



U.S. DEPARTMENT OF  
**ENERGY**  
OFFICE OF  
**ELECTRICITY**

**Event:** NREL's 7<sup>th</sup> Autonomous Energy Systems Workshop

**Title:** Networked Microgrids As Distributed Quasi-Autonomous Energy Systems in An Evolving Grid

**Presenter:** Dr. Emeka Obikwelu, PhD PE PMP, *Grid Systems Director, Grid Systems and Components Division, Office of Electricity, U.S. Department of Energy*

# Office of Electricity

**Working closely with industry and other stakeholders, the Office leads the Department's efforts to ensure that the Nation's most critical energy infrastructure is secure and resilient to disruptions. These efforts will strengthen, transform, and improve electricity infrastructure so consumers have reliable access to clean sources of energy.**

- ✓ DOE Research, Development & Demonstration (RD&D) activities that drive grid technology evolution and provide long-term transformational strategies to ensure that transmission and distribution systems can support evolving generation and new types of loads, including distributed energy resources, while operating reliably under a variety of conditions
- ✓ DOE's efforts to ensure the grid builds-in security and resilience considerations through grid modernization



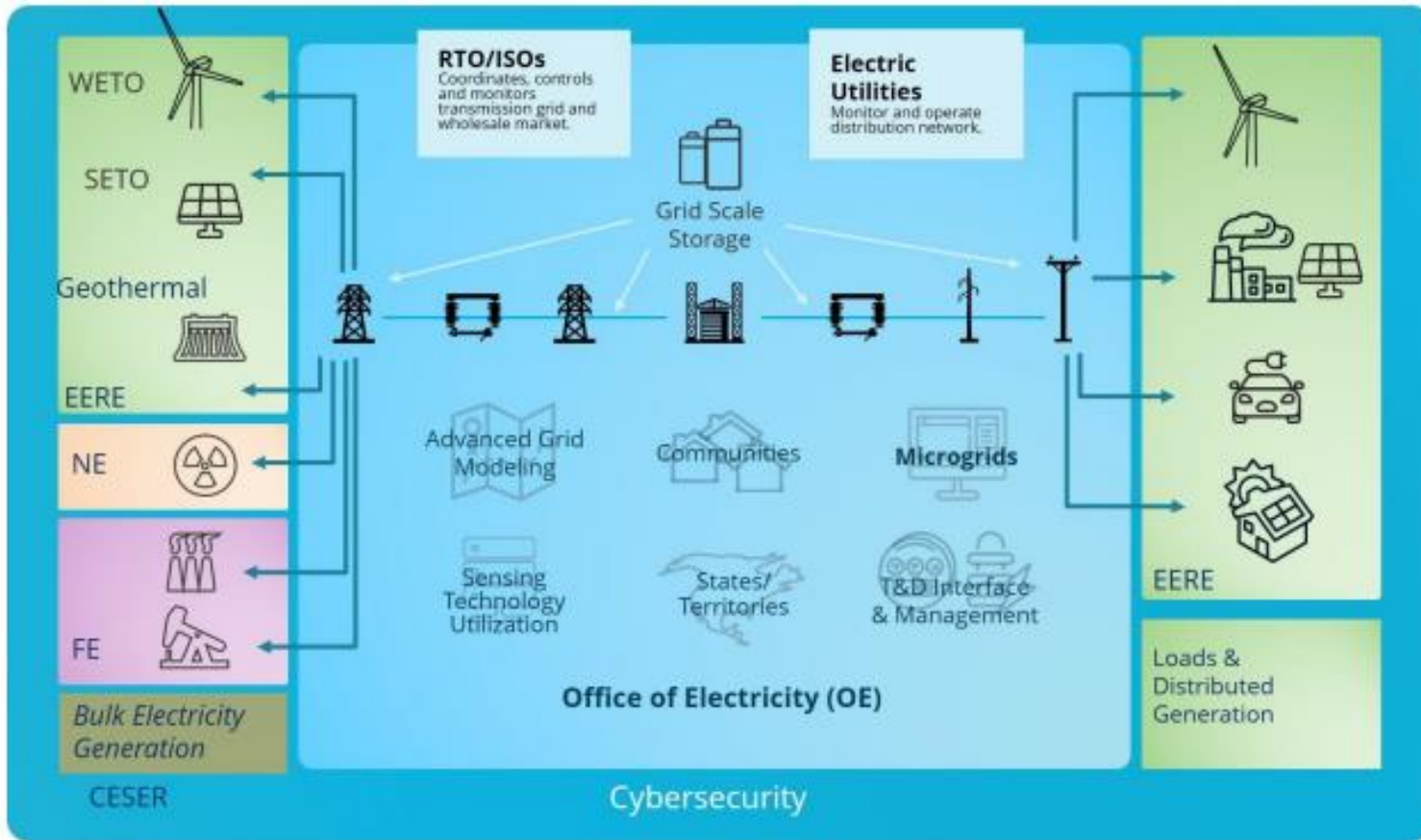
*OE Website: <https://www.energy.gov/oe/office-electricity>*



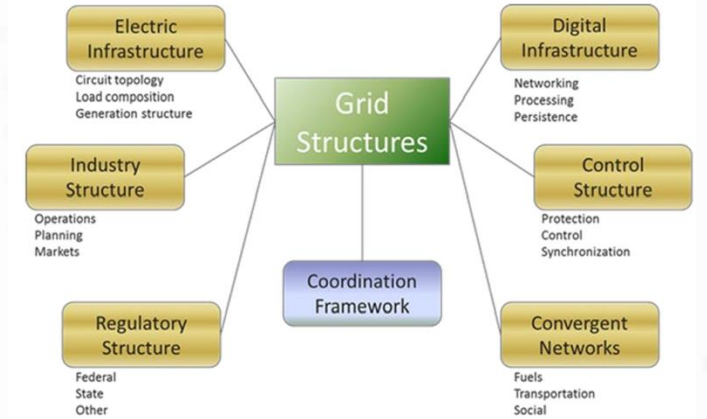
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# Electricity Delivery System

DOE offices invest in RDD&D activities that span the entire grid system from centralized electricity generation to consumption and other end-uses – enabling multi-structural grid evolution toward a more reliable, resilient, secure, and sustainable future, as compelled by multiple transformation vectors.



End-to-End Electrical Grid Illustration. **Source:** DOE/Lab



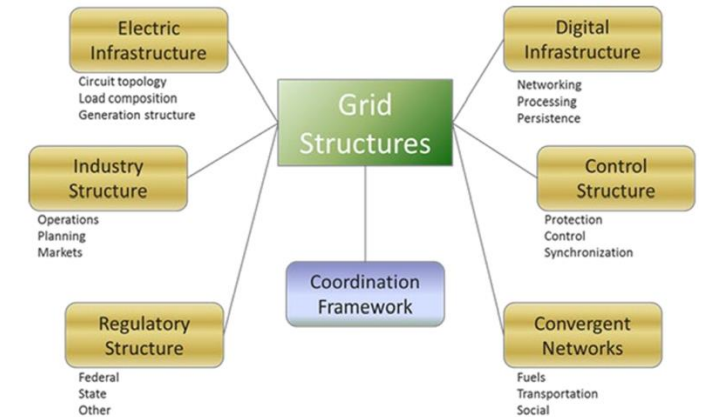
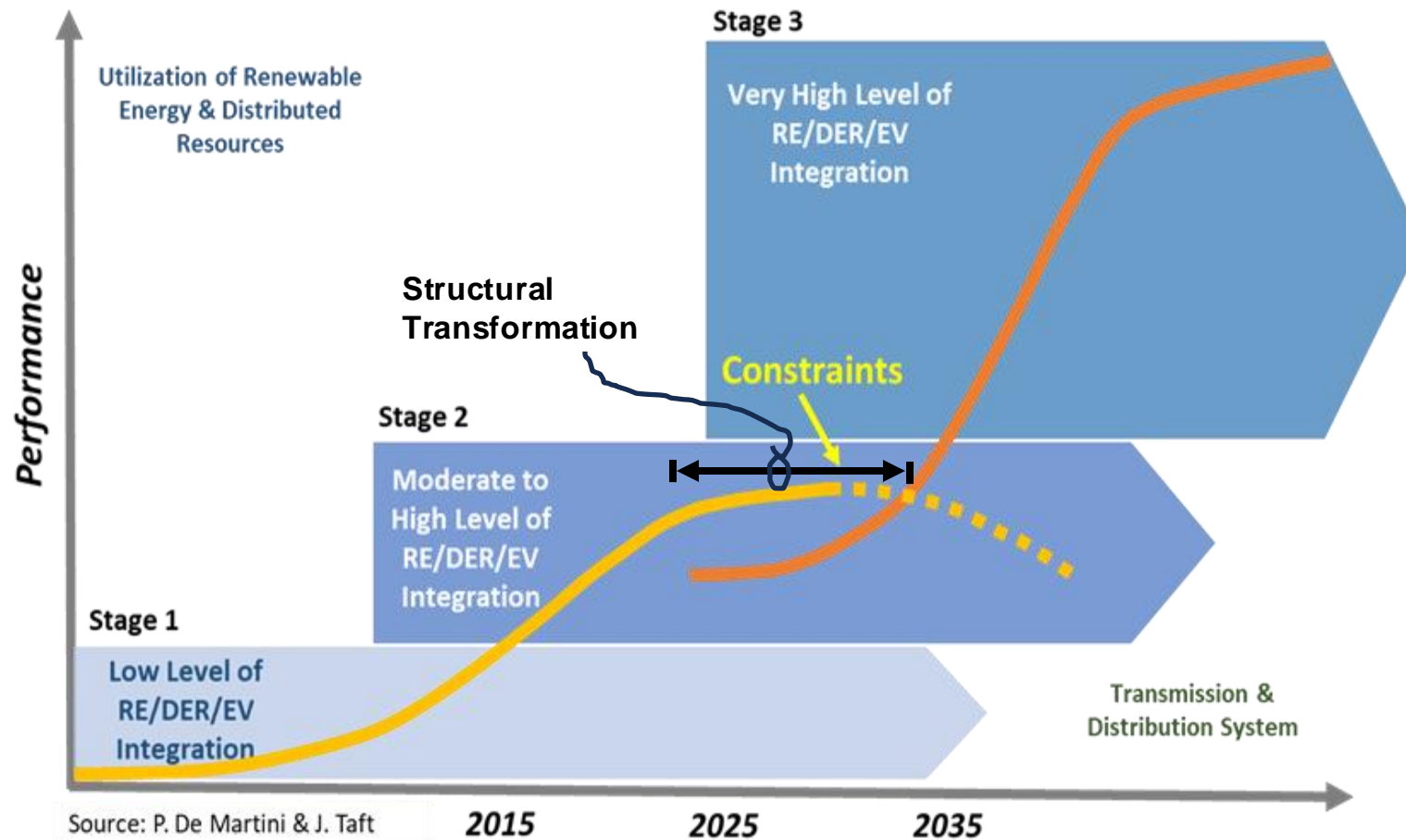
Grid Structures. **Source:** DOE/PNNL

# Major Transformation Drivers

- ✓ **Efforts to decarbonize the grid and the US economy**
  - ✓ Rise of non-dispatchable and inverter-based resources
  - ✓ Changing grid edge – bi-directional power flow
- ✓ **Increasing electrification across economic sectors**
- ✓ **Digital transformation, as enabler for AI, advanced computing, and operational efficiency gains**
- ✓ **Frequency of extreme weather events**
- ✓ **Aging infrastructure under mounting system demands**
- ✓ **Impact of energy transition on employment**
- ✓ **Efforts to improve energy justice**
- ✓ **Increase in consumer choice and demand-side participation.**
- ✓ **Globalization of supply chains**



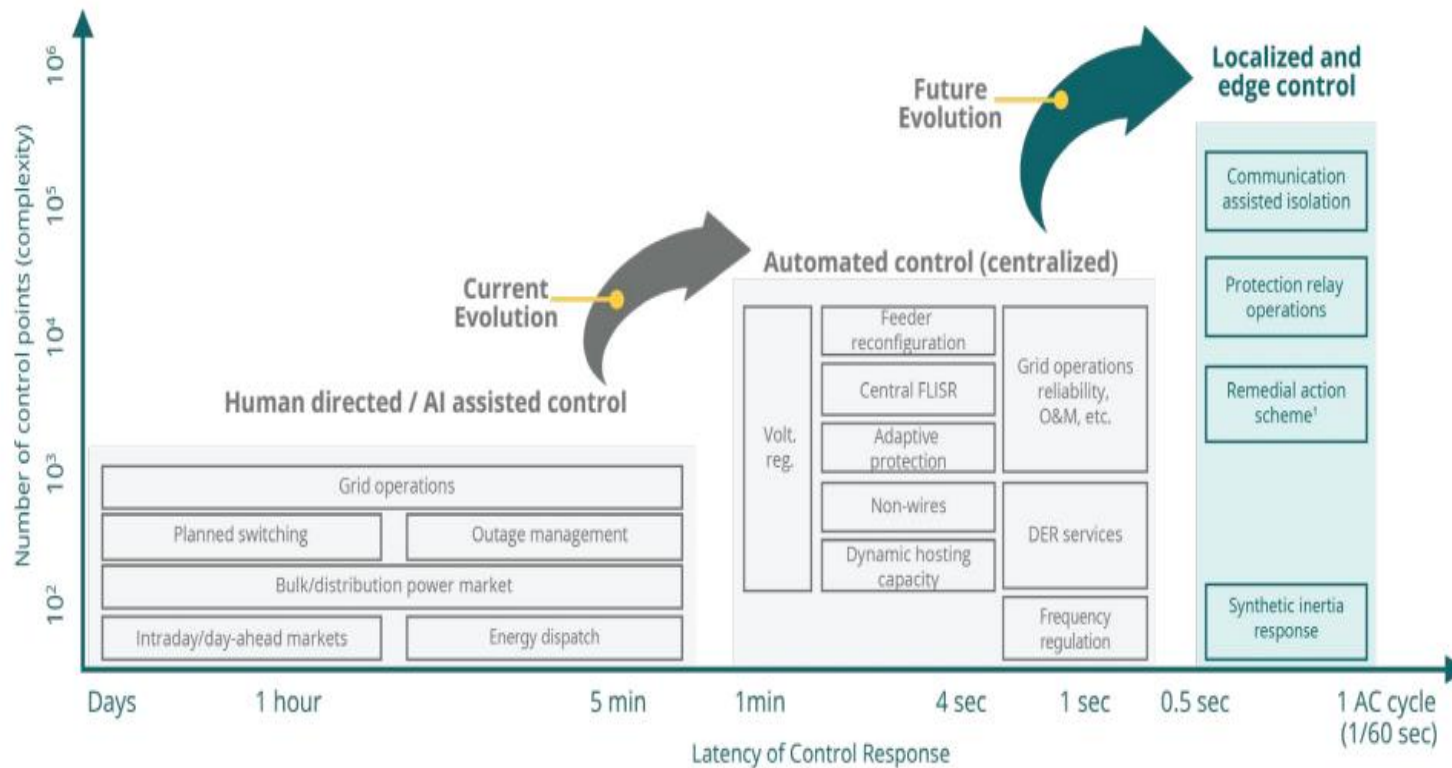
# The Electric Grid is Undergoing a Dramatic Multi-Structural Transformation



Grid Structures. Source: DOE/PNNL

# Future Distribution System Attributes

An open distribution system that enables the use of DER, energy storage, evolving business, industry, and market structures, and convergence with building and transportation infrastructures



Source: Southern California Edison, Reimagining the Future, Dec 2020

## Quick Fun Exercise: $10^6$ Control Points, REALLY?

### ASSUME:

- 1 distributed energy asset has 2 or more Control Points,  $o_i$
- 1 residential building has multiple distributed assets (say,  $n$ )
- 1 commercial building has multiple distributed assets (say,  $m$ )
- 1 industrial building has multiple distributed assets (say  $k$ )
- Sample Electric Utility Service Area (SA) has 2 million building customers.

### LET:

- A: number of industrial buildings in SA
- B: number of commercial buildings in SA
- C: number of residential buildings in SA
- D: combination of other types of buildings in SA

Where:  $k \geq m \geq n$

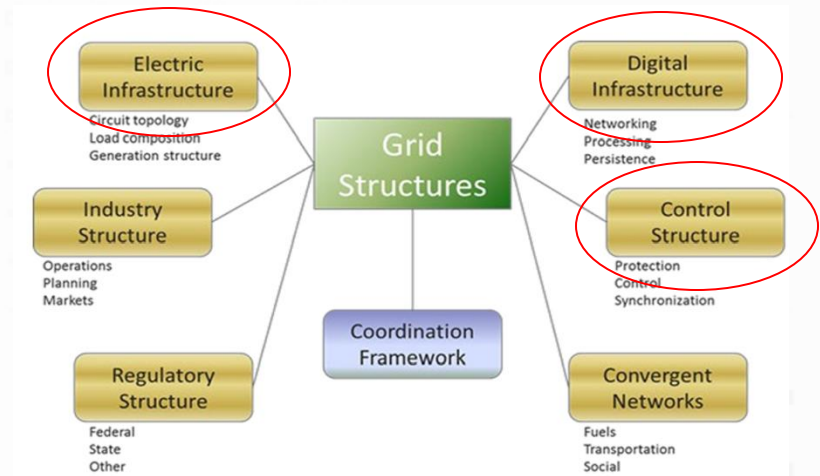
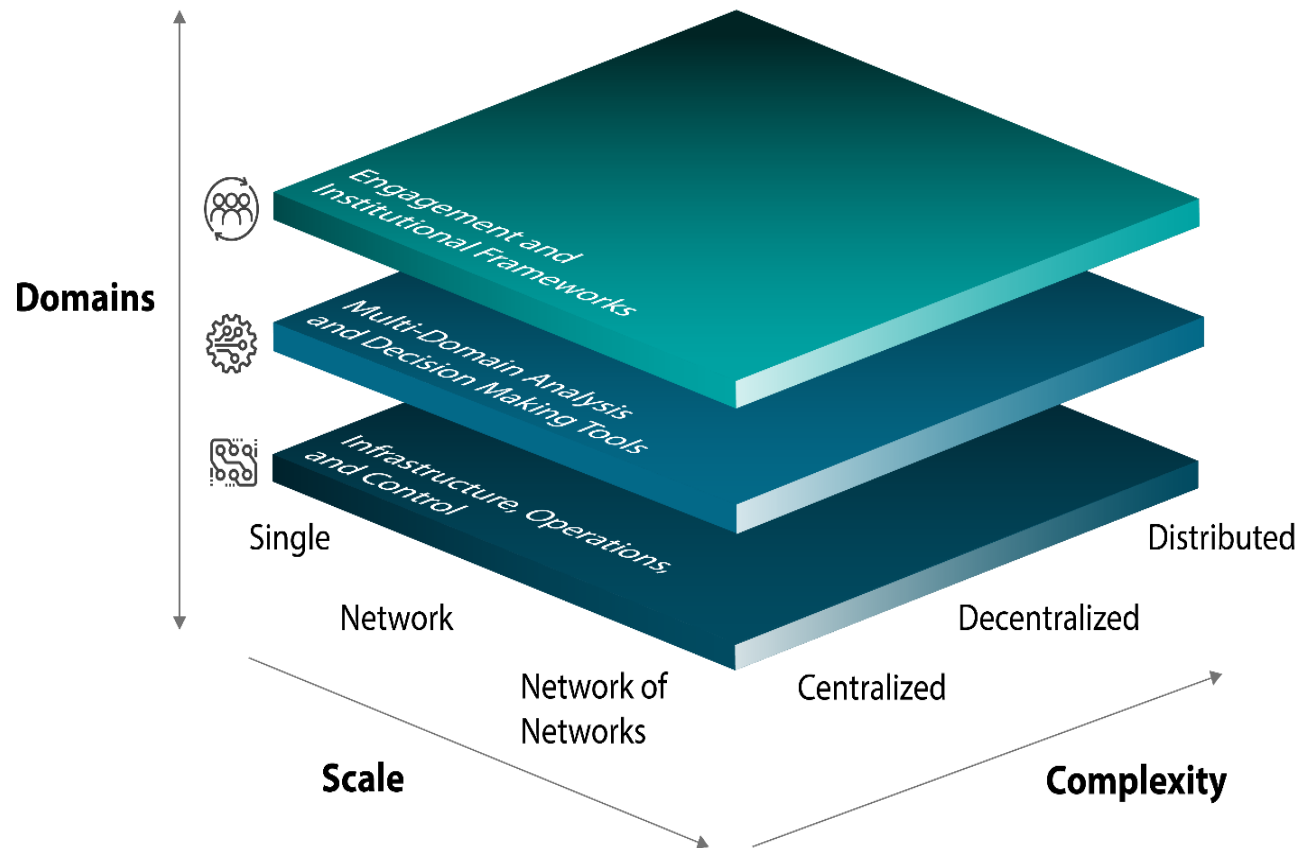
And:  $A + B + C + D = 2 \text{ million}$

### THEN:

$A * k * o_k + B * m * o_m + C * n * o_n + \{\text{total control points per D buildings}\} = \text{Total Number of Control Points per [The Sample] Service Area}$

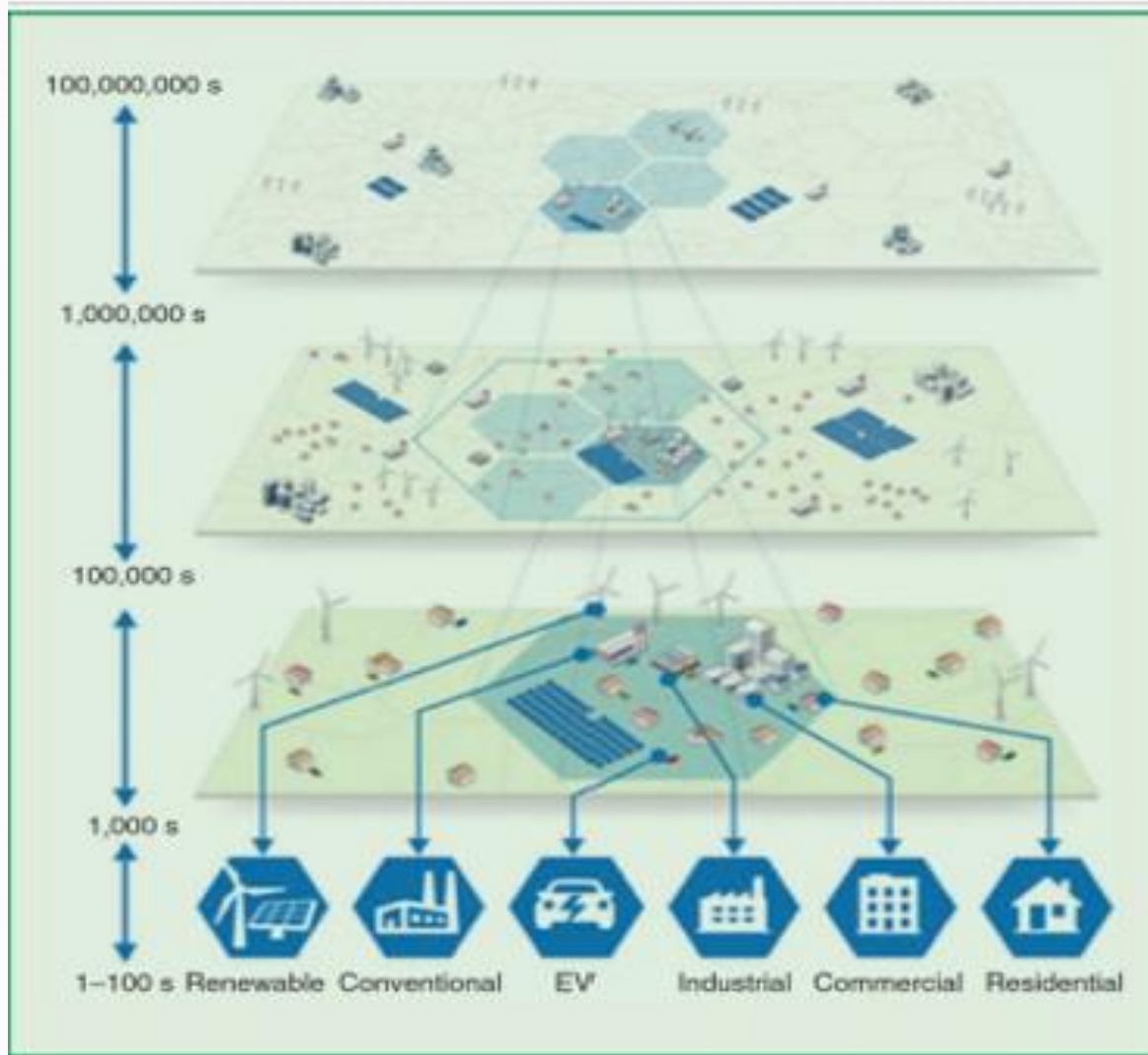
# OE Microgrid RD&D Program Strategy

The strategy is based on the vision to accelerate the modernization and decarbonization of the nation's grid using, adaptive, distributed, modular microgrid architectures, achieving enhanced grid reliability, resilience, security and affordability.

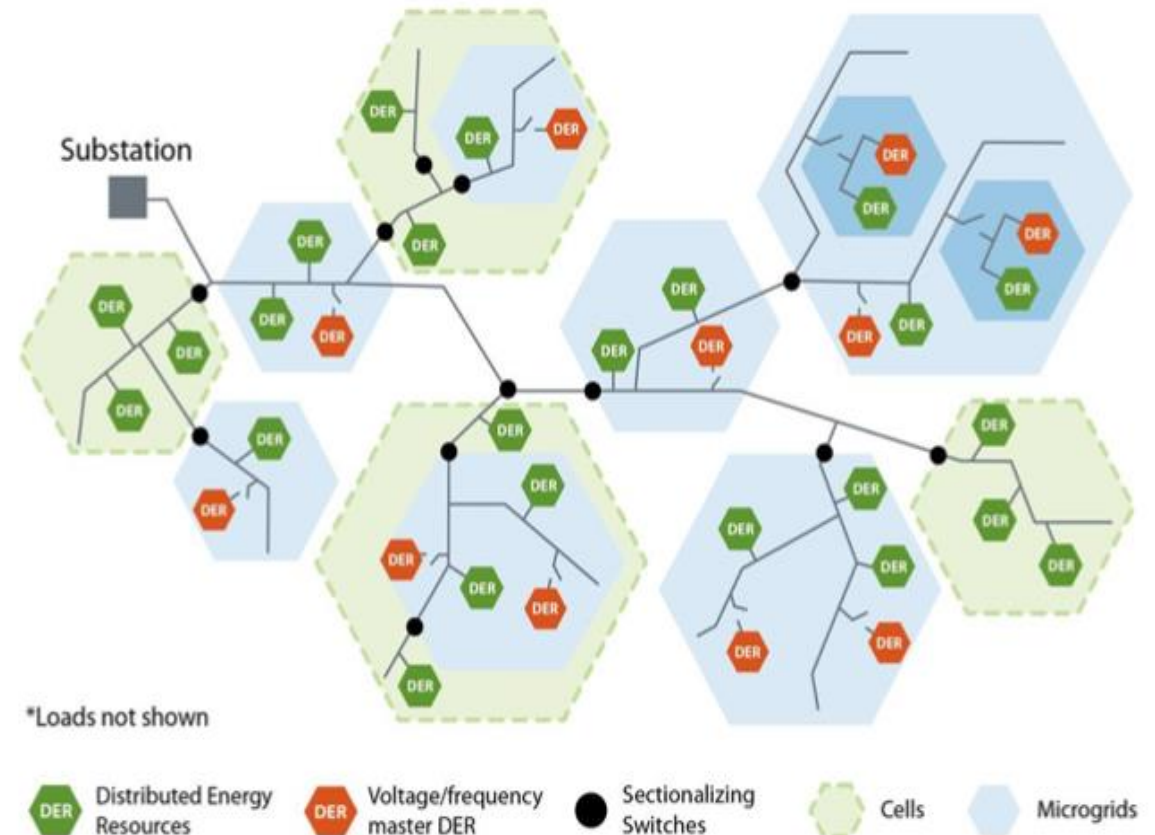


Grid Structures. **Source:** DOE/PNNL

# Grid Edge Microgrid-Enabled DER Aggregation Concepts



Conceptual hierarchical architecture for aggregating distributed assets.  
**Source:** OE Microgrid Program Strategy White Papers

