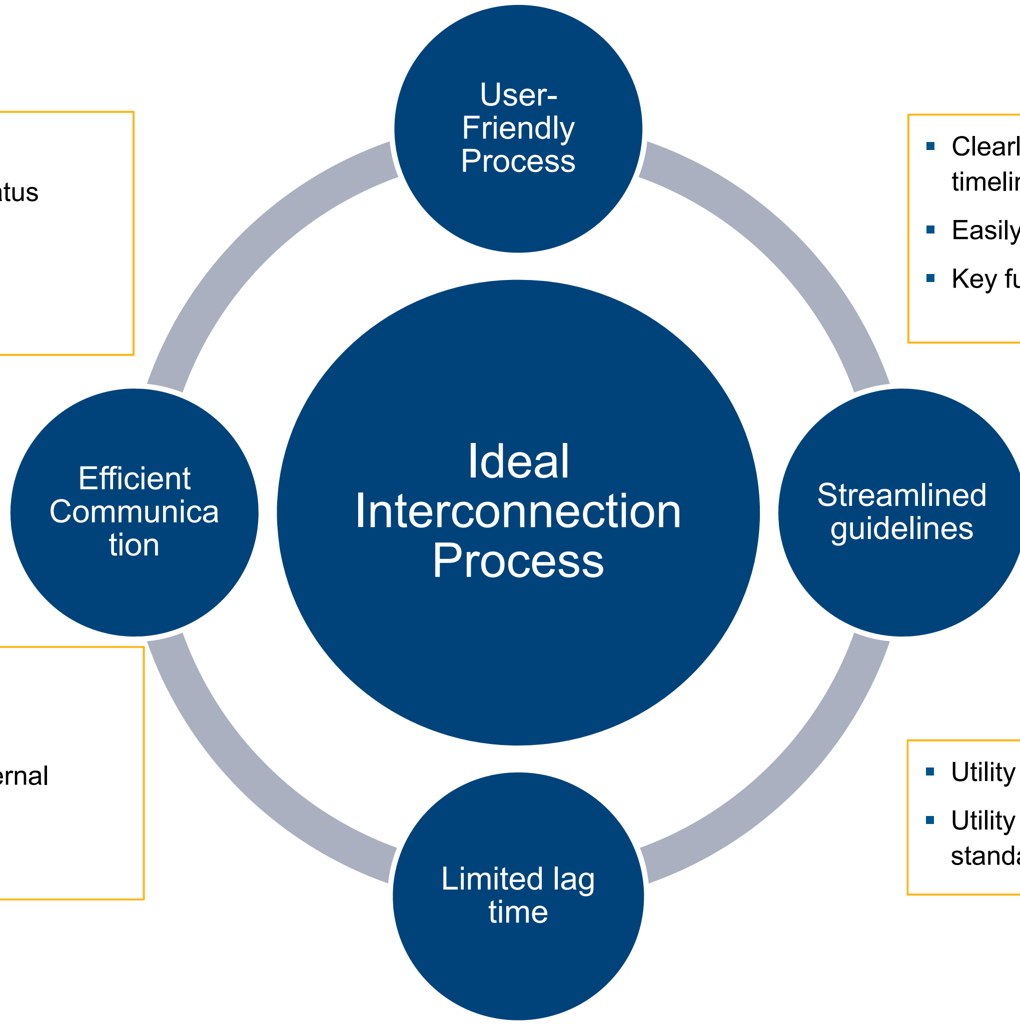
Interconnection
(separate proceeding)

Interconnection Considerations For DER Integration

- Transparency
- Updates on application status
- Communication to resolve challenges

- Clearly outline developer data and timeline
- Easily access utility databases
- Key functionalities in user-interface

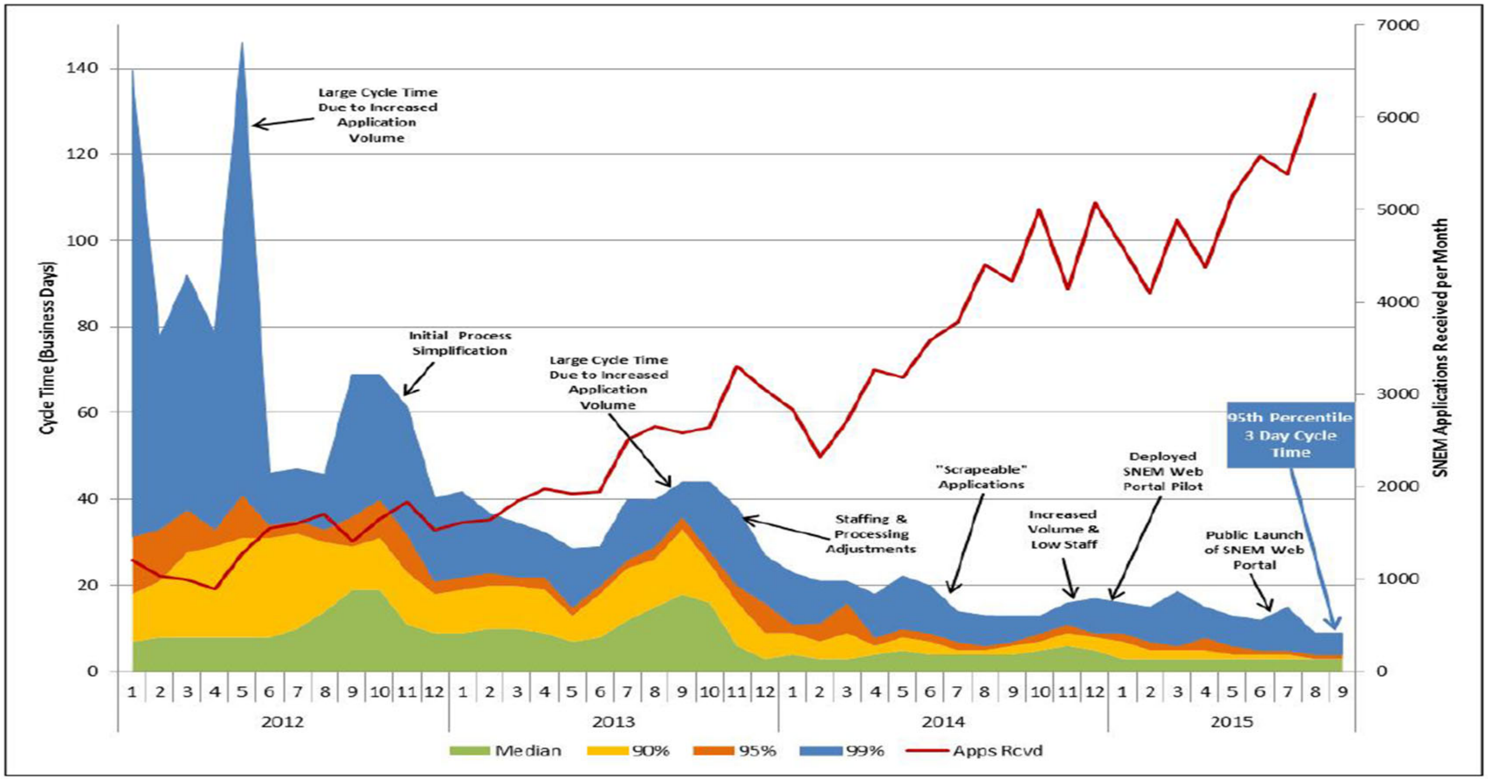


- Application pre-screening
- Automation of process
- Enhance internal and external coordination

- Utility specific
- Utility guidelines defining standard equipment

Challenges to Interconnection Process

NREL 2015: Interconnecton Process Improvements at PG&E



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Key Takeaways

- **Operational visibility and utility data needs should inform application requirements for DG interconnection**
- **Consider technical capabilities to meet standard interconnection protocols such as Smart Inverters**
- **Enhanced coordination between various internal teams (Forecasting, customer strategy, operations, etc.) will be necessary to effectively manage interconnection applications**
- **Technical screens allow the utility to design a formal and streamlined approach to interconnection**
  - Use of FERC SGIP Screens, California Rule 21, Sandia Screens and the New York SIR all include a 15% of annual peak load screen
- **Leverage hosting capacity analysis in the context of interconnection use cases**

