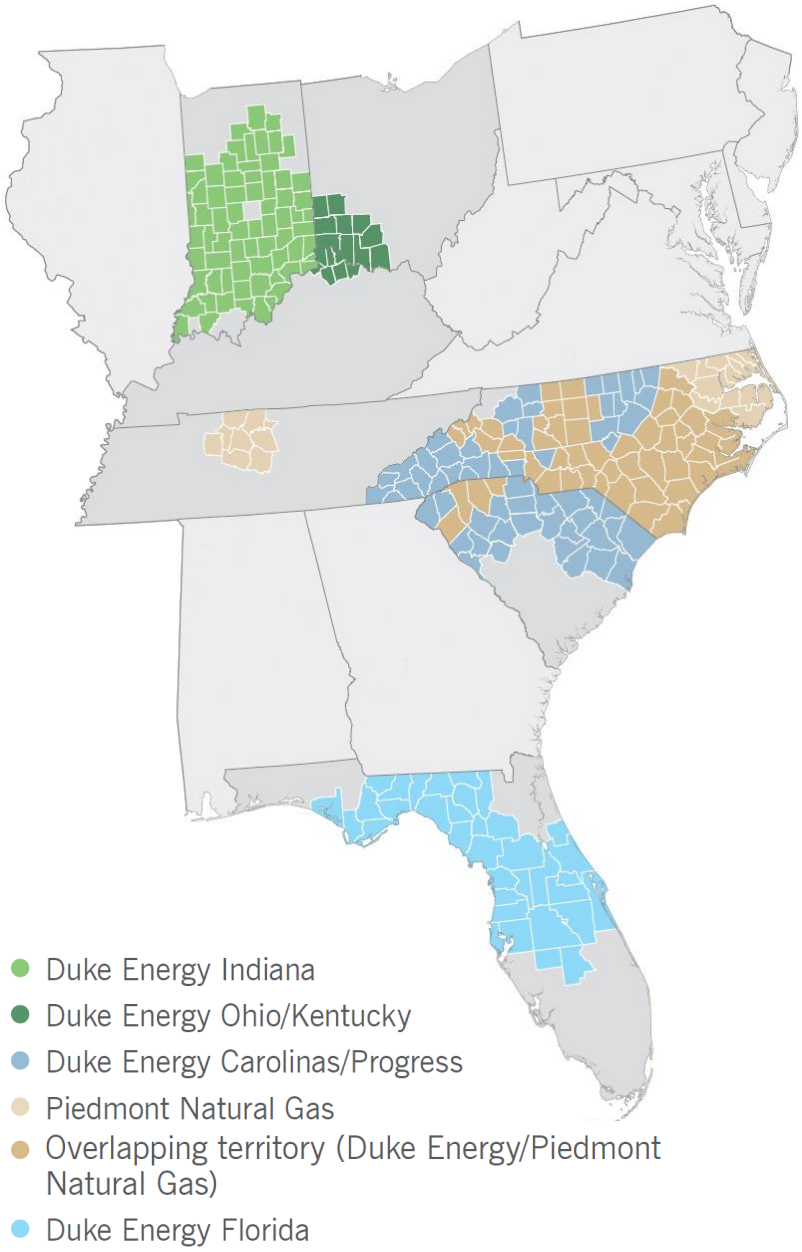
Duke Energy Emerging Technology Office

Enabling Grid-Edge Interoperability to Accelerate DER Adoption and Integration

Stuart Laval

About Duke Energy

- One of the Largest Electric Holding Companies in the United States
- Electric Utility operations in North and South Carolina, Indiana, Ohio, Kentucky, Tennessee, and Florida serving **7.5 million customers**
- **50,000 MW** of regulated generation
- **6,500 MW Renewables to Date:**
  - 3,000 MW of wind
  - 1000 MW of solar
  - 40 MW of battery energy storage
- **Renewable Goals:**
  - 8,000 MW of wind/solar/biomass by 2020
  - 300 MW of battery energy storage by 2025

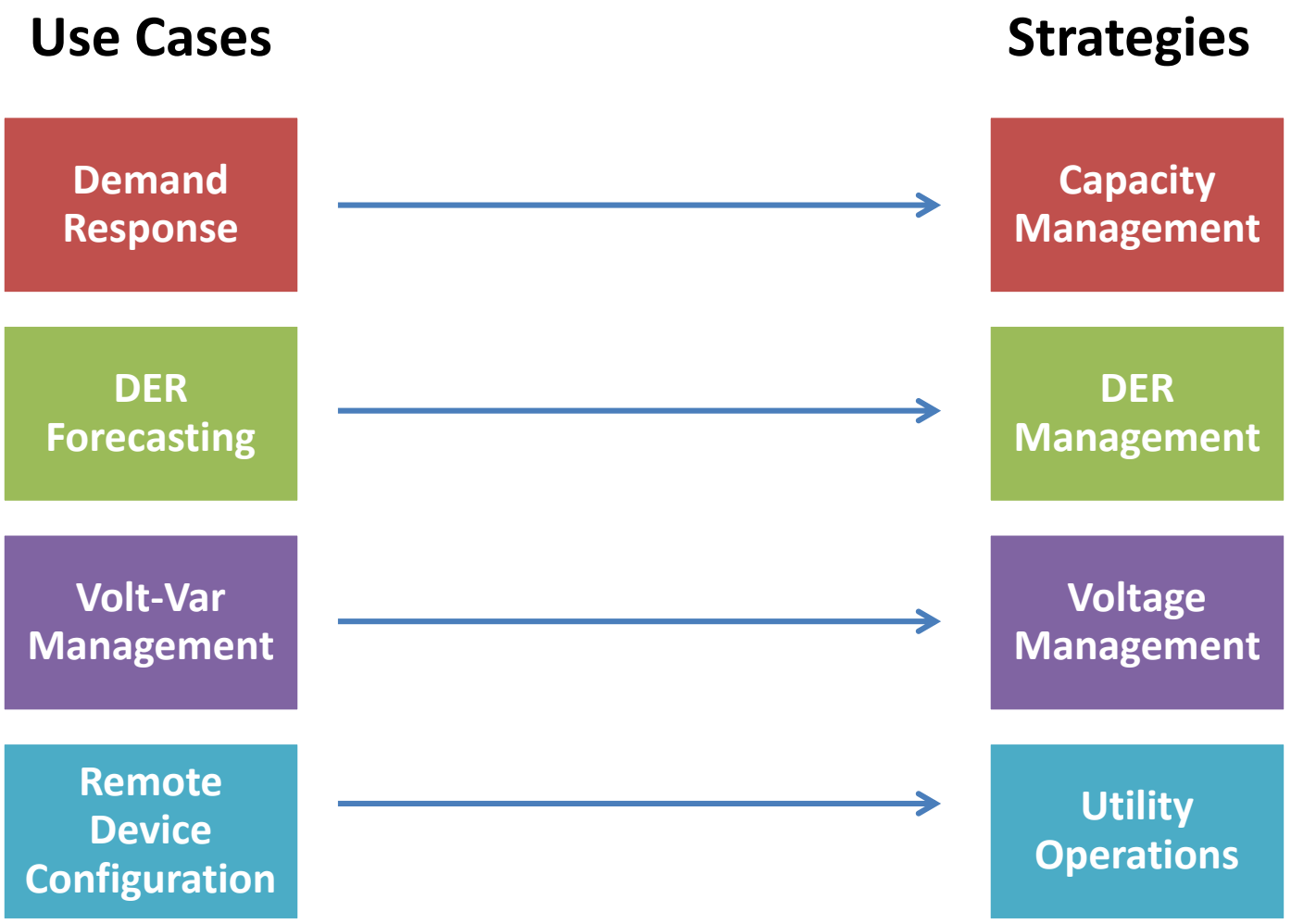


Impacts and Pain Points of DER Adoption

- Many Utilities committing to achieve Net Zero Carbon by 2050
  - Enhanced Distribution and Integrated Resource Planning tools
  - High DER Penetration with Bi-directional real and reactive power flow
  - Responsive, proactive, and dynamic Grid Management with Load shaping capabilities
- FERC 2222/841 opening up wholesale markets to all DERs
  - Fleet level aggregated views for Transmission & Distribution Control Centers
  - Secure communications and dispatch schedules to remote Grid/DER assets
  - Federated approach required to simplify complexity of Grid Operations
- Inverter-based Grid-Forming DERs/Microgrids pose interconnection issues
  - System impact studies leverage static tools without high-fidelity models of inverter controls
  - Limited understanding of island operation in coordination with automated protection schemes
  - PQ ramp rates are slowed down to dampen voltage impacts
  - Low inverter fault currents impacting microgrid system grounding design
  - Circuit re-energization challenges during black-start
  - Traditional brute-force methods for mitigating inadvertent islands
  - Many microgrid & battery storage deployments being limited to parallel operation only
- Grid Controls being delegated to Substation or Localized Circuit Segments
  - Starts with large grid-tied DERs & microgrids with gradual transition to full circuit
  - Grid-edge deployments of micro-SCADA and localized controllers expected
  - Dynamic topologies, via HIL, help assess Transient/Stability, Protection, Grounding, & Power Quality
  - New toolsets, procedures, and design standards for streamlining DER interconnection
  - Plug-n-play interoperability and multi-objective use-cases being standardized at the feeder level

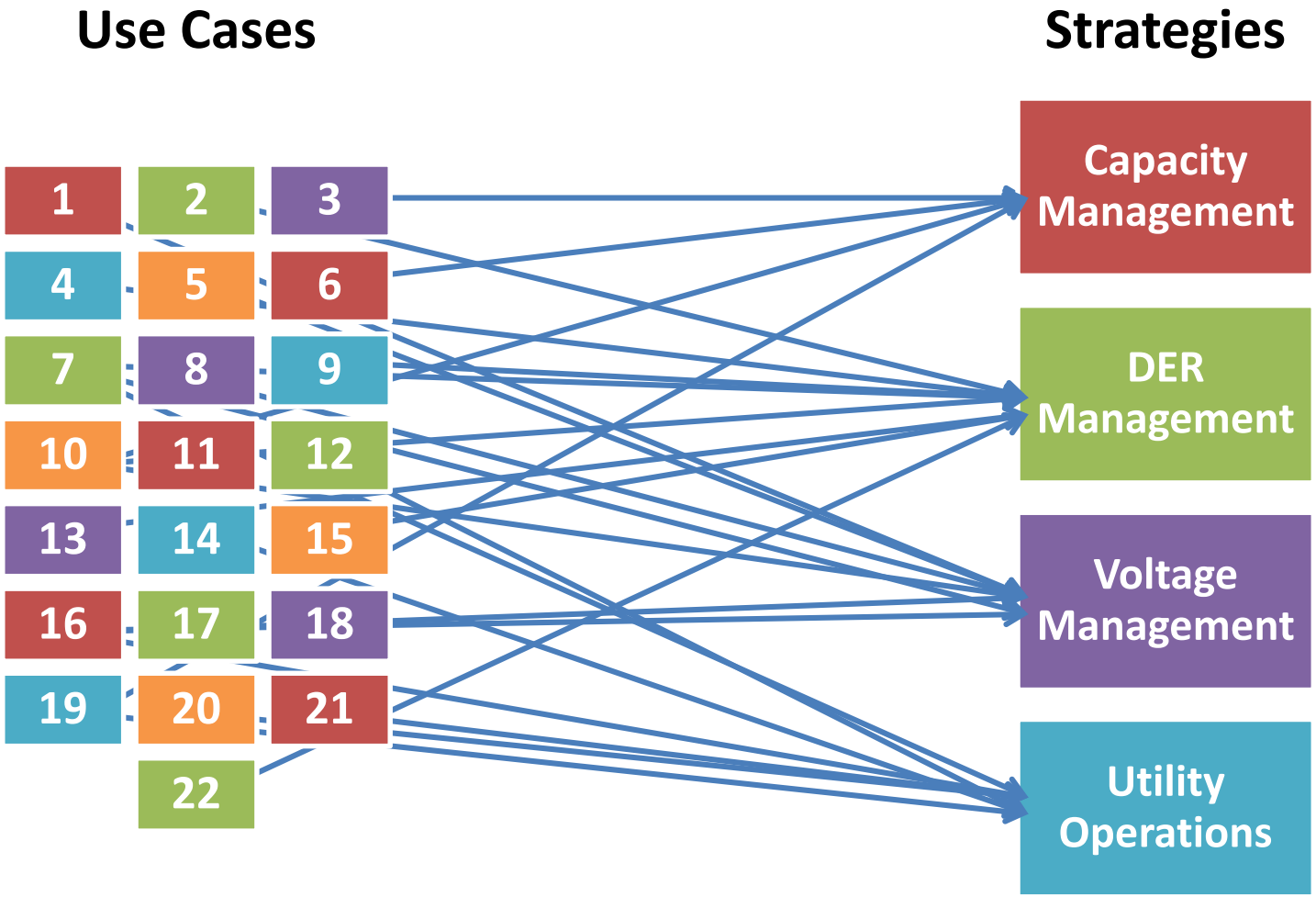
Traditional Approach

Conventional deployed assets support a single use case and outcome



Proposed Approach

Distributed Intelligence (DI) deployed assets support multiple use cases and outcomes leading to stacked benefits



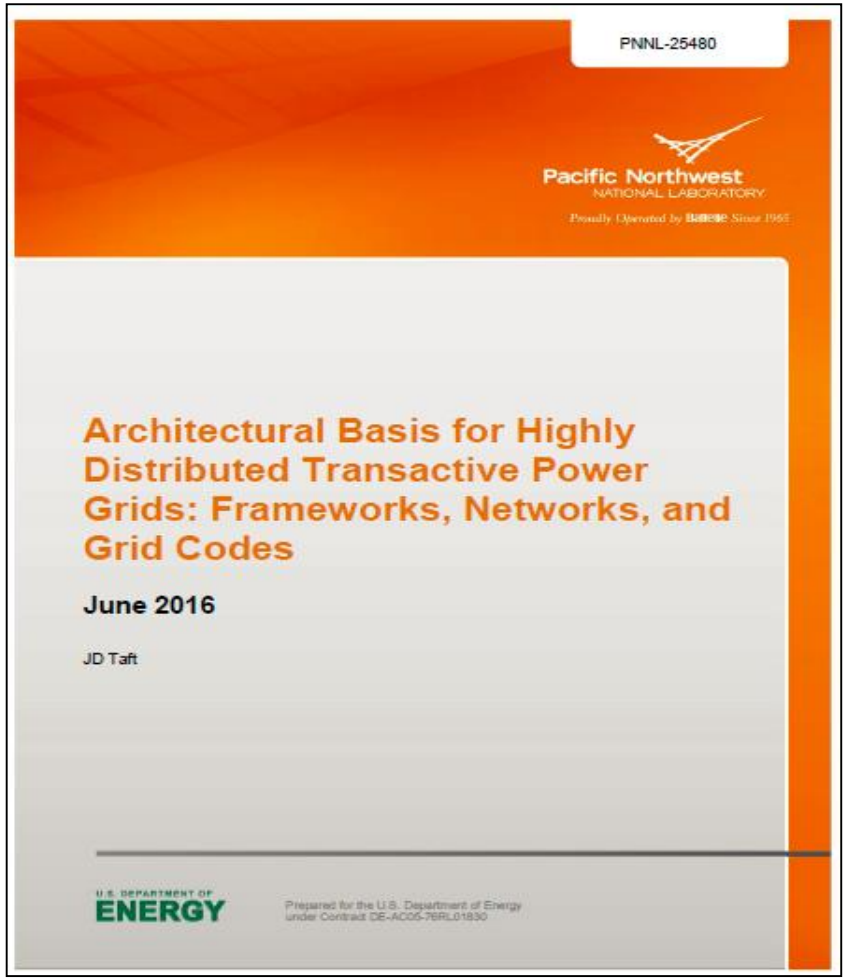
Stacking of Distributed Intelligence (DI) Use-cases

Of the 51 identified DI use-cases, 22 could be associated with a set of four deployment scenarios.

Use Case	Capacity Management	Voltage Management	DER Management	Utility Operations
DER Circuit Segment Management	✓	✓	✓	✓
Baseload Storage Monitoring/Mgmt.	✓		✓	
Peak Power Management	✓		✓	
DER Forecasting w/ Meters	✓		✓	
DER Forecasting w/ Weather Stations	✓		✓	
DER Optimization (Cust. Inverter)	✓		✓	
DER Optimization (DE Inverter)	✓		✓	
Demand Response Optimization	✓			
PCC Monitoring/Mgmt./Opt. (DE µgrid)	✓	✓	✓	
PCC Monitoring/Mgmt. (Cust. µgrid)	✓	✓	✓	
Volt/VAR Management	✓	✓	✓	✓
Grid Connectivity Discovery				✓
Remote Device Configuration			✓	✓
SCADA Point Aggregation			✓	✓
Enhanced COMS Network Ops. Status				✓
Improve Asset Maint. Practices				✓
Localized Protection Alarms & Events			✓	✓
Self Healing Radial Network			✓	✓
Solar Smoothing		✓	✓	
Solar Smoothing (+Battery)		✓	✓	
Inadvertent Island Detection			✓	
DER Integration & Interconnection			✓	

Viable Distributed Intelligence (DI) Frameworks

DOE PNNL's Grid Architecture 2.0: Laminar Coordination Framework (LCF)



PNNL-25480 (Courtesy of JD Taft)
Available at http://gridarchitecture.pnnl.gov/

UCAIug's Open Field Message Bus (OpenFMB): Internet of Things (IoT) Interoperability Framework

NAESB RMQ.26 Version 3.3
Please contact naesb@naesb.org

UCAIug: Supporting all Control Paradigms and Data Models

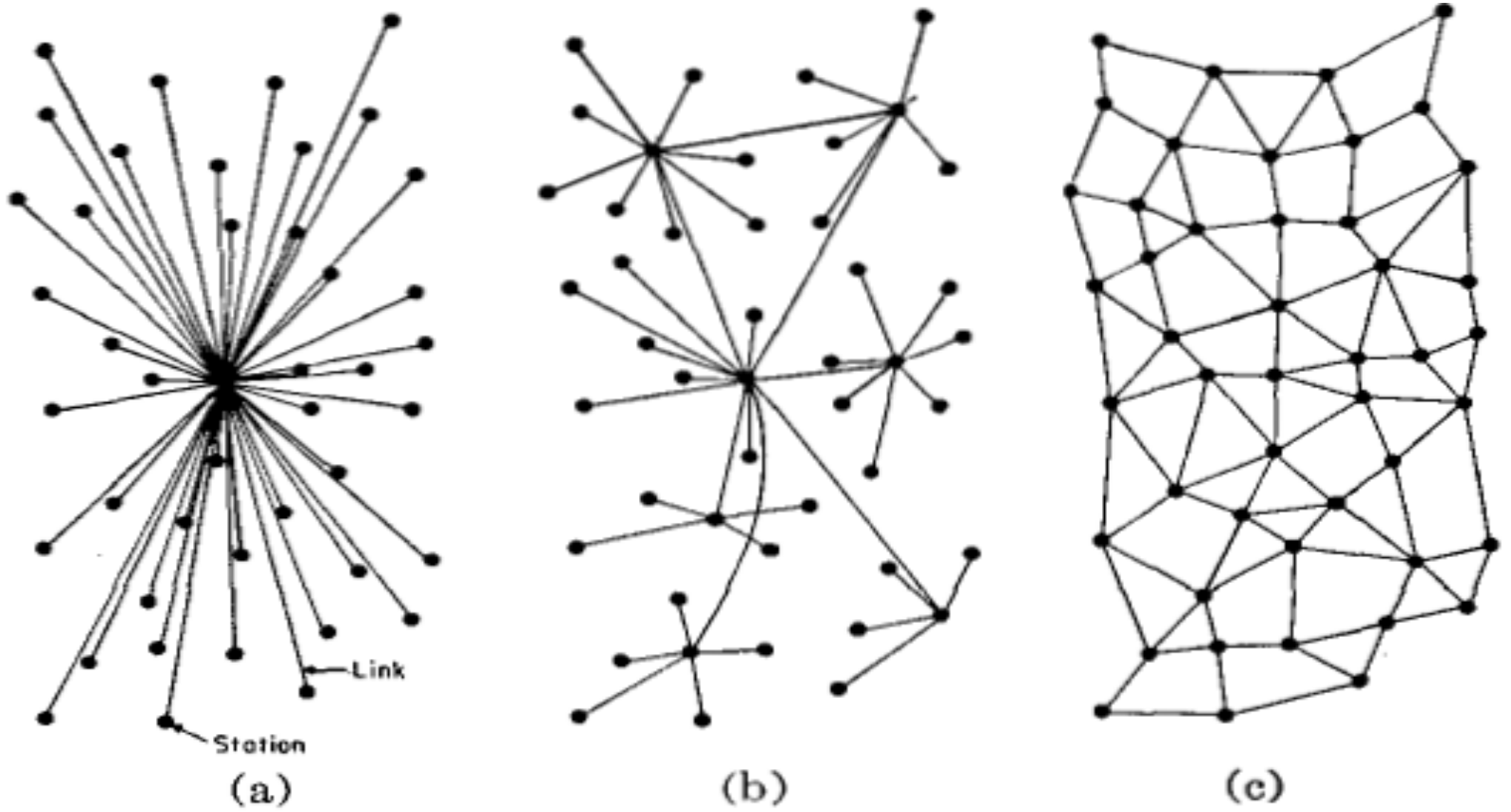


Fig. 1—(a) Centralized. (b) Decentralized. (c) Distributed networks.

Common Information Model (CIM)

CIM users group

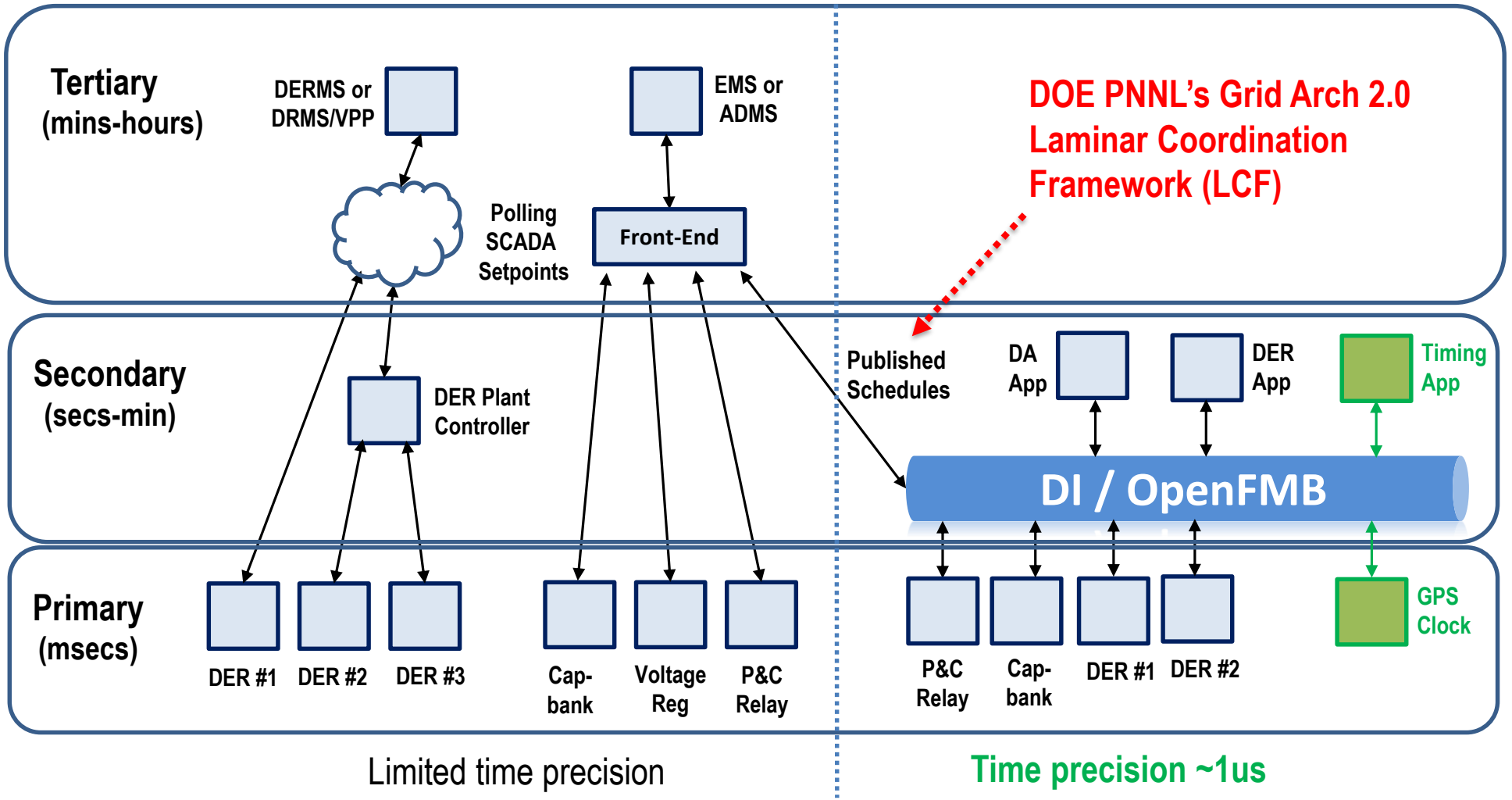
IEC 61850

IEC 61850 users group

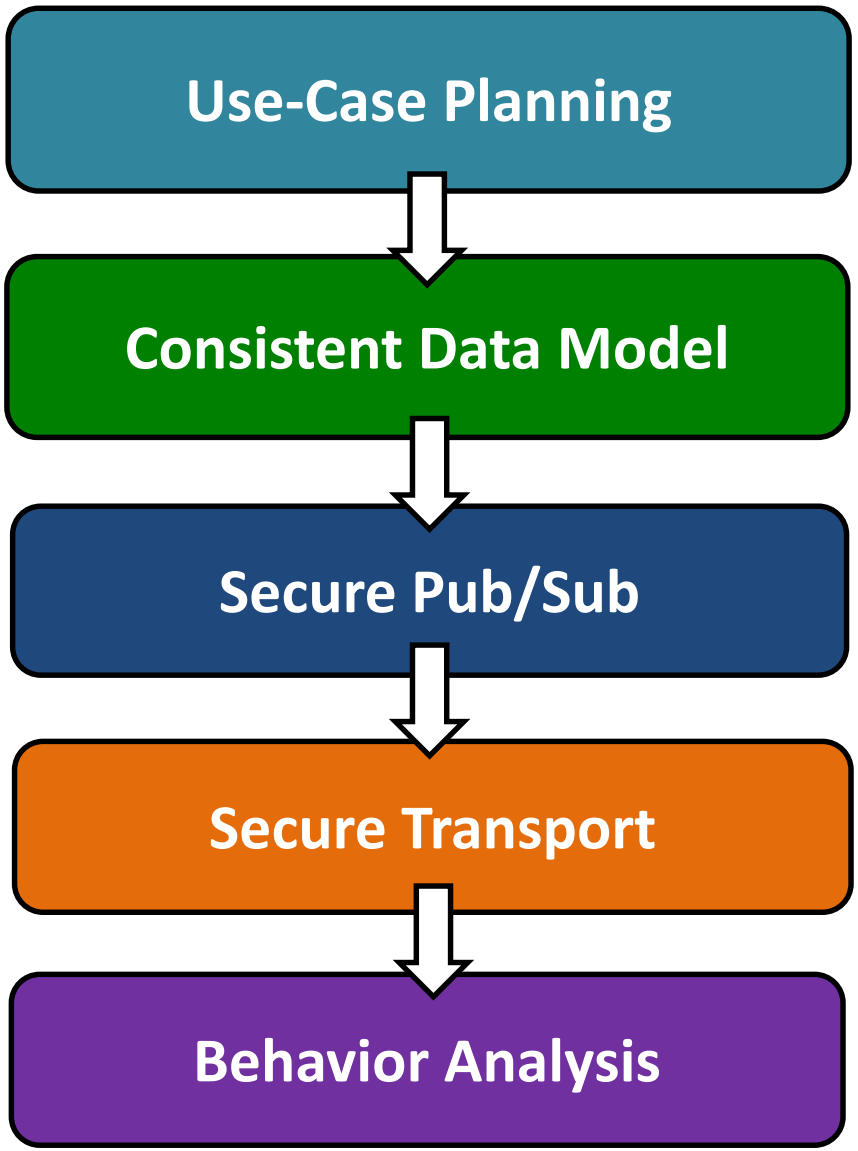
Open Field Message Bus (OpenFMB)

OPEN FMB users group

Co-Existence of Legacy and Future Controls



OpenFMB: Secure Interoperability Framework



Describe

Identifying Normal Behavior & Good Actors: Commissioning, Updating & Operating.

Define

Profiles, Topics, Semantics, Behavior: Operational Functions & Security Policies

Messaging

White-listed & Encrypted Payloads: Pub/Sub on top of the UDP/IP or TCP/IP

Transport

Transport Layer Security (TLS) 1.2 or later

Behavior Analysis

Analytics: Optimization & Control Logic

Domain Knowledge: Topology, State, Constraints

OpenFMB Use-Case Extensions on top of DER Circuit Segment Management

Solar Smoothing

Voltage Mgmt

Anti-Islanding

Federated FLISR

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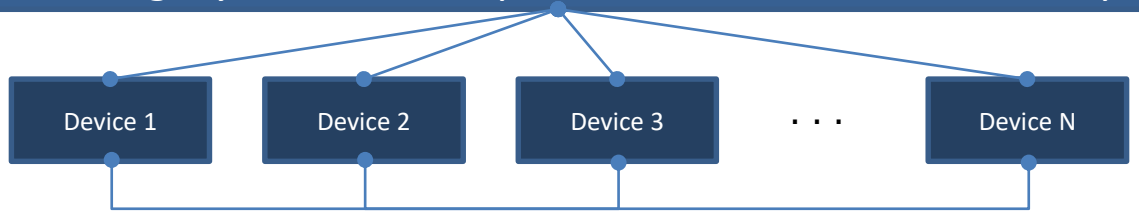
Future Extensions

DER Circuit Segment Management

Multi-Layer Circuit Segment Services, Electrical Connectivity/State, Markets, Load/Weather Forecast

OpenFMB

Common Data Models, Legacy Protocol Adapters, Pub/Sub Protocols, Transport Layer Security



DOE Grid Modernization Lab Consortium (GMLC) Resilient Distribution Systems (RDS) Project Overview

➢Practical Use-Cases

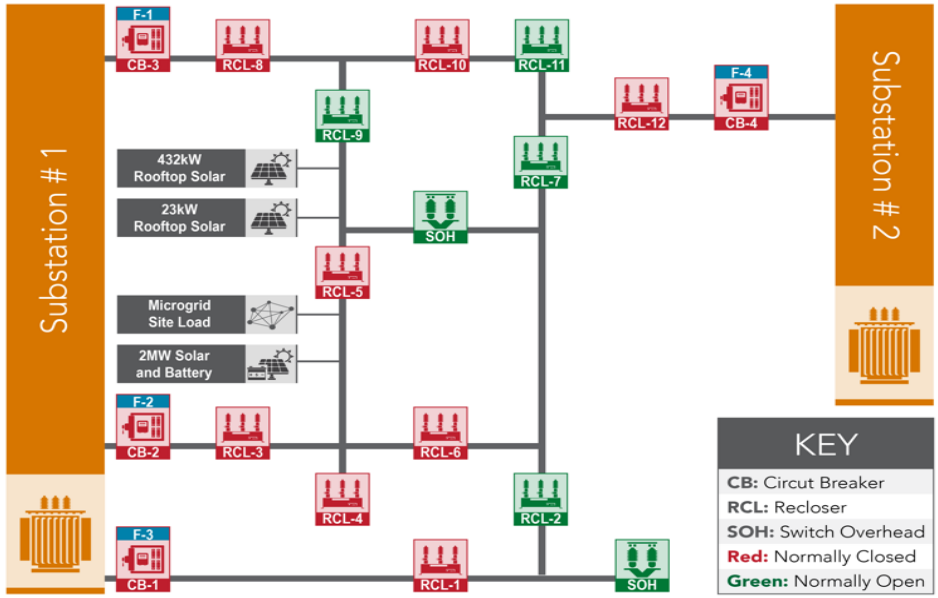
- ➢Segment-based Decentralized FLISR
- ➢Integrated DERs & Islandable Microgrid
- ➢Centralized ADMS Coordination
- ➢Incentive-based Optimization

➢Multi-Layered Controls

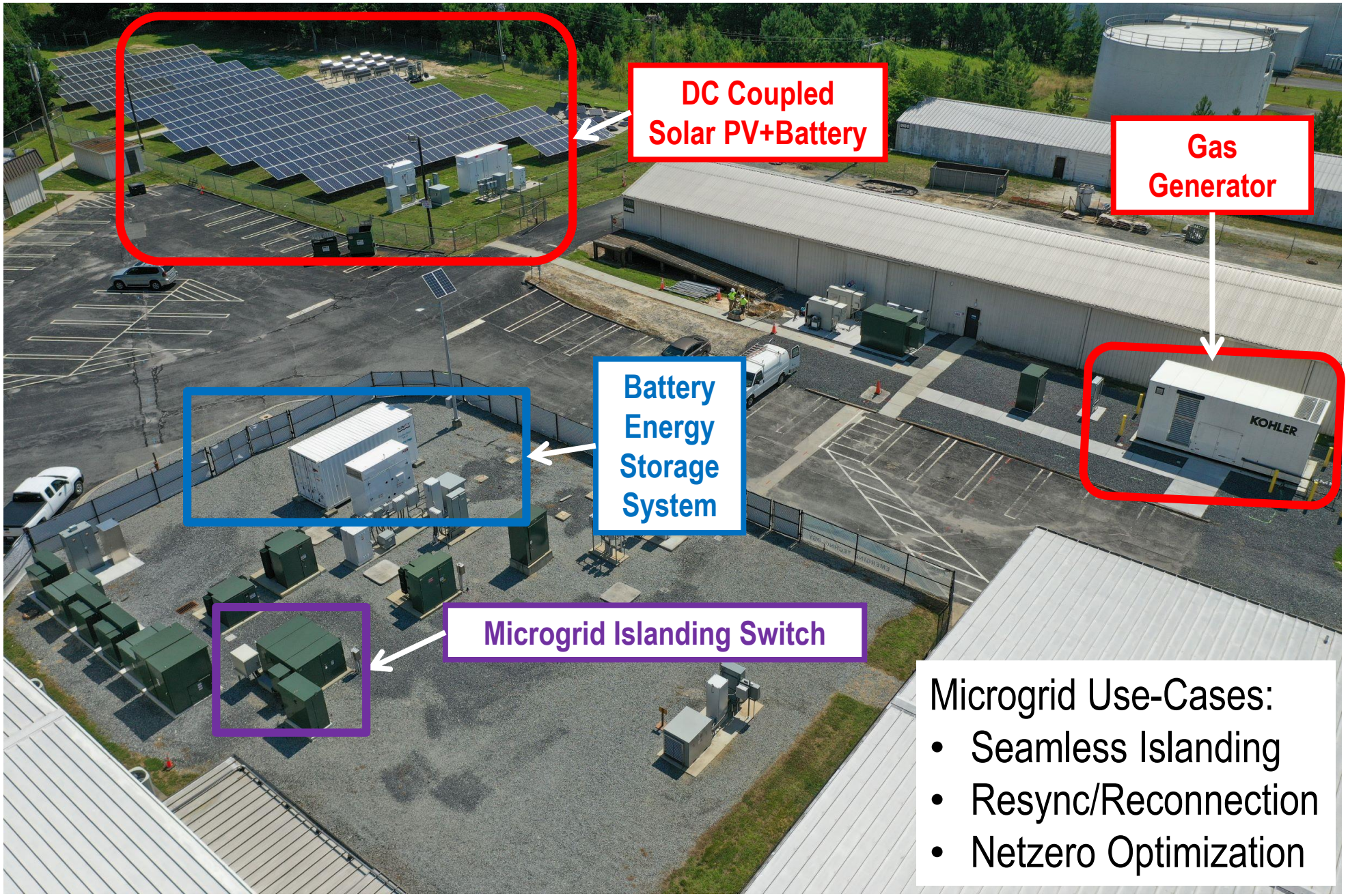
- ➢Layer 1: Local Breaker/Recloser Fault Isolation
- ➢Layer 2: OpenFMB for Protection Coordination
- ➢Layer 3: Centralized ADMS self-healing
- ➢Layer 4: Transactive Signal (Simulated)

➢Multi-Staged Validation Workflow

- ➢Co-Simulation
- ➢HIL-Simulation
- ➢Emulation
- ➢Implementation



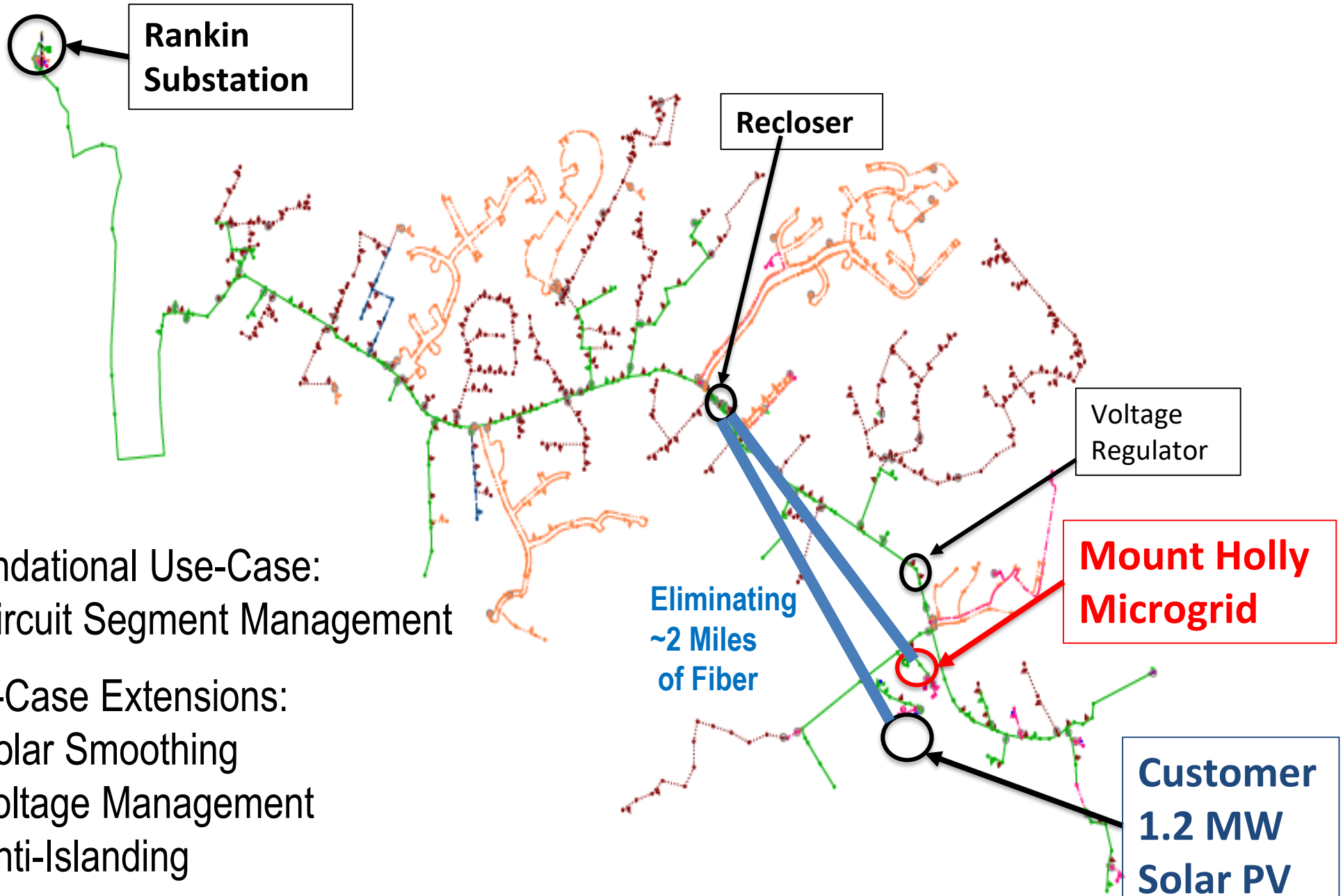
Microgrid Test Site in Mount Holly, NC



Microgrid Use-Cases:

- Seamless Islanding
- Resync/Reconnection
- Netzero Optimization

Rankin Feeder Pilot Test Site in Mount Holly, NC



Foundational Use-Case:

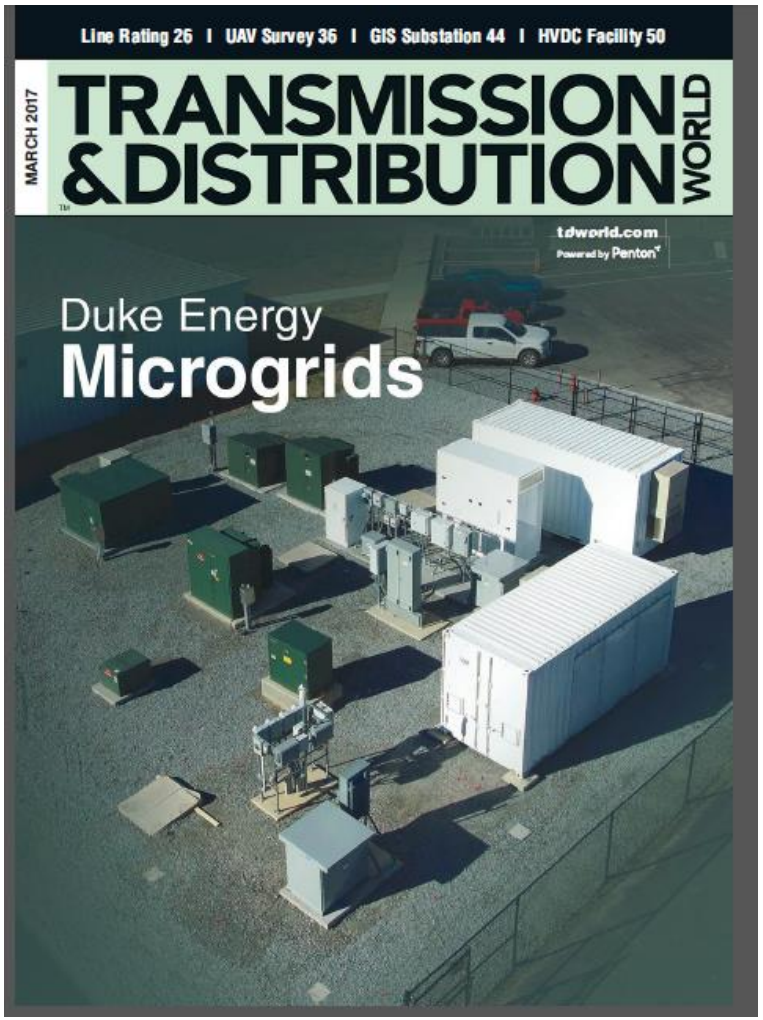
- Circuit Segment Management

Use-Case Extensions:

- Solar Smoothing
- Voltage Management
- Anti-Islanding

Duke Energy T&D World Publications

T&D World March 2017 issue



tdworld.com/march-2017

T&D World March 2019 issue


Avista Utilities and Duke Energy partner to create an energy operating system available to the entire utility industry.

By **Curtis Kirkeby**, Avista Utilities Inc., and **Stuart Laval**, Duke Energy Corp.

The electric utility industry is increasingly challenged by external drivers such as regulatory obligations and mandates as well as competitors who want to disintermediate utility customers from their current energy provider. Distribution system operator (DSO) models and aggregator participation are challenging the status quo for utility business models.

The utility industry must navigate these changes and help to shape the new business models while still providing safe, reliable and affordable energy to customers. At the same time, customer participation should be empowered, so there is reasonable influence on the type of resource consumed, the location of the resource, and who provides the energy. This is extremely challenging to support with a typical utility's portfolio of operating technologies.

Duke Energy Mount Holly, NC Microgrid Site.

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https://utilityanalytics.com/2019/06/utilities-collaborate-on-open-source-software/

Thank You!

For more information contact:

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