

Electric Utility Distribution and Operations

DOE Energy Innovator Fellows Informational Webinar

Cody Davis, Electric Power Engineers

March 24, 2026

This work was funded by the U.S. Department of Energy under Contract No. DE-AC02-05CH11231.



Agenda

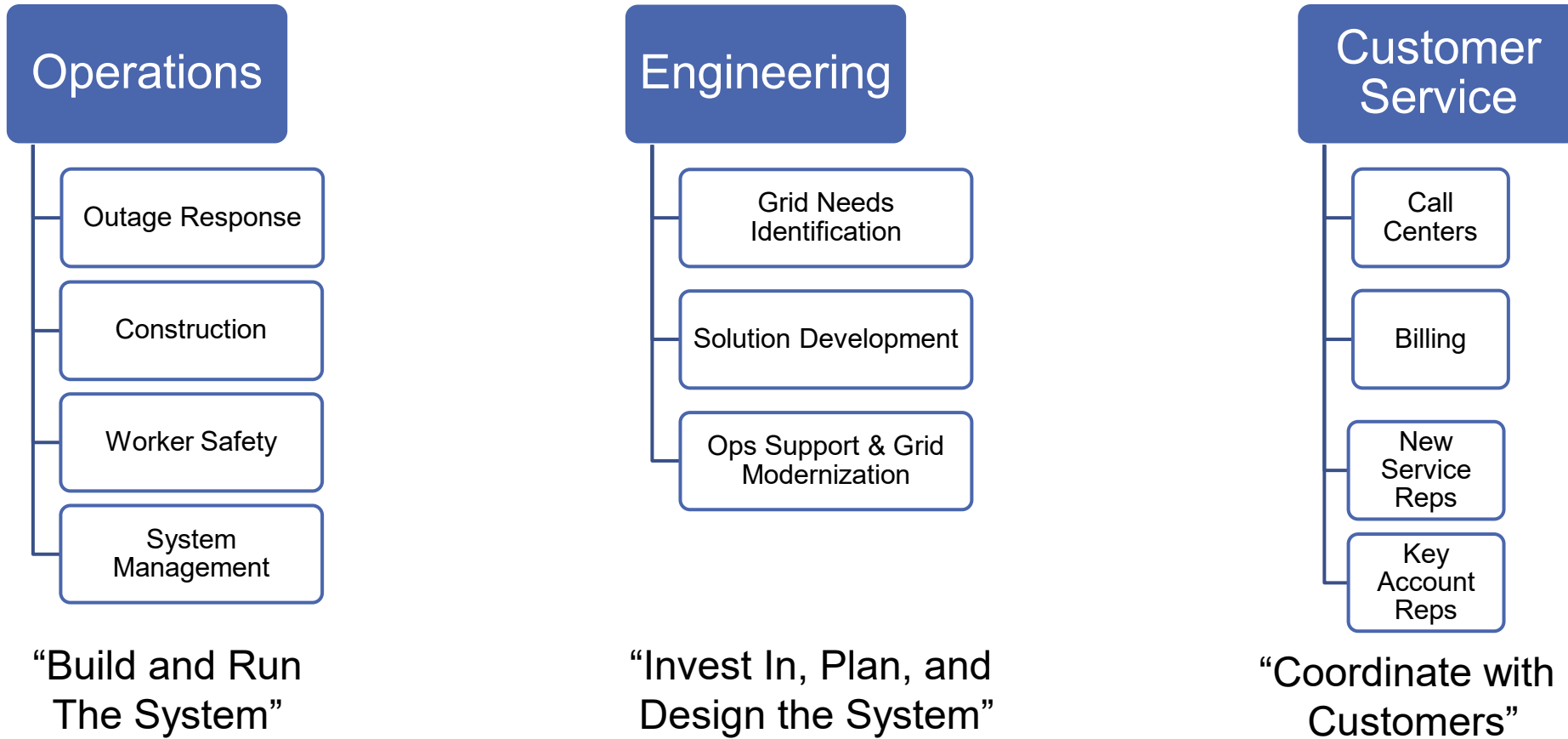
- ❖ **Overview - Distribution Utility Roles and Responsibilities**
- ❖ **Primary Functions of Distribution Operations**
- ❖ **Primary Functions of Distribution Engineering**
- ❖ **Emerging Topic Areas**



Overview – Distribution Utility Roles and Responsibilities



Utility Essential Functions



Support Personnel – IT, Regulatory, Project Management, Training, Finance, etc.



