U.S. DEPARTMENT OF ENERGY
Office of Electricity Delivery & Energy Reliability

Considerations for a Modern Distribution Grid

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U.S. Department of Energy

Midwest Distribution System Planning Workshop — January 16, 2018

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."
from Grid 2020, Resnick Institute Report, Sept 2012

Federal, State and Local Policies

- Renewable and Efficiency Portfolio Standards
- Carbon Dioxide Reduction
- Reliability and Resilience
- Integration of Distributed Energy Resources

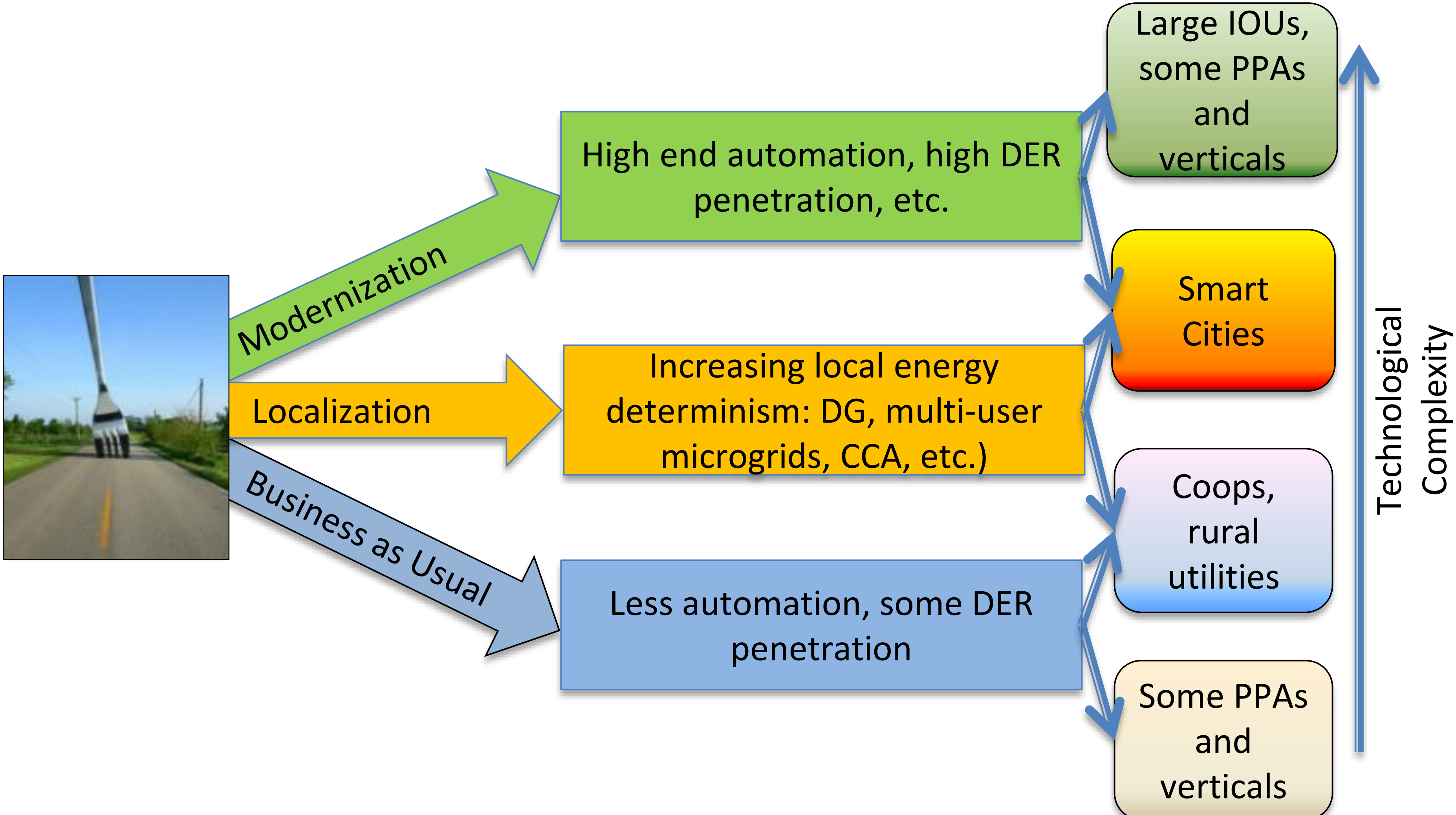
Technology Availability

- Information and Communication Technology
- Electric Vehicles
- Solar and Wind
- Energy Storage
- Building Energy Management Systems
- Microgrids

New Participants

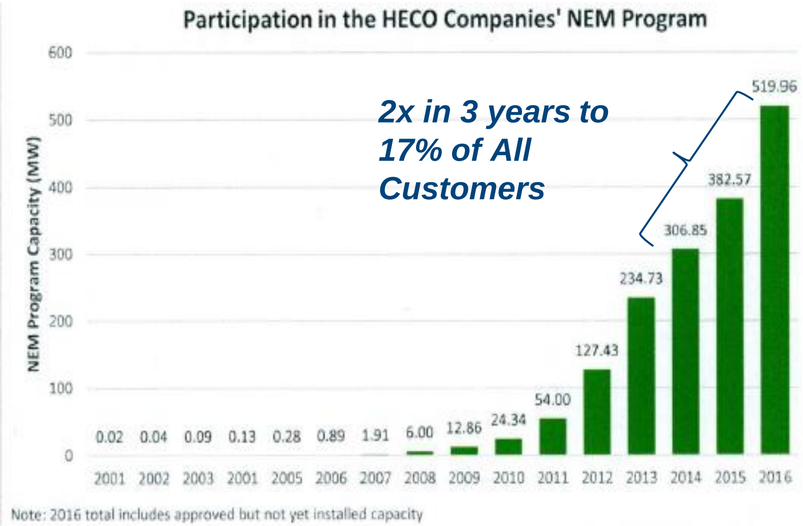
- Customers/Prosumers
- Merchants
- Technology Providers