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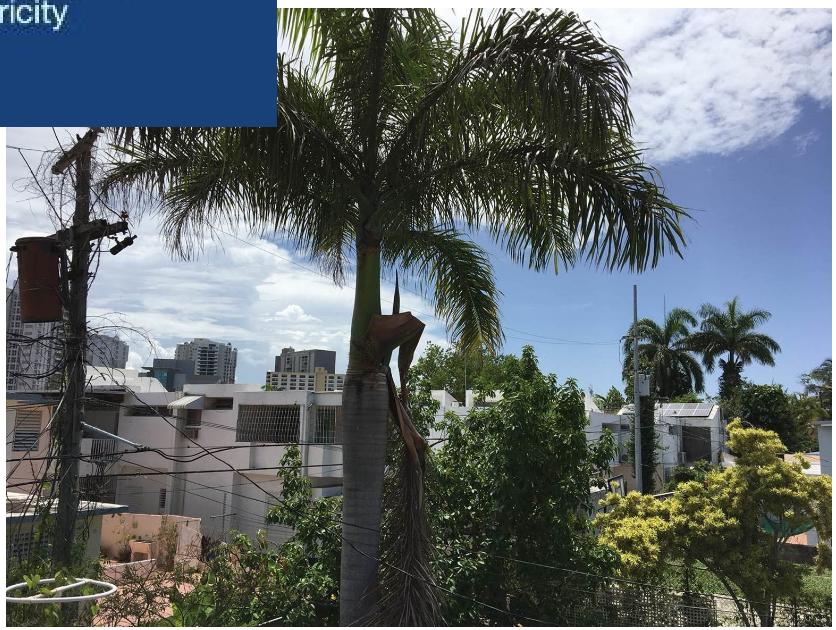


Grid Modernization Planning

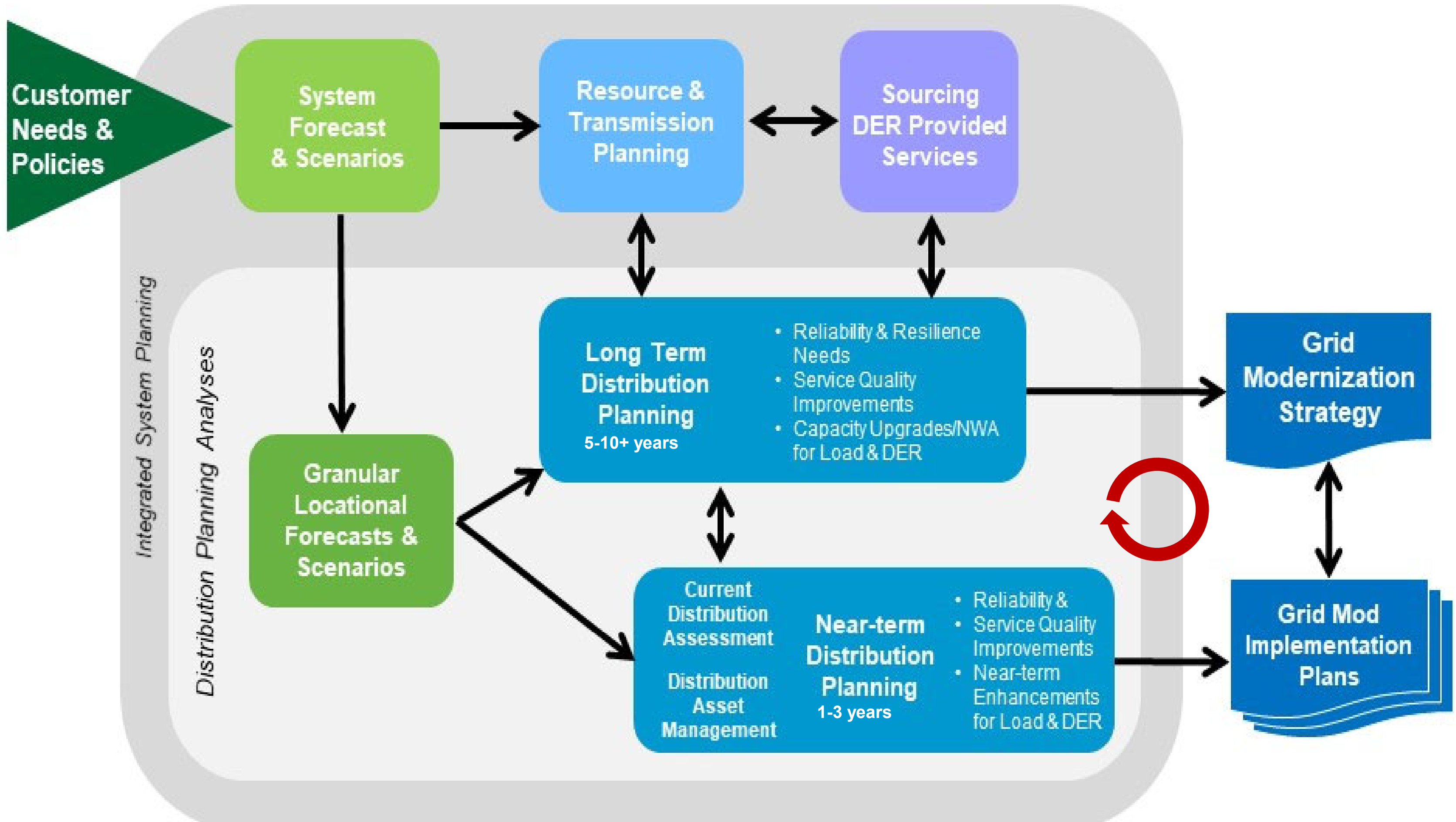
Joe Paladino, Technical Advisor
Office of Electricity, U.S. DOE

Puerto Rico Energy Bureau
Distribution System Planning Stakeholder Workshop

August 16, 2019

Integrated Planning

Integrated planning identifies "Where", "When" and "How Much"



Source: P. De Martini

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Scope of Grid Modernization

Grid modernization planning should address policy objectives and customer expectations, yet respect timing and affordability considerations

Some key elements:

- Integration of customer and 3rd-party systems with utility systems
- Coordination, control, and application of distributed energy resources (DERs)
- Improvement in reliability, resilience and operational efficiency
- The application of advanced sensing, communications, control, information management, and computing technologies to enable the above
- The application of grid architecture to ensure the building of a coherent system that is scalable
- Business process redesign to support effective planning, grid operations, and market operations

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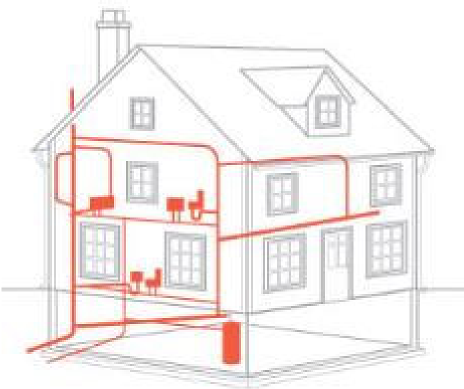
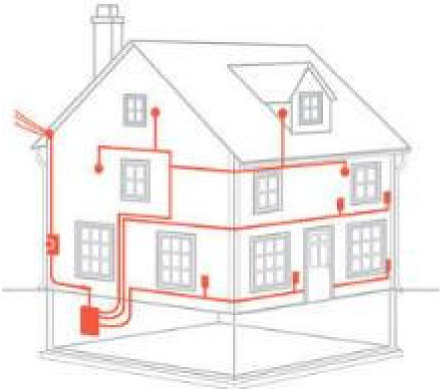
Architecture Manages Complexity

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





So, pick-up a pencil

Before trying to hang windows

Resist temptation to start with technology choices

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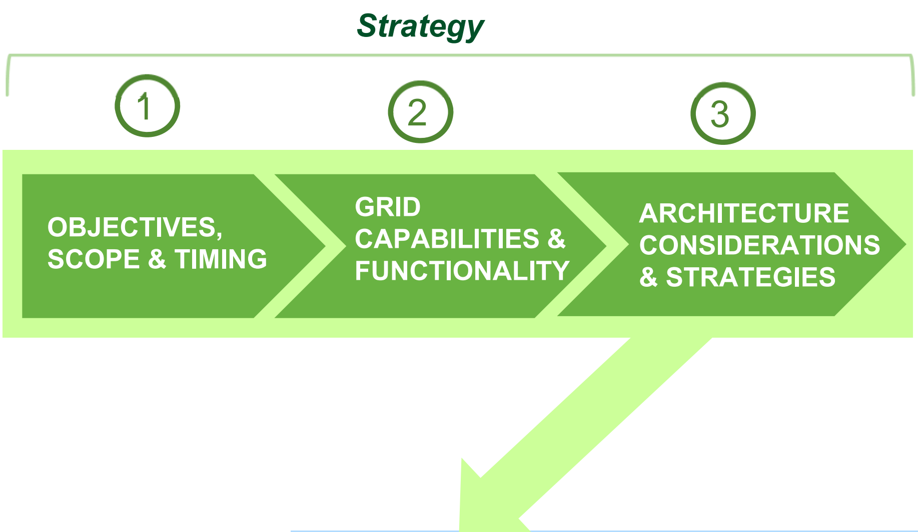
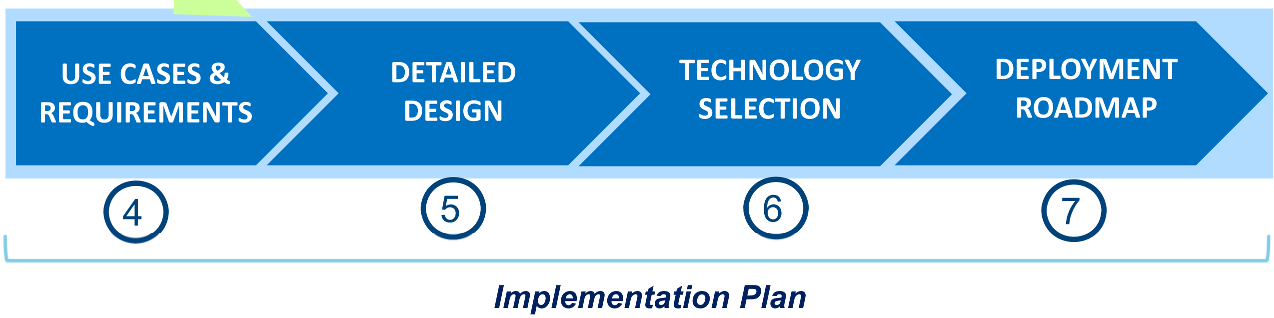
Grid Modernization Planning Process



1. **Identify Grid Mod Objectives, Scope & Timing**
2. **Identify Grid Capabilities & Functionality Needed**
3. **Identify Grid Architecture Considerations & Develop Strategies** (e.g., assessment of grid state, coordination framework, operational data/information management and flow, communication system requirements, central vs distributed control, cybersecurity)



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

Version 3.0 091818

Distribution System Capabilities

Capabilities derived from customer, policy & business objectives

Distribution System Planning	Distribution Grid Operations		Distribution Market Operations
Scalability 3.1.1	Operational Risk Management 3.2.1	Situational Awareness 3.2.2	Distribution Investment Optimization 3.3.1
Impact Resistance and Impact Resiliency 3.1.2	Controllability and Dynamic Stability 3.2.3	Management of DER and Load Stochasticity 3.2.4	Distribution Asset Optimization 3.3.2
Open and Interoperable 3.1.3	Contingency Management 3.2.5	Security 3.2.6	Market Animation 3.3.3
Accommodate Tech Innovation 3.1.4	Public and Workforce Safety 3.2.7	Fail Safe Modes 3.2.8	System Performance 3.3.4
Convergence w/ Other Critical Infrastructures 3.1.5	Attack Resistance/Fault Tolerance/Self-Healing 3.2.9	Reliability and Resiliency Management 3.2.10	Environmental Management 3.3.5
Accommodate New Business Models 3.1.6	Integrated Grid Coordination 3.2.11	Control Federation and Control Disaggregation 3.2.12	Local Optimization 3.3.6
Transparency 3.1.7	Privacy and Confidentiality 3.2.13		

Source: DOE-OE, 2017. *Modern Distribution Grid, Volume I: Customer and State Policy Driven Functionality*. Available online at: https://gridarchitecture.pnnl.gov/media/Modern-Distribution-Grid_Volume-I_v1_1.pdf

Taxonomy Example

Objective	Attribute	Capability	Function	Technology
Enable customer choice	Information to support customer decisions	Provide online customer access to relevant & timely information by 2020 for small business & residential customers	Remote meter data collection & verification Customer data management Energy management & DER purchase analysis	Customer Portal Customer analytic tools Greenbutton Time interval metering Meter Data Management System Customer Info System Data Warehouse Meter communications

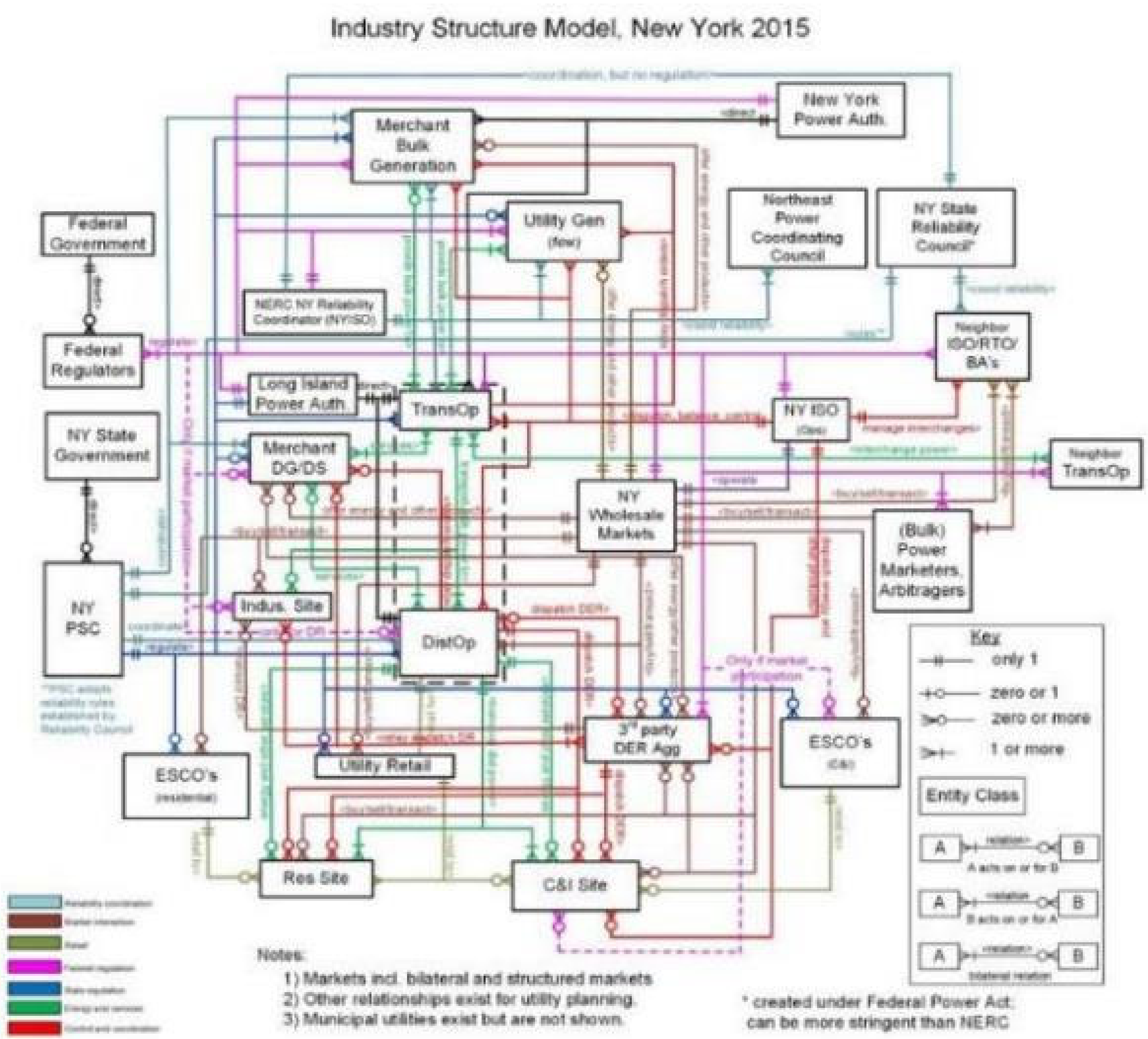
Source: DOE-OE, 2017. *Modern Distribution Grid, Volume I: Customer and State Policy Driven Functionality*. Available online at: https://gridarchitecture.pnnl.gov/media/Modern-Distribution-Grid_Volume-I_v1_1.pdf

Architectural Considerations

Grid architecture is primarily about structure and ensuring coherence

- ***Coordination*** **is the process that causes or enables a set of decentralized elements to cooperate to solve a common problem**
  - How will we coordinate utility and non-utility assets?
  - How will we address the information sharing requirements among participants?
- ***Scalability*** **is the ability of a system to accommodate an expanding number of endpoints or participants without having to undertake major rework**
  - How do we enable optimal performance locally and system-wide?
  - How do we minimize the number of communication interfaces (cyber-intrusion)?
- ***Layering*** **is applying fundamental or commonly-needed capabilities and services to a variable set of uses or applications through well-defined interoperable interfaces (Leads to the concept of *platform*)**
  - How do we build out the fundamental components of the system to support new applications and convergence with other infrastructures?
- ***Buffering*** **is the ability to make the system resilient to a variety of perturbations**
  - How do we address resilience and system flexibility requirements (role of storage)?

Industry Structure



Participants:

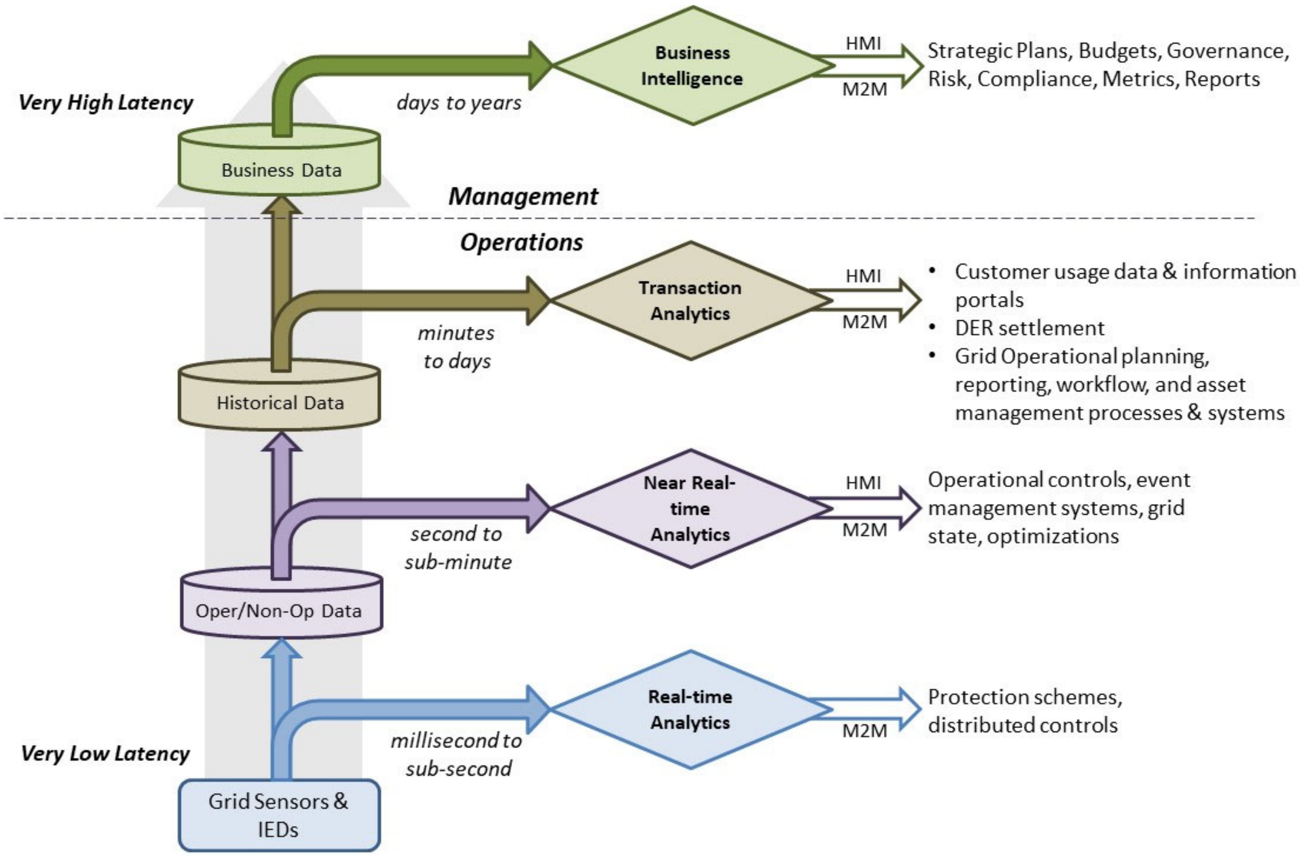
Federal Government
Federal Regulators
NERC NY Reliability Coordinator
Northeast Power Coordinating Council
NY State Reliability Council
NY ISO (Ops)
Neighbor ISO/RTO/BAs
NY Wholesale Markets
Bulk Power Marketers/Arbitragers
Merchant Bulk Generation
Utility Generation
NY Power Authority
Long Island Power Authority
Transmission Operators
Neighbor Transmission Operators
NY State Government
NY PSC
Distribution System Operator
Utility Retail
Residential Customers
C&I Customers
ESCOs
Third-Party DER Aggregator

Nature of Interaction:

Reliability coordination
Market interaction
Retail
Fed/state regulation
Energy and services
Control and coordination

Observability Drives Data Requirements

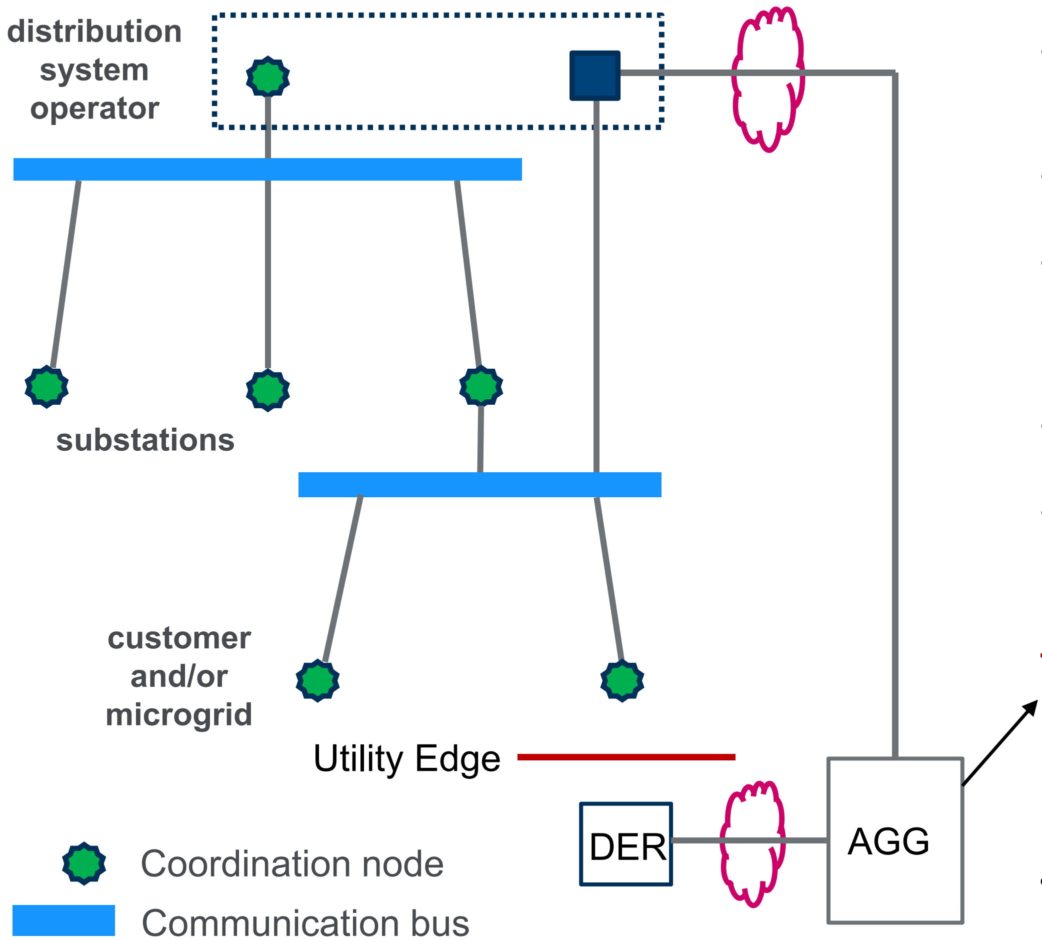
Time sensitivity of specific data/information defines communications requirements and the need for an architectural layering to support the unique needs for multiple applications



Source: J. Taft, P. De Martini, L. von Prelwitz, 2012. *Utility Data Management & Intelligence*, Cisco Systems. Available online at: https://energyenvironment.pnnl.gov/pdf/managing_utility_data_intelligence.pdf

Coordination of DER

The presence of DER not owned by utilities changes the problem from direct control to a combination of control and coordination



- Elements need to coordinate to solve common problems of grid operations (in the presence of DER)
- Each element has performance constraints and optimization objectives
- By examining relationships and interfaces, can develop coordination frameworks and underlying control and communication requirements
- Laminar coordination allows us to manage an increasing number of nodes
- Proper coordination permits local/system optimization

T/D Markets

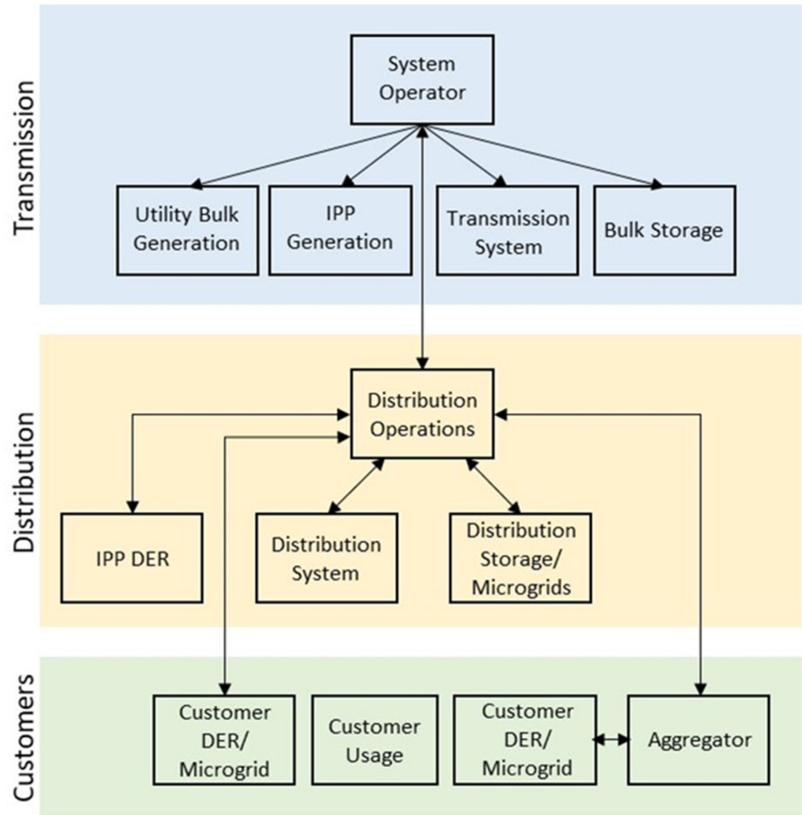
From JD Taft, Architectural Basis for Highly Distributed Power Grids: Frameworks, Networks, and Grid Codes, PNNL-25480, June 2016

Coordination Framework

A coordination framework should identify roles, responsibilities and information sharing requirements

Grid architecture principles for examining and comparing coordination models:

- Observability
- Scalability
- Cyber security vulnerability
- Layered decomposition
- Tier bypassing
- Hidden coupling
- Latency cascading



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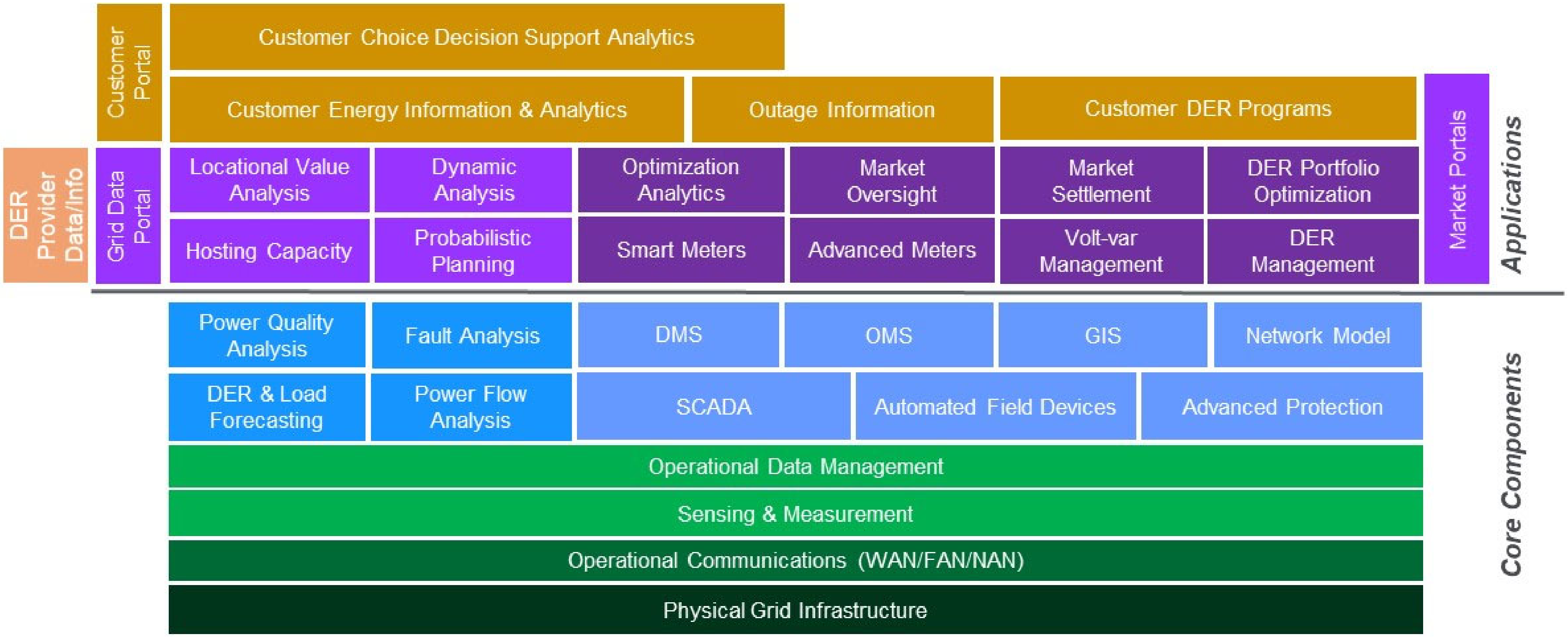
Distribution System Platform

