Transactive Energy Challenge Preparatory Workshop

Grid Challenges and Consumer Side Participation

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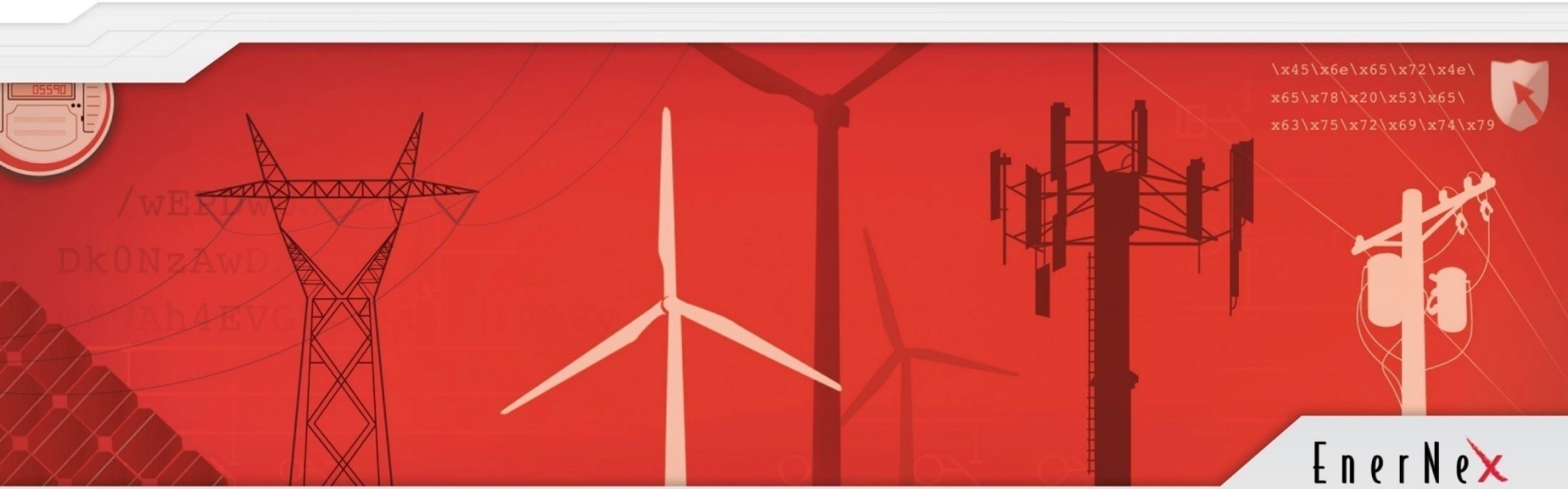

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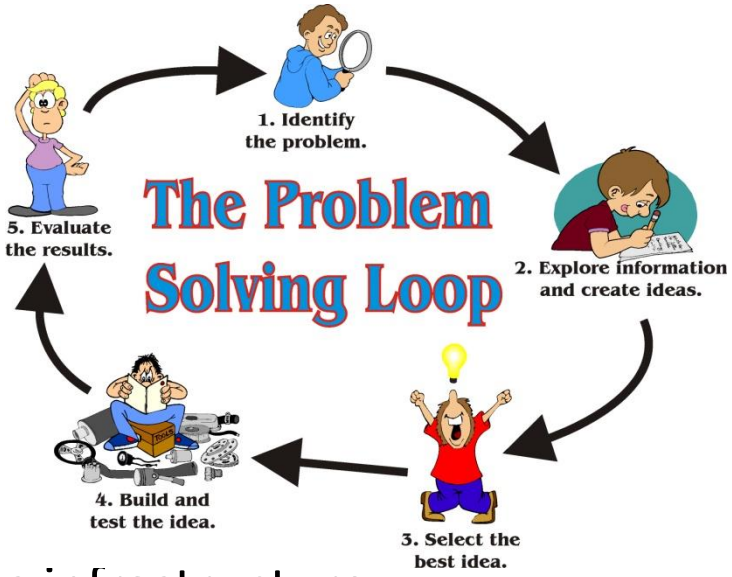
What's the Problem We're Trying to Solve?

- Increasing desire by customers to manage their "energy destiny" (security of supply, resiliency, quality, cost) more directly using a self serve model with the support of regulators and legislators
- Desire and potential need for a more transaction oriented approach to market interaction of all stakeholders
- Which implies higher penetration of distributed resources
- Which puts demands on the network for capabilities not originally designed for
- Which requires upgrades in power systems infrastructure, communications, topological models, market systems, enterprise applications, processes, and personnel
- Delivered along a timeline compatible with need
- Using intelligent investment that meets a business case



Traditional Distribution System: designed for one-way power flow from transmission to meet peak load

Old design paradigm:

- *Like a water system – larger wire decreasing to smaller wire at customer*
- *Largely analog protection and control systems*
- *Voltage managed by controlling drop from transmission to customer*
- *"If it works at peak load, it always works"*