Co-Existing Futures



Courtesy of Jeffrey Taft, PNNL

DERs Present 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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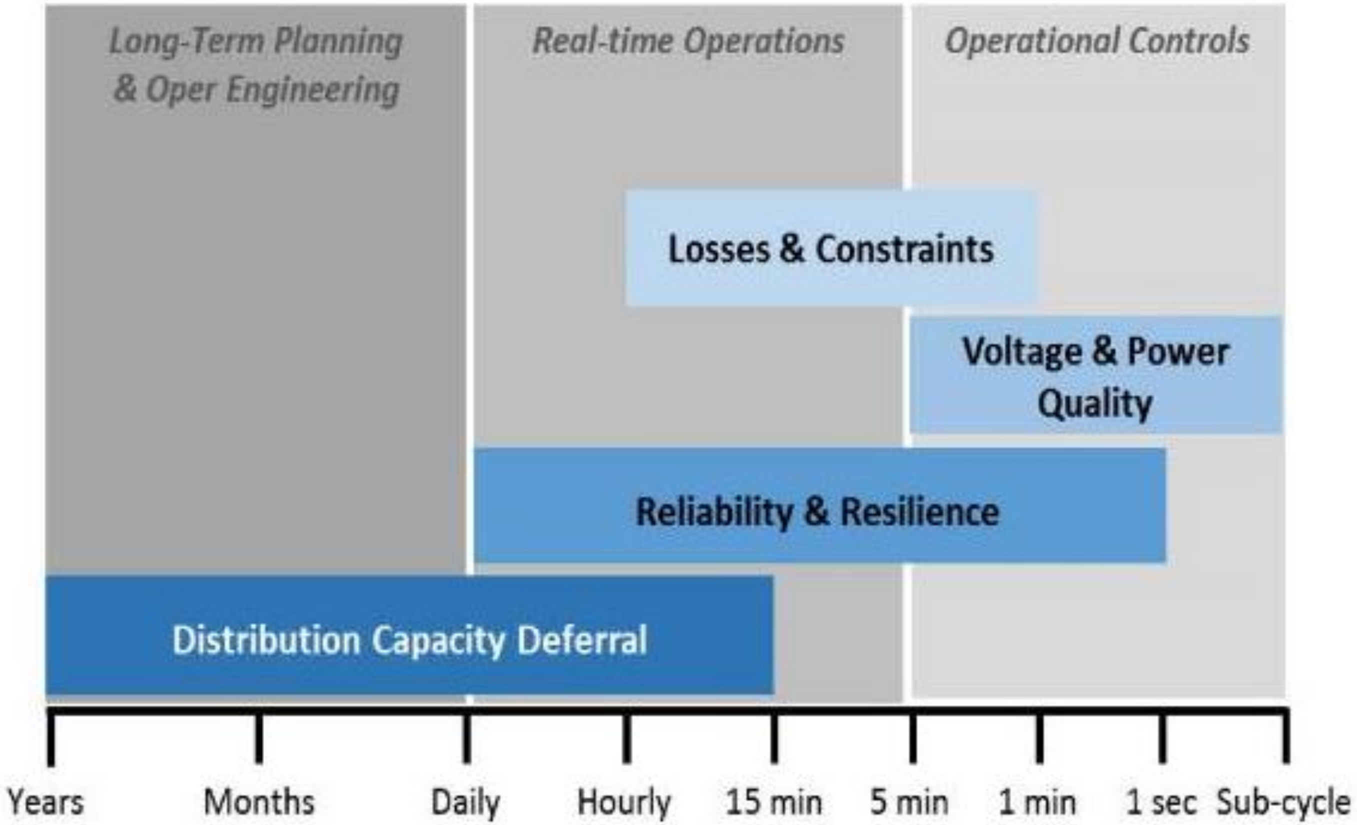
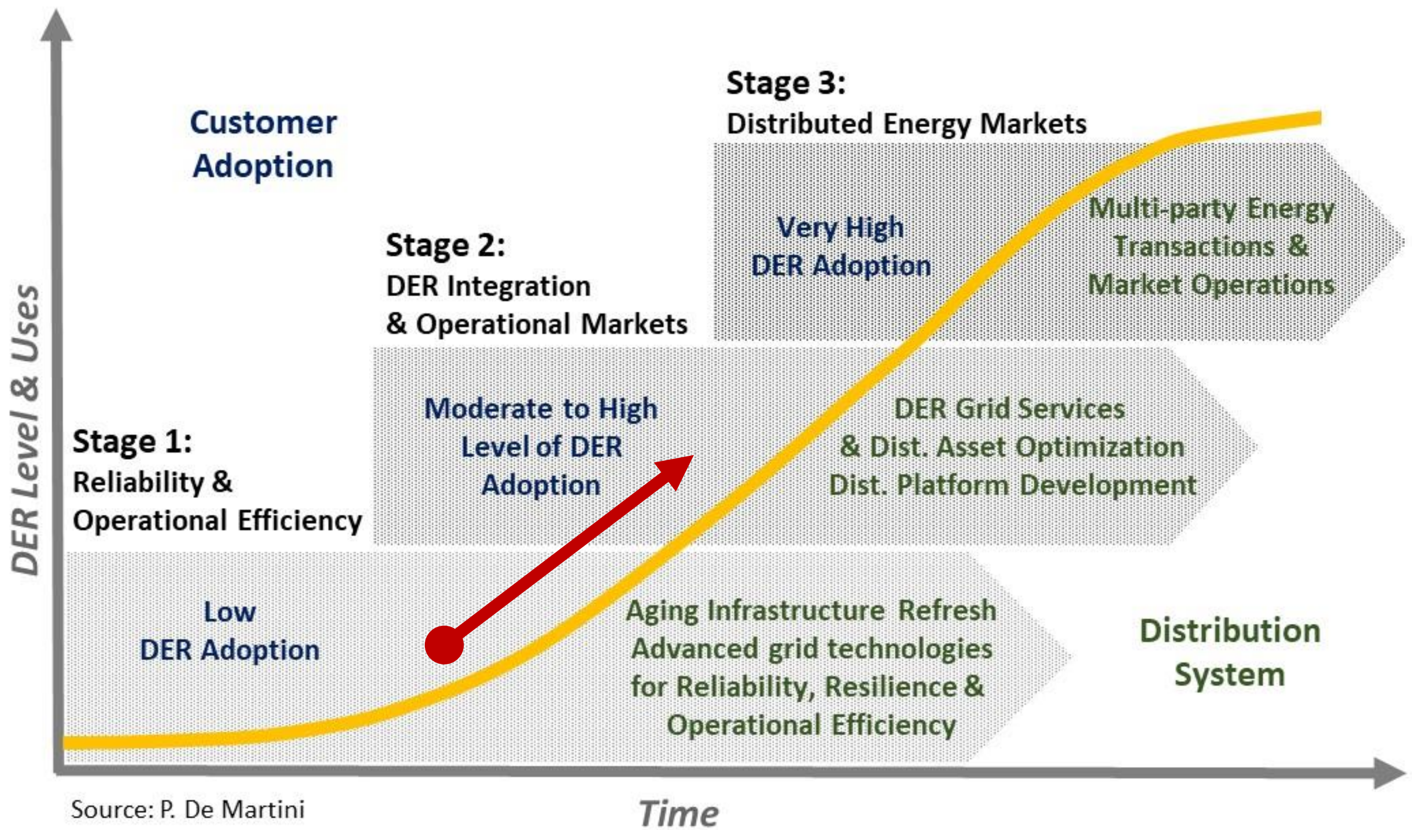
DERs Provide Value