Logical layering of core components

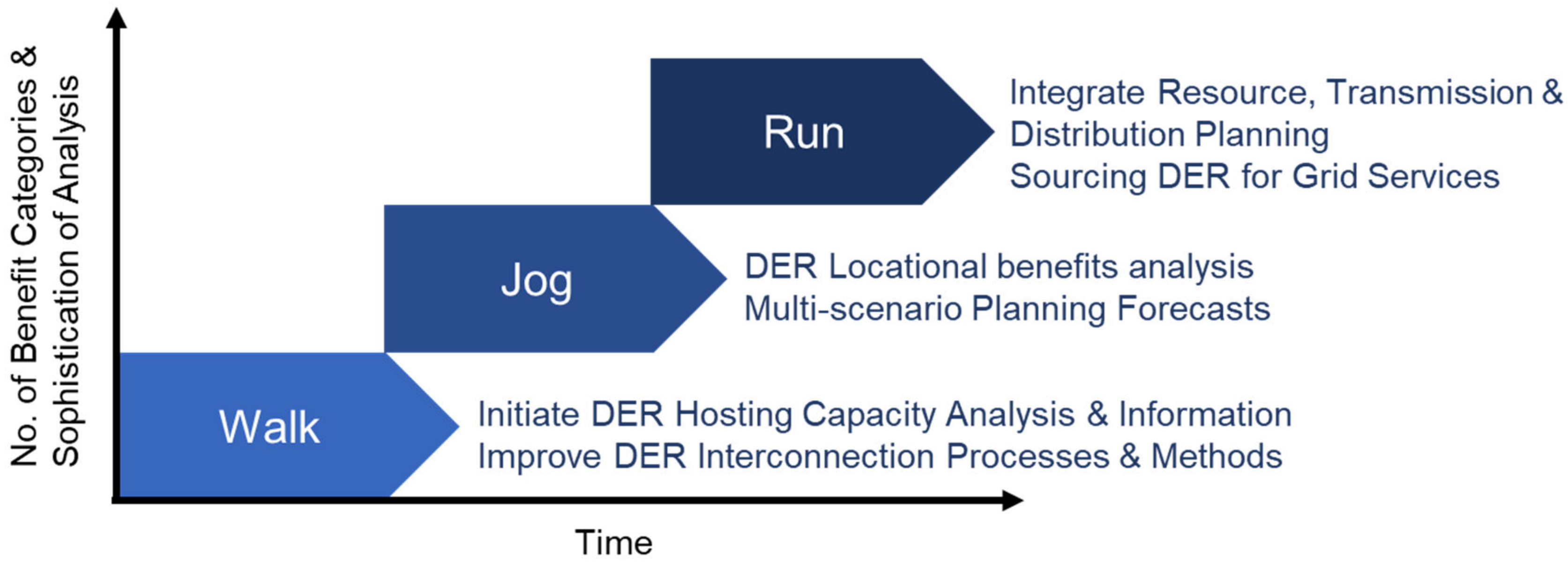


Green - Core Cyber-physical layer
Blue - Core Planning & Operational systems
Purple - Applications for Planning, Grid & Market Operations
Gold - Applications for Customer Engagement with Grid Technologies
Orange - DER Provider Application

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

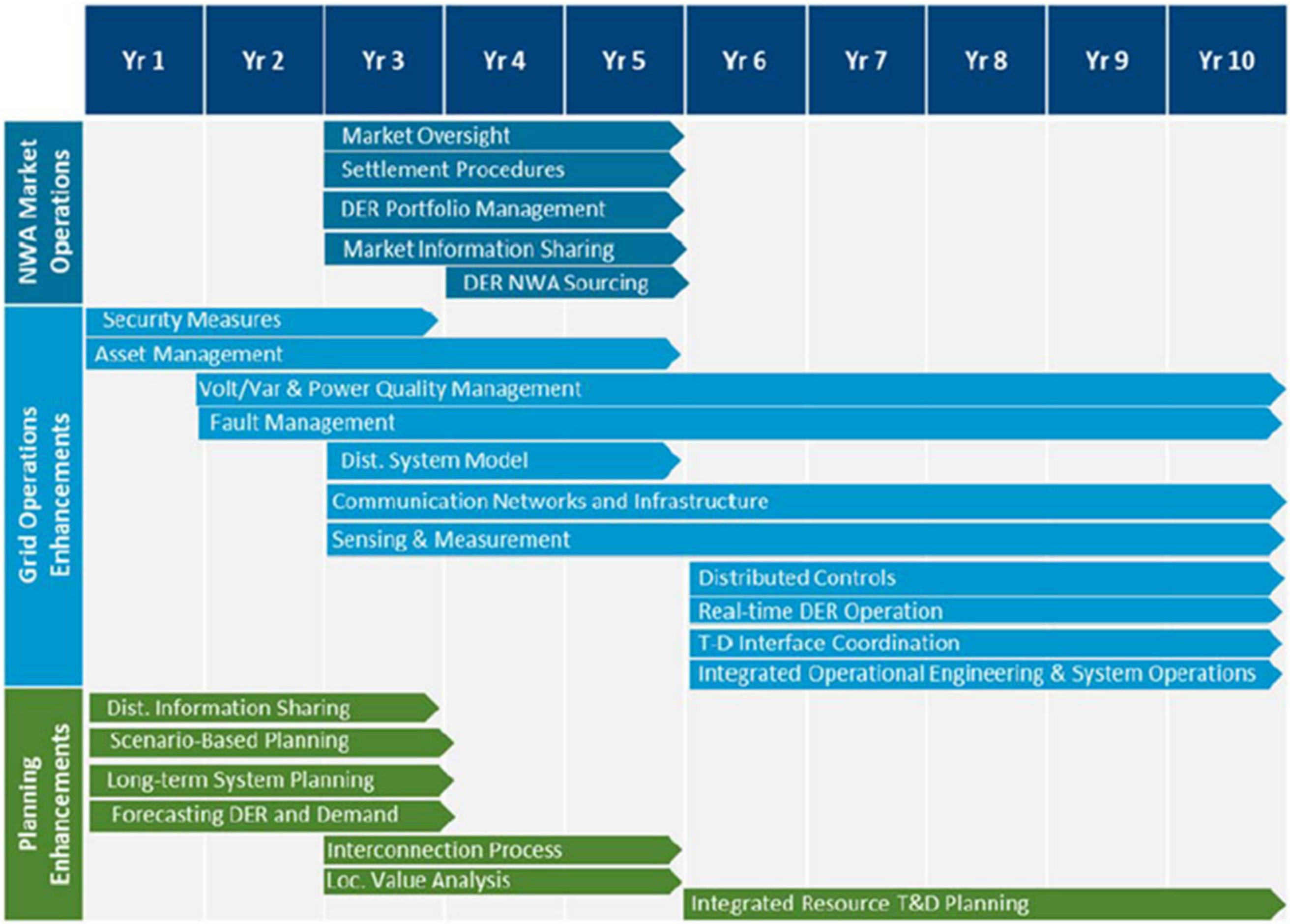
Timing & Pace Considerations

Align implementation of changes to pace of DER adoption & customer value (affordability)



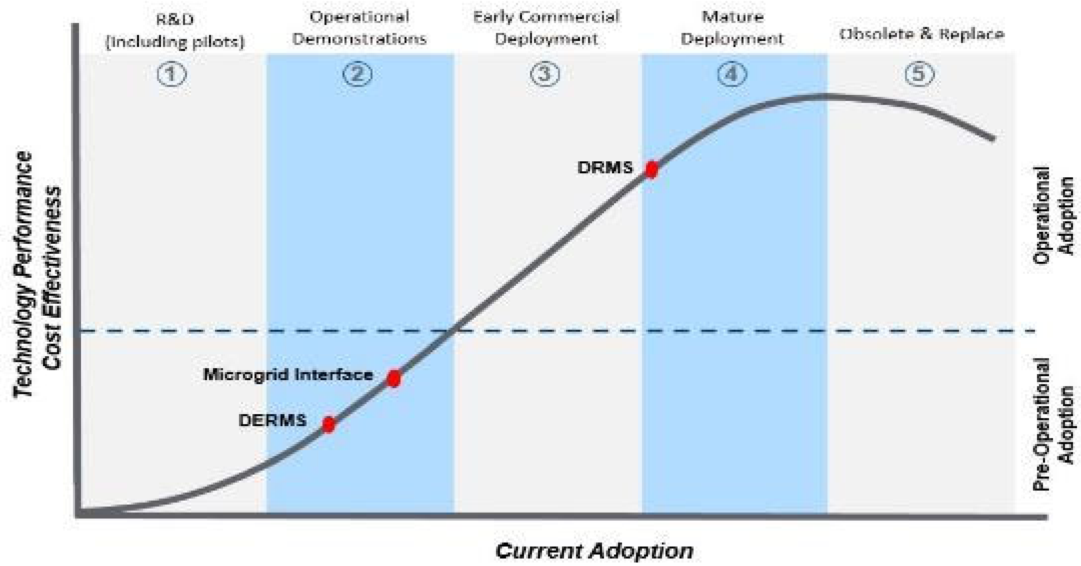
Strategic Roadmap

Strategic roadmaps provide a logical sequence for investments

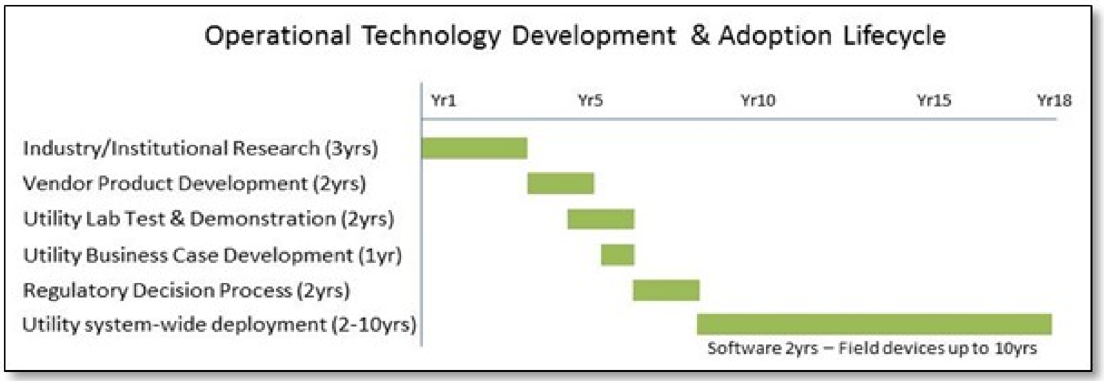


Source: Newport Consulting

Technology Adoption Considerations

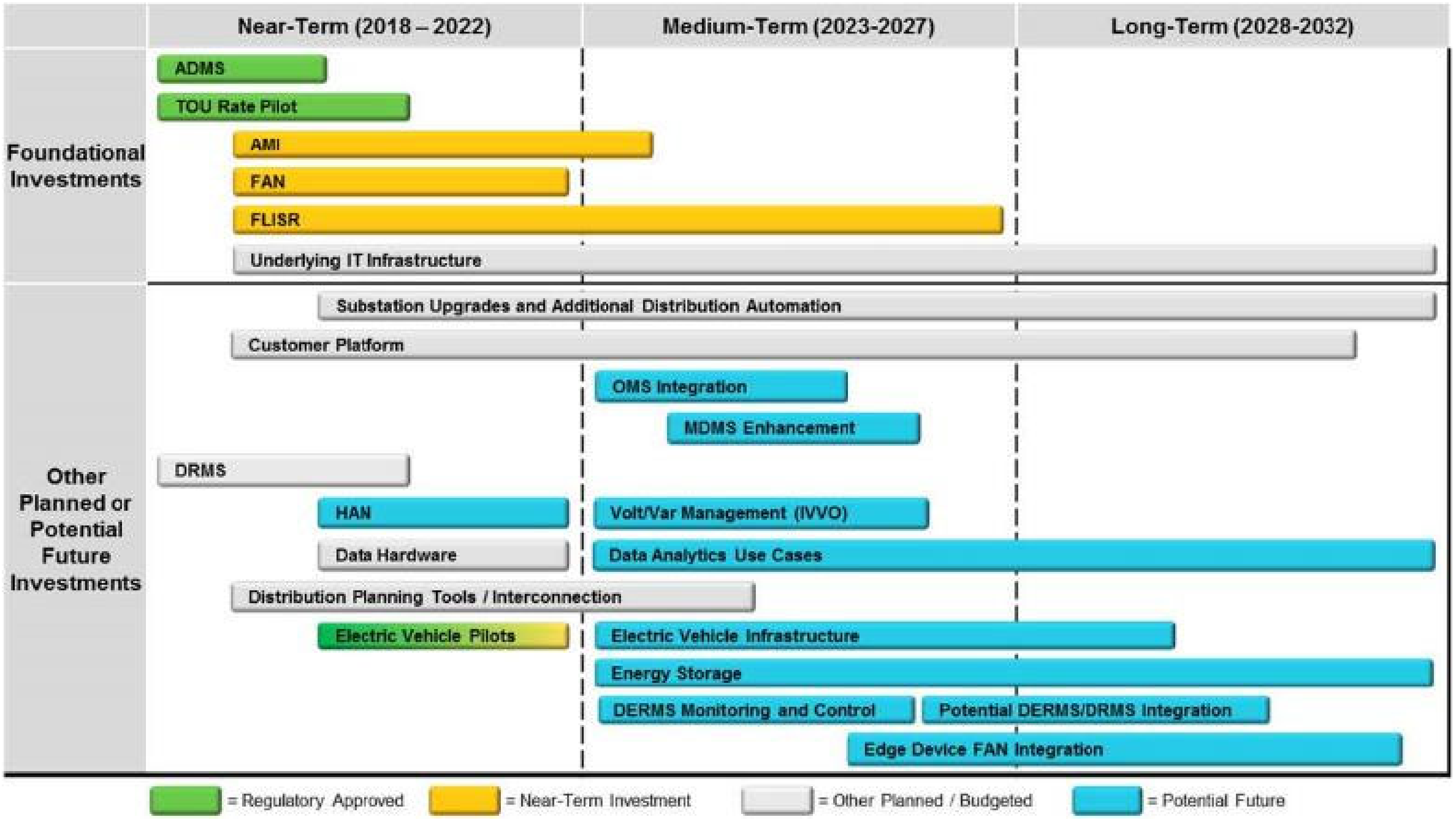


Source (above): U.S. Department of Energy-Office of Electricity Delivery and Energy Reliability, 2017. *Modern Distribution Grid, Volume II: Advanced Technology Maturity Assessment. Link*: https://gridarchitecture.pnnl.gov/media/Modern-Distribution-Grid-Volume-II.pdf