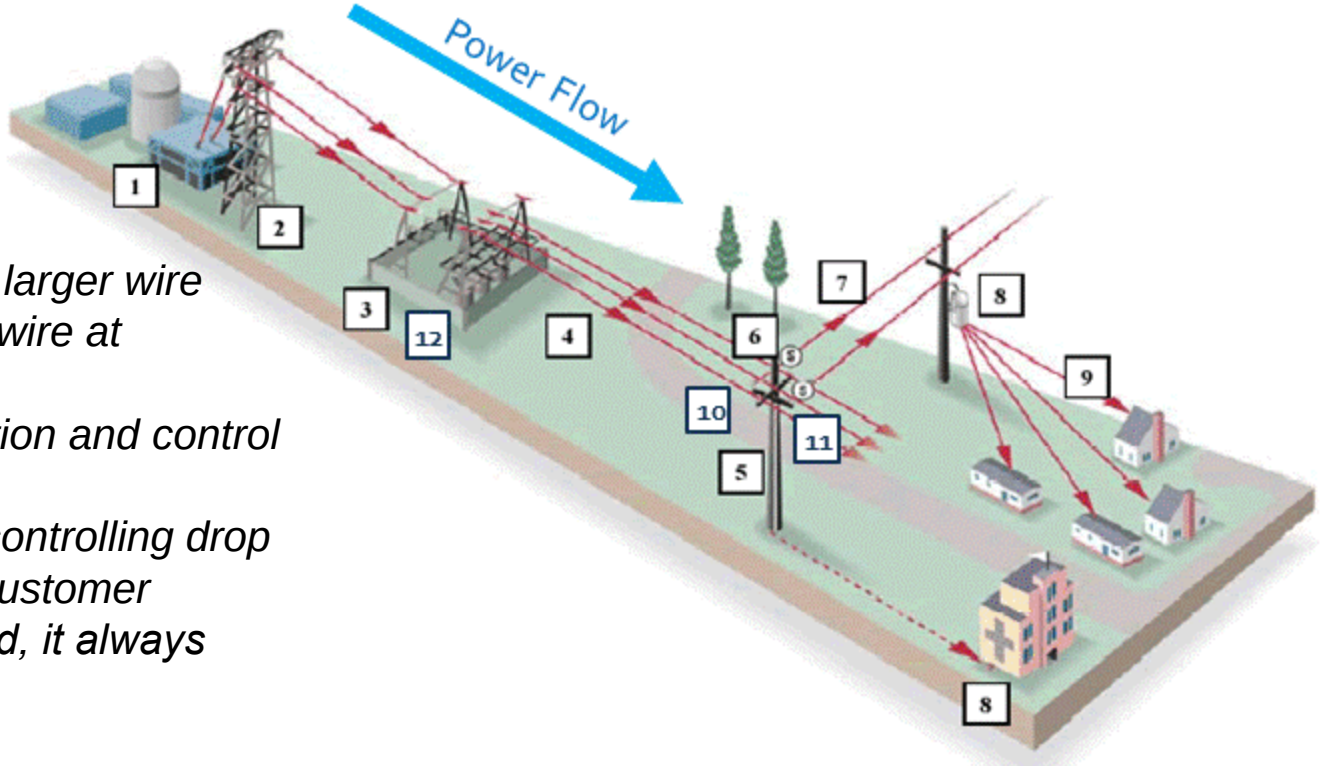
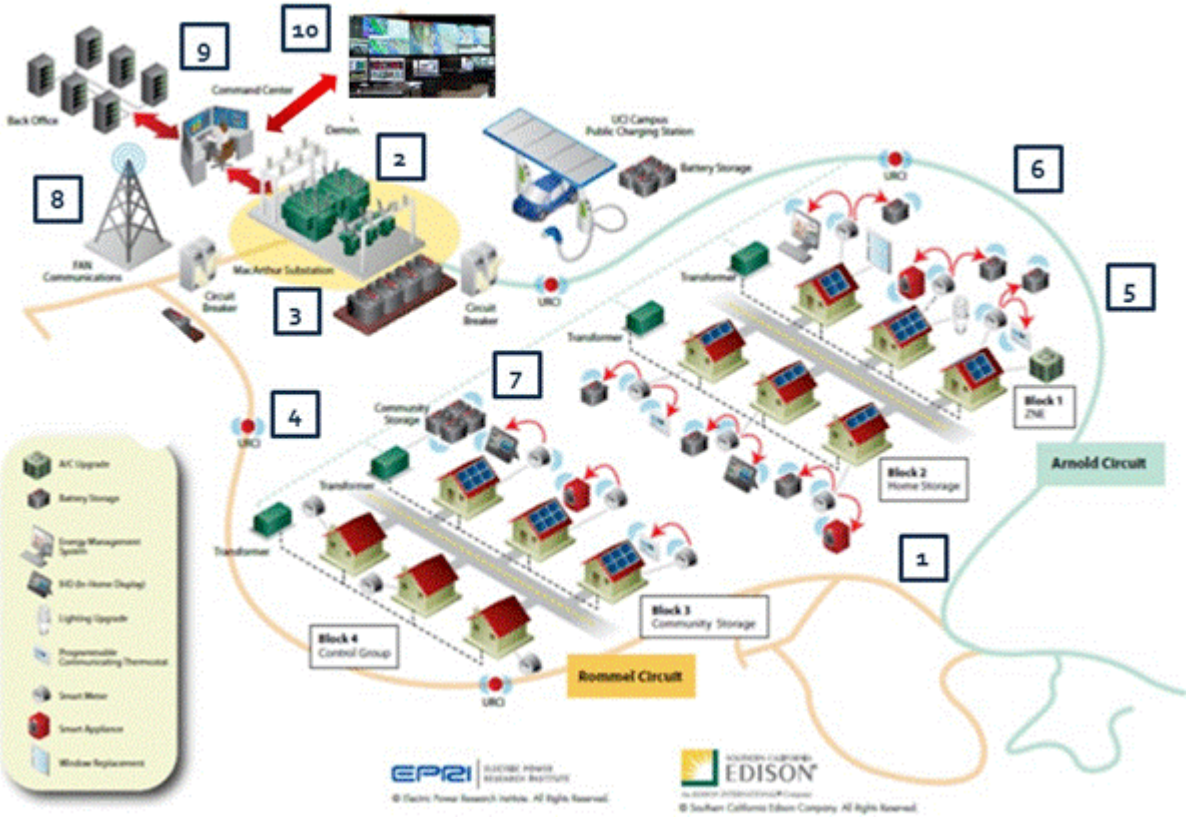


Diagram illustrates the major components of the traditional system used to deliver electricity to homes and businesses. From left to right **: (1)power plants** and renewables, **(2) transmission lines**, **(3) transmission to distribution substation**, **(4) distribution feeder**, **(5) power pole, (6) fuse, (7) tap line** (the type of line that runs along many streets, **(8) pole-top or pad-mount transformer**, **(9) service lines** to individual homes, **(10) Pole mounted capacitor banks or line regulators** to adjust voltage downstream, **(11) Pole mounted switches** mechanical, automated line sectionalizers and automated reclosers used to isolate sections of line, reconfigure circuits and automatically restore sections after an outage, **(12) substation load tap changers and capacitor banks** to adjust feeder voltage

Integrated Distribution System:

Designed for resiliency & multi-way power flows across distribution with millions of integrated DER