Personnel Groups – Operations

Control Center / Dispatch

- Dispatchers (“the desk”) – Monitor and control the system
- Operational Systems Support – Maintain operational technology (e.g., Supervisory Control and Data Acquisition, Advanced Distribution Management System)

Regional Operations

- Trouble Truck – Respond to outage events, perform routine inspections, make minor repairs
- Line Crews – Construct new facilities, make major repairs
- Substation Maintenance – Inspect and repair substation equipment
- Operations Management – Coordinate outage response, construction activities, and dispatch



Line Crew Construction – [Portland General Electric](#)

Personnel Groups – Engineering

Engineering

- Planning – Ensure available system capacity to serve new load connections, perform system studies
 - May include DER interconnection studies (e.g., gas generator, solar PV, battery storage)
- Asset Management – Coordinate asset inspections, replacements, and other investments
- Reliability – Monitor and improve reliability
- DER Integration – Manage DER interconnection processes and perform screenings/studies
- Design – Develop construction drawings for line extensions and system upgrades
- System Protection – Coordinate system protection devices and operation (e.g., circuit breakers, reclosers)
- Regional Engineer / Field Engineer – Responsible for some or all of the above responsibilities within a geographic area



Example Distribution Planning Process
([Xcel Energy 2025 Integrated Distribution Plan](#))

Primary Functions of Distribution Operations



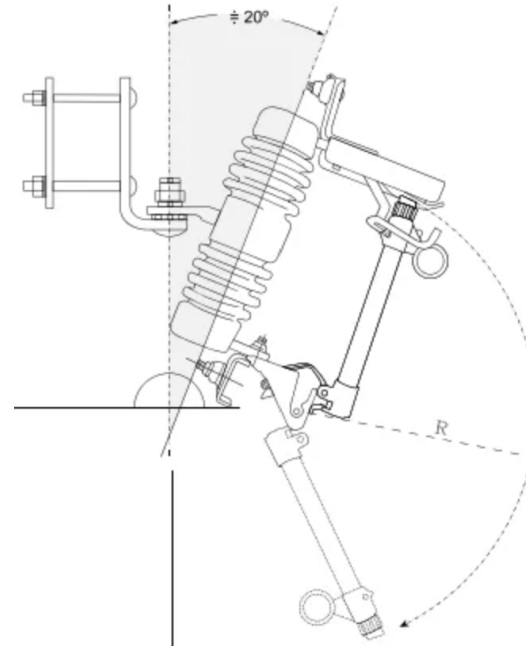
Outage Restoration

How are outages caused?

- ❑ Faults – unintended electrical contact, often resulting in very high currents that can damage equipment (e.g., tree contact)
- ❑ Protective devices - Detect faults and disconnect the faulted portion of the system
 - Fuses – meltable link, common and low-cost
 - Reclosers – multiple operations, opens and “recloses” to clear temporary faults
 - Circuit breakers – Heavy-duty substation devices, relay controlled

Outage restoration

- ❑ Goal: Remove fault source (if needed) and re-energize customers
- ❑ Routine outages handled by trouble truck
- ❑ Large-scale outages involve Dispatch, Operations Supervisors, and Crews

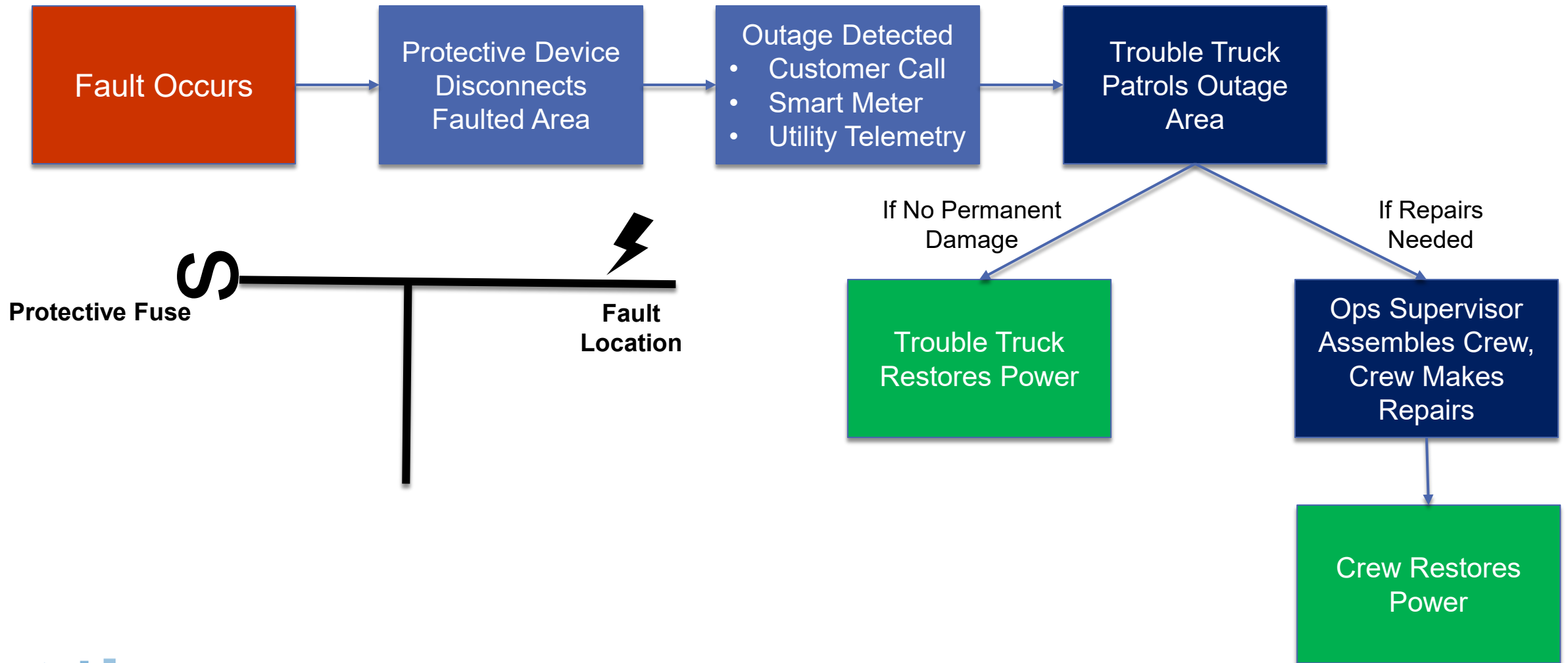


Fused Cutout
Operation
(APlusPower)



Hydraulic
Recloser

Typical Outage Restoration Process Flow



Worker Safety

- Distribution construction can be performed with the equipment energized or de-energized, each requiring unique safety precautions
- For energized work:
 - Reclosing must be disabled (i.e., “Hazard”)
 - Insulated Tools Required
 - Insulating Cover-Up Utilized
 - “Hot Arms” for pole replacement
- For de-energized Work:
 - Open points must be established and locked
 - Crew installs temporary conductors between energized phases and grounded neutral
 - “Observe, Test, Ground”
- Reclosing, switching, and locked open points controlled by dispatch



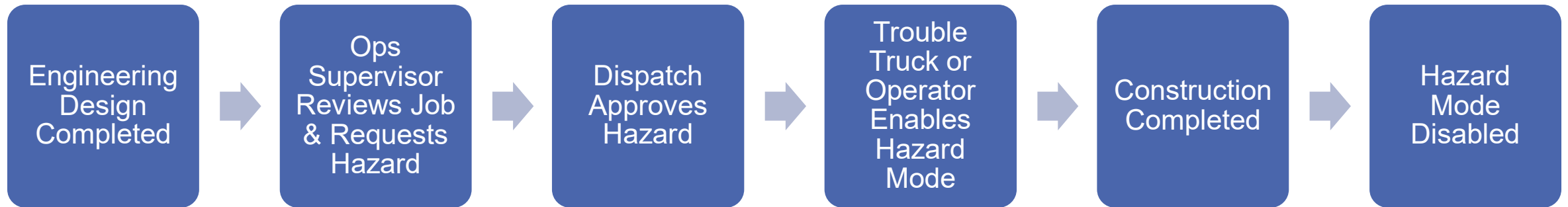
“Hot Arms”
([Custom Truck](#)
[One Source](#))



Insulated Cover-Up
([Hubbel](#))

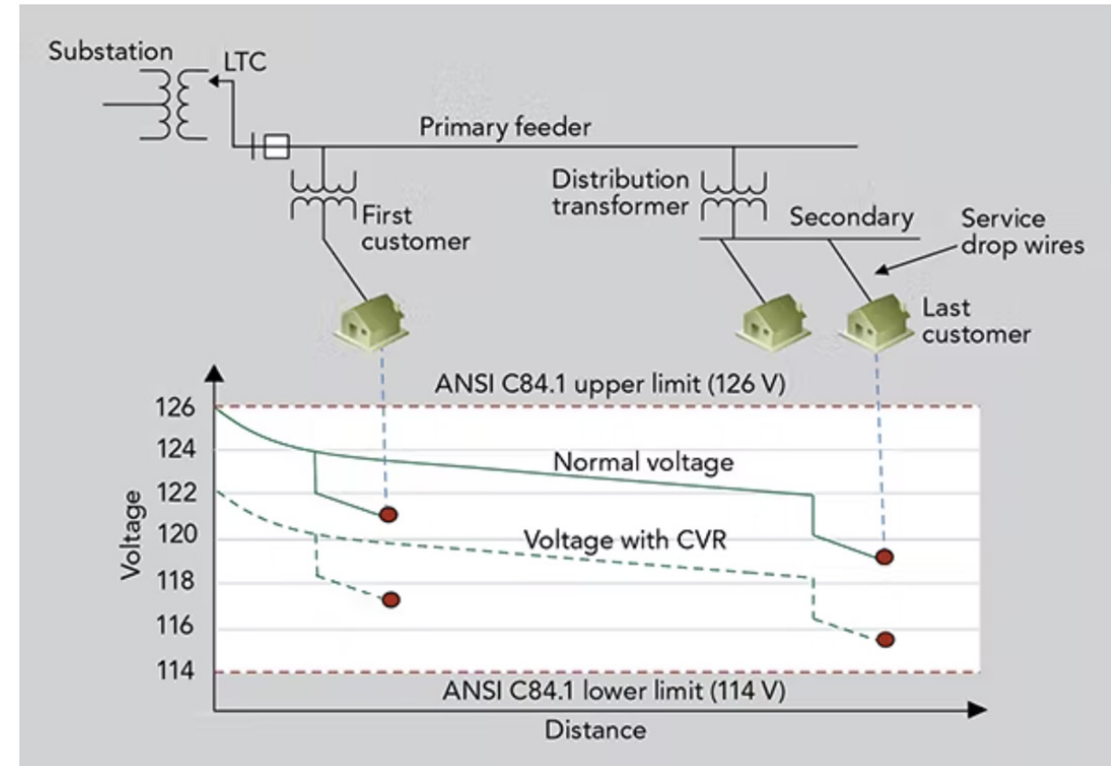


Line Construction Process for Energized Lines



System Optimization

- Modern operations also manages advanced optimization tools that improve system performance
 - Advanced Distribution Management System (ADMS) – Central control system that can coordinate system equipment operation
 - Voltage Optimization – Coordinate equipment operation to reduce voltage violations and improve system efficiency
 - Conservation Voltage Reduction
 - Volt/Var Optimization
 - Fault Location, Isolation, and Service Restoration (FLISR) – Coordinate switches and protective devices to minimize customer outage impact



Conservation Voltage Reduction Example Operating Profile
([Source](#))



Primary Functions of Distribution Engineering



Identifying Grid Needs and Solutions

What are grid needs?

- Reliability – Reduce the frequency or duration of outage events
- Capacity – Accommodate new loads or interconnections
- Asset Health – Sustain operation without equipment failure due to age/condition

How are grid needs identified?

- Reliability – Metric Tracking
 - e.g., SAIFI/SAIDI, Worst Performing Circuits
- Capacity – Forecasting and Modeling
 - e.g., Interconnection studies, contingency analysis
- Asset Health – Inspections and Records
 - e.g., Pole inspections, transformer oil analysis

Grid Needs – Types and Solutions

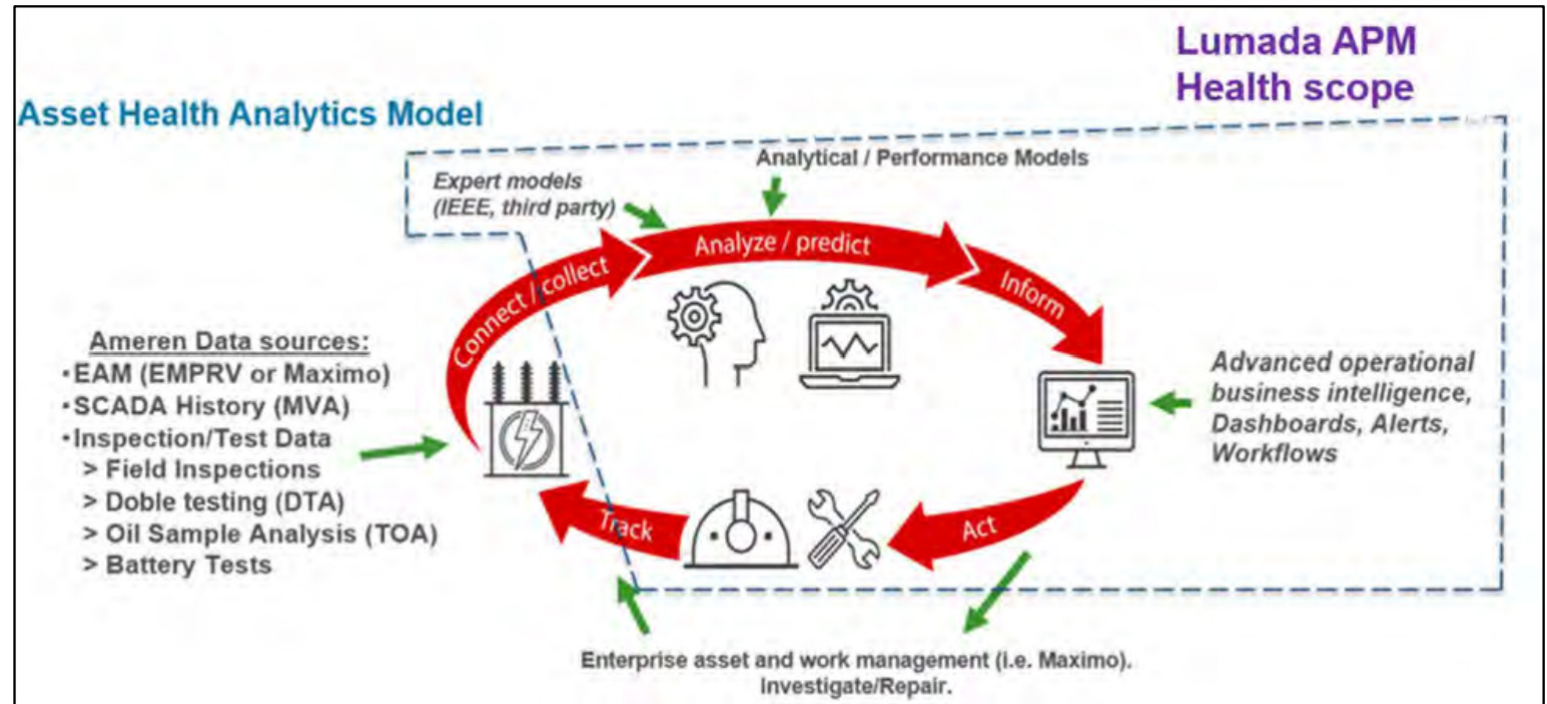
Reliability	Capacity	Asset Health
<ul style="list-style-type: none">• New Circuit Ties• Tree Trimming• Undergrounding• Animal Guarding• Lightning Protection• New Fuses or Reclosers• New Substation• Non-Wires Solutions (e.g., Microgrid)	<ul style="list-style-type: none">• Equipment Replacement (Upsizing)• Reconductor• New Feeder / Substation• Phase Balancing• Capacitor Banks• Non-Wires Solutions (Capacity)	<ul style="list-style-type: none">• Equipment Replacement (condition)• Environmental Equipment Risk Assessment (e.g., Substation Flood Risk)



Asset Management

Asset Management Goals

- ▣ Efficient utilization of existing equipment
 - Maximize asset life
 - Avoid equipment failure
- ▣ Optimal spending to achieve system-level needs and goals (portfolio optimization)
- ▣ Program development and management
 - Develop and administer programs to address recurring issues
 - e.g., Pole inspections, animal guarding, lightning arrestors

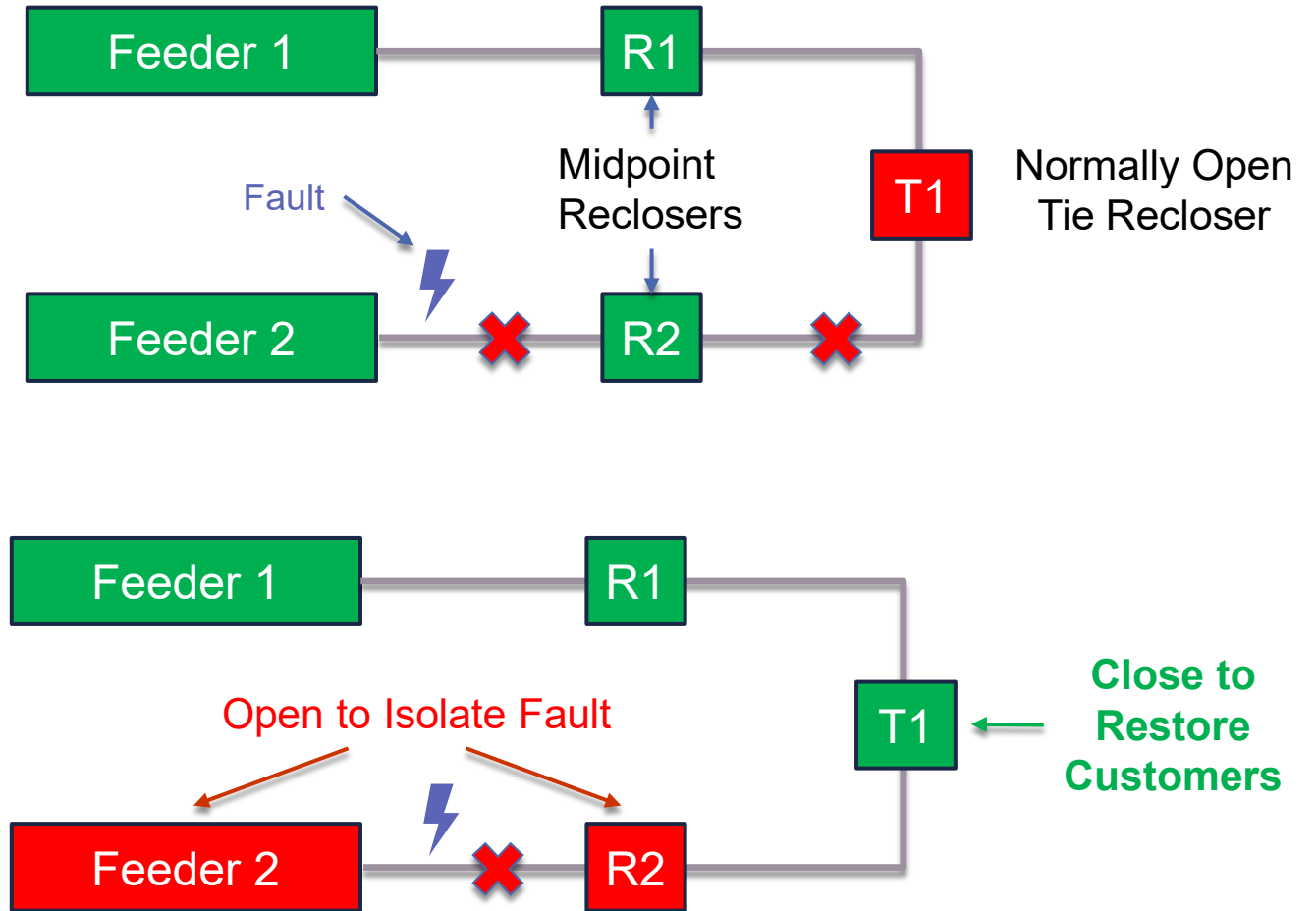


Source: Ameren Illinois [2025 Grid Plan](#)



Operational Support and Grid Modernization

- System studies for operational switching
 - ▣ Ex: Switching plan for taking a substation transformer out for maintenance
- Evaluate and deploy new technology/hardware to improve grid operations
 - ▣ Voltage optimization – capacitors and voltage regulators
 - ▣ FLISR – reclosers
- Monitor grid modernization technology performance and add hardware
 - ▣ New capacitors and regulators to meet voltage reduction targets
 - ▣ Performance metrics – e.g., voltage reduction, FLISR outage prevention



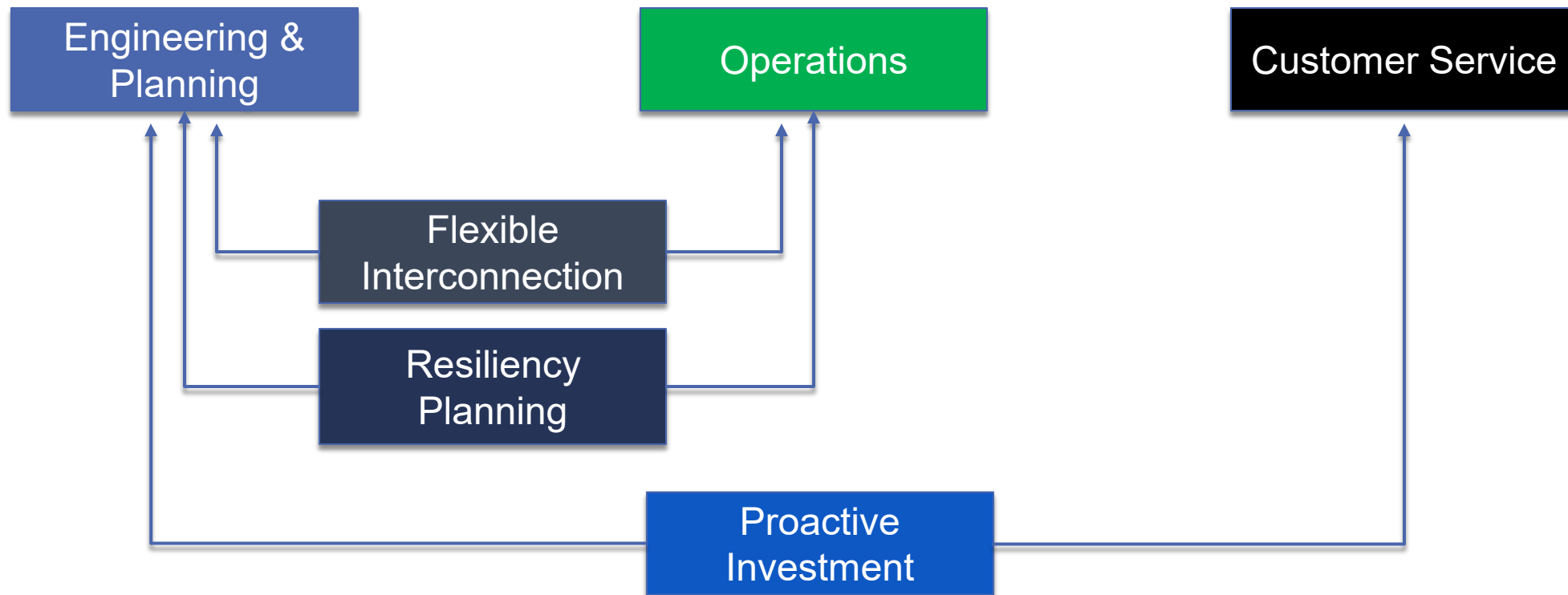
Example Fault Location

Emