Annual Meeting 2019

Evolving Transmission, Distribution, and Customer System Coordination

Wednesday, September 11 – Thursday, September 12

Austin, Texas

NATIONAL COUNCIL ON ELECTRICITY POLICY

Welcome to the NCEP Annual Meeting 2019

The Honorable Paul Kjellander, President of NCEP and President at the Idaho Public Utilities Commission (PUC)

Welcome to the NCEP Annual Meeting 2019

All Attendees in the room.

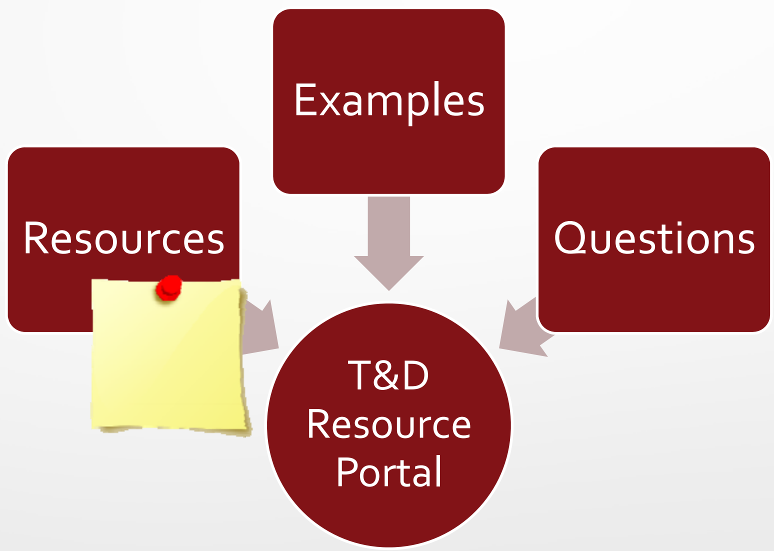
All Attendees on the phone.

Agenda & Objectives
Facilitation Overview
Housekeeping

Agenda & Objectives

- **Discuss experiences**
  - Discussion: Resources, Experiences, and Needs
- **Examine ideas**
  - Expert Insight
- **Participate in an ongoing conversation**
  - Compendium
  - T&D Resource Portal
- **Hear insights and lessons learned**
  - Engage

Facilitation Overview



Minimum: Considerations

Facilitation Overview

Compendium of Resources for State Electricity Policy Officials: Evolving Transmission & Distribution Intersections

Transmission & Distribution Resource Portal

Linked on meeting agenda.
Few Desk Copies Available at Registration.

Housekeeping & Questions

- Breaks and Lunchbreaks
- Please sign in
- Listserv Update: MYNARUC account
- Questions

Inaugural Jan Brinch Award for Collaboration in Public Service

Gratitude from Jan's Family

Cheryl LaFleur
Inaugural Award Recipient

Cheryl LaFleur

Inaugural Jan Brinch Award for Collaboration in Public Service Award Recipient

Keynote & Welcome to Texas

Dub Taylor

Texas State Energy Conservation Office Director

Physical System & Operating Essentials

Hon. Nick Wagner, Moderator

Paul De Martini

Jeff Taft

GRID ARCHITECTURE

Grid Architecture Concepts for TDC Coordination

September 11, 2019

Pacific Northwest
NATIONAL LABORATORY

How to Build A House

What do you pick up first:

a shovel

or a pencil?

The Word "Architecture" Is Used Many Ways

- House or building layouts
- Master plans
- Organization models
  - device like an integrated circuit chip
  - company internal arrangement
- Block diagrams
- High level ("logical") design views of IT systems
- System designs or implementations
- Other abstractions like layer models

We need to be clear on what we mean by grid architecture.

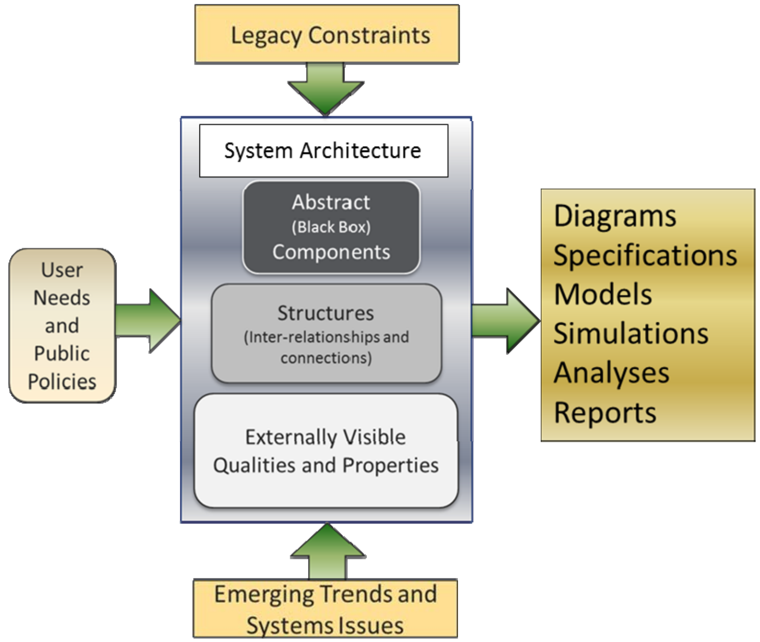
System Architecture

Architecture

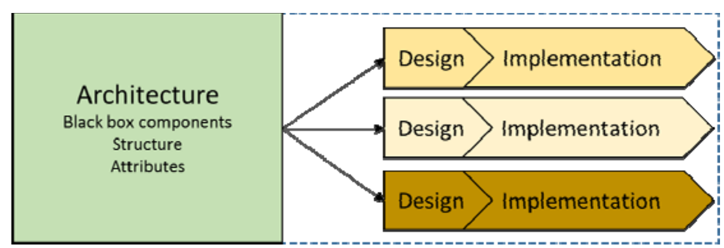
- An abstract depiction of a system, consisting of black box components, structure, and externally visible properties

Purposes:

- Identify legacy constraints
- Remove barriers and refine essential limits
- Help manage complexity (and therefore risk)
- Support early stage modernization processes
- Identify gaps in structure, technology
- Assist communication among stakeholders
- Define platforms
- Inform interfaces and interoperability

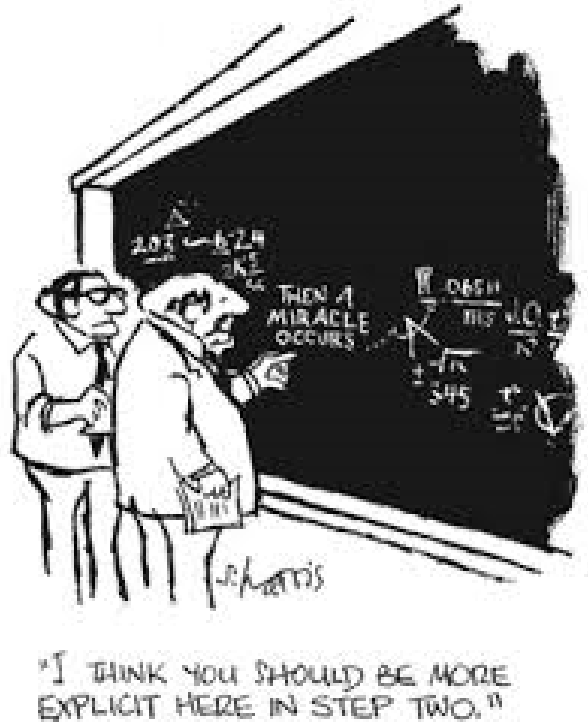


Architecture is *not* design.



Elements of System Architecture: Components

- Abstract components
  - The individual parts, viewed as “black boxes”
  - Example: storage battery
    - At this level we do not specify how the battery works
    - Care about externally visible characteristics like storage capacity, max power rating
  - But thoroughly grounded in reality
    - no “magic” boxes, miracles, or anti-gravity



Source: Sidney Harris

Elements of System Architecture: Structure

- Abstract components
  - The individual parts, viewed as “black boxes”
  - But thoroughly grounded in reality (no “magic” boxes)

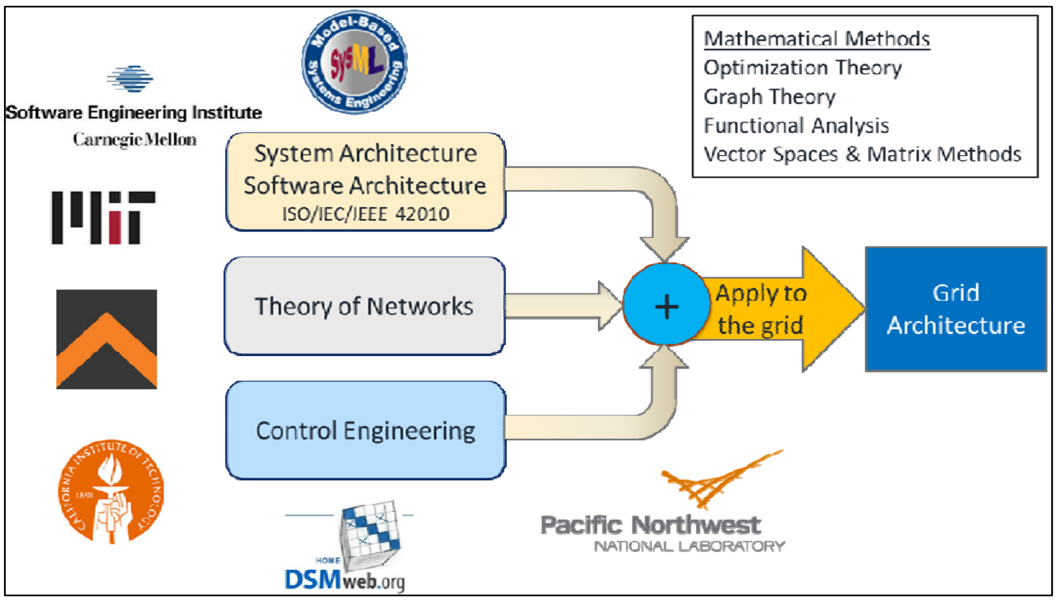
- Structures
  - The overall shape of the system and how components interact
  - Any complex system has multiple structures, requiring multiple views
  - No real architecture can be represented in a single diagram



Grid Architecture is
System Architecture for the Grid

Grid Architecture is the application of system architecture, network theory, and control theory to the electric power grid.

A grid architecture is the highest level description of the complete grid, and is a key tool to help understand and define the many complex interactions that exist in present and future grids.



System Complexity and Electric Grids

Low Complexity

Medium Complexity

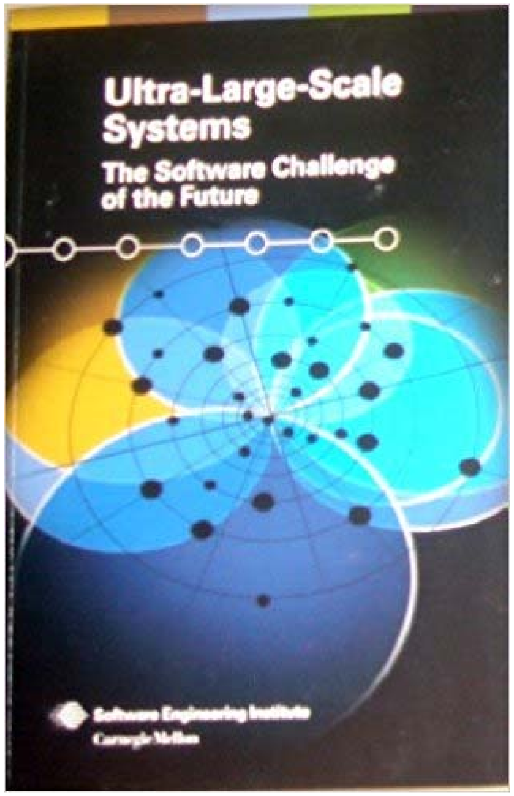
High Complexity

Power systems are off the chart…

Complexity is the hidden bear in the room when dealing with grid modernization.

Ultra-Large-Scale Systems

- Based on concepts/theory developed at Carnegie-Mellon University
- Mark Klein, Linda Northrop, et. al, Ultra-Large-Scale Systems, Software Engineering Institute, Carnegie-Mellon University, 2006
- This is a kind of system, not an architecture
- Basic presumption is that some classes of systems have levels of complexity that “push far beyond the size of today’s systems and **systems of systems** by every measure…”
- Defense systems – DoD
- US health care system
- Electric Power Grids

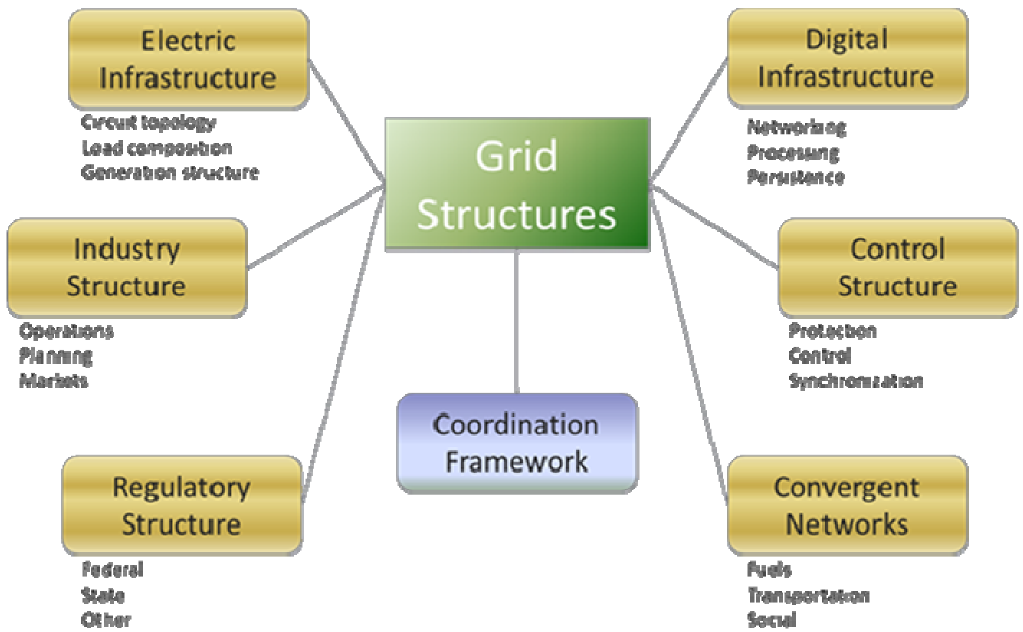


Seven Ultra Large Scale Systems Characteristics

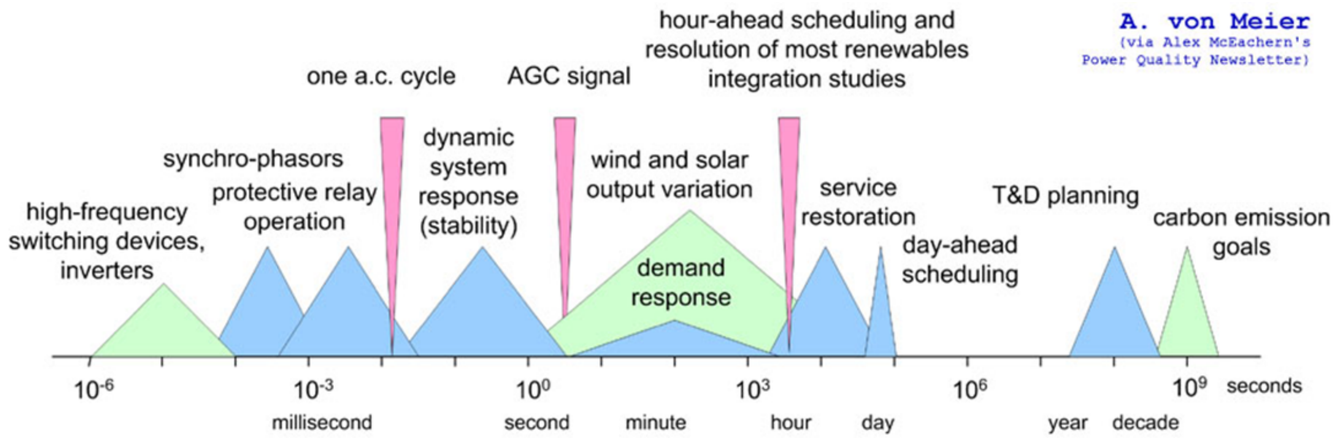
1. Inherently conflicting diverse requirements
2. Decentralized data, control, and development
3. Continuous (or at least long time scale) evolution and deployment
4. Heterogeneous, inconsistent, and changing elements
5. Wide time scales
6. Wide geographic scales
7. Normal failures

Why is the Grid Ultra-Large-Scale Complex?

- The grid is comprised of many already complex structures
- These structures are interconnected and interact in complex ways
- This results in an explosion of complexity.

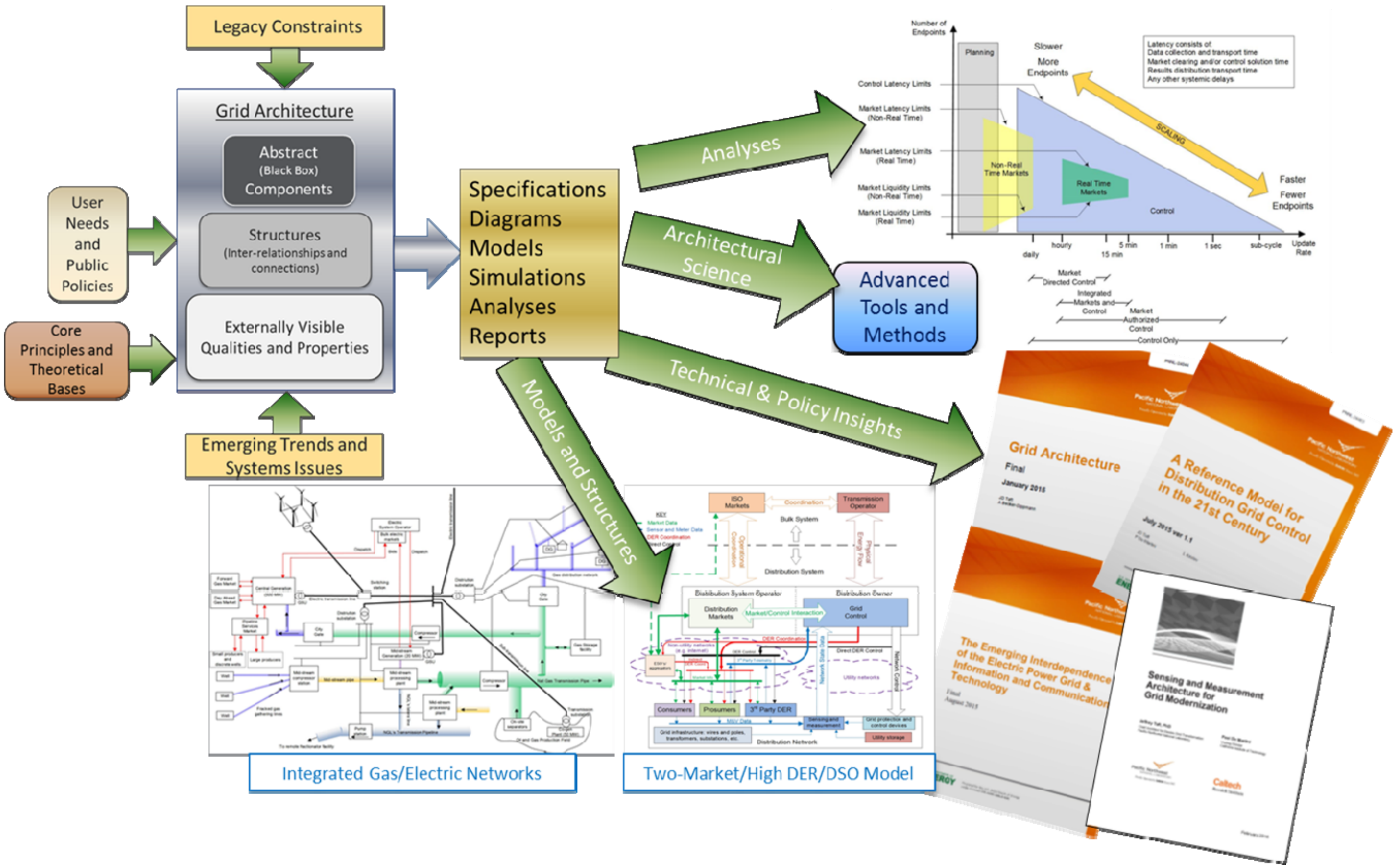


Wide Time Scales



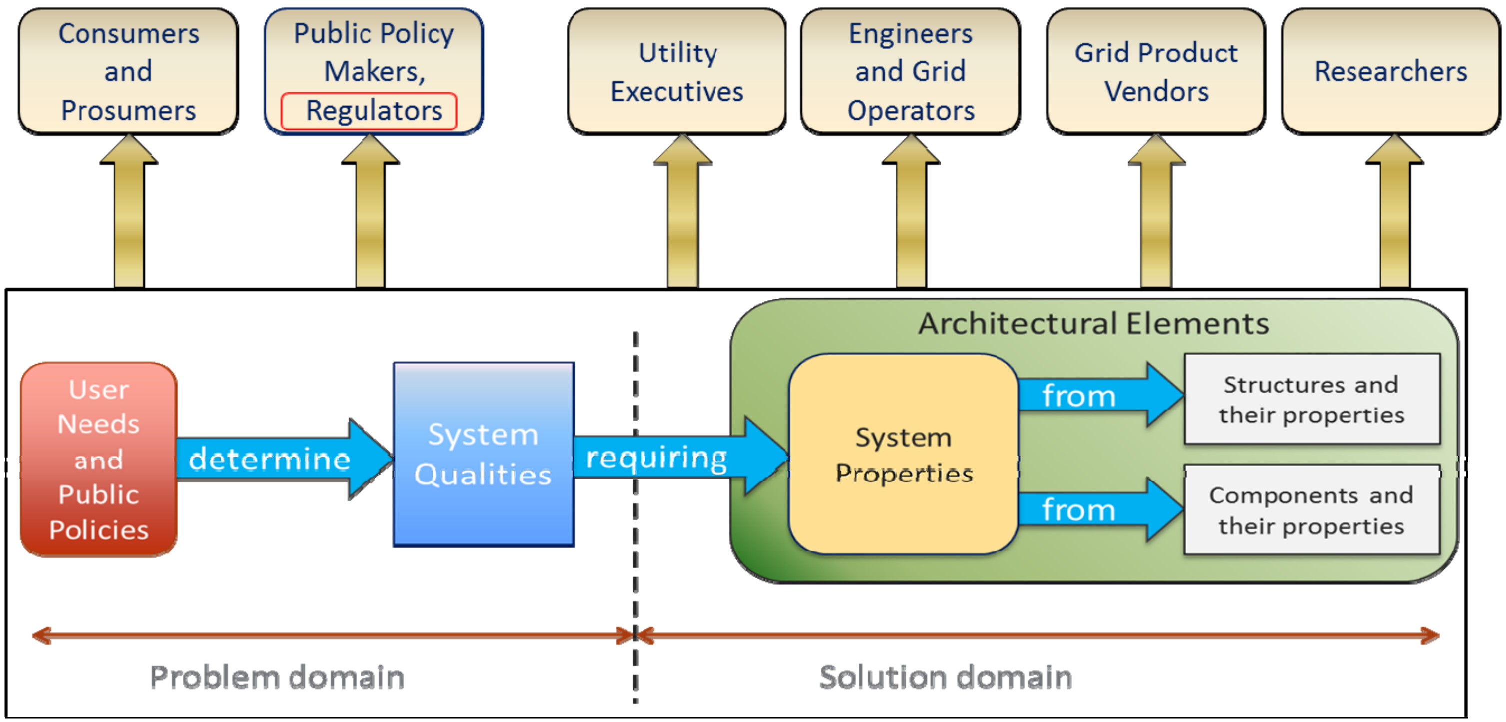
- Most control theory assumes a narrow range of relevant time scales
- Grid control must be structured for anything from milliseconds to days at least
- If planning is understood to be part of the overall control process, then the time scales extend to years
- Distribution level dynamics are shifting toward shorter time scales due to distribution level VER penetration (wind and solar PV)
- The value to be extracted from DER depends in part on temporal granularity
- DER control and coordination must be capable of handling the faster dynamics

Manage Complexity; Produce *Insight*

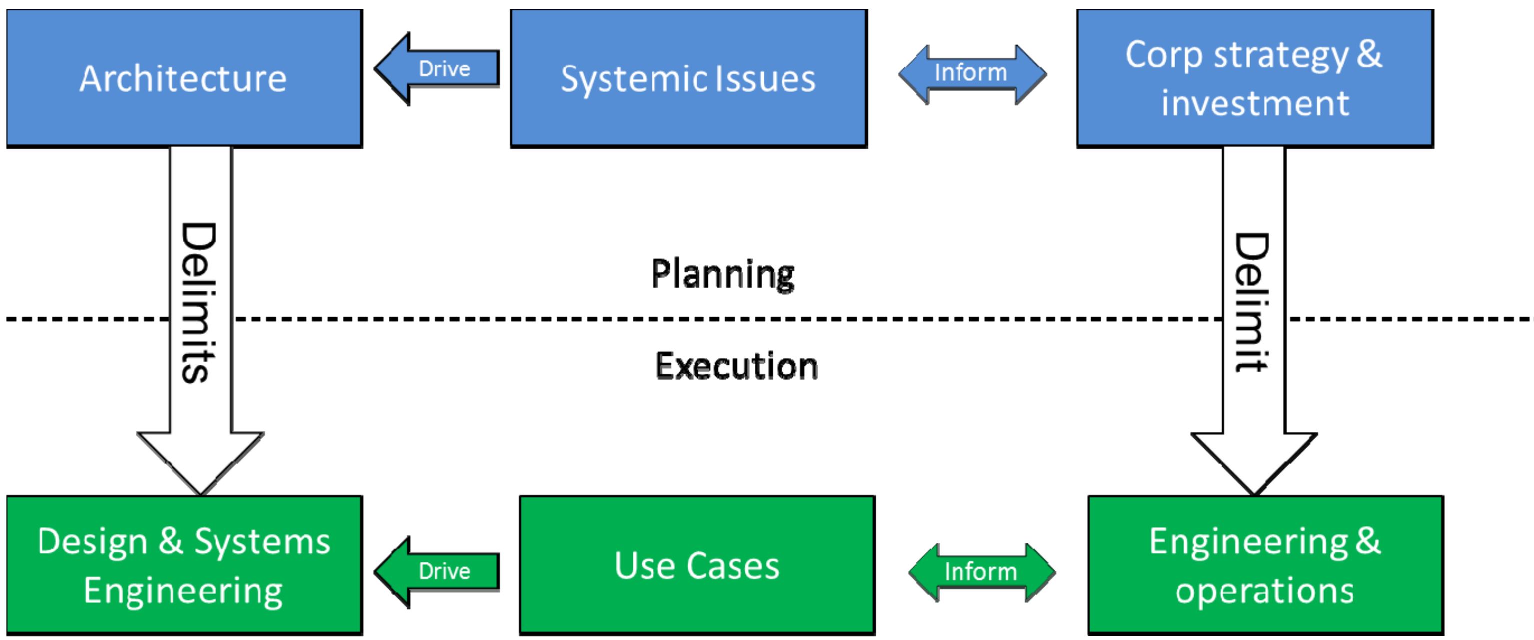


You Do Not Have to be an Architect to Use the Results of Grid Architecture

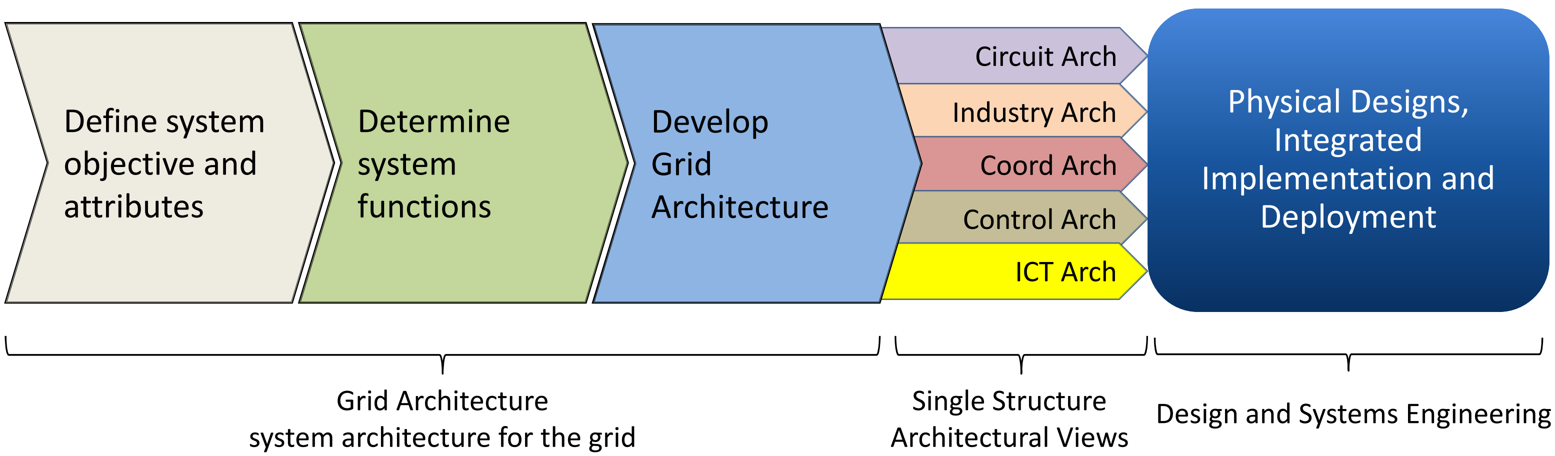
Grid Architecture supports a wide range of stakeholders, including:



Architecture and Design



Sequential Relationship of Architecture, Design, and Systems Engineering



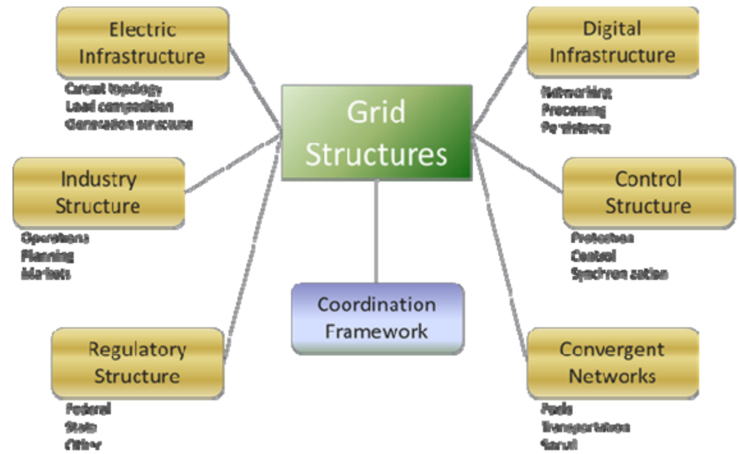
With Grid Architecture You Get…

Without Grid Architecture You Get…

Structure

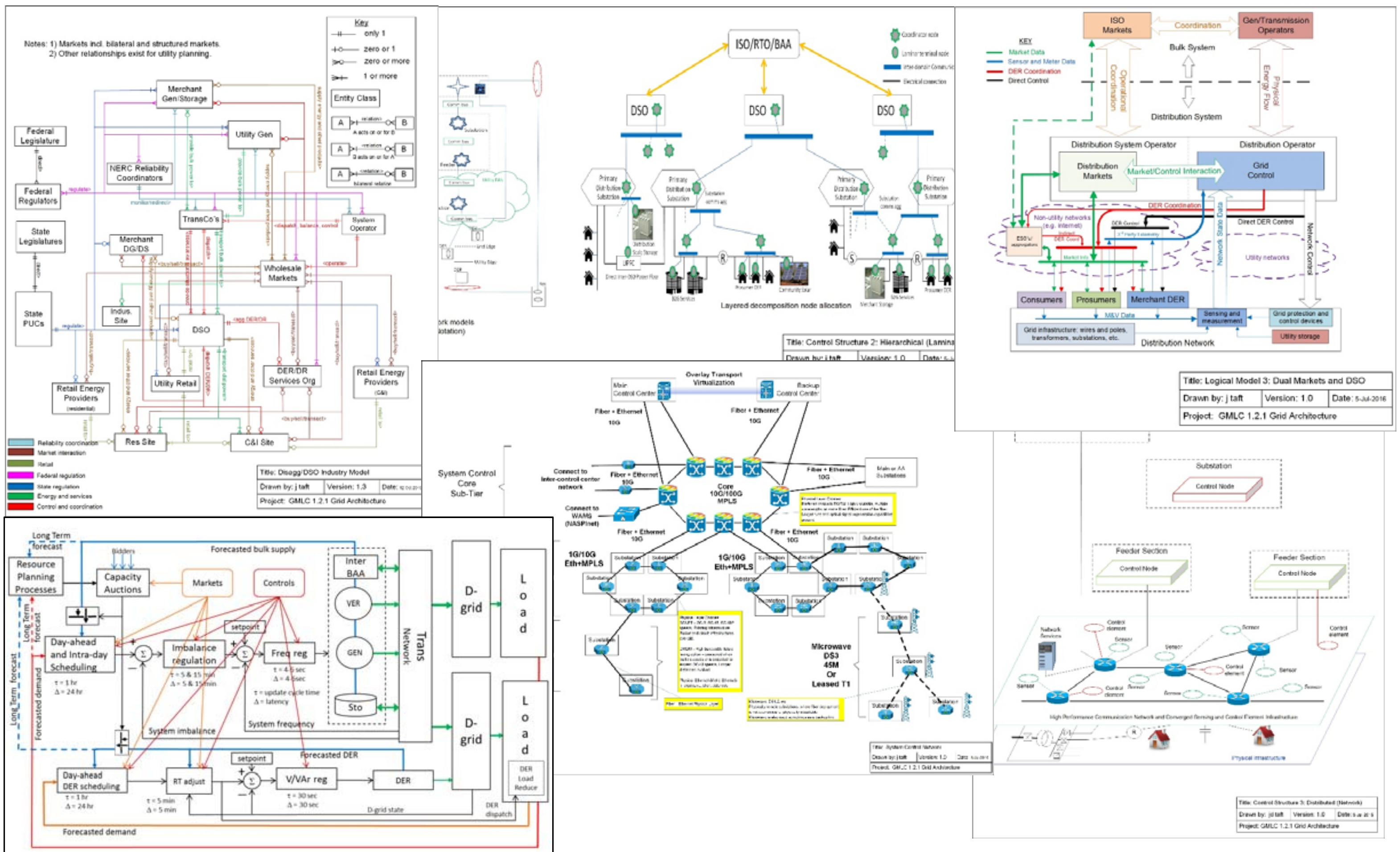
Grid Architecture Focuses on Structure

- The grid is composed of many inter-linked structures
- Because we have inherited much legacy grid structure, new capabilities and improved characteristics can require understanding of existing grid structure and potential changes to grid structure
- Determining minimal changes to relieve structural constraints is a key grid architecture problem

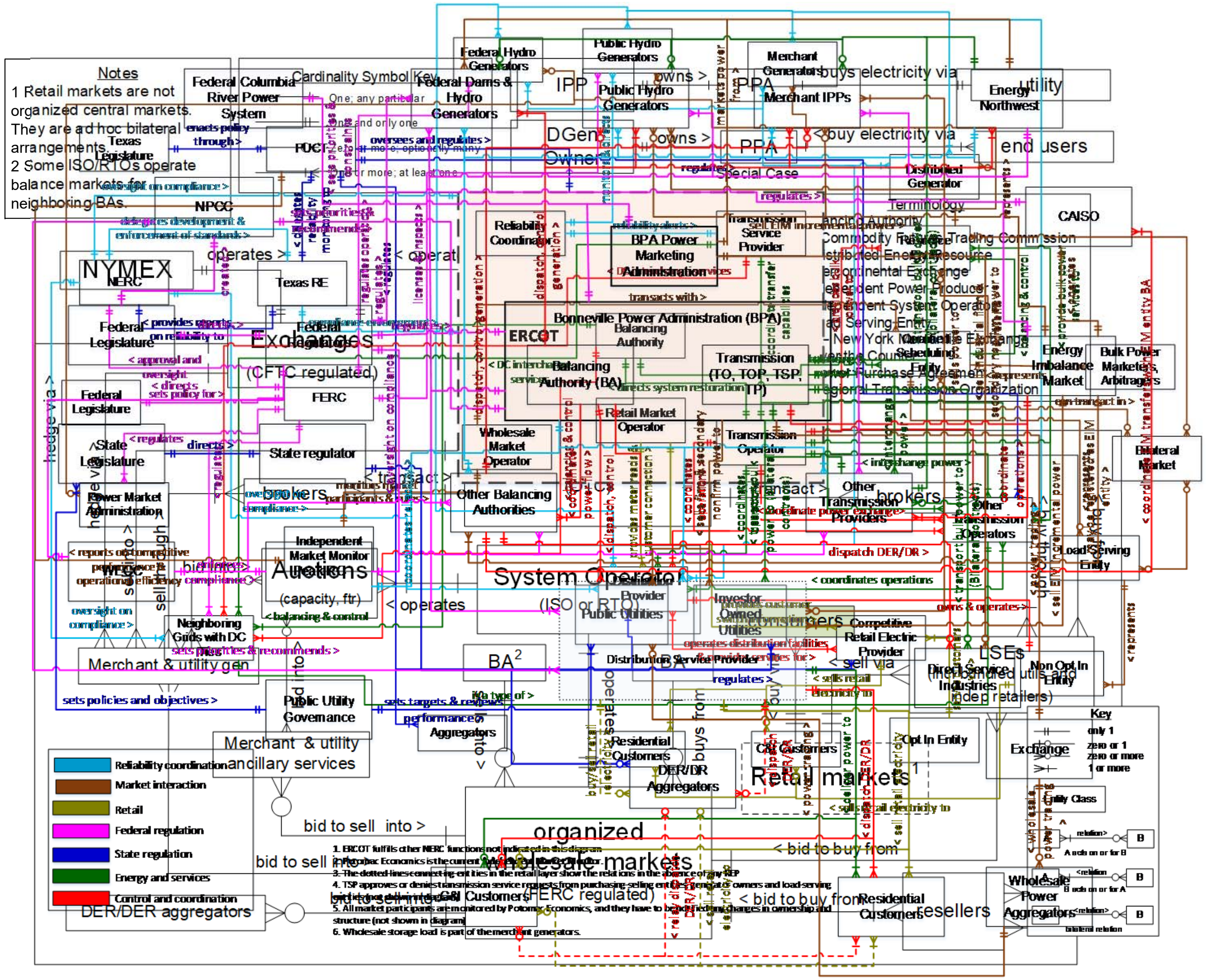


- Get the structure right and all the pieces fit into place neatly, all the downstream decisions are simplified, and investments are future-proofed
- Get the structure wrong and integration is costly and inefficient, investments are stranded, and benefits realization is limited

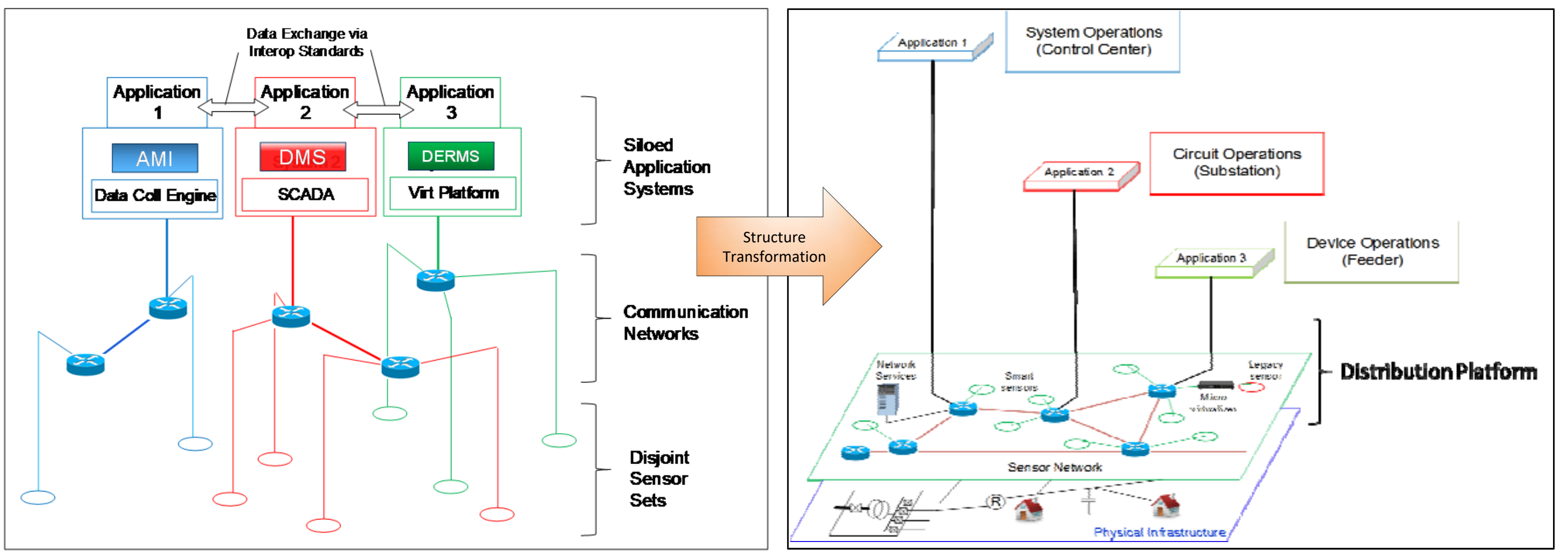
The Grid = Multiple Structures



Structural Models



Sensor-Communications Network Layers: Reduce Dependency & Brittleness



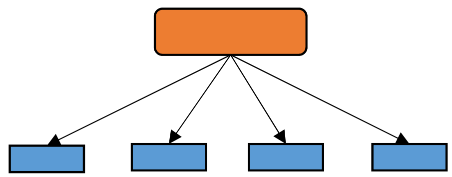
Brittle & Expensive

Resilient & Future-proofed

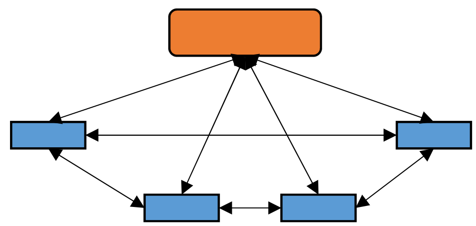
Coordination Structure

Definitions

- Decentralized System – multiple separate entities operating independently with at most some small amount of supervision



- Distributed System – decentralized system where the parts cooperate to solve a common problem



- This implies some form of peer-to-peer interaction and communication

- Coordination is the means by which a set of decentralized elements to cooperate to solve a common problem, thus becoming a *distributed system*
  - This is the essence of distributed system function

- Therefore *coordination structure* is a key aspect of distributed systems, distributed control, etc.

Definition: The Grid Coordination Problem

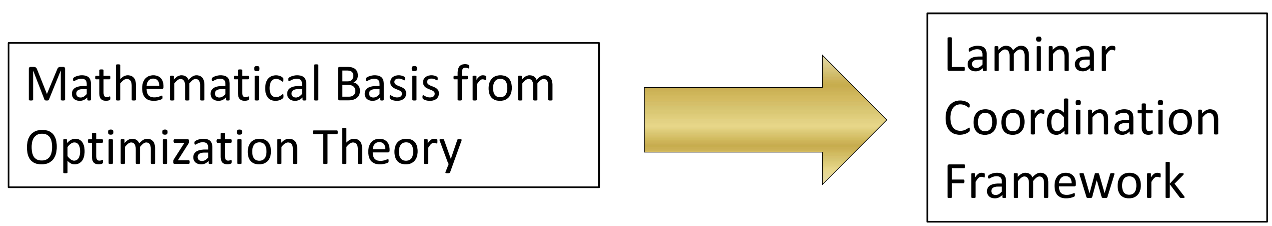
- Grid coordination is the systematic operational alignment of utility and non-utility assets to provide electricity delivery
- Coordination was not a well recognized issue for electric distribution until fairly recently
  - Some forms have been around a long time
    - C&I DR
    - Bulk gen in deregulated industry segments
- The motivation for the present level of interest is the rise of two things:
  - Distribution connected DG and DS
  - Flexibly controllable loads

This is an issue because many of these resources are not owned by the utility and often cannot be controlled directly.

Layered Decomposition

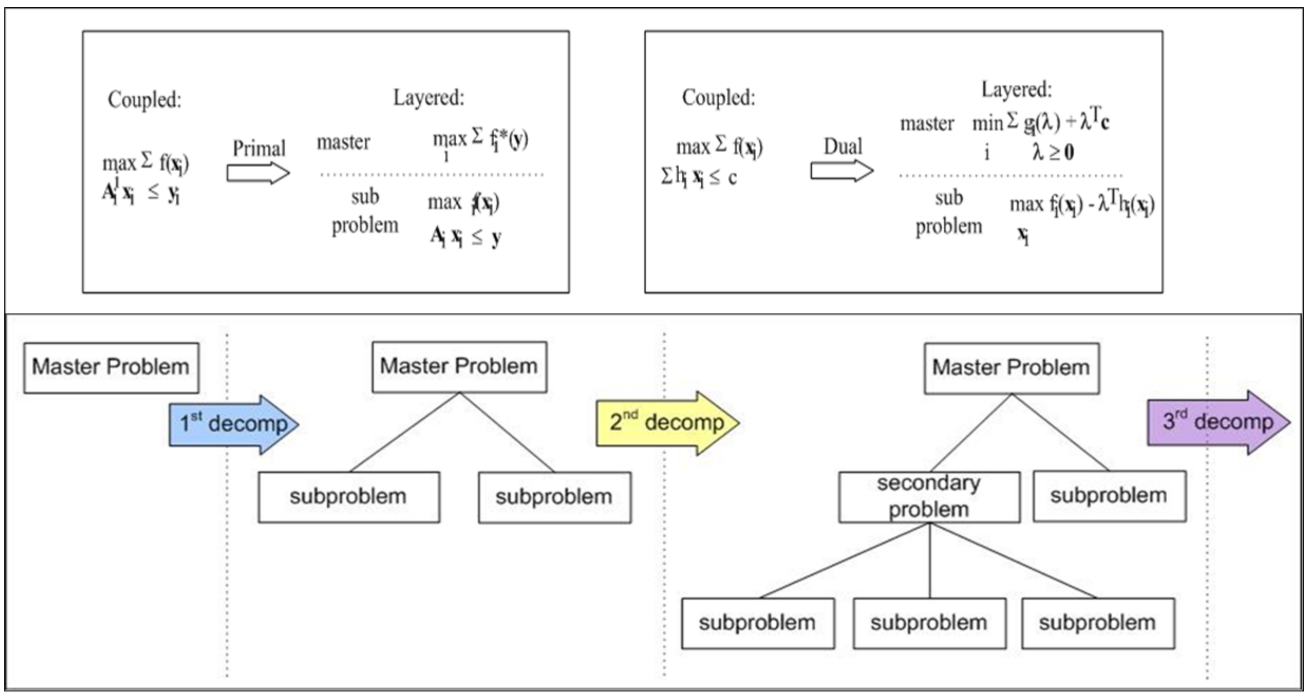
Structural Basis for System Coordination

- Want structure to be derived rigorously
- Need a distributed form with knowable properties
- Here we are not interested in a specific solution but rather a class of solutions
- We wish to extract essential *structure* by understanding the problem class



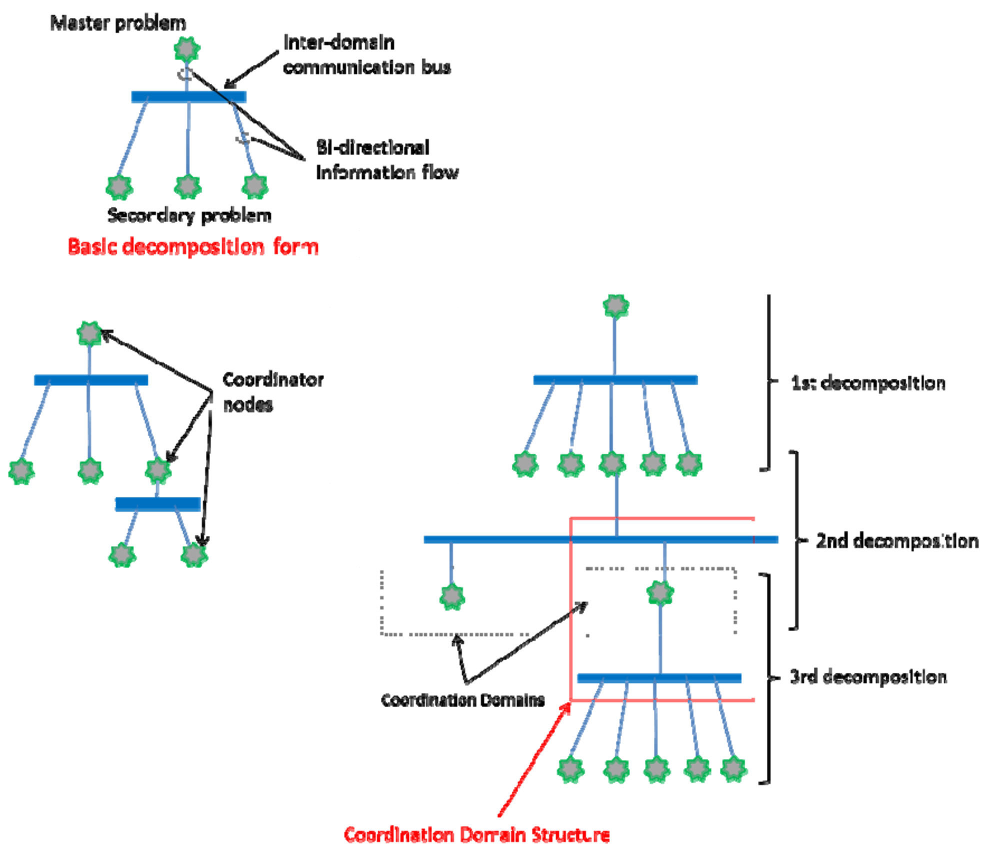
Network Utility Maximization via Layering for Optimization Decomposition

- Well-known in optimization theory for solving problems with highly coupled constraints
- We will use the math to *induce* a coordination structure



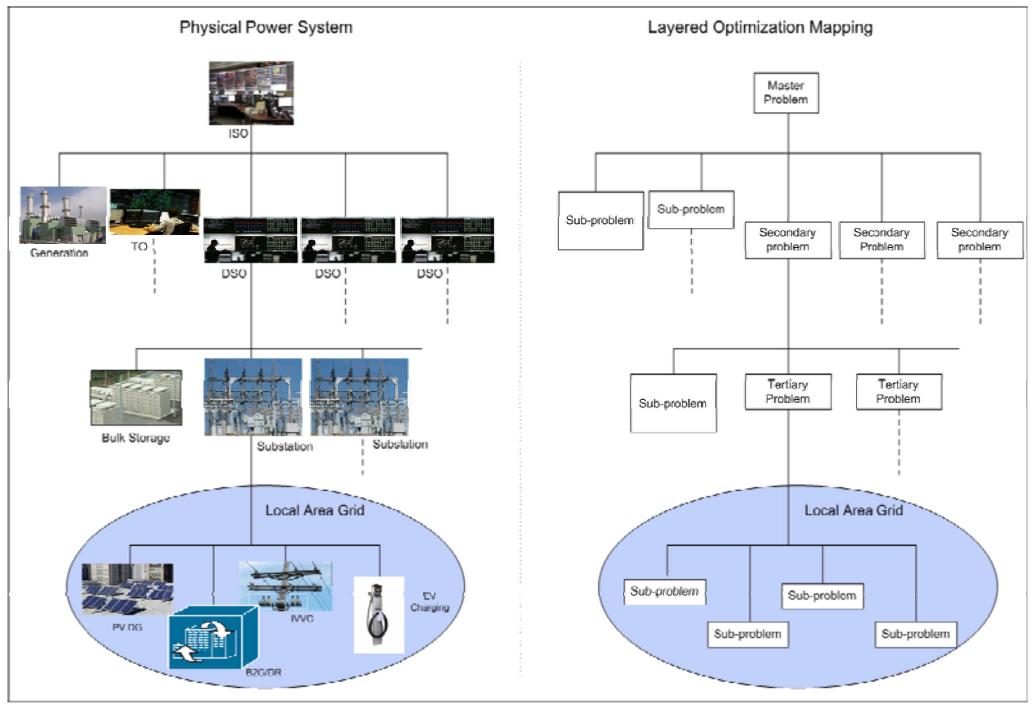
Essential Laminar Coordination Structure

- Multi-layer structure
- “Vertical” chain of coordination nodes: scalable message flow
- Core repeating building block: coordination domain



Mapping to the Grid

- Decomposition can be applied to as many levels as needed
- Boundary deference
- Multi-level constraint fusion

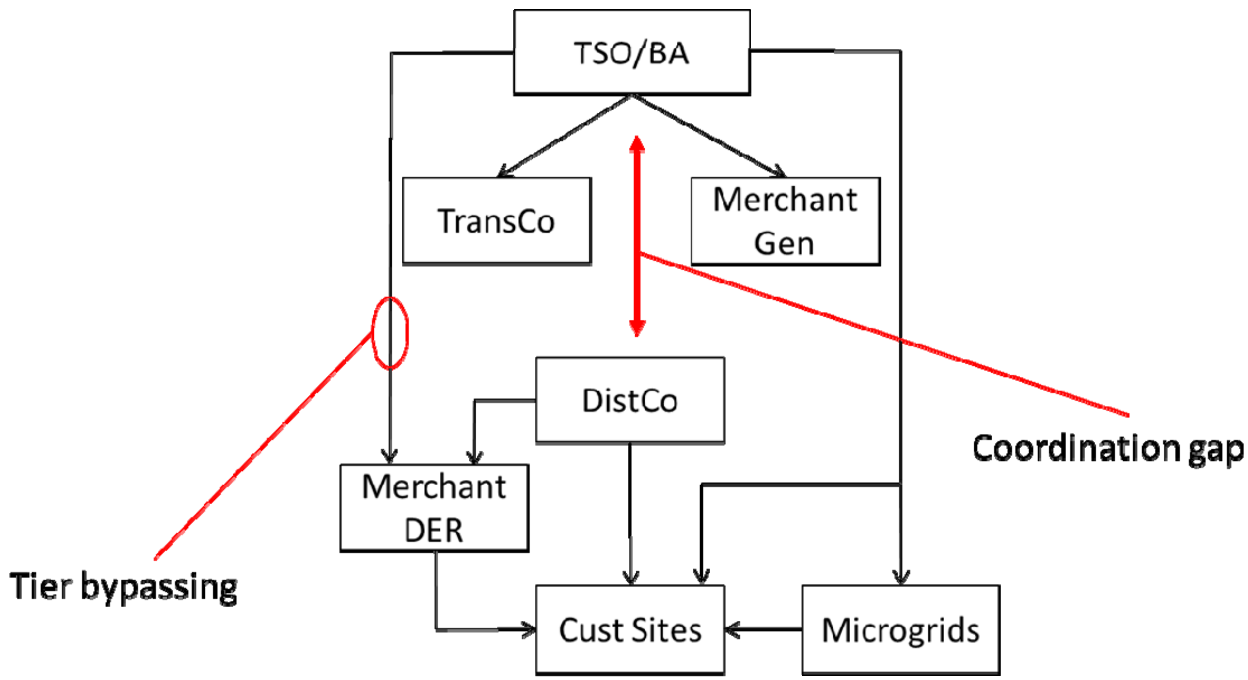


This Approach Leads to General Principles

- Multi-layer form
- Local selfish optimization inside global coordination
- Allows mixed coordination signal models:
  - Allocations (control)
  - Prices (market-like methods)
- Scalable inter-layer interaction
- Proportional buildability

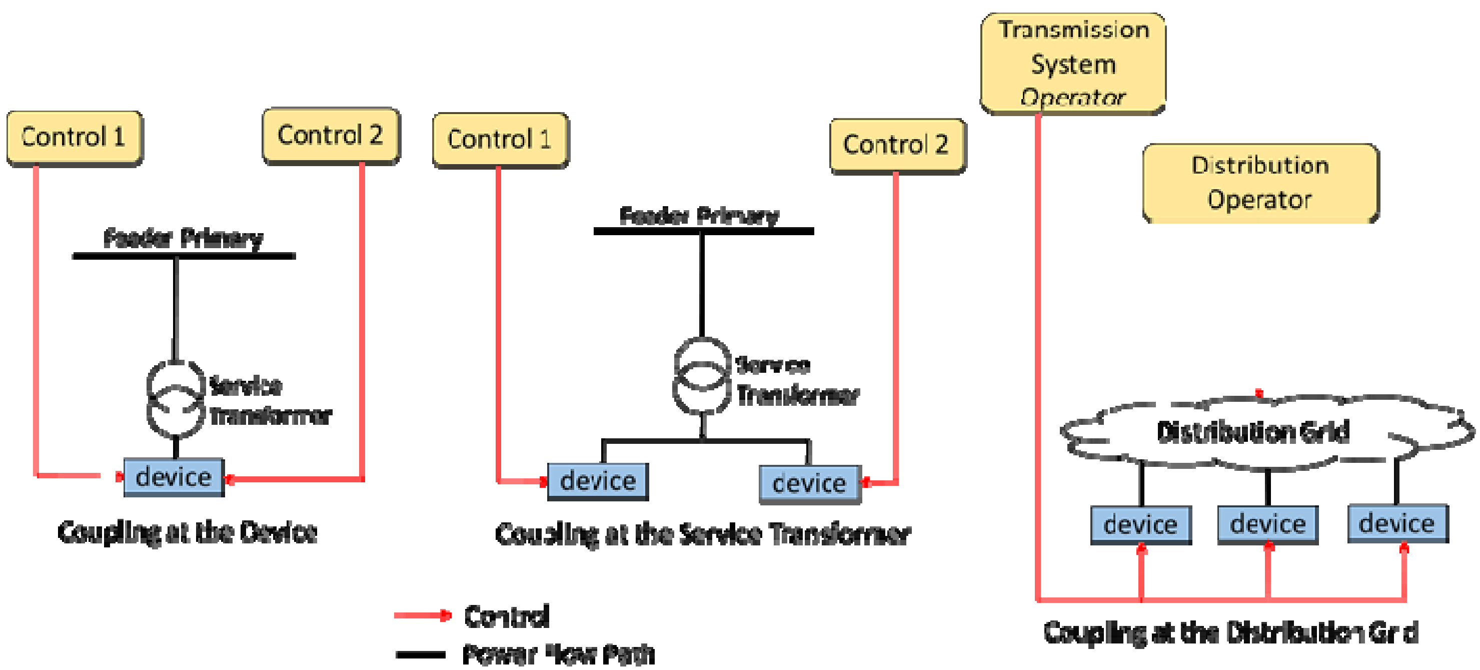
Structural Problems to Avoid-1

- Tier Bypassing
- Coordination Gapping

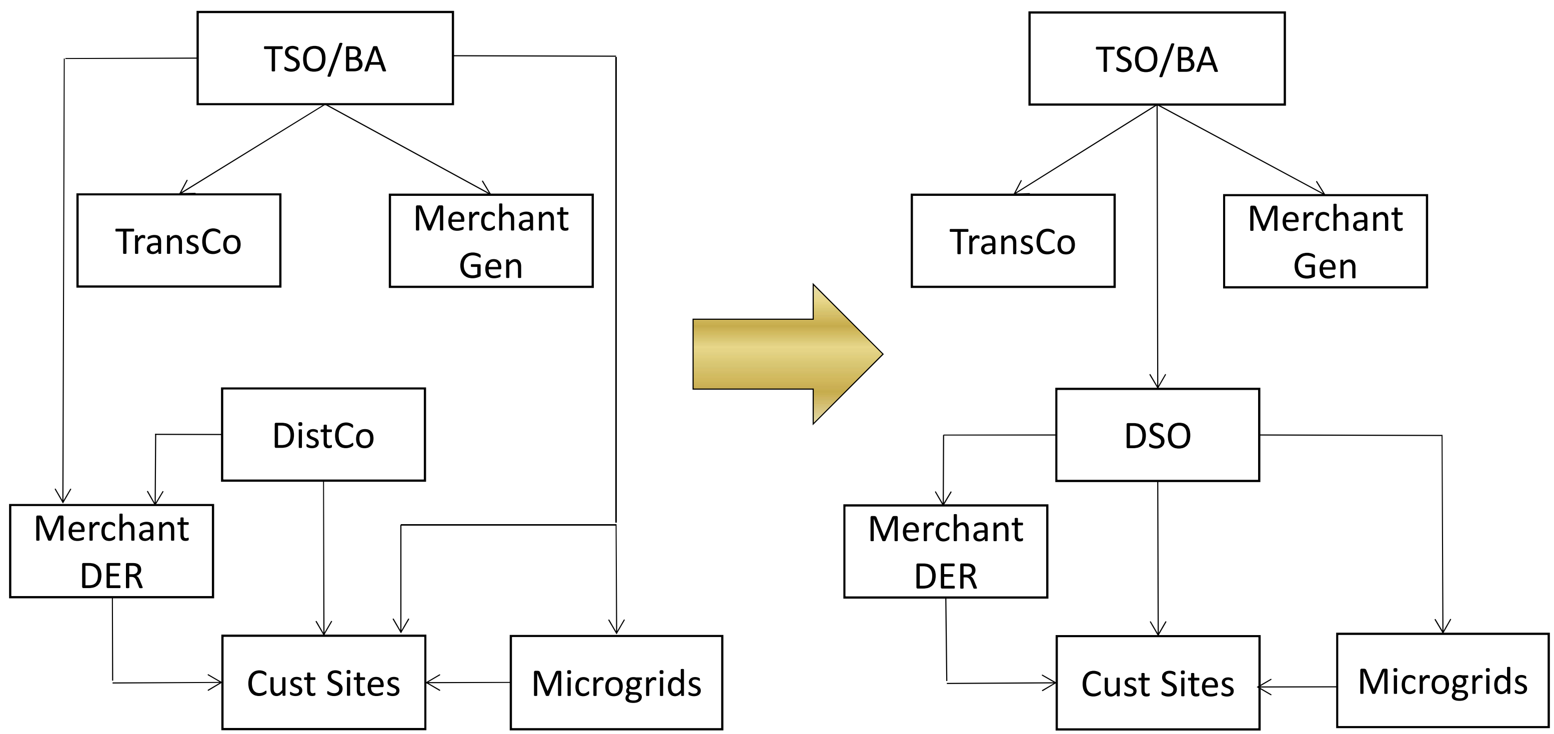


Structural Problems to Avoid-2

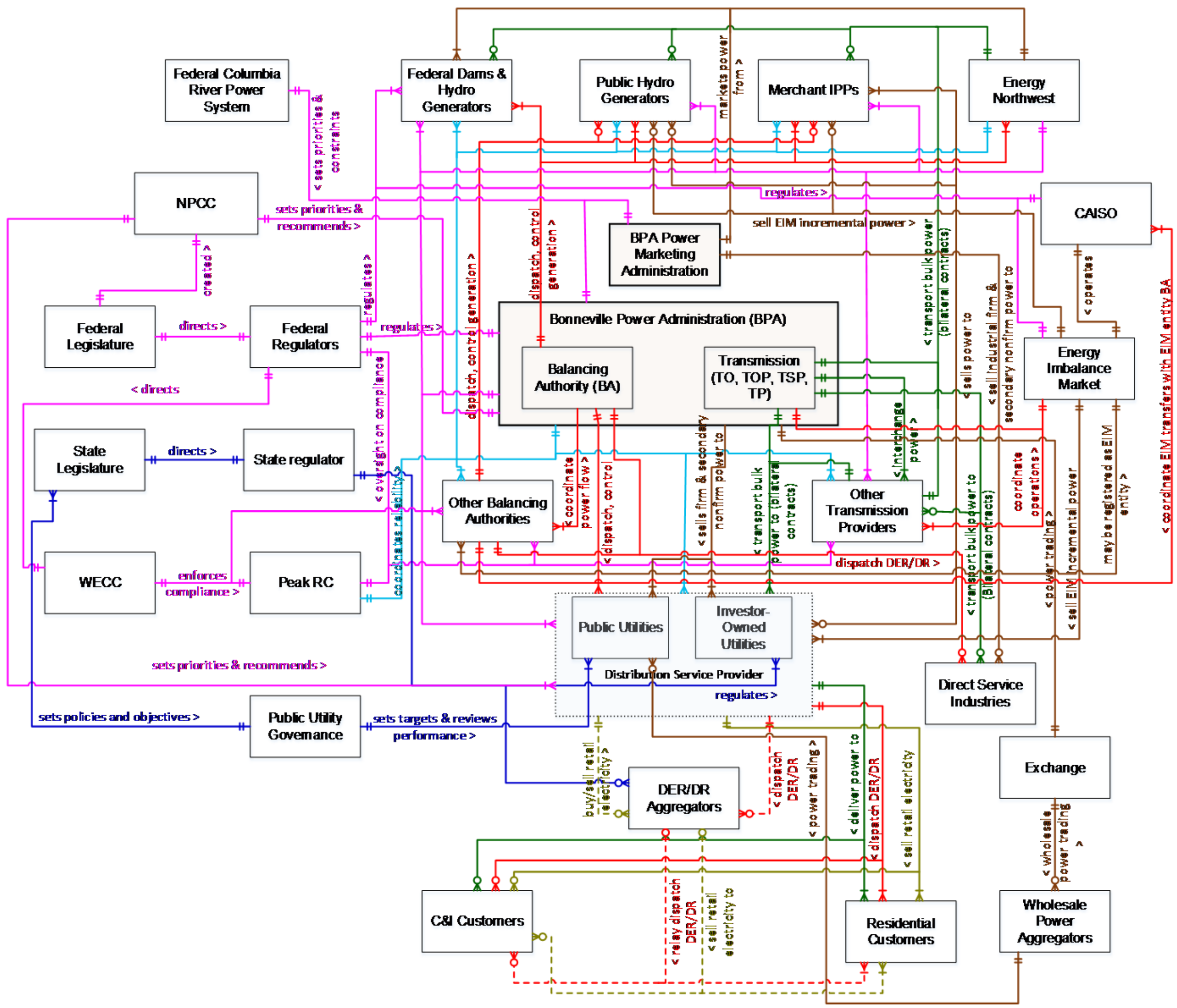
- Hidden Coupling



Adjusting Coordination Structure

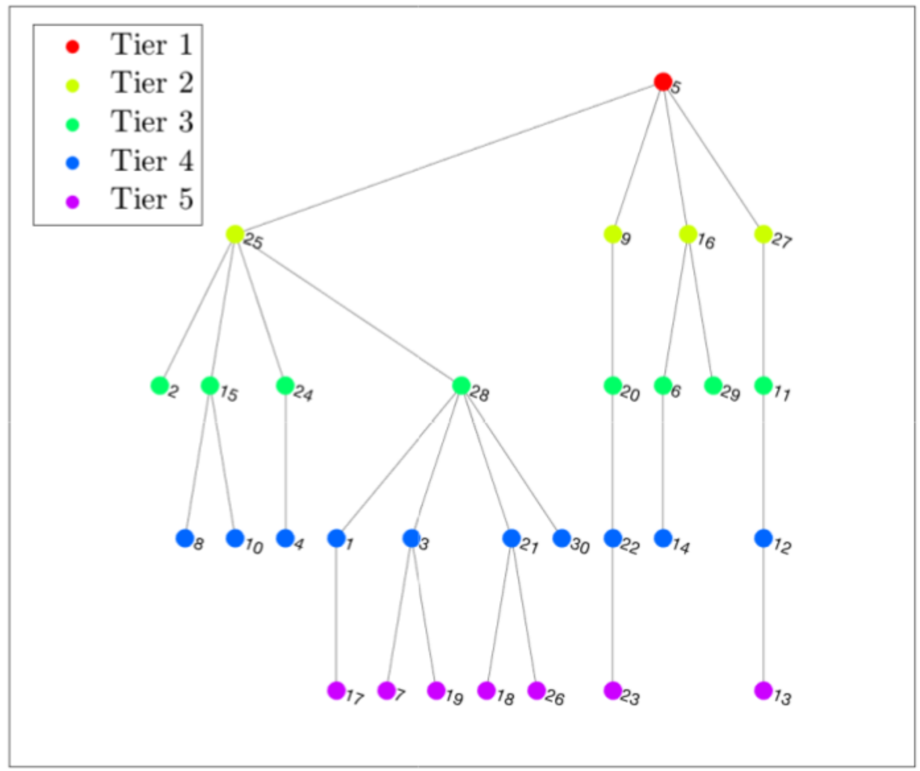


Not So Simple in Real Situations

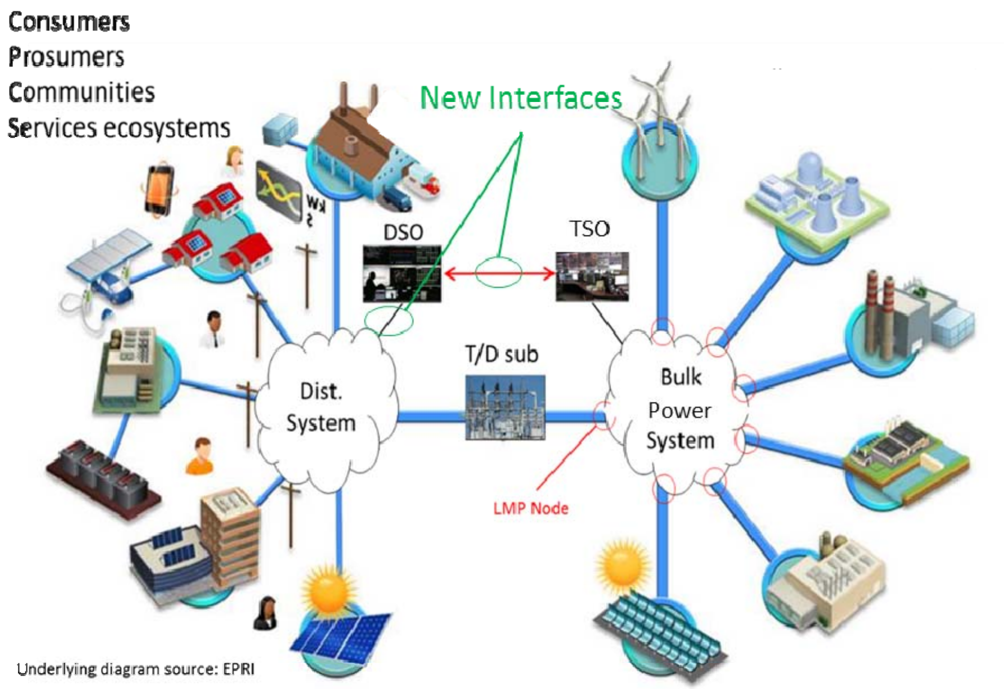


Idealized vs. Real

- Idealized architectures can look elegant and be intellectually pleasing
- Those are almost always not real
- Real architectures have to take into account lots of factors and can become messy
- We use GA methods to manage the messiness



Grid Architecture Informs the TDC Coordination Problem in Useful Ways



- Roles and Responsibilities
- Grid observability
- Distributed control
- Coordination structure

- Scalability, granularity
- Functional flexibility
- Distribution platforms
- Cyber security

GRID ARCHITECTURE

TDC Coordination

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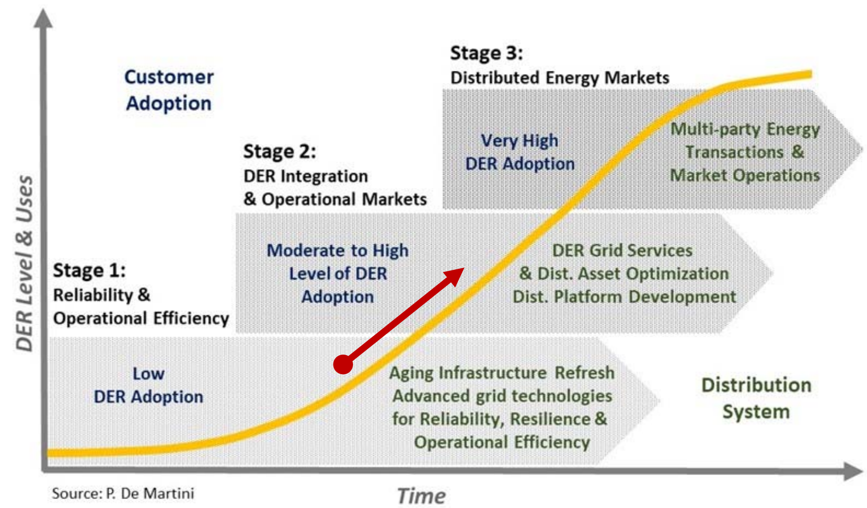
Industry Evolution: Changing Role of DER

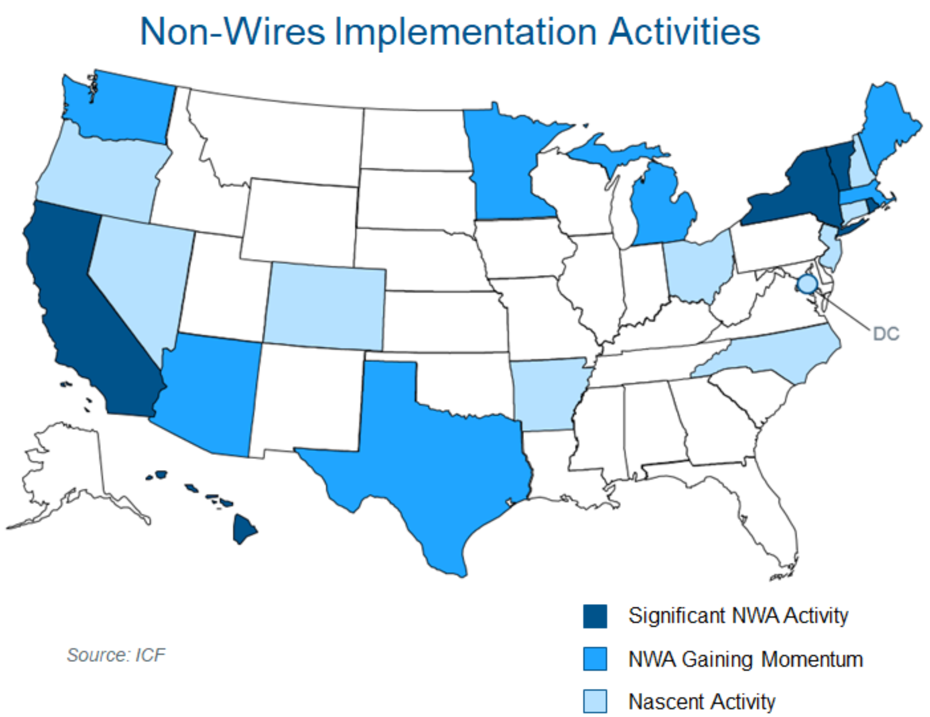


Stage 2: Operational Markets

A. Use of DER as load modifying resource for both Distribution non-wires alternatives (NWA) and Bulk Power capacity and ancillary services
B. Participation of DER export energy (discrete/aggregated ahead of the meter and aggregated behind the meter) in bulk power markets

Non-Wires Alternatives Today

- Still in largely 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



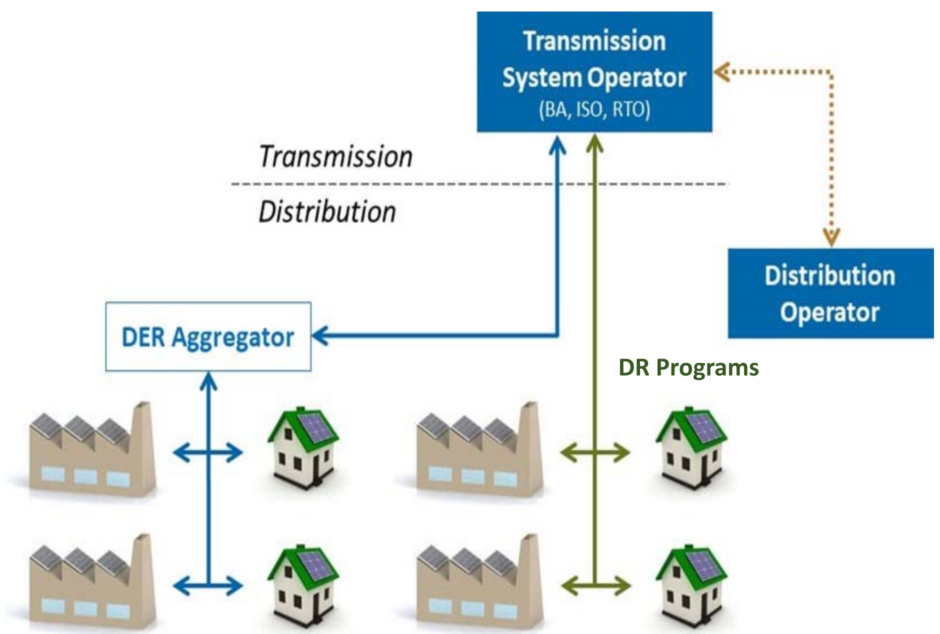
Integrated System Operations Evolution

A spectrum of possible designs can be envisioned in terms of the complementary roles of DSO and TSO at the T-D interface.

Total TSO:	**Hybrid DSO**:	**Total DSO**:
TSO optimizes the entire power system into the distribution system, including dispatch coordination of all DER services and schedules	TSO optimizes the bulk power system – including dispatch of all wholesale DER services – but has no visibility into the distribution system	TSO optimizes the bulk power system. TSO sees a single aggregate or "virtual" resource at each T-D Interface managed by DSO
DSO responsible for reliable distribution network operations & providing distribution network visibility to TSO	DSO optimizes the distribution system – including dispatch of all distribution DER services & coordinates with TSO on all DER dispatch	DSO responsible for physical coordination & aggregation of all DER services into single resource at T-D Interface & wholesale market
Customer/Aggregator coordinates with TSO – no operational interface with DSO	Customer/Aggregator coordinates with both TSO and DSO	Customer/Aggregator coordinates with DSO – no operational interface with TSO

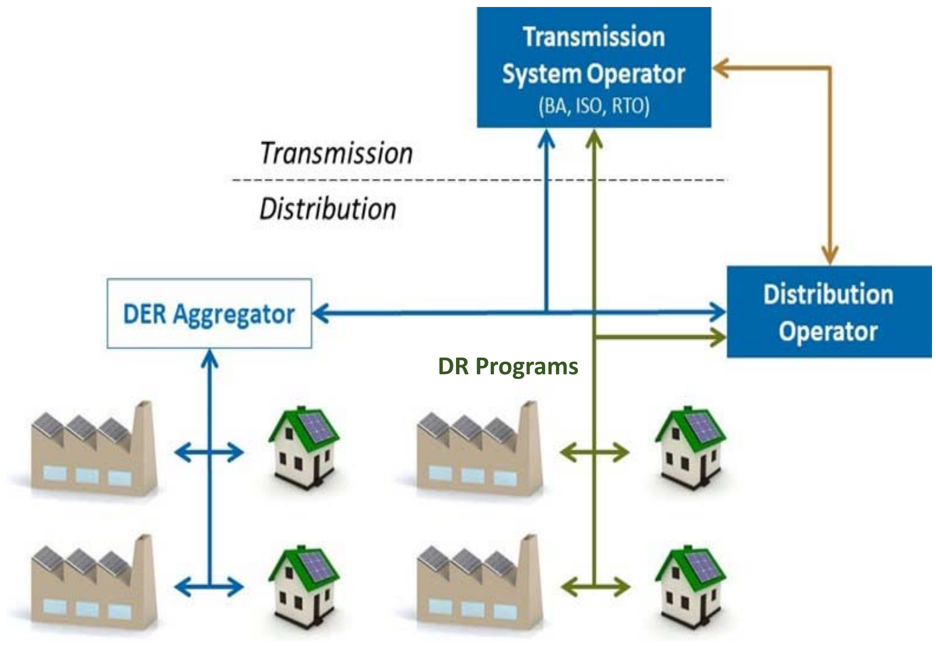
Total TSO Conceptual Reference Model

Centralized control of all DER resources across T&D – Requires TSO to also dispatch distribution NWAs and coordinate distribution operations



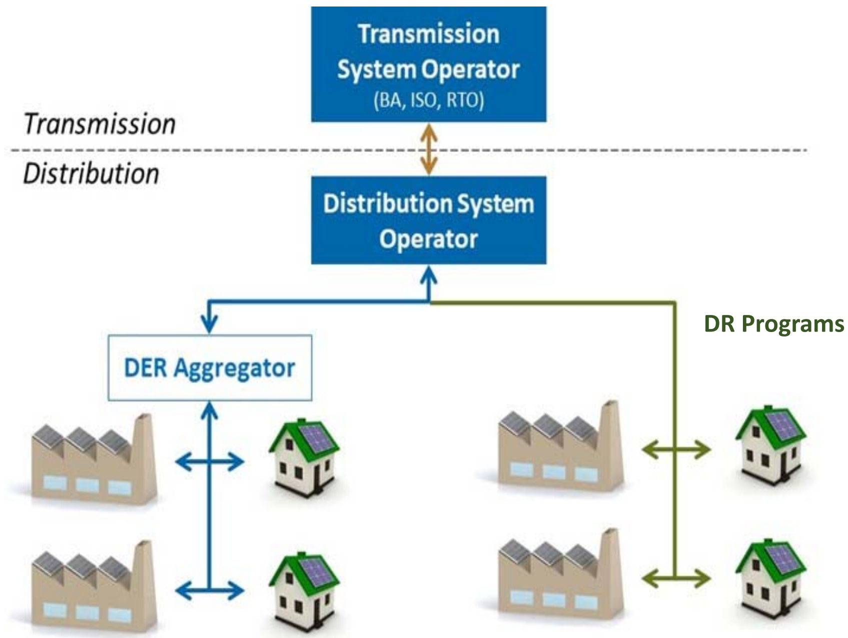
Hybrid DSO Conceptual Reference Model

Shared responsibility for use of DER for Wholesale markets and Distribution NWAs as well as coordination of grid operations



Total DSO Conceptual Reference Model

Fully Layered Approach – DSO provides the single operational interface between DER and Wholesale Market Operator



GRID ARCHITECTURE

Thank You

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Pacific Northwest NATIONAL LABORATORY

Physical System & Operating Essentials

Hon. Nick Wagner, Moderator

Paul De Martini

Jeff Taft

Coordination Principles

Hon. Ted Thomas, Moderator

Paul De Martini

Jeff Taft

GRID ARCHITECTURE

Application of Grid Architecture for TDC Coordination

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Architectual Considerations

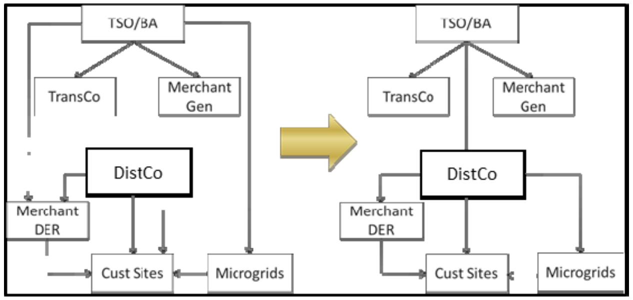
(for TSO-DSO Coordination)

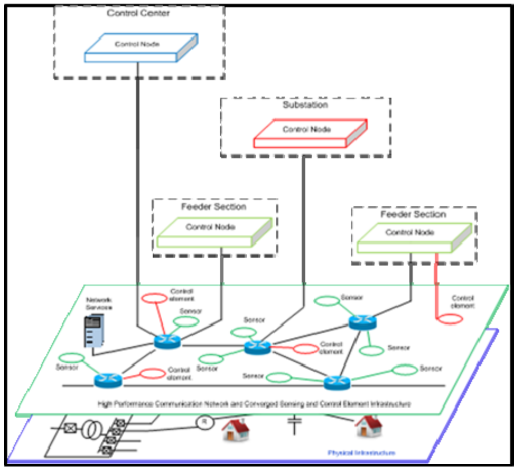
Considerations	Description
Observability	Function related to operational visibility of the distribution network and integrated DER. Observability needs of DSO and TSO depend on how the coordination framework is specified.
Scalability	Ability of system's processes and technology design to work well for very large quantities of DER resources. Coordination architecture can enhance or detract from this desired capability.
Cyber security vulnerability	Reduce cyber vulnerability through architectural structure. Structure can expose grid systems to more or less vulnerability depending on data flow structure, which depends on coordination framework.
Layered Optimization	Large-scale optimization problems are decomposed into multiple sub-problems at discrete layers of the electric system within a coordinated structure.
Tier bypassing	Creation of information flow or instruction/dispatch/control paths that skip around a tier of the power system hierarchy, thus opening the possibility for creating operational problems. To be avoided.
Hidden coupling	Two or more controls with partial views of grid state operating separately according to individual goals and constraints; such as simultaneous, but conflicting signals DER from Customer, DSO and TSO. To be avoided.
Latency cascading	Creation of potentially excessive latencies in information flows due to the cascading of systems and organizations through which the data must flow serially. To be minimized.

Source: J. Taft, Pacific Northwest National Laboratory

Some Key Architectural Issues

- Role Assignments
  - Responsibility/role matching
  - Feedback loops
    - Information flows and latencies
  - Competing or conflicting objectives
    - Local selfish optimization vs. global coordination
- Assignments cannot just be arbitrary
  - Based on solid architectural principles
  - Explain why, not just what

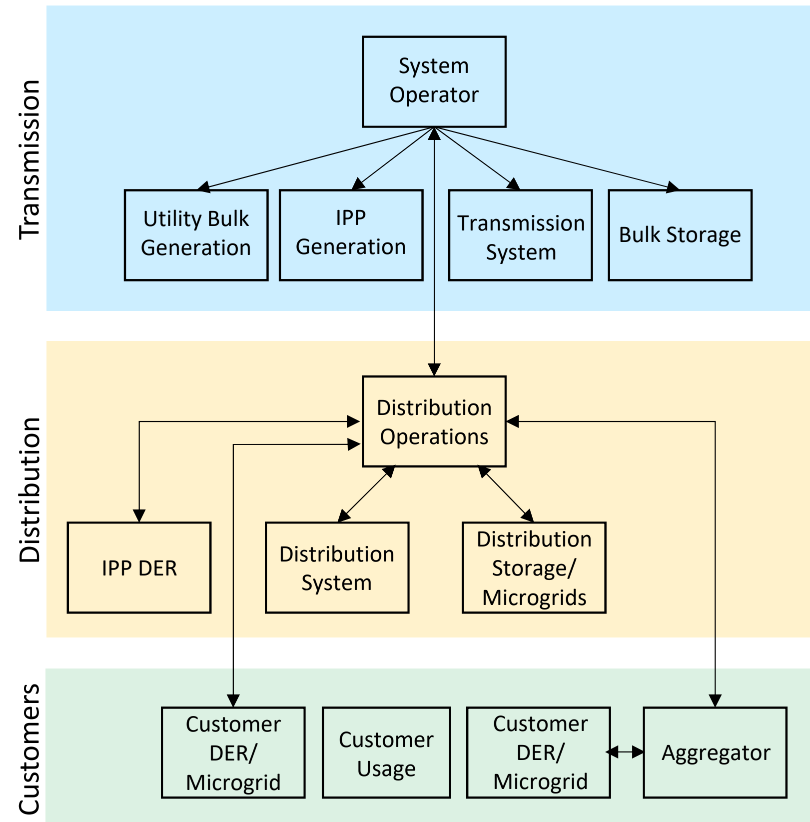




Source: J. Taft, PNNL

Coordination Framework Skeleton Diagram

- Derives from Complex Industry Structure Diagram
- Focuses on key issues to address (e.g., architectural principles)
- Indicates flow of coordination
- Use layered decomposition model (i.e. Laminar Framework) as basis for the diagrams and analysis



Source: J. Taft & P. De Martini

UK Coordination Models

Current & Future Models Under Discussion

- UK Open Networks initiative evaluating alternative TSO-DSO Coordination Models
- 5 Future Models have been identified and under evaluation
  http://www.energynetworks.org/electricity/futures/open-networks-project/

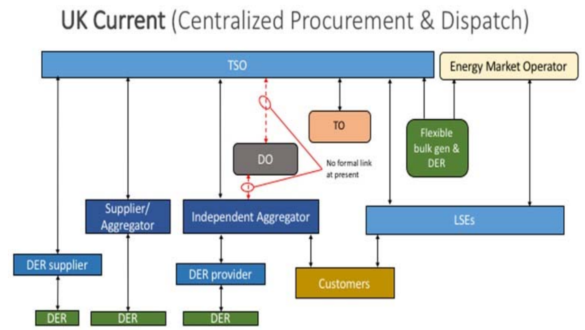
Example Grid Architectural Analysis:

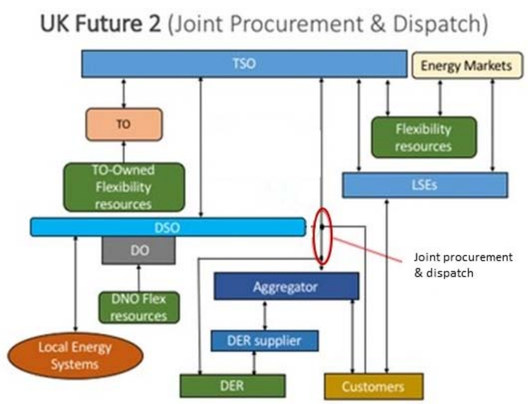
UK Option 2, the responsibility for DER coordination is shared by the DSO and TSO, leading to a more complicated arrangement involving these parties and the aggregators, although the sharing mechanism is not clear.

This model is somewhat similar to the Total DSO model, but the sharing arrangement results in a blending of roles that will require extra coordination to perform.

Option 2 partially **degrades the layered decomposition** structure and allows for **some tier bypassing**, although the proposed function-sharing ("joint procurement and activation") may prevent that from being an issue. This structure **increases the coupling** between the TSO and DSO (not hidden in this case), since the DSO cannot manage the DER in its service area alone while interfacing to the TSO in a modular fashion.

The joint arrangement results in **data flow complexity** involving the DSO, the TSO, the aggregators, the customers, and DER. This is a result of the structure shown in the red oval which comes about due to the definition of **joint roles instead of clean separation of functions**.





Source: J. Taft, L. Kristov & P. De Martini

NY Coordination Models

Current & Future Models Under Discussion

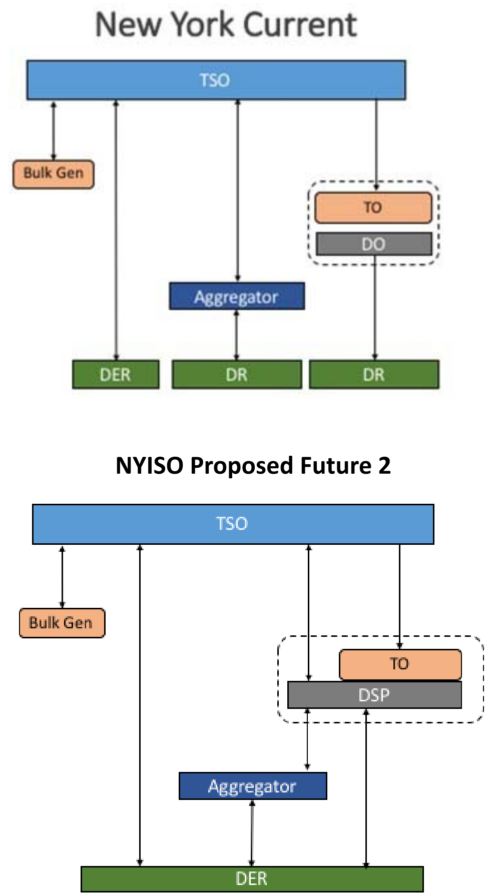
Example Grid Architectural Analysis:

Future 2, the removal of the link between the aggregator and the TSO creates **some of the layered decomposition** structure by **eliminating one source of tier bypassing**, but the presence of a link from DER to the TSO **still allows for tier bypassing, hidden coupling, scalability issues, and cyber vulnerability** at the TSO level.

Future 2, the DSP is potentially somewhat better able to manage the DER, and if coordination between TSO and DSP is well organized, the **tier bypassing problem may be mitigated**.

If some **DER are bidding into the wholesale markets and some into a DSP market**, for example, then the **potential for mis-coordination exists**.

The potential **ability of aggregators to participate at the TSO level is eliminated** in this model that **reduces tier bypassing**. However, it **does not eliminate tier bypassing** as some DERs can still bypass. The **hidden coupling problem remains** but likely at a low level.



Source: J. Taft, P. De Martini & L. Kristov

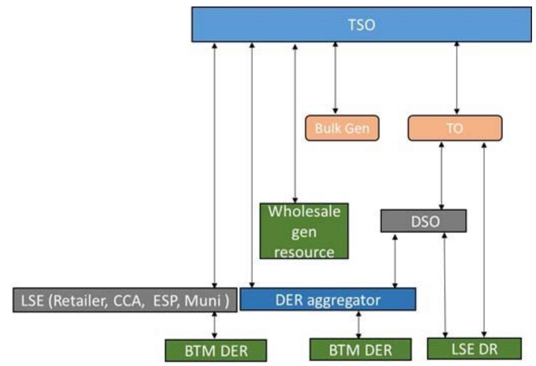
CA Coordination Models

Prior & Future Models

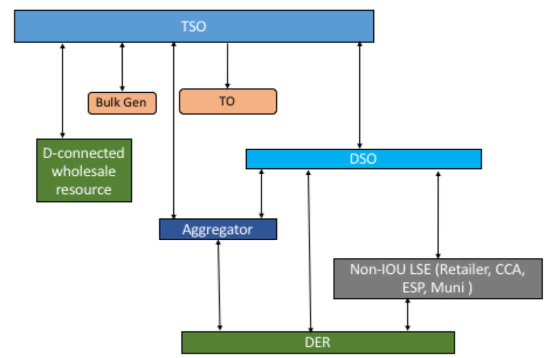
Example Grid Architectural Analysis:
The previous California structure reflects DER services provided directly to the TSO as well as the existing demand response (DR) programs that distribution utilities operate for the benefit of wholesale market operations. The resulting complexity involves a large number of entities and a somewhat **ad hoc coordination structure**. Note there are **no coordination links between the CAISO (TSO) and the DSO**.

A future **Hybrid DSO based model**, may be politically feasible in near-term. A hybrid model will **continue to exhibit tier bypassing** due to the path from DER to aggregator to TSO that bypasses the DSO. In addition, the potential for **hidden coupling exists, with some aggregators, LSEs and the DSO all connecting to DERs** unless some coordination mechanism is worked out. The presence of the direct aggregator-to-TSO connection also presents a moderate cyber vulnerability to the bulk energy system.

California Prior



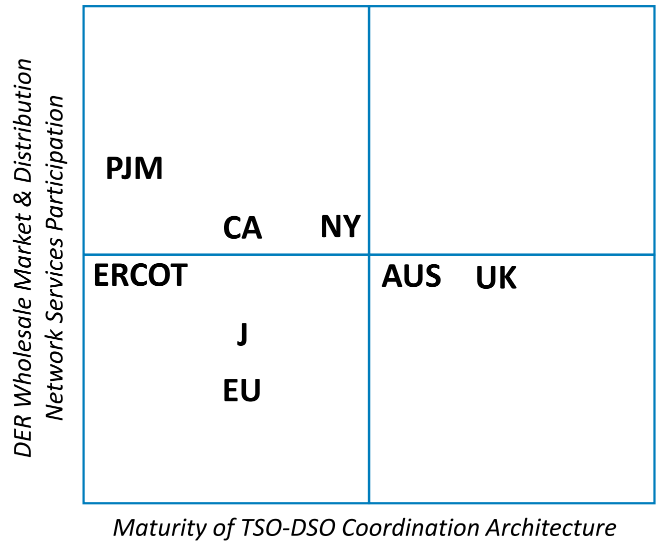
California Future



Source: J. Taft, P. De Martini & L. Kristov

2018 International TSO-DSO Comparative Assessment

Primary and secondary research supporting comparative assessment of TSO-DSO development efforts in 8 regions/countries

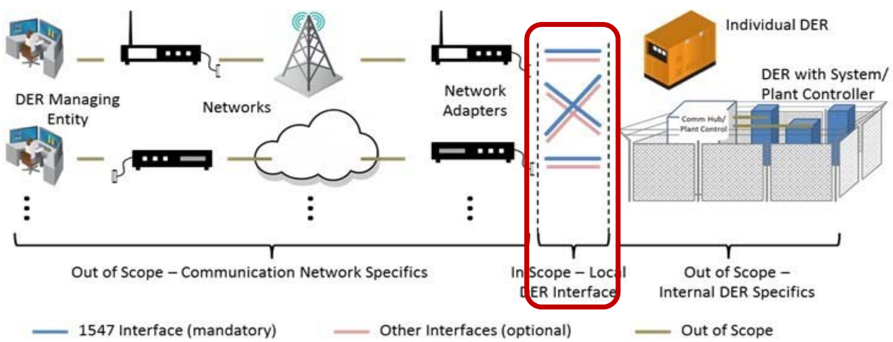


UK & AUS have the most sophisticated approaches and analysis conducted to-date. But, are hampered by a strong institutional and stakeholder bias towards real-time centralized markets despite the significant operational issues.

Distribution Grid Code

- IEEE 1547 enables, but does not directly specify, cyber security – responsibility falls on inverter manufacturers and energy service firms' to establish security for aggregated devices.
- Develop a general distribution grid code that can be adapted to individual state needs.
- Distribution Grid Code would incorporate IEEE 1547-2018 standard and related advanced inverter functions, *and* address the additional operational information, control, communication and cybersecurity requirements as well as roles and responsibilities.

Scope of DER Communications & Security



Source: IEEE 1547-2018 Standard

"When integrated with energy demand management programs and technologies, these combined technologies significantly increase the attack surface of the national power grid and opportunity for risk to system operation from malicious actors." Sandia National Lab

Takeaways

- Current DER coordination models for all locations exhibit considerable distribution operator bypassing, with the attendant issues of hidden coupling and cyber vulnerability.
  - Primarily due to use of Hybrid approaches
- Future models involve two schools of thought regarding coordination structure:
  - Centralized approach where the TSO performs all coordination, and
  - Layered approaches where a DSO has a significant role in coordination.
- Customer DER to distribution interconnection standardization and operational integration technology maturity for the provision of services is currently inadequate.

GRID ARCHITECTURE

Thank You

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Pacific Northwest
NATIONAL LABORATORY

Coordination Principles

Hon. Ted Thomas, Moderator

Paul De Martini

Jeff Taft

Lunch Break

Until 1:00

Executive Committee Meeting: Southpark AB

State Examples: Advancing Transmission, Distribution, and Customer System Coordination

Hon. ToNola Brown-Bland, Moderator

Mark Oliver

Constance McDaniel Wyman

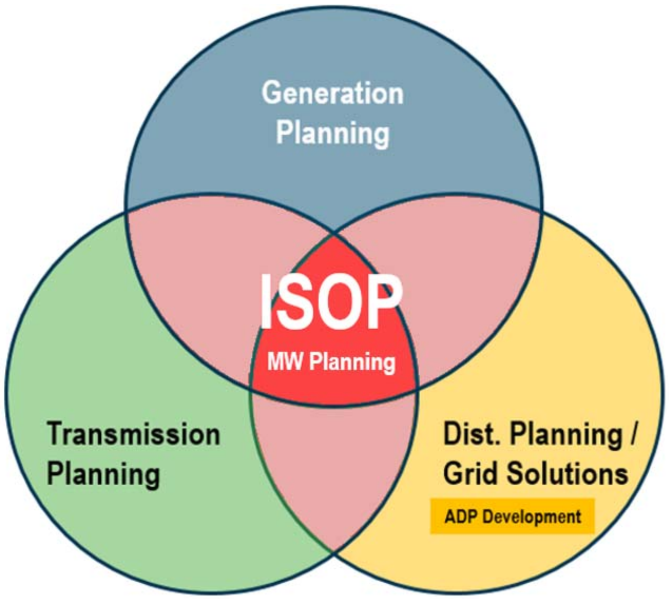
Integrated System & Operations Planning (ISOP) Overview
National Energy Policy Council

September 11, 2019

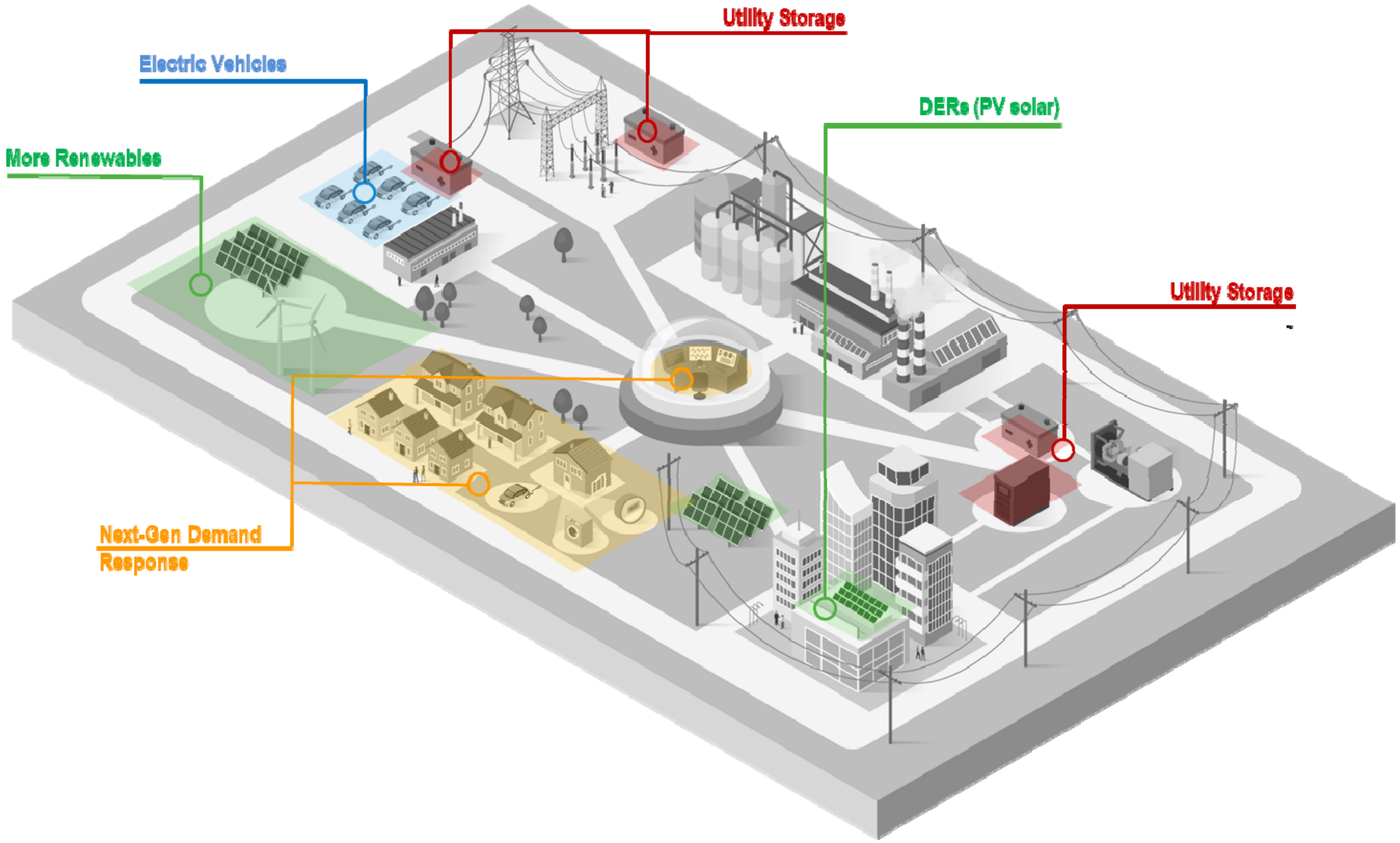
What is ISOP?

The Integrated System & Operations Planning (ISOP) vision is a planning framework that optimizes capacity and energy resource investments (MW/MWh) across Generation, Transmission, Customer Delivery and Customer Solutions. The framework will address:

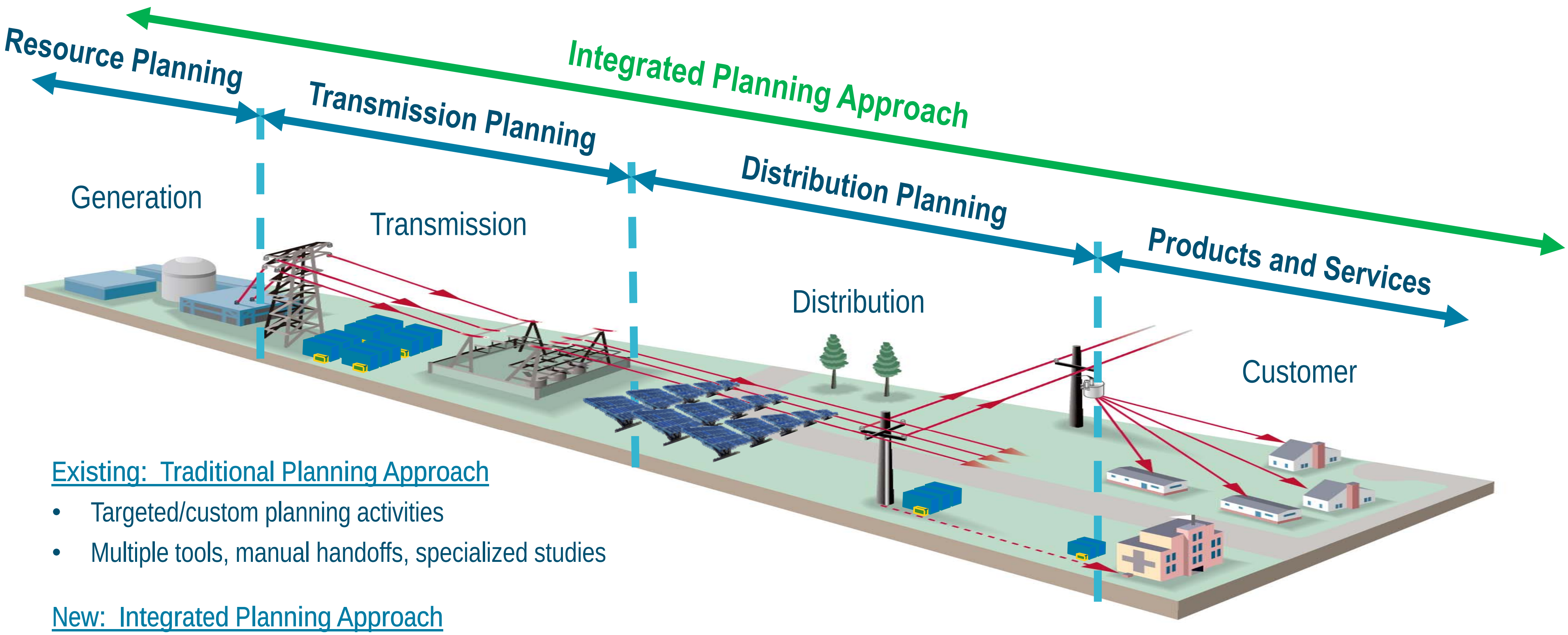
- Operationally feasible plans while accommodating rapid renewable growth
- Enhanced modeling to value new technologies such as energy storage, electric vehicles, and intelligent grid controls/customer programs (non-traditional solutions for Distribution and Transmission)
- Ability to evaluate different asset portfolios across a broader range of potential future scenarios



Emerging grid and customer-side technologies will impact supply/demand balancing



Existing Planning Paradigm Vs. New Integrated Planning Approach



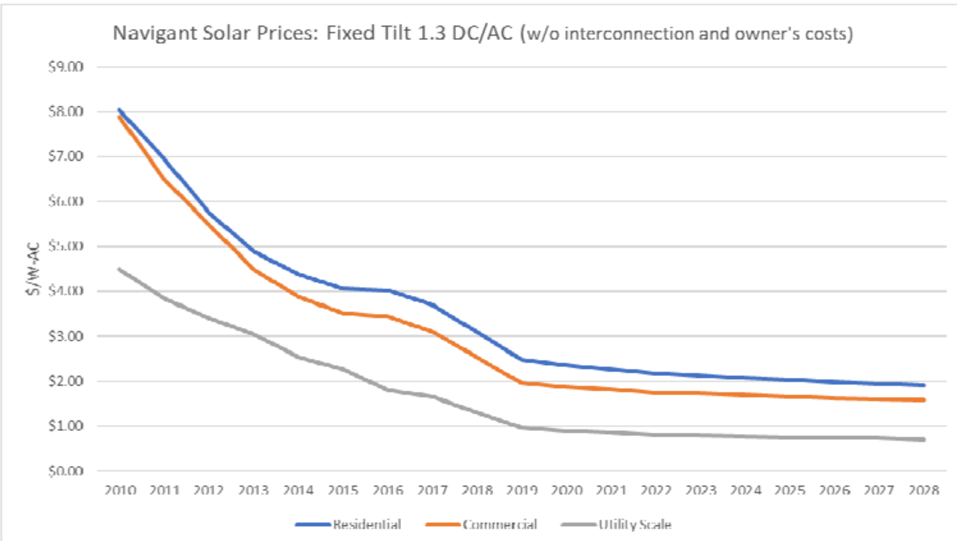
Existing: Traditional Planning Approach

- Targeted/custom planning activities
- Multiple tools, manual handoffs, specialized studies

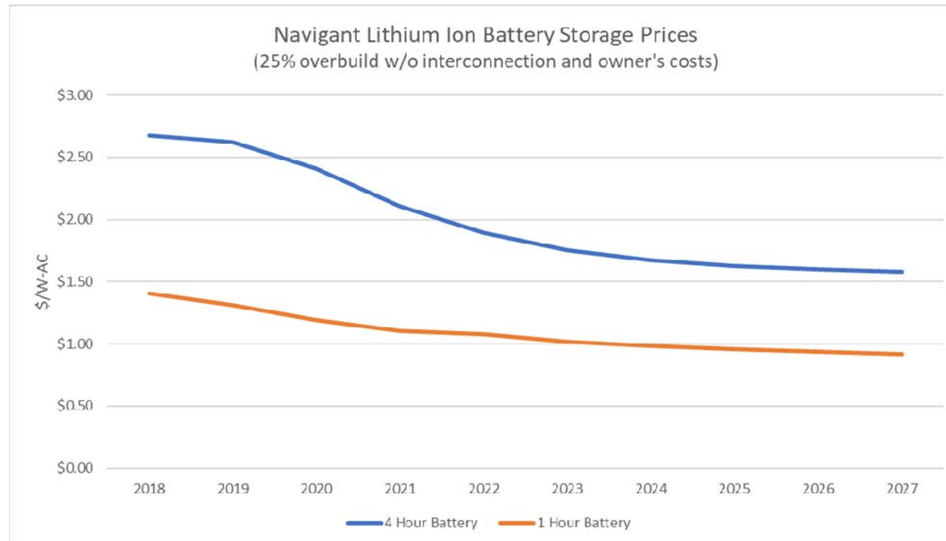
New: Integrated Planning Approach

- Integrated, automated processes and tools for planning
- Non-traditional solutions studied to address system needs

What is Driving the Change?



Rapid drop in PV costs; rate of decline is slowing.

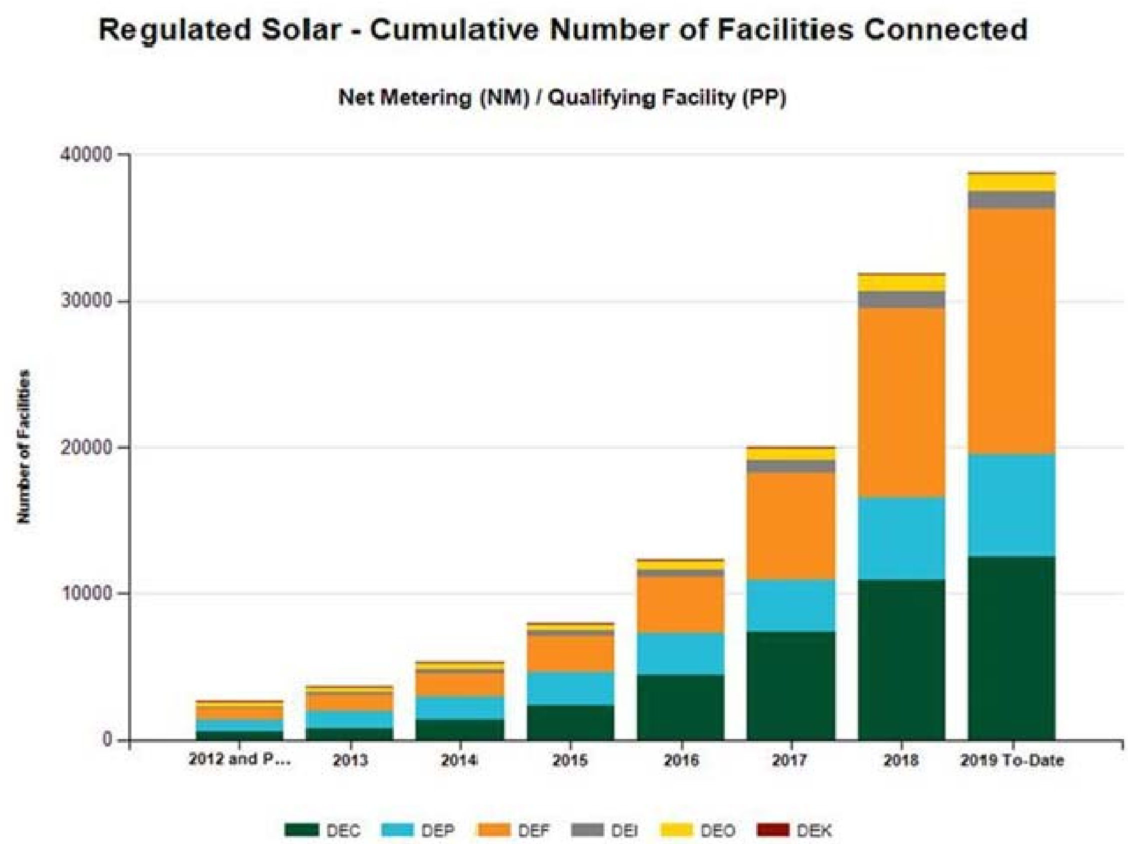


Storage costs expected to drop 40% by 2025, but economics are still challenging.

Solar costs appear attractive, but solar does not contribute effectively to the winter capacity needs that factor heavily into the economics of Carolinas resource planning.

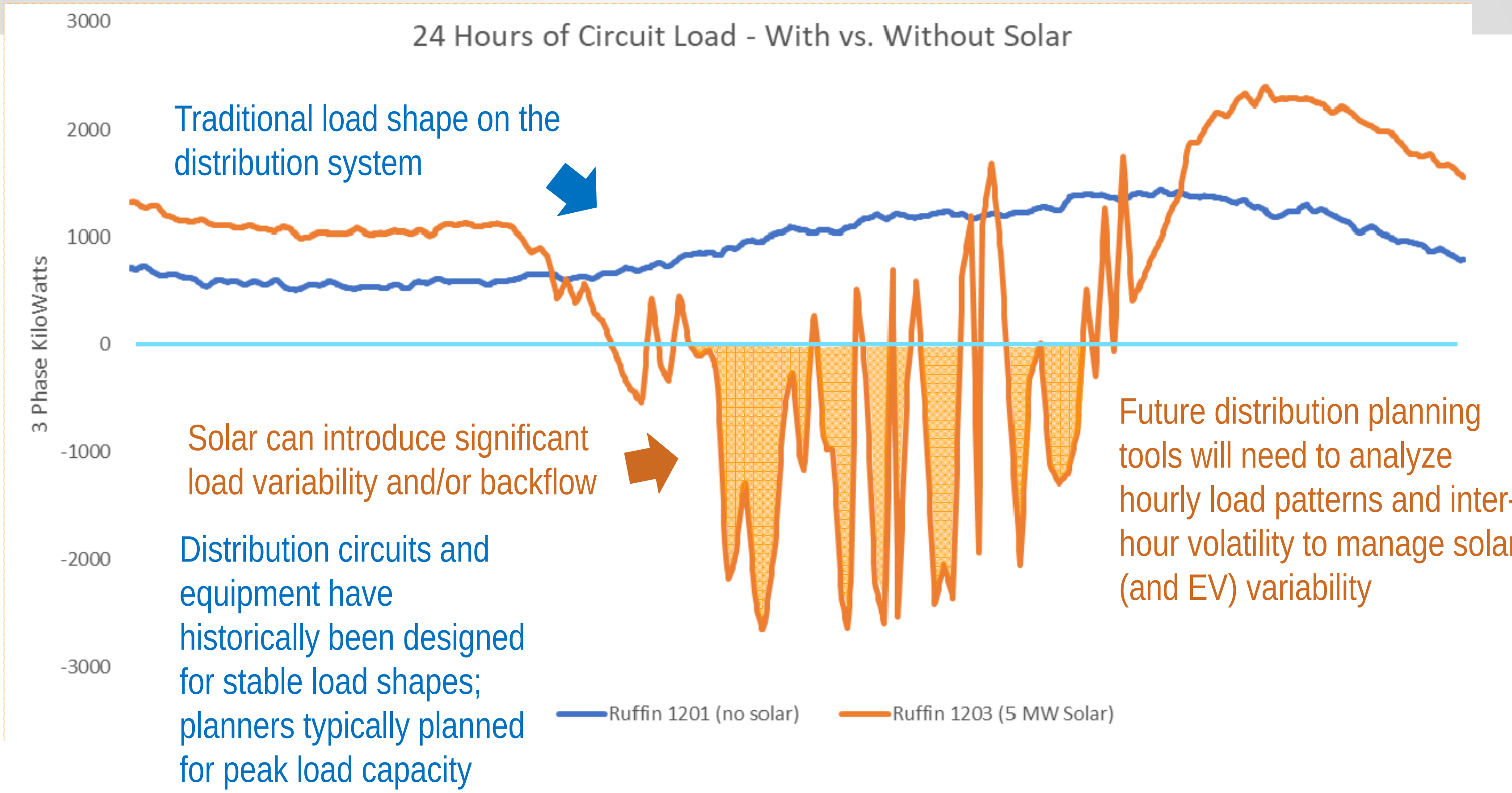
The Pace of Solar Interconnections Continues to Increase

Over 40,000 solar interconnections in Duke's territories since 2012



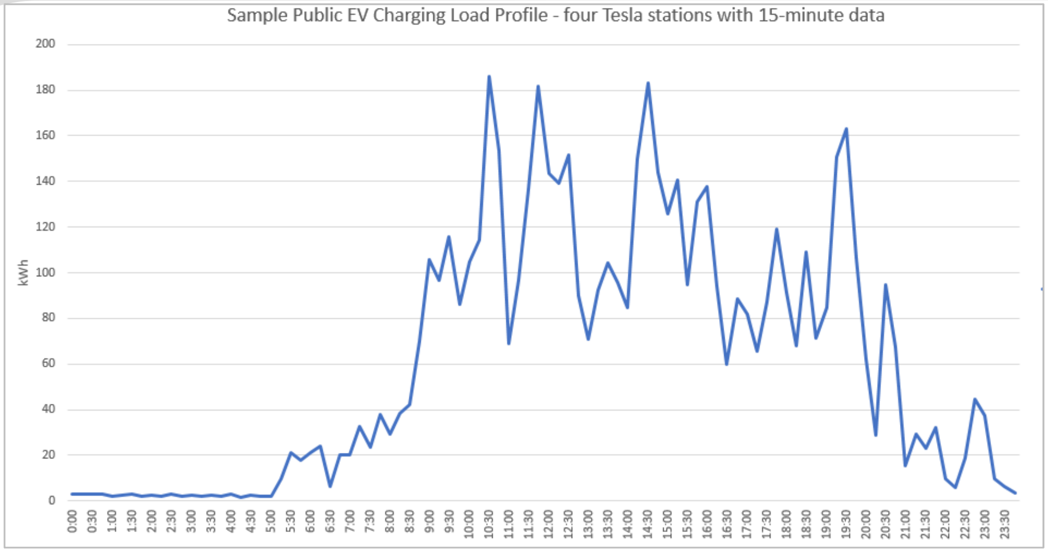
The trend of solar growth is continuing and will become increasingly impactful.

What does this mean for Distribution and Transmission Planning?



Utility storage can help address intermittency and reverse flow challenges. Detailed hourly analysis is needed to assess costs and benefits for storage applications.

EV charging can introduce localized impacts on Distribution & Transmission Planning



Loading Example for Tesla Fast Charging Station

EV's are critical for reducing GHG, and also put downward pressure on electric rates, but can pose planning challenges in high penetration areas:

- Increase load volatility
- Concentrate large new delivery points
- Introduce short lead times for upgrades
- Accelerate circuit capacity needs

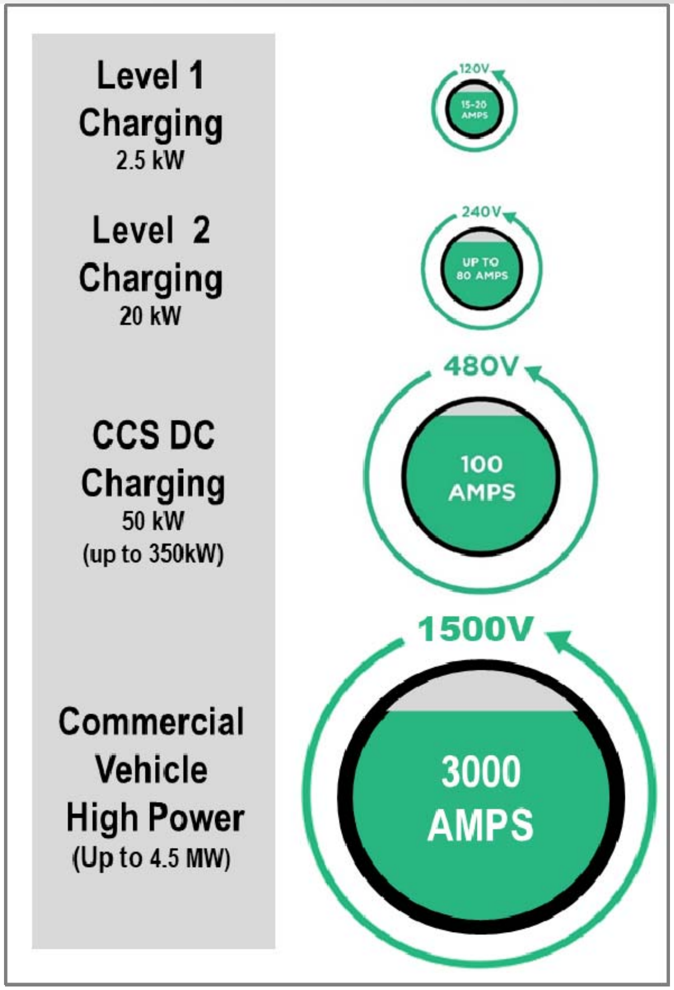
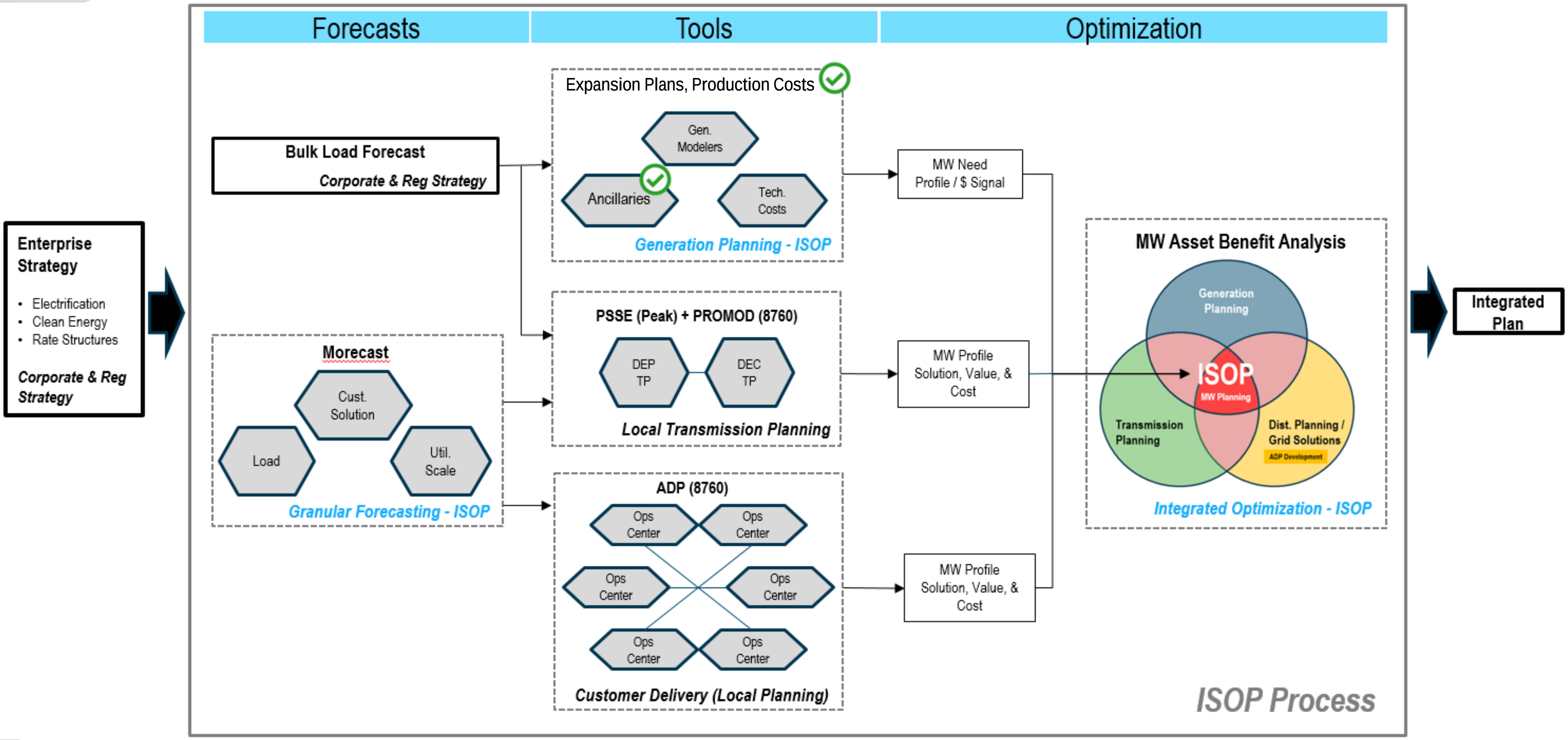


Illustration – Last Mile Logistics Customer

- Existing facility load ~ 1 MW
- 50 Medium-Duty Package Delivery trucks
  - 15 kW each (overnight)
- 20 electric semi-trucks
  - 2 "mega-chargers" @ 1-1.5 MW each (day)
  - 5-10 "slow" chargers @ 100 kW (night)
- Vehicles arriving in late 2020
- Expected load increase ~ 3-3.5 MW
- Circuit capacity ~ 3.5 MW
- Total vehicles on site (if full electrification)
  - 60 Semi-trucks
  - 200 Delivery trucks

ISOP High Level Process Flow

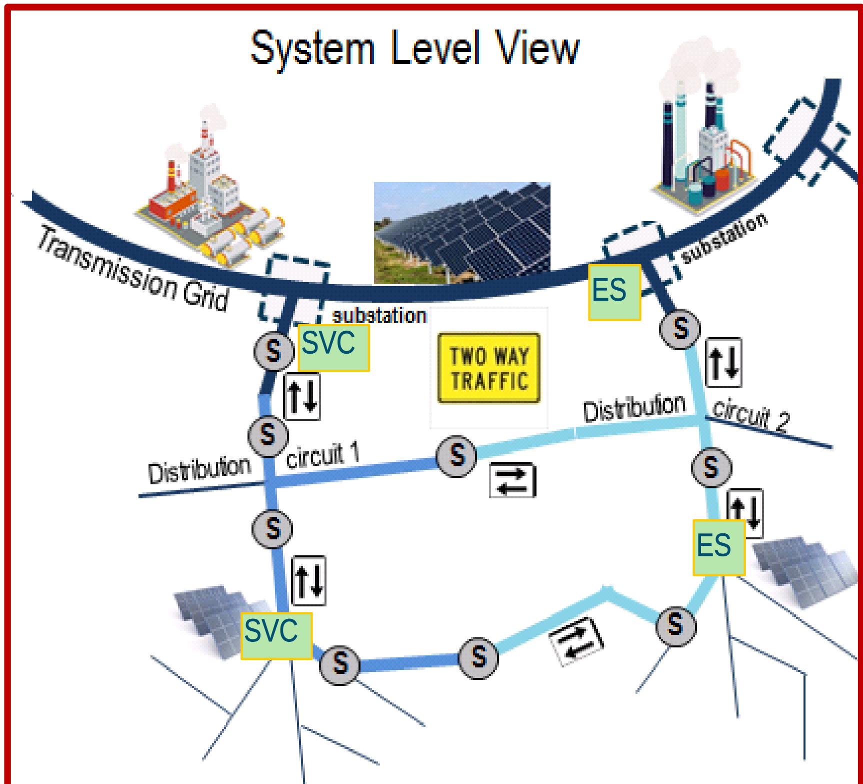


Questions?

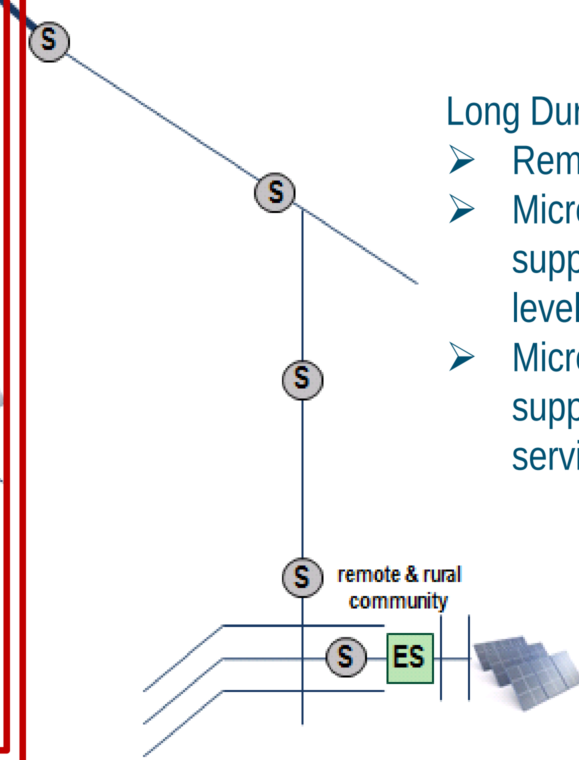
DUKE ENERGY®

Appendix Materials

How Does ISOP Relate to the Grid Improvement Plan ?



Local dynamic switching capability to better balance local supply / demand



Long Duration Outage Community

- Remote, rural, radial
- Micro-grid (Island) for loss of supply in everyday storms at city level
- Micro-grid (Island) for loss of supply in major events at critical services level

State Examples: Advancing Transmission, Distribution, and Customer System Coordination

Hon. ToNola Brown-Bland, Moderator

Mark Oliver

Constance McDaniel Wyman

Distributed Energy Resources

Constance McDaniel Wyman

Presented to NCEP

2019

Distributed Energy Resources

Three-part presentation

- Regulatory framework
- Case study of Utility A and Company B
- Current status and projects

The Regulatory Framework

Electric Infrastructure Puzzle

All three US power grids exist in Texas

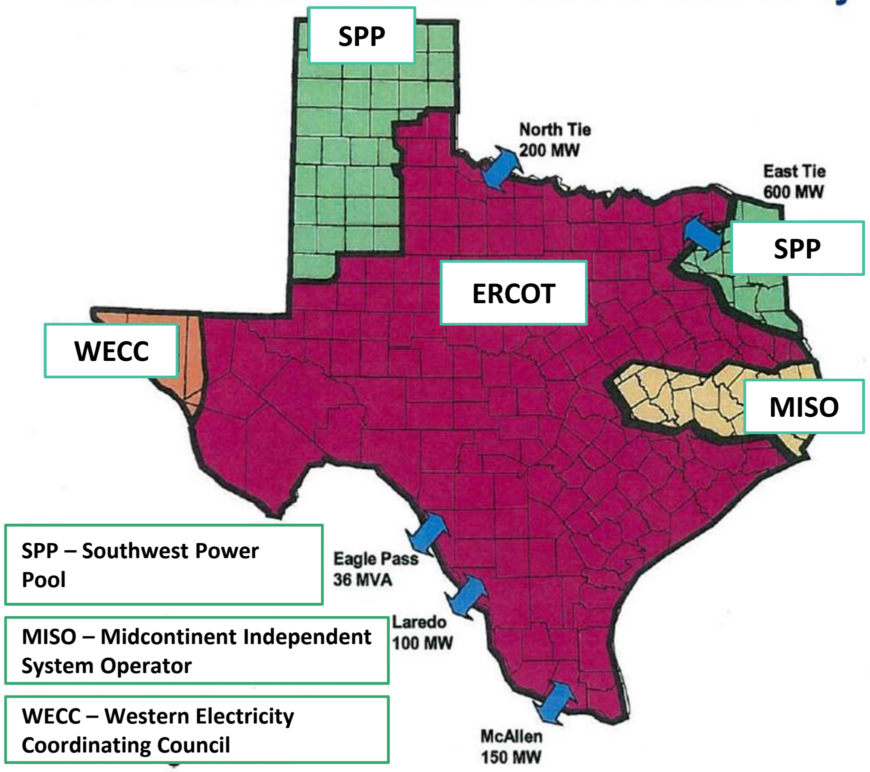
- Eastern Interconnection (EI)
- Western Interconnection (WECC)
- The Electric Reliability Council of Texas (ERCOT)

Regional Transmission Organizations (RTO’s)

- ERCOT (TX only; ~85% of state; state regulated)
- Southwest Power Pool (SPP); part of EI; state and federal regulation
- Mid-Continent Independent System Operator (MISO); part of EI; state and federal regulation
- The Texas portion in WECC has no RTO; state and federal regulation

Electric Infrastructure Puzzle

Within Texas, the ERCOT grid serves 85% of the electric load, and covers 75% of the land. ERCOT is connected to the Eastern Interconnect and Mexico by DC ties.



SPP – Southwest Power Pool

MISO – Midcontinent Independent System Operator

WECC – Western Electricity Coordinating Council

ERCOT – Electric Reliability Council of Texas

The Regulatory Quilt

Vertically integrated utilities vs. wire and poles utilities

In EI (MISO & SPP) and WECC

- Investor owned utilities (IOU's), Municipally owned utilities (Muni's), and Electric Cooperatives (Coop's)
- All vertically integrated
- No customer choice

In ERCOT electric utilities can be

- IOU's which are "wires and poles" only
- Muni's and Coop's (vertically integrated)
- Coop's with or without customer choice and can be wire/poles, have generation, or be vertically integrated

The Regulatory Quilt

Regulation vs. De-regulation/Competition

- Non-ERCOT no competition
- ERCOT TDU's – competition
- ERCOT Coop's and Muni's opted in or out of competition

PURPA standard implications

- In non-ERCOT areas DER's sell power directly to the vertically integrated utility
- Within ERCOT an interconnecting DER selects a Retail Electric Provider to whom to sell their power. (It must be the same REP from whom they buy power.)

The Regulatory Quilt

Munis and Cooperatives:

- Political subdivisions of the state
- Vertically integrated
- Can write their own standards for implementation of DER
- Can choose to offer financial incentives for the installation of DER
- Can choose meter configuration

Non-ERCOT IOU's:

- Vertically integrated
- Specific tariffs containing class sizes and rates for various DER's
- Can net-meter; AMS coming soon
- Must buy the power

ERCOT IOU's:

- Only wires and poles
- All have AMS
- Obligation to interconnect, but not to buy power
- Power purchased through agreement with a REP

Distributed Resources and Regulation

- Each different combination of power grid, utility type, and regulatory framework leads to a slightly different construct for renewable energy interconnection.
- Each different combination provides different incentives and has different types installations and degrees of renewable penetration.
- The commission’s rules address DG interconnection and technical requirements, metering for DRG, and are applicable statewide
- Although the rules are statewide the non-ERCOT IOU’s have not had statutory language regarding cost recovery of meter conversion on AMI, hence the “coming soon” label.
- For TX DRG means a renewable energy system of <2MW; DG means 0-10 MW of any generation source

Reported Distributed Resources

- PUCT receives reports from ERCOT and Non-ERCOT IOU’s detailing the distributed generation interconnections on their system. The reports for 2018 are available under **Project 49067**.
- The following numbers are from the report of CenterPoint Energy Houston Electric
- What’s on this one utility’s system:
  - 269.6 MW of DG on system before 2018
  - 100.4 MW of new interconnections in 2018 (brings current total to 370.0 MW)
  - 185.8 MW pending interconnection
  - 76.2 of previously ending projects were cancelled
  - 24.7 MW removed for the system in 2018
  - <u>370 MW is equivalent to a large scale transmission interconnected generation plant.</u>

Reported Distributed Resources

- CenterPoint DG numbers (cont'd)
- What are these connections is made up of:
  - Landfill gas, diesel and natural gas generators, hydro? Yes, all → but mostly its small solar
  - Largest of the 3080 DG installations to CenterPoint's system only 119 are greater than 50kW.
  - Most of the systems from 12,000 to 50kW are natural gas or diesel generators, with the exception of a few 5,000kW solar installations that were added in 2018.
  - The vast majority of systems <50kW are solar installations.

The
Case Study:
Utility A
and
Company B

The Complaint

- Utilities A, Q, and Z all are “wires and poles” transmission and distribution providers in the ERCOT region.
- Company B provides back-up generation for large box stores, and when the system is in normal operation sells power onto the grid (into the market) via distribution interconnection.
- Company B has installed or is working to install their systems in the service areas of all three utilities.
- Company B complained that Utility A required different types of equipment for interconnection of the DER facilities than Utilities Q and Z, which resulted in increased costs for comparably sized installations.
- Company B also complained that Utility A was unreasonably limiting the size of the units that could be installed on a given feeder.
- Taken together these factors reduced the net economic value of the projects to Company B.

The Issues (general)

- Bulk power system visibility for dispatch and market purposes
- Policy and standardization questions that could not be addressed via complaint between a company and a utility
  - Standardization of protection schemes
  - Visibility of feeder loading to market participants
    - Fairness to all market participants
    - Physical security considerations
- Transparency in model assumption and cost estimates
- Nominal voltage used for voltage trips
- Aggregate vs. single DER configuration on a feeder

The Issues (complaint-specific)

- While the bulk power system is operated at the RTO level, and therefore, modeled and designed consistently across the transmission grid, individual utilities' distribution systems are often independent of other utilities' systems
  - Different planning and operation specifications, and tariffs
  - Different procedures, relay settings, and timings

- Different protection schemes
  - Company B favored the use of a reverse power protection scheme which was acceptable to Utilities Q and Z, but not Utility A.
  - Utility A preferred a Direct Transfer Trip (DTT) that it controlled and initiated at the substation
  - The timing for the reverse power protection was too slow for the relay settings on Utility A's system

The Issues (complaint-specific)

- Utility A has felt it was operationally prudent to model the lowest load for feeders under contingency situations where the distribution system might be in a configuration other than its normal operating configuration.
  - The $1/3^{rd}$ rule: generation located on a given feeder should not exceed one-third of the load on the feeder or should employ DTT

The Process

- PUC engineering staff acted as a mediator to bring Utility A, and Company B into constructive discussions.
- Utility A and Company B both took turns presenting the issues from their perspective. Over time this led to a series of technical discussions that helped lead to resolution:
  - Possible adjustments to relay setting and timing
  - Determination of appropriate generation : feeder loading

- Utility A participated in an independent study to examine the feasibility of RP protection configuration under various scenarios
- The discussions served as a platform to educate PUC staff about real issues involved in the incorporation of the expected growth in DER's on the system

The Resolution

- The independent study informed the technical feasibility of RP protection schemes in certain scenarios
- Utility A and Company B were able to determine that RP protection schemes were feasible at some, but not all of, Company B's proposed locations
- Utility A and Company B were able to come up with a process and transparent calculations for determination of minimum feeder load that gave better certainty to the project planning of Company B.
- Company B was able to move forward with commissioning of additional synchronously-connected DER systems

The Take Away

- Additional work needs to be done in order to facilitate additional deployment of DER's on the distribution system
- Standardization and regulatory certainty are vital across individual utilities' systems and across the state
- Additional work is needed to address transmission level issues and dispatchability of DER resources
- A commission project may be called for after technical investigations are concluded

Which leads us to….

Current Status and Projects

Current Conundrums

Visibility of DER
- Power grid modeling
- Market pricing
- Managing utilities (planning, voltage stability, safety)

Adoption and Incorporation of new IEEE 1547
- Voltage and frequency (ride through)
- Communications and visibility
- Different from state rule 16 Texas Administrative Code §25.212

Distributed Energy Resource (DER) vs. Distributed Generation Resource (DGR)
- DER can choose to sell power to the market when advantageous to the owner, but is not dispatchable
- DGR is dispatchable and may provide ancillary services to the grid
- Certainty of DRG availability

Interconnection Agreements
- Necessary changes to include information regarding the transmission grid
- PUC project regarding signatories (PUCT Project 45078)

ERCOT Activities

Recent ERCOT process changes through the stakeholder processes

- **NPRR 866**: Mapping Registered Distributed Generation and Load Resources to Transmission Loads in Network Operations Model - regarding requirements for registration of exporting DG, and codifying the mapping process.

- **NPRR 889**: Replace Non-Modeled Generator with Settlement Only Generator – replaces definitions and adds clarity between distribution-connected and transmission-connected resources.

- **NPRR 891**: Removal of NOIE Capacity Reporting Threshold for the Unregistered Distributed Generation Report – Remove the 50kW size floor for the reporting of DG to capture more completely the DG resources reported to ERCOT.

ERCOT Activities

Recent ERCOT process changes (cont'd)

- **NPRR 917**: Nodal Pricing for Settlement Only Distributed Generation and Settlement Only Transmission Generators – adjusts pricing signals for SODG's and SOTG's

ERCOT is currently analyzing and considering:

- The information and data it is receiving regarding the visibility of registered system
- The processes necessary to ensure that dispatchable DGR's provide the same level of reliability as other dispatchable GR's
  - possible implications for the interconnection agreements
  - need for relationship to the DSP's comparable to the current relationship with TSP's

Projects and References

State rules relevant to DER

- **16 TAC §25.211**: Interconnection of On-Site Distributed Generation
- **16 TAC §25.212**: Technical Requirements for Interconnection and Parallel Operation of On-Site Distributed Generation
- **16 TAC §25.213**: Metering for Distributed Renewable Generation and Certain Qualifying Facilities
- **16 TAC §25.217**: Distributed Renewable Generation

PUCT Rulemaking and project (PUCT website on the 'filings' page)

- Project **48023**: Project regarding the use of non-traditional technologies
- Coming Soon: AMI project regarding cost recovery for non-ERCOT utilities
- Future potential project regarding 16 TAC §25.212, if indicated by ERCOT process

ERCOT reports

- DER Concept Paper (Aug 19, 2015)
- Reliability White Paper (March 22, 2017)

Questions?

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State Examples: Advancing Transmission, Distribution, and Customer System Coordination

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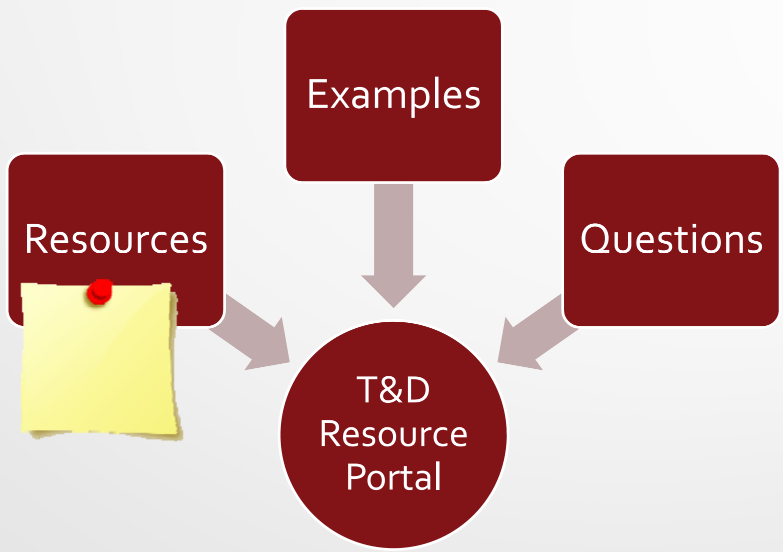
Facilitation Overview



Minimum: Considerations

Resources

What other projects, policies, or examples offer insights into these topic?

1)

Examples

Where can attendees find good resources to inform their decision making?

Questions

What lingering questions do you have about this topic? What research is needed?

I.

Parking Lot

1.

Pecan Street Site Visit

Break with Refreshments

NATIONAL COUNCIL
ON ELECTRICITY POLICY

Adjourn Day 1

Annual Meeting 2019
Evolving Transmission, Distribution, and Customer System Coordination

September 11, 2019
Austin, Texas