Major components of an Integrated Grid. (1) Distribution **circuit designs** that enable bi-directional flow and increased resiliency, (2) **Digital protection systems and distributed controls** and **phasor measurement units (PMUs)**, (3) **Substation energy storage** to manage distribution peaks and circuit balancing, (4) **Automated circuit switches** for line sectionalizing and restoration, (5) **Communicating line sensors** for fault current, power and power quality measurement, (6) power electronics based **power flow controllers** to manage voltage, VAr and power quality, (7) **Community energy storage** units, (8) **Unified operational field area telecommunications** network linking edge devices to substations and utility wide area network, (9) Advanced distribution operational **software and data management systems**, (10) **Integrated T&D&DER situational & control systems** with bulk power system ISO/Balancing Authorities

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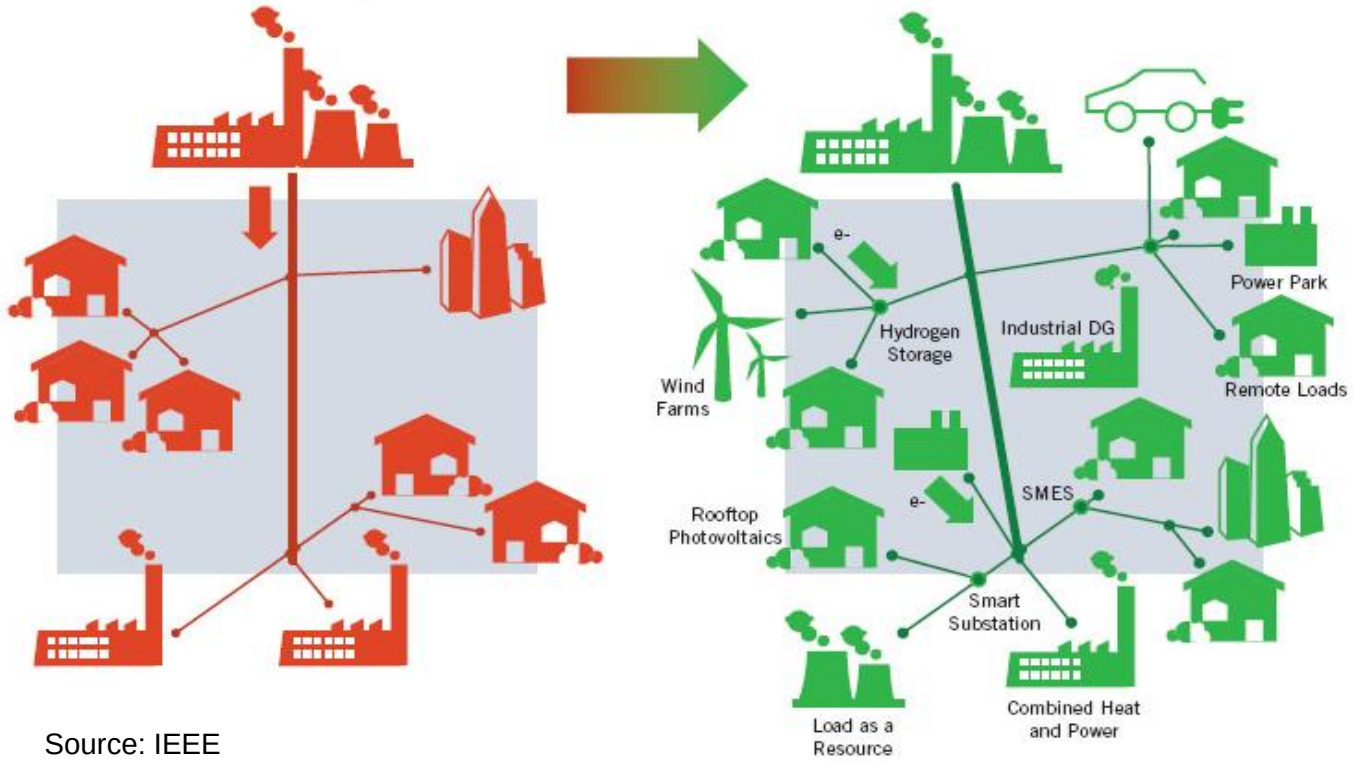
Grid Evolution:
One-way Road to Grid of Things

Grid increasingly becoming a multi-directional network interconnecting millions of intelligent consuming devices and flexible DER and back-up generation



Source: IEEE

Operating such a system requires greater situational visibility and collaboration with customers and their services providers

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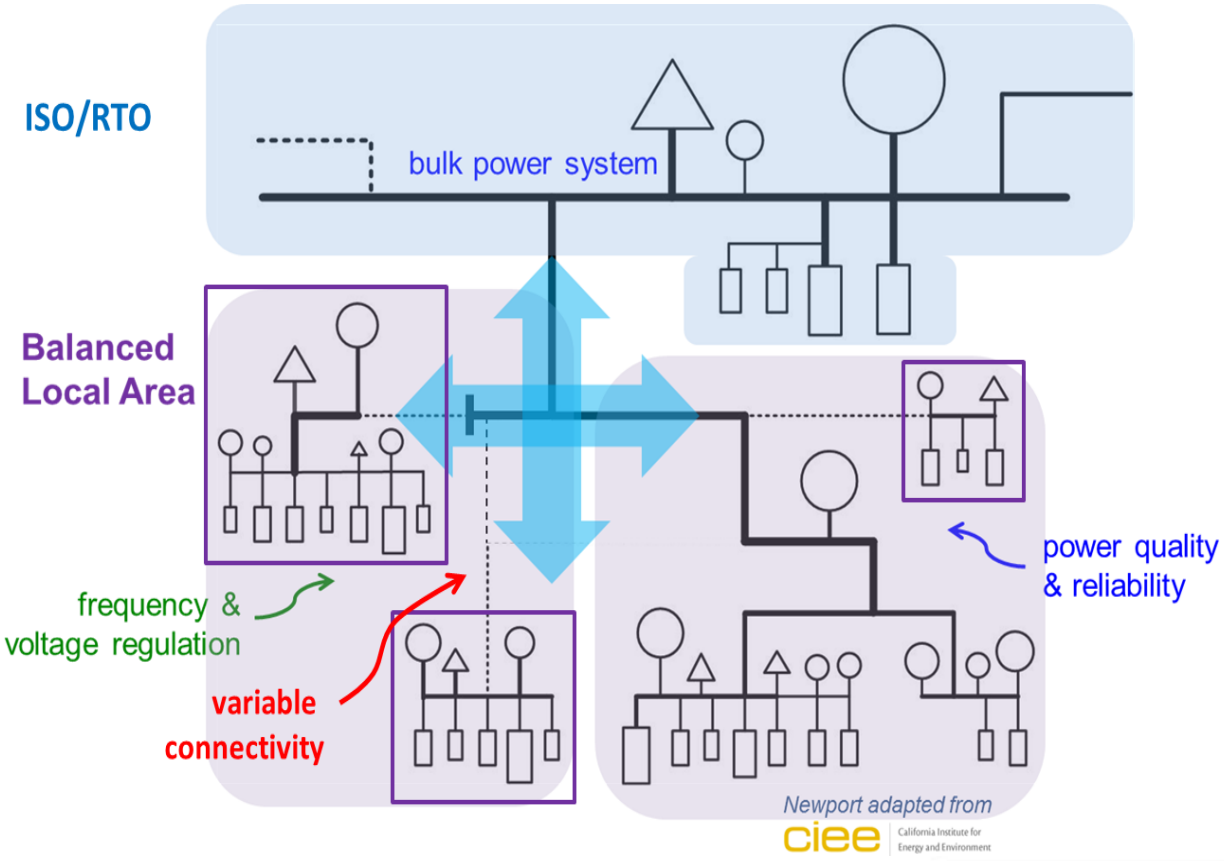
Multi-directional Power Flow

Multi-party transactions across distribution and T-D interface requires **power flow control devices**, **grid based energy storage** and **transaction management systems**



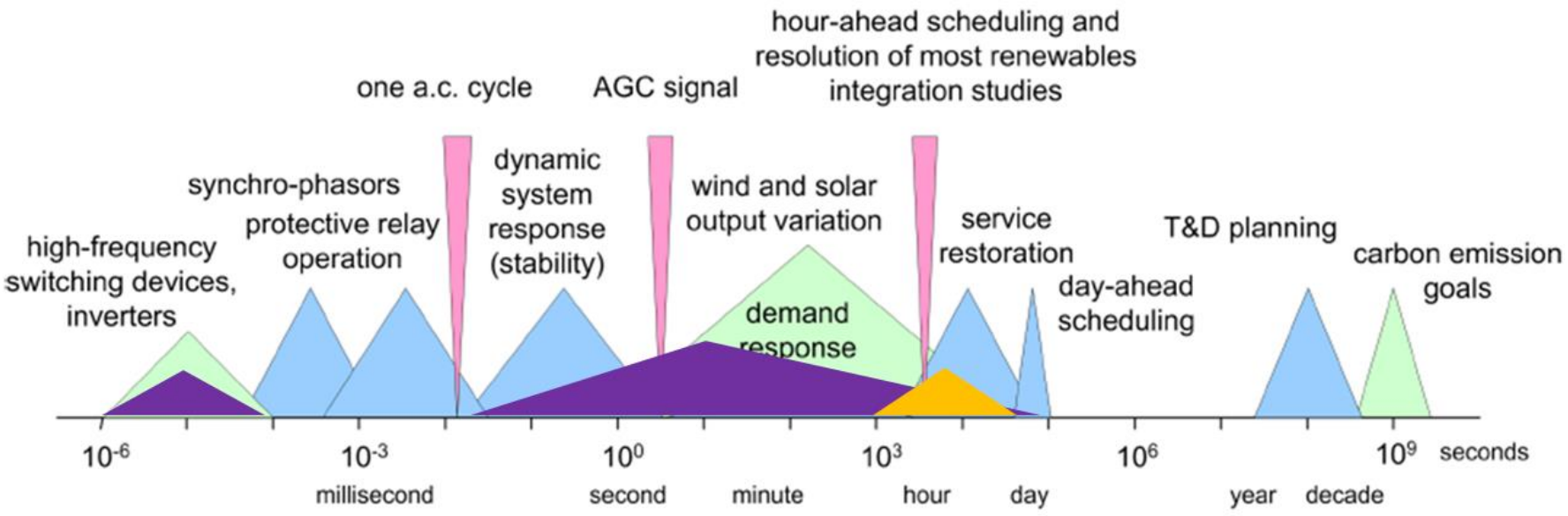
Operational Challenges – Those Pesky Laws of Physics

- Changes to Net Load Curves and Real-time Dispatch Needs
- Distribution Voltage and Power Quality Impacts

- Multi-directional power flow at scale
  - Impact on system over voltage and over current protection
  - Line worker safety
- Policy enabled customer participation in market and grid operational services

Operational Challenges - Timing

Increased Variability Requiring More Dynamic Operations on Shorter Time Cycles



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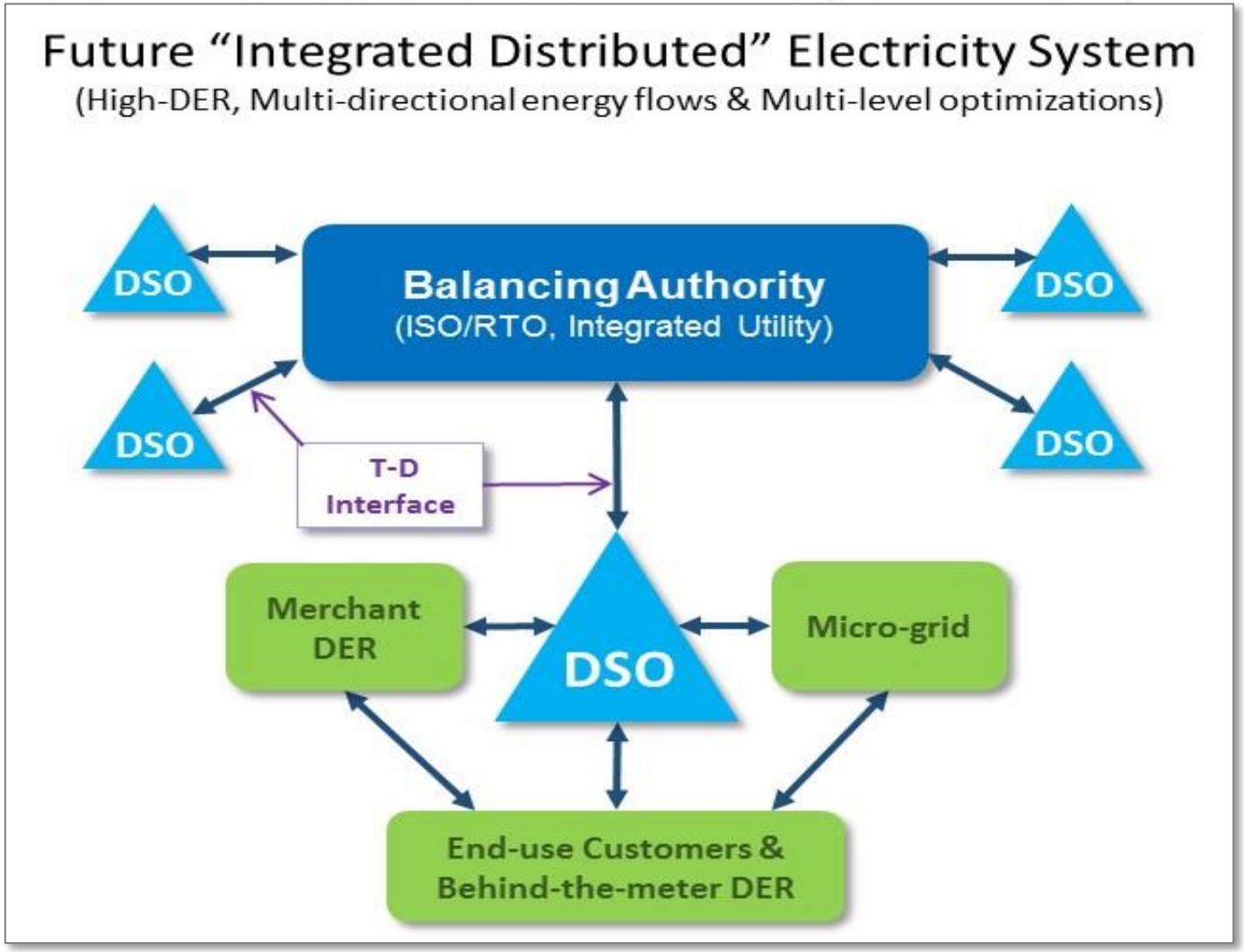
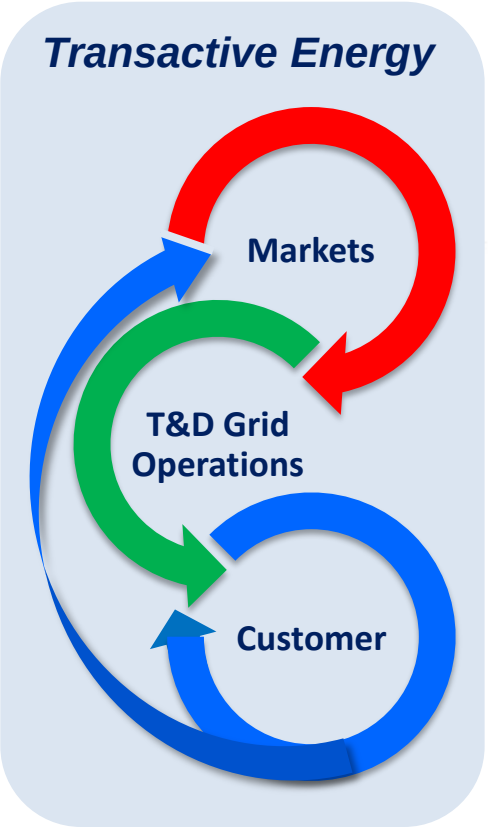
Distribution Network Operations



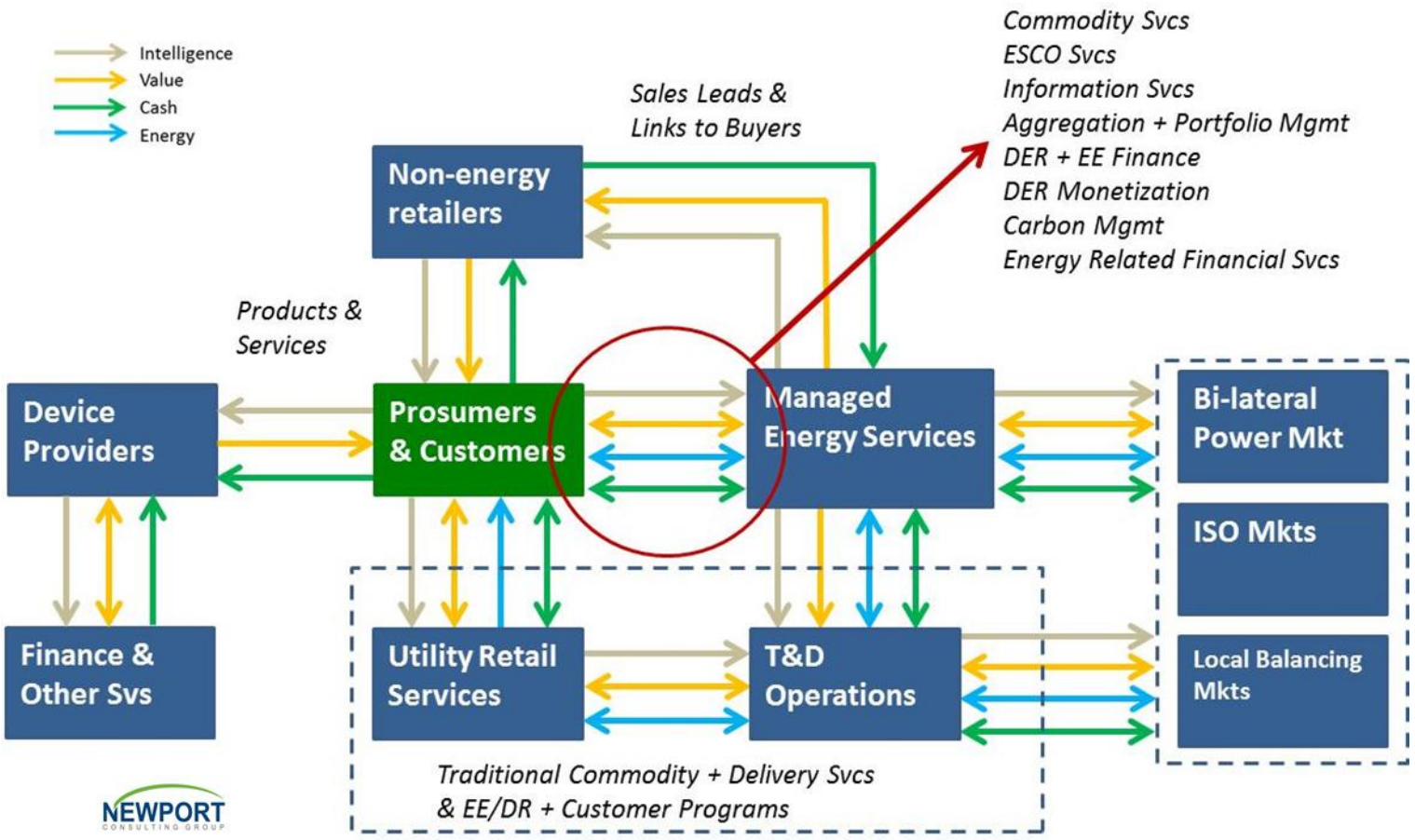
Transactive Energy:
Engineering-Economic Based Operational Controls

"Transactive Energy is the ability of customers and others, using value driven control systems, to optimize their use and sale of electric services to markets and grid operators to enhance economic efficiency and reliability."

- Addresses need for reconciliation of converging multi-party business and operational objectives and constraints
- Not just markets, but also a broader integrated cyber-physical control system to ensure reliable electric services

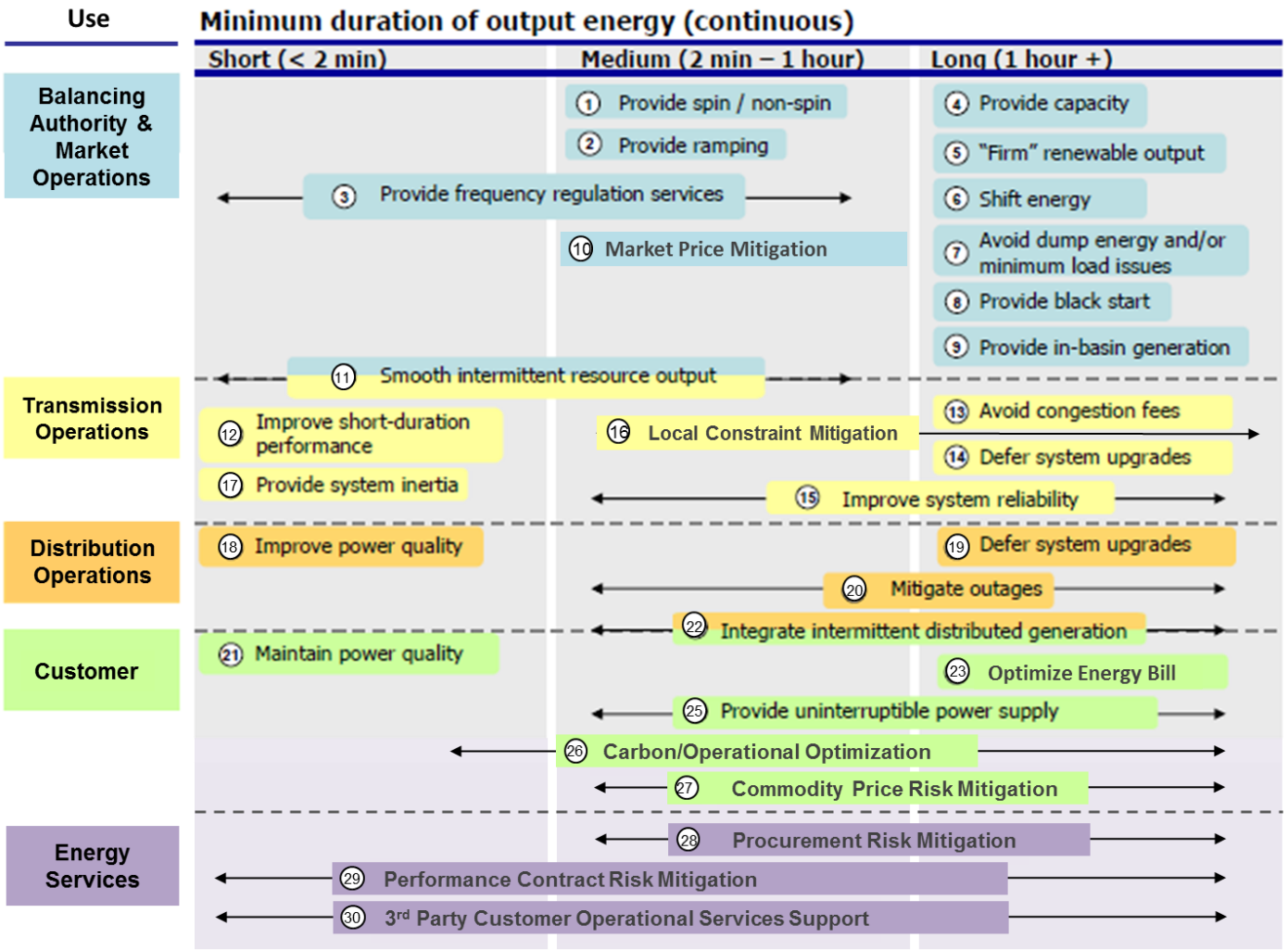


Conceptual View of Customer Energy Related Transactions Occurring Today



Values & Differentiated Services

30 potential values, only a handful can be effectively monetized today



Source: SCE, Adapted by Newport Consulting

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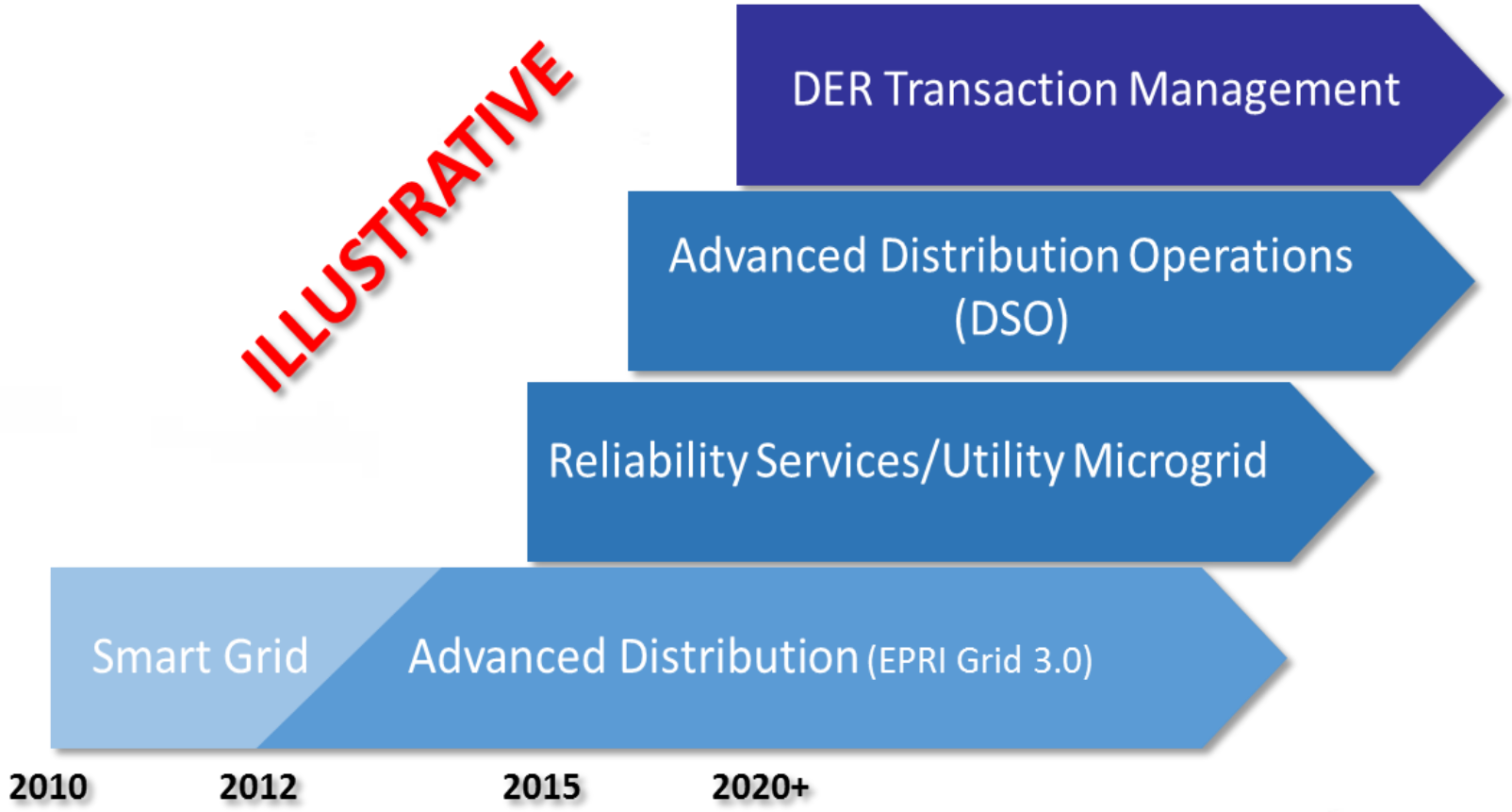
A Roadmap to Transactive Energy

Network Service Provider/Integrator Business Model Evolution



Who wants to play?

- **Traditional Customers**
- **Traditional Energy Service Companies**: Companies such as Constellation, NRG, Schneider/Summit, etc. will bundle energy with other value added services for customers
- **DER Services Firms:** Companies like EnerNoc, Comverge, and now SolarCity, STEM, Sunverge and others that develop and aggregate DER will look to aggregate DER to participate in distribution level, and expanded wholesale market opportunities.
- **Platform Providers**: Companies like Google, Apple, Verizon, Comcast and others will continue to expand their platforms to offer energy-related services to customers, utilizing data and analytics

TRANSACTIVE ENERGY CAPABILITIES

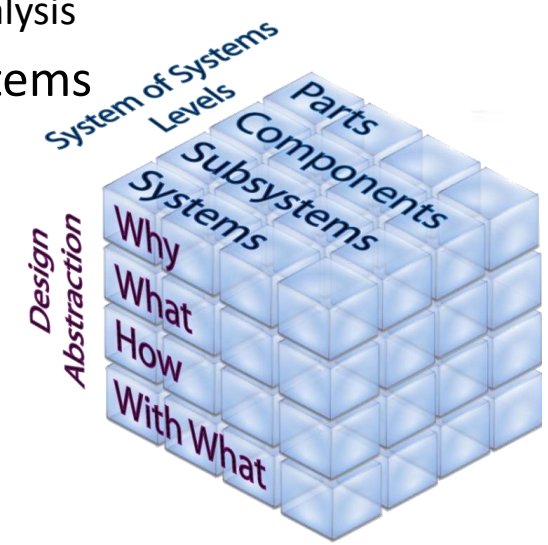
People, Processes, Technology

TE People Capabilities

- Novel & Adaptive Thinking
  - The average employee will need a greater understanding of business strategy and proficiency at thinking and coming up with creative, non-rule-based solutions
  - Specific groups of employees (e.g. account managers or commercial employees) will need much deeper knowledge of DER alternatives and cost/benefit information as well as stronger commercial skills (strategic sales, contracting, negotiation, etc.) to solve problems for the customers of the future and provide solutions to manage their energy needs
- Transdisciplinarity
  - Linemen and other operations personnel will need additional knowledge and training to support the evolution from an analog to digital grid and the integration of distributed energy resources, market systems and greater literacy in and ability to understand concepts across multiple disciplines
- Virtual Collaboration
  - Will need to develop the ability to work productively, drive engagement and demonstrate presence as a member of a virtual team as we may have to work even more actively with “channel” partners – with human processes and with technology – to satisfy our new customers’ needs
- Computational Thinking
  - Development of new product and service offerings will require the ability to translate vast amounts of data into abstract concepts and to understand data-based reasoning
- New Media Literacy
  - In order to meet raised customer expectations, employees will need to be able to critically assess and develop content that uses new media forms, and leverage these media for persuasive communication

TE Engineering Skills

- Basic electrical and electric power engineering
  - Electronics, load flow, short circuit, stability, transients
- Communications
  - Physical media, protocols, info models, networks, traffic analysis
- Distributed Computing / Intelligence / Complex Systems
  - Software, distributed agent based computing, local automation, stochastic processes
- Security
  - Physical and cyber
- Systems of Systems Engineering
  - Integration, control theory, reliability, stability, security



- Enterprise Architecture
  - Databases, Service Oriented Architecture, transaction management, micro-transactions
- Business, Economics, Markets and Regulation
  - Understanding the business, cost/benefit, business case, the dynamics of markets
- Interpersonal Relationship
  - Internal to break down silos, external to understand customer needs

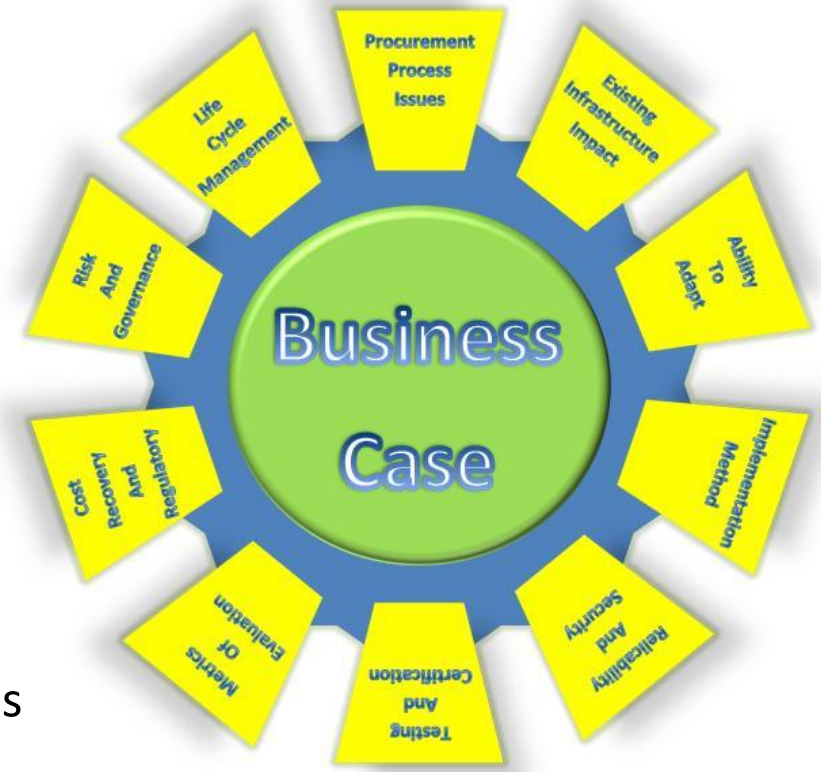
Grid Management Process Change

- Existing customer and several grid operational processes incrementally evolve over time
- Transactive Energy introduces substantial changes to distribution planning and new operational functions
- New customer services create new processes with greater complexity

GTM Grid Edge Cube

Technology Adoption Life Cycle

- Clear Business Objective
- Technology Selection
- Impact on Existing Infrastructure
- Ability of Organization to Adapt
- Method of Implementation
- Reliability and Security Impacts
- Testing and Certification
- Metrics to Evaluate Implementation Effectiveness
- Cost Recovery and Other Regulatory Issues
- Business Risk Assessment and Overall Governance
- Life Cycle Management
- End of Life



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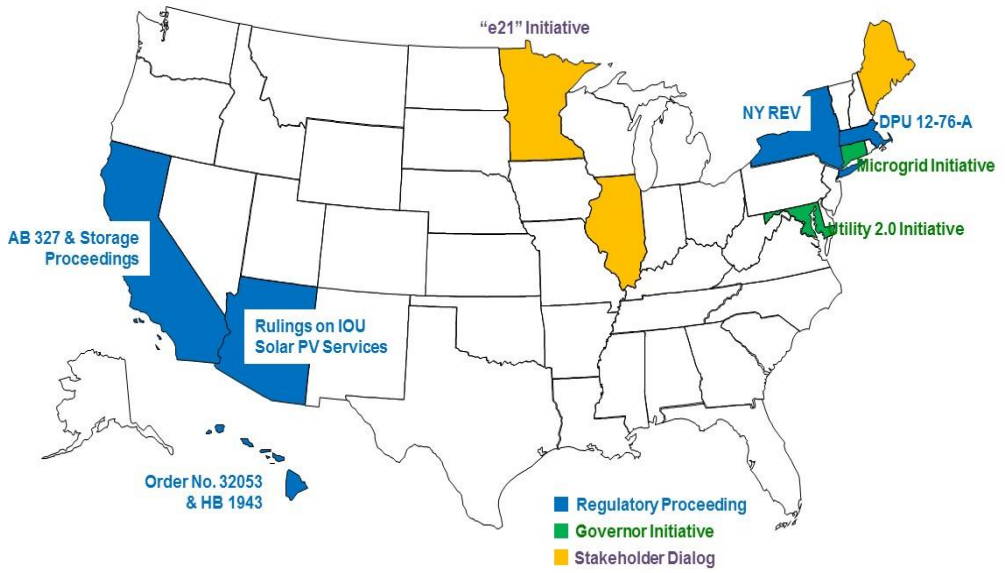
One More Thing - State Regulatory Evolution

Several states have open proceedings or having preliminary stakeholder dialogs

- **New York** REV
- **California** DER/EV related proceedings
- **Hawaii** Grid Modernization & DER integration
- **Arizona** Utility DER services & ownership



Focus of Regulation & Advocacy

- **Distribution as an enabling network**
  open access platform & distribution system operations as market facilitator
- **Expanding customer services**
  opportunities for utilities to facilitate and/or provide DER, microgrid and other competitive customer services
- **Reforming Regulation**
  - Performance based ratemaking (extensive metrics)
  - Rate case process changes (e.g., future test year, length)
  - NEM/TOU Rate reform

"Utilities must transform into "market-makers" who solve problems at the edge of the system"

Audrey Zibelman, Chair, NY PSC May 2014

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Conclusions

- Transactive Energy is simultaneously several things:
  - An abstract concept of how we could manage energy infrastructure
  - A value driven control system
  - A framework for future energy markets
- A consumer needs oriented approach is required
- A disciplined approach based on strategic drivers is required to implement and evolve TE
- Substantial investment is required
- New technology adoption is a challenge for any business but especially so in traditionally stable, slow evolving businesses – e.g. electric power industry
- Extensive changes will be required to electric power and business systems modeling and simulation – new tools are required
- With change comes opportunity!

Questions?

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