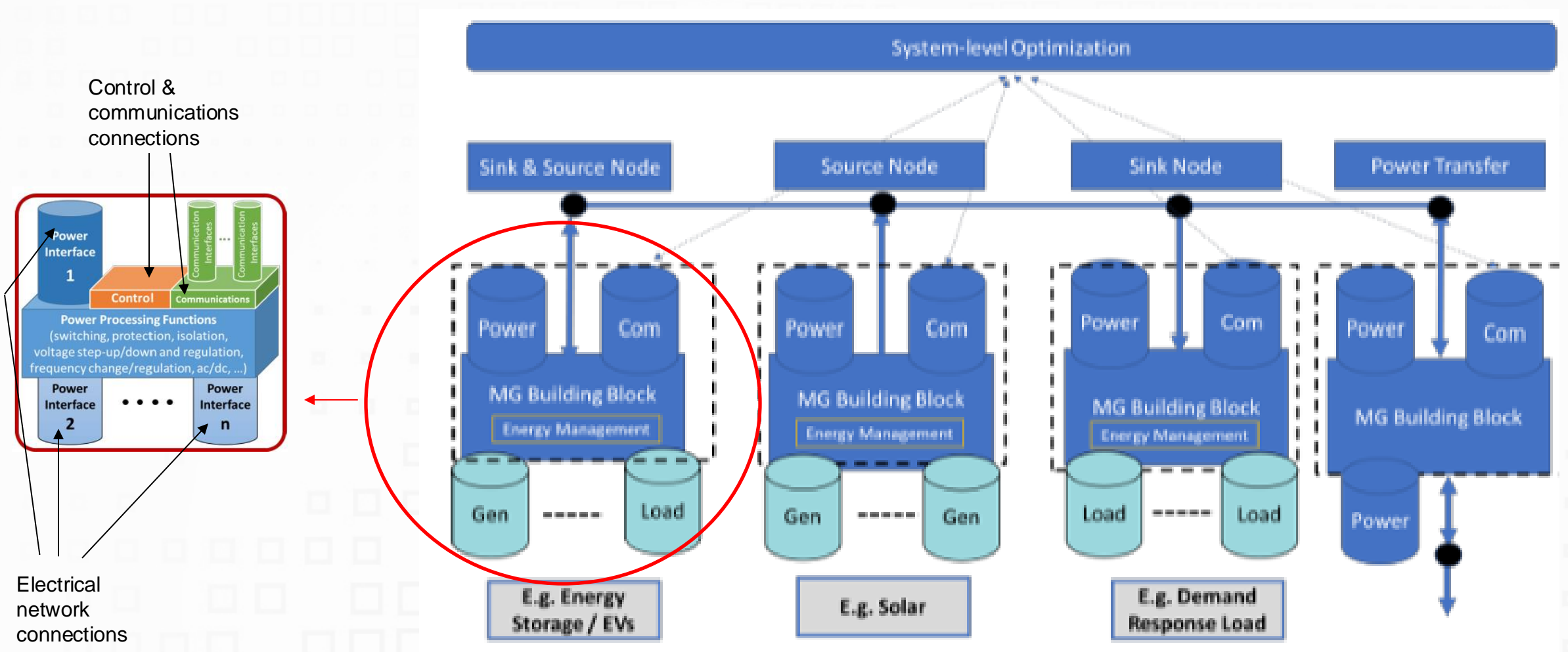


Conceptual distribution feeder featuring hierarchical architecture for aggregating distributed assets.

**Source:** OE Microgrid Program Strategy White Papers



# Microgrid Building Blocks (MBB's) Approach - Illustration

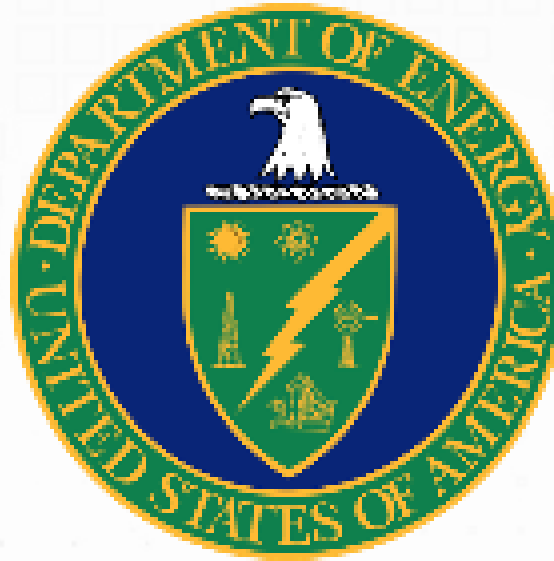


Source: OE Microgrid Program Strategy White Papers

# How to Keep In-Touch with OE!

- ✓ Visit our website: <https://www.energy.gov/oe/office-electricity>
- ✓ Follow OE on LinkedIn: <https://www.linkedin.com/company/office-of-electricity>
- ✓ Reach out to our Communications team if you have inquiries, or if you have success stories to share involving industry-implemented solutions that OE invested in: <https://www.energy.gov/contact-us>





# Thank You

Dr. Emeka Obikwelu – Grid Systems Director  
U.S. Department of Energy, Office of Electricity,  
Grid Systems and Components Division

# Bipartisan Infrastructure Law

## (Infrastructure Investment and Jobs Act)

The Bipartisan Infrastructure Law's more than \$65 billion investment includes the largest investment in clean energy transmission and grid in American history.

It will upgrade our power infrastructure, by building thousands of miles of new, resilient transmission lines to facilitate the expansion of renewables and clean energy, while lowering costs. And it will fund new programs to support the development, demonstration, and deployment of cutting-edge clean energy technologies to accelerate our transition to a zero-emission economy.