From “Evolving Distribution Operational Markets” by Paul De Martini, Resnick Institute, Caltech, and Brenda Chew, Dale Murdock and Steve Fine at ICF

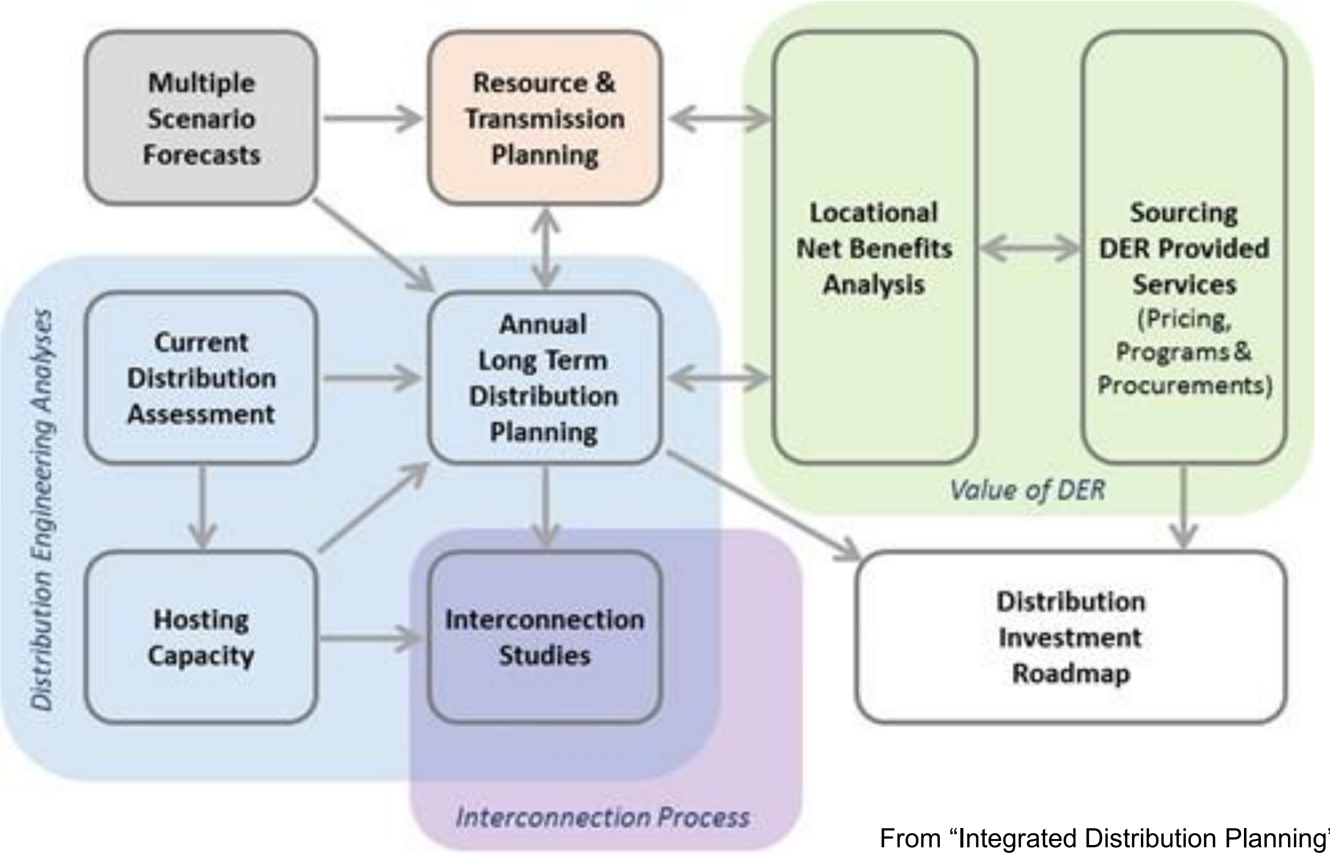
Distribution Grid Evolution

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



Integrated Planning Considerations

Integrated planning and analysis needed within and across the transmission, distribution and customer/3rd party domains



From "Integrated Distribution Planning", August 2016, prepared for the MN PUC, ICF International

Architecture Manages Complexity

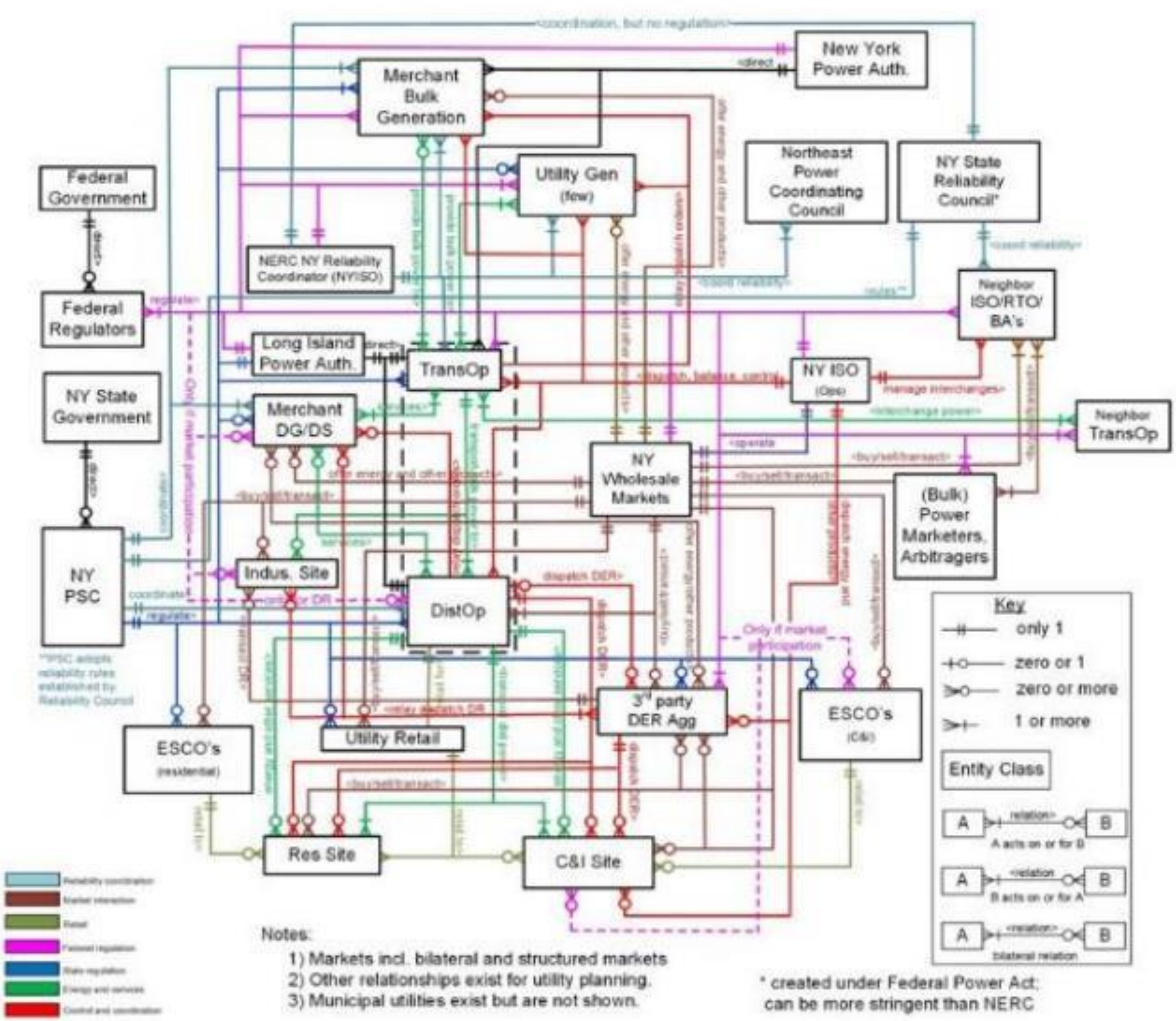
The engineering issues associated with the scale and scope of dynamic resources envisioned in policy objectives for grid modernization requires a holistic architectural approach

So, pick-up a pencil

Before trying to hang windows

Coordination Considerations

Industry Structure Model, New York 2015



Participants

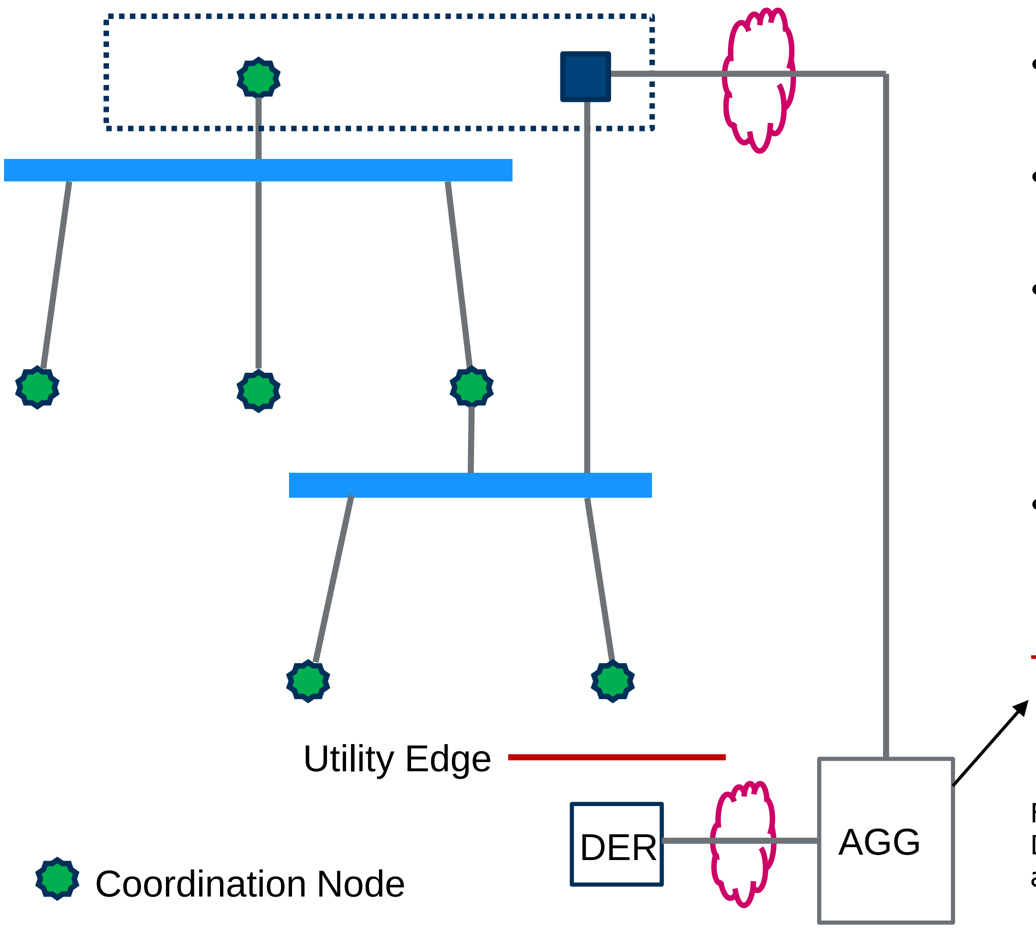
- Federal Government
- Federal Regulators
- NERC NY Reliability Coordinator
- Northeast Power Coordinating Council
- NY State Reliability Council
- NY ISO (Ops)
- Neighbor ISO/RTO/BAs
- NY Wholesale Markets
- Bulk Power Marketers/Arbitragers
- Merchant Bulk Generation
- Utility Generation
- NY Power 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

Interaction Types

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

Coordination Frameworks

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

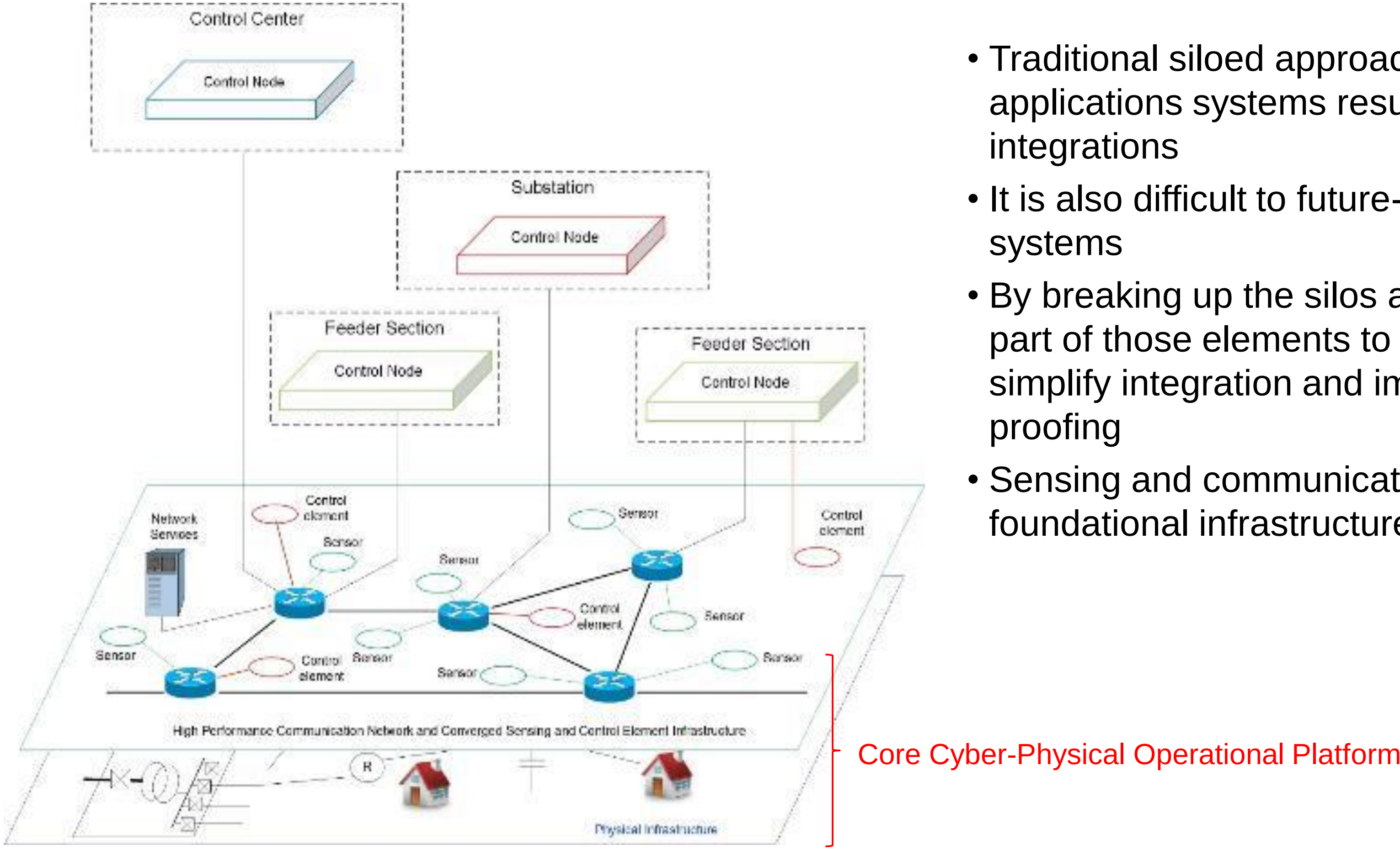


- Elements need to coordinate to solve common problems
- Each element has performance constraints and optimization objectives
- By examining relationships and interfaces, can develop coordination frameworks and underlying control and communication requirements
- Laminar coordination permits local/system optimization

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

Architectural Considerations

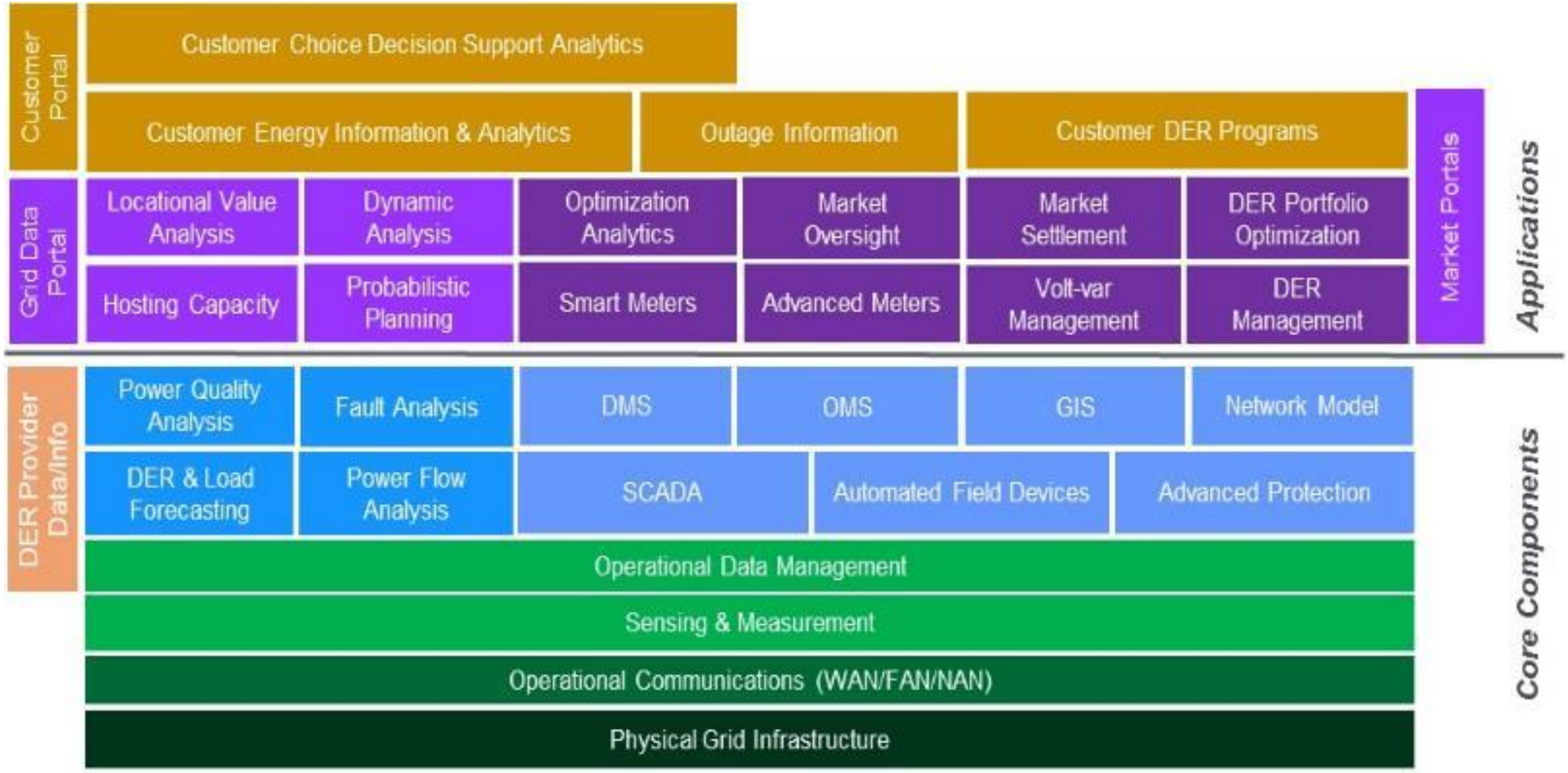
Grid architecture is a systems analysis discipline that begins with objectives and determines how structures integrate and coordinate



- Traditional siloed approaches to applications systems result in complex integrations
- It is also difficult to future-proof such systems
- By breaking up the silos and converting part of those elements to a layer we can simplify integration and improve future-proofing
- Sensing and communication can become a foundational infrastructure layer

Platform Considerations

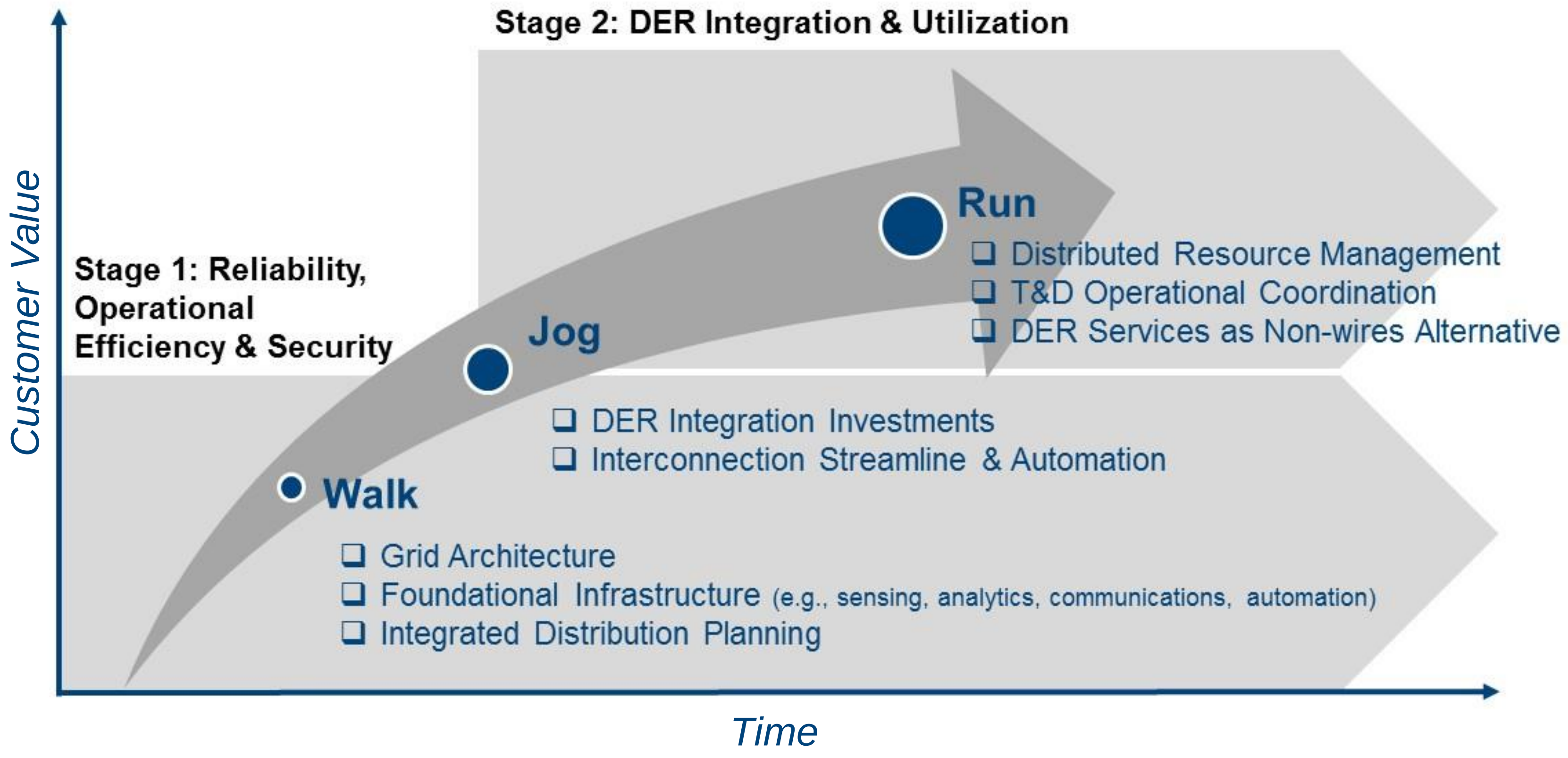
Core components form a foundational layer; applications sit on this foundation as additional functionality is needed



From DSPx, Volume 3 – Decision Guide, under review

Timing & Pace Considerations

Pace & scope of investments are **driven by customer needs** & policy objectives. **Proportional deployment to align with customer value**



Data Requirements

Data are required from both utilities and DER providers to support planning, operations, and markets

Walk – Provide clear objectives and begin stakeholder discussions

- System planning data – determine data needs among participants; establish coordination processes
- Regulatory compliance data – clear descriptions of avoided cost methodologies and inputs; performance objectives

Jog – Establish sourcing mechanisms and situational awareness

- Commercial transaction data – create transparency in planning processes; establish operational market mechanisms
- Grid operational data – coordinate transaction schedules between distribution operators, wholesale market operators, and DER providers; provide situational awareness

Run – Enable full utilization of DERs

- In general – data is needed for market coordination and constraint management (across distribution/transmission systems)
- Market efficiency data – needed to provide market oversight and assess market efficacy

Modern Distribution Grid Report

A rigorous approach to support development of grid modernization strategies and implementation plans based on best practices

Volume I: Maps Grid Modernization Functionality to Objectives

- Grid architectural approach that maps grid modernization functionality to state objectives within a planning, grid operations & market operations framework

➢ **Enables evaluation of functionality required to meet a specific objective**

Volume II: Assessment of Grid Technology Maturity

- Assessment of the readiness of advanced grid technology for implementation to enable functionality and objectives identified in Volume I.

➢ **Enables evaluation of technology readiness for implementation**

Volume III: Implementation Decision Guide

- Decision criteria and considerations related to developing a grid modernization strategy and implementation roadmap with examples to illustrate application

➢ **Enables development & evaluation of grid modernization strategies and roadmaps for implementation**

Conclusions

- DERs provide capacity, energy and ancillary services, yet require flexible systems due to the variability they introduce.
- Integrated T, D (& C) planning, operations and markets are required at some level of DER integration (and to enable their full value)
- Coordination frameworks (establishing rules, responsibilities, points of interconnection and data requirements among participants) are required:
  - For scheduling and dispatch:
    - Transmission system operators require the predictability and assurance of DER commitments (visibility component)
    - Distribution system operators will need dispatch rights to ensure local reliability (or markets)
  - To enable scalability and optimization (local vs system)
  - To determine the communication and control structure (e.g., who controls the DER resource?)
- Need better optimization tools (to handle various time-scales)
- Need technologies to enable flexible operations (e.g., smart inverters and energy storage)

Thank You

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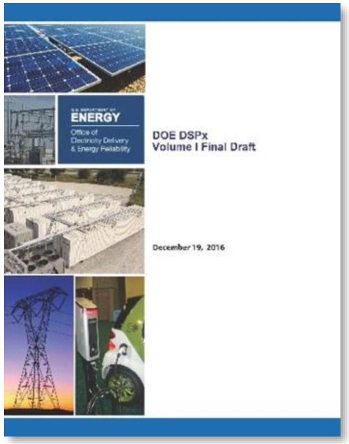
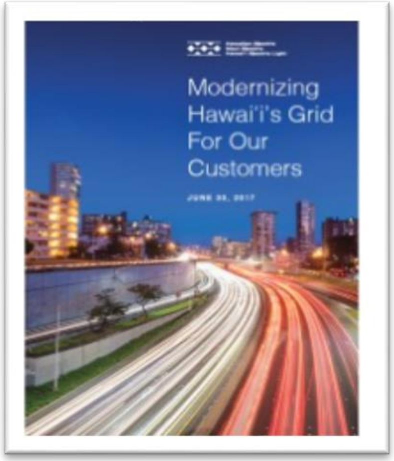
References:

Modern Distribution Grid Report



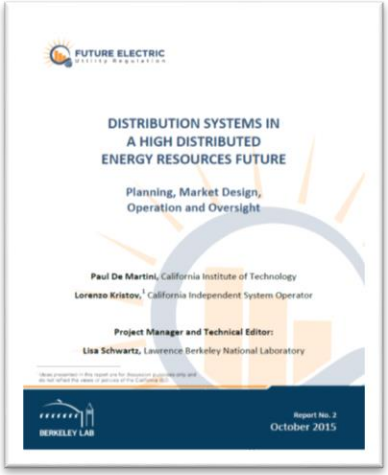
www.doe-dspx.org

Grid Modernization Strategy Using DSPx



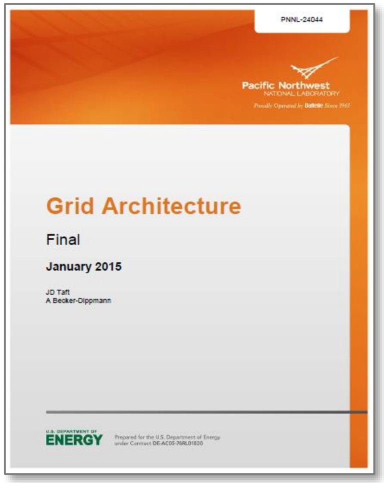
www.hawaiianelectric.com/gridmod

DSO Paper



https://emp.lbl.gov/projects/feur

Grid Architecture



http//gridarchitecture.pnnl.gov