U.S. DEPARTMENT OF ENERGY | OFFICE OF ELECTRICITY

Moving to the Grid of the Future

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Deputy Assistant Secretary

Grid Systems and Components

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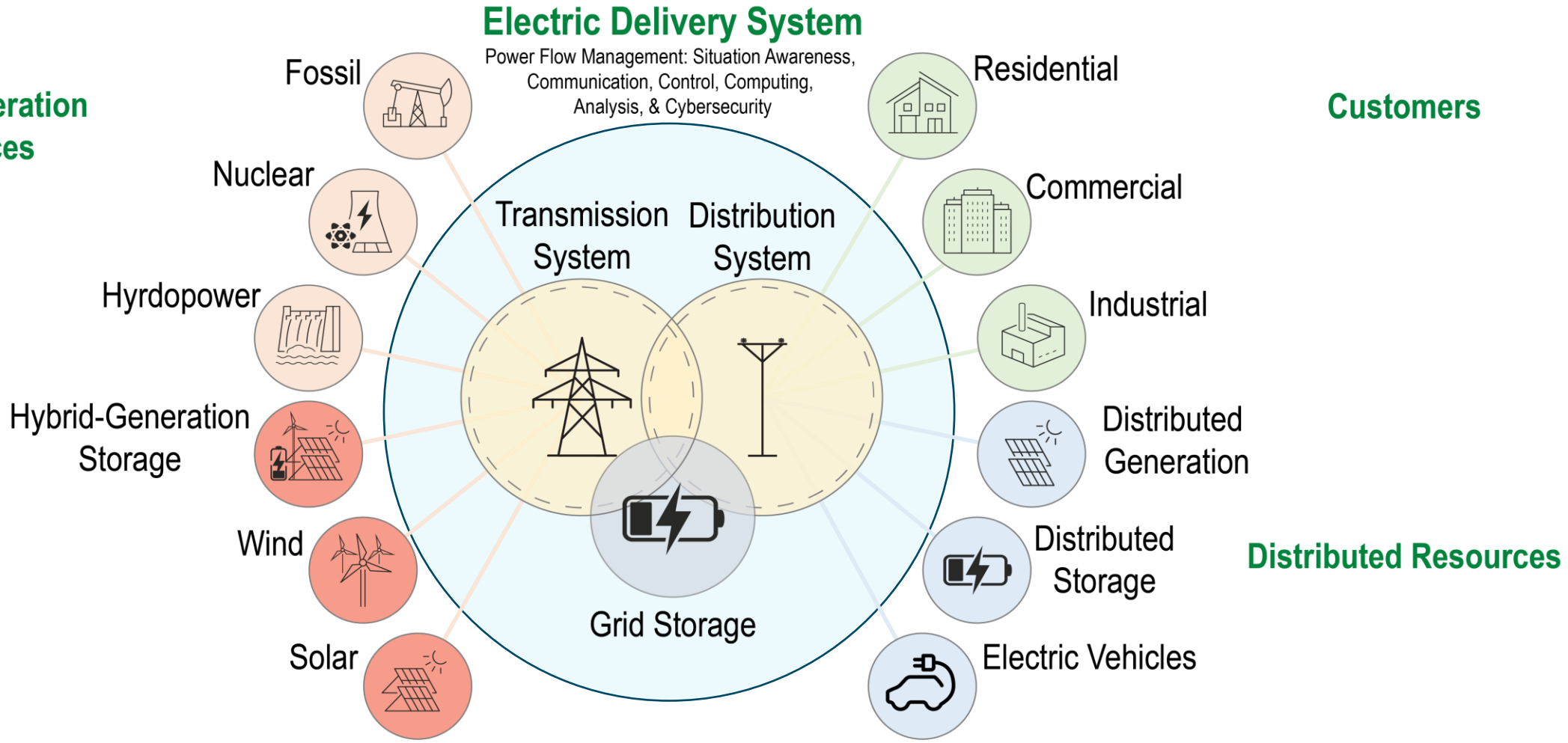
Electricity Grid



Drivers of Change

- **Efforts to decarbonize the grid and the US economy**

- Rise of non-dispatchable generation
- Rise of invertor-based generation
- Changing grid edge
  – bi-directional power flow
- Evolving demand for electricity
  – Electrification

- Growing physical and cyber threats
- Energy Justice - efforts to reduce social inequalities
- Workforce - impact of energy transition on employment
- Globalization of supply chains

Fundamental Changes

Historical Grid

- Rotational Inertia
- Dispatchable Generation
- Passive / Predictable Loads
- “Static” T&D Infrastructure

Operator-Based Grid Management

Centralized Control

SCADA Measurements

Off-Line Analysis / Limit Setting

Emerging Grid

- Reduced Stability / Faster Dynamics
- Stochastic Generation
- Engaged Consumers
- “Adaptive” T&D Infrastructure

Flexible and Resilient Systems

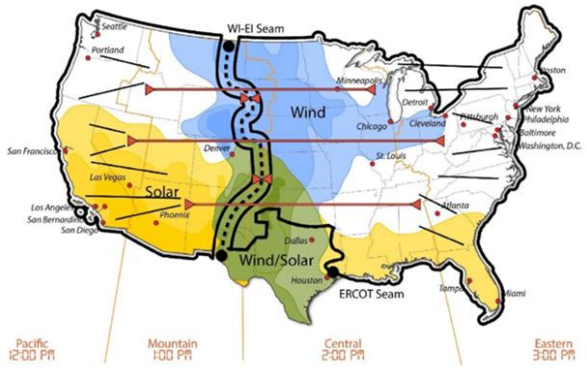
Multi-Level Coordination / Precise Control

Advanced Sensors and Data Acquisition

Robust and Secure Communications

Faster-than-Real-Time Analysis

Grid Trajectory Considerations



Loose Coupling
Agile/Flexible

High RE Penetration, High-Voltage AC+DC Grids, and Storage

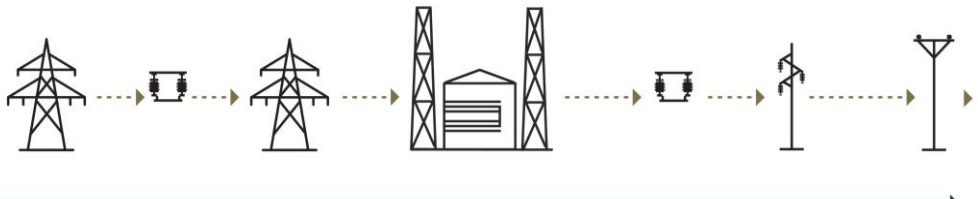
Dynamic and Coordinated Grid across TD&C

Capital Intensive
Economies of scale

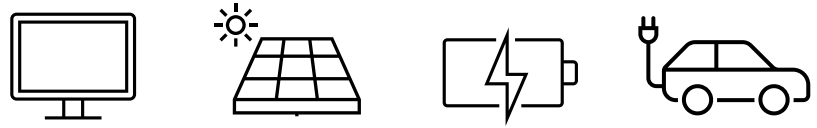
Capital Diffuse
Network economies

Current Grid

High DER + Complex Industry Structure



Tight Coupling
Rigid/Brittle



Next-Generation Electricity Network

- Control of flexible generation and load
- Energy storage
- Synthetic inertia
- Multi-directional power flow
- Varied/dynamic grid configuration
- Evolving business and market structures

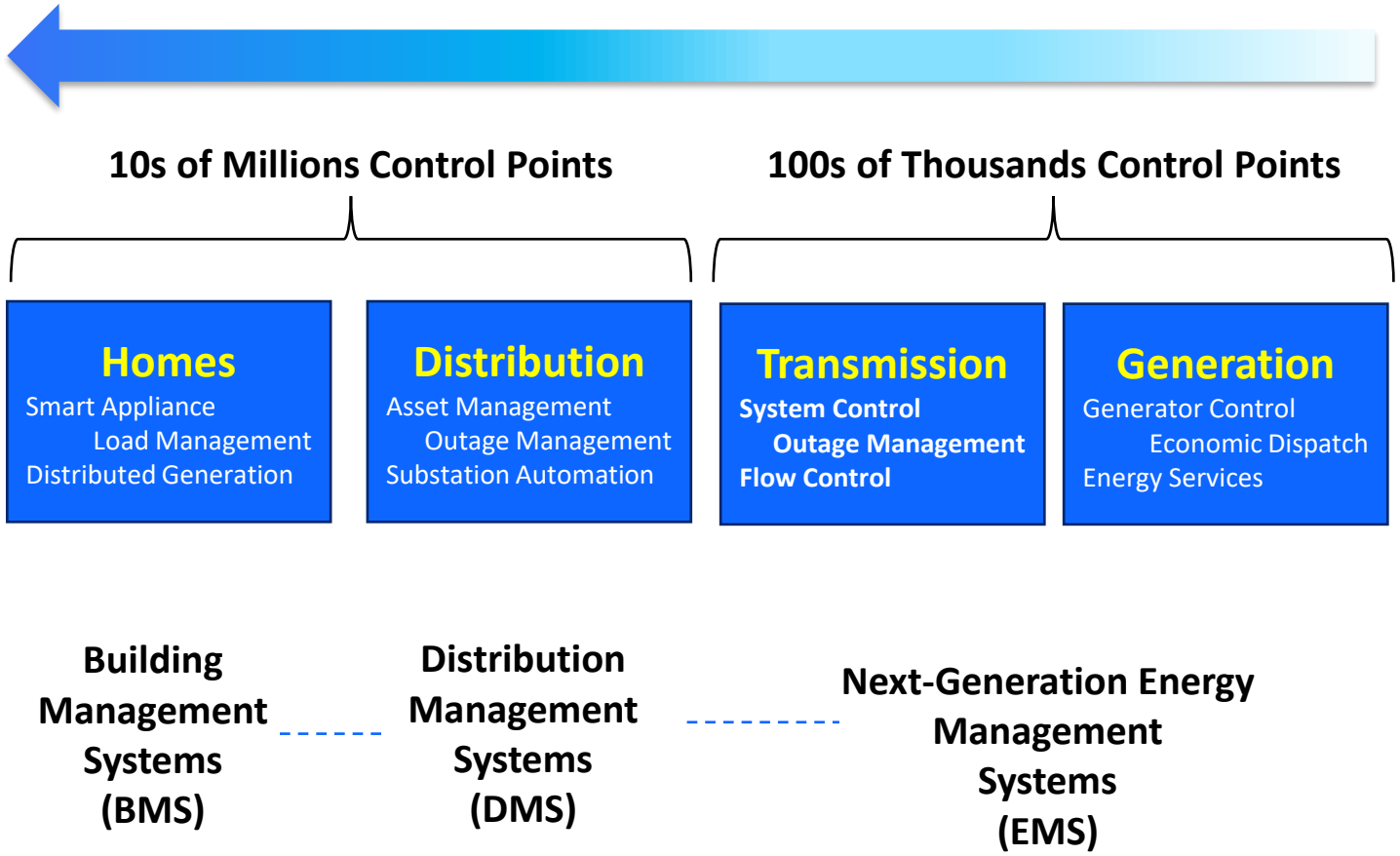
Transmission Capacity Expansion

- Grid Enhancing Technologies (GET)
  - Dynamic Line Rating (DLR)
  - Power Flow Controllers (PFCs)
  - Topology Control Algorithms
- Advanced Conductors
- High Voltage Direct Current (HVDC)

"HVDC converter stations are the costliest component of long-distance transmission. The Department is directed to develop an **HVDC moonshot** initiative to support research and development to reduce the costs of HVDC technology and long-distance transmission."

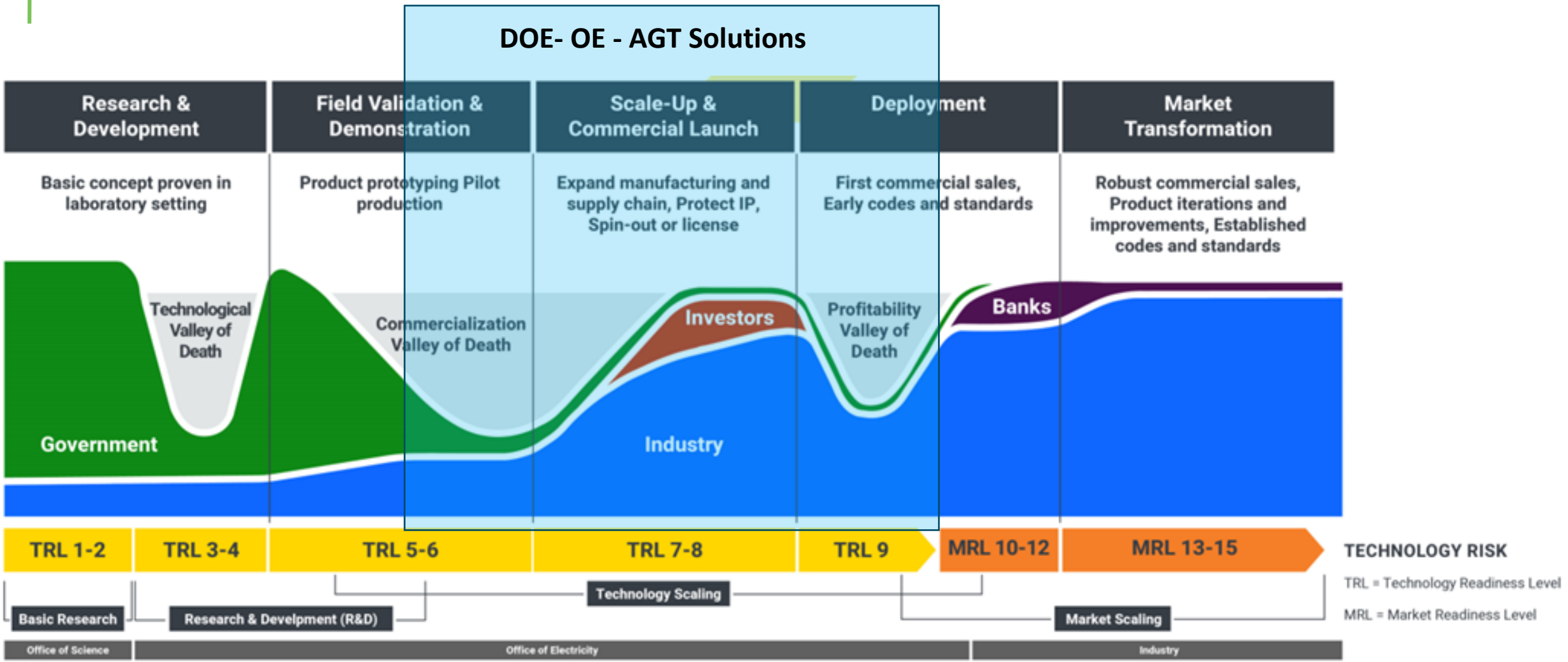
ENERGY AND WATER DEVELOPMENT AND RELATED AGENCIES APPROPRIATIONS ACT, 2023 – TRAC/HVDC

Seamless Integration Enable Flexibility Critical to Reliability/Resilience



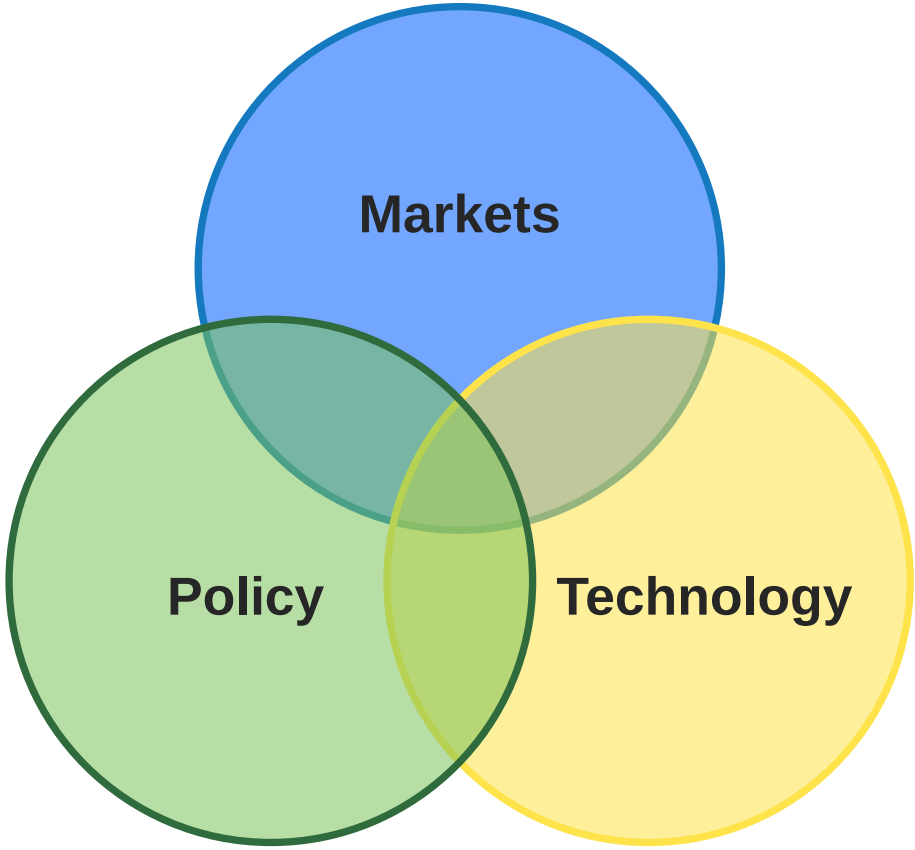
- Tighter integration and coordination between transmission, distribution, and loads
- Grid architecture must accommodate more distributed systems
- Lines between transmission & distribution will be blurred
- Linkage of EMS and DMS will be important

Support Technology Evolution – Applied Grid Transformation



Basic Science Research & Discovery → Application Driven Materials Development → Applied Device and System R&D → Cost & Performance Metrics, Targets → Demonstration and Performance Validation → Systems Analysis and Valuation → Commercialization Strategy

Our ability to transform the electric grid will require a coordinated strategy



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