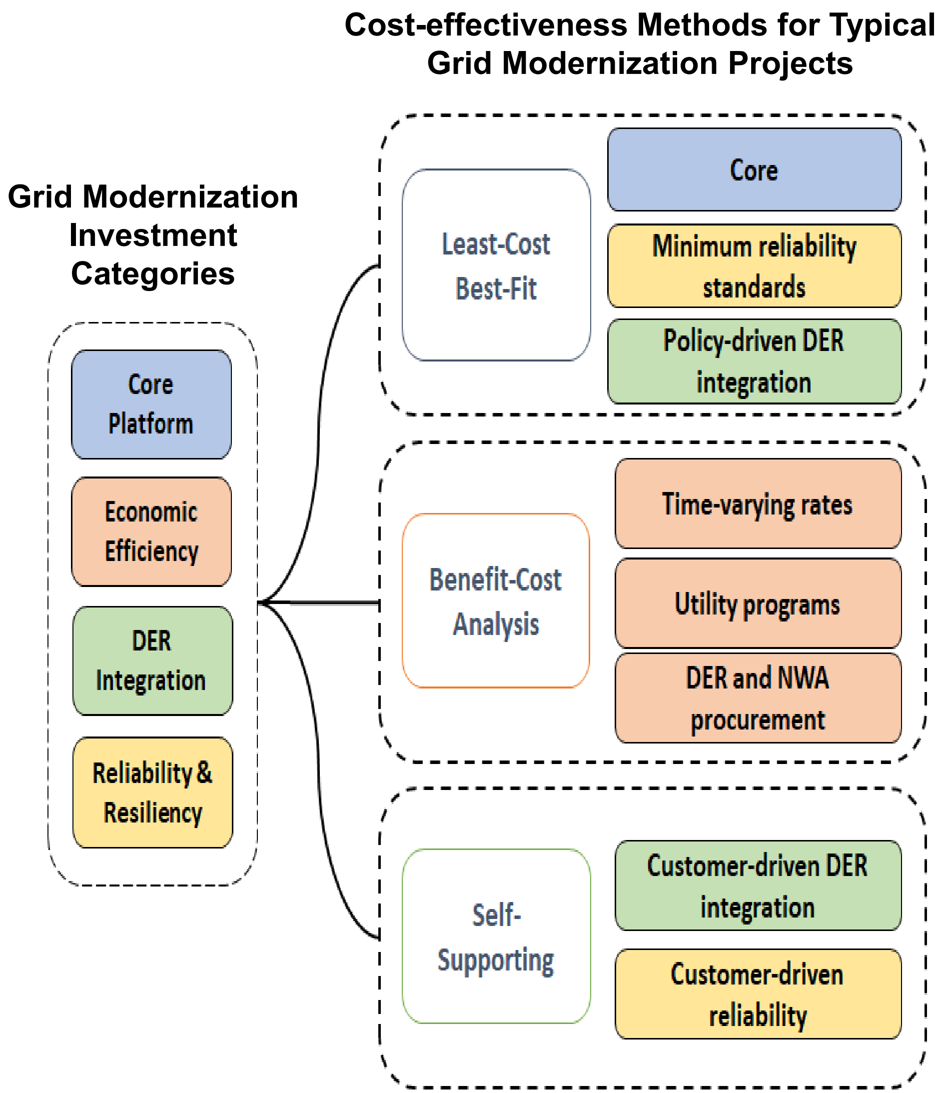
Sequencing of Investments

15-year view of the planned and potential advanced grid investments presented in the Xcel Energy 2018 Integrated Distribution Plan



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=20181-147534-01

Cost-Effectiveness Framework



Least-cost, best-fit for core grid platform and grid expenditures required to maintain or reliable 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.

Strategy and Implementation Roadmap

Regulators, utilities and stakeholders have respective roles in the process; regulators approve the strategy, implementation process, and roadmaps

Grid Modernization Strategy

- Articulation of grid modernization objectives
- Determination of timing, scale and scope of grid capabilities to meet objectives
  - Based on needs identifies through integrated planning efforts, including forecasts (load, DER uptake and service expectations)
- Includes strategies to address grid architecture considerations
  - Coordination framework
  - Sensing and measurement; assessment of grid state
  - Operational data flow and information management (including computing requirements)
  - Central vs distributed control
  - Communication system requirements
  - Platform/applications and convergence strategy
  - Cybersecurity strategy

Implementation Roadmap

- Scope and schedule for achieving grid mod capabilities and functions
- Articulation of implementation strategy for various technologies and business process changes
- Articulation of technology adoption strategy
- Cost-effectiveness assessment

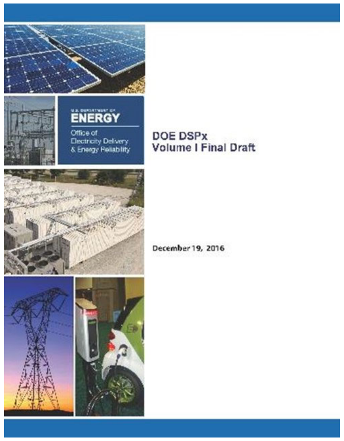
Thank You

Contact:

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

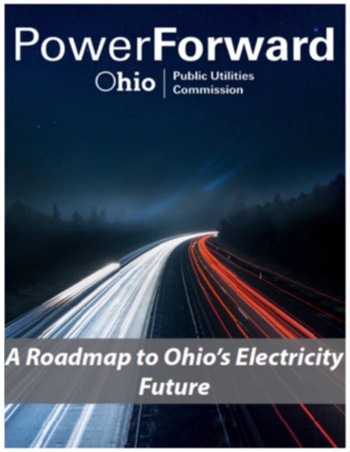
References:

Modern Distribution Grid Report



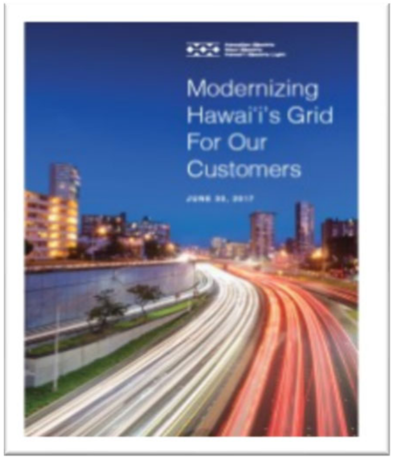
https://gridarchitecture.pnnl.gov/modern-grid-distribution-project.aspx

PUCO Grid Mod Roadmap



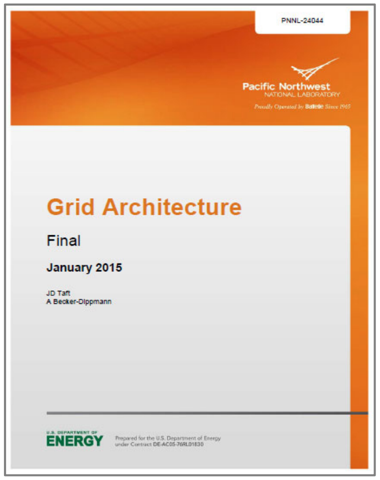
https://puco.maps.arcgis.com/apps/Cascade/index.html?appid=59a9cd1f405547c89e1066e9f195b0b1

Grid Modernization Strategy Using DSPx



www.hawaiianelectric.com/gridmod

Grid Architecture



http//gridarchitecture.pnnl.gov

APPENDIX

Potential Discussion Topics

- IRP-IDP coordination
- Load and DER forecasting
- Hosting capacity analysis
- DER sourcing
- Locational value assessment
- Microgrids
- Interconnection processes
- Net metering tariffs
- Observability strategy
- Resilience

Common Questions

- What is done today in Puerto Rico?
- What is the future vision?
- What are the steps to get from the current state to future state?
- What challenges will need to be addressed?
- What are the recommended next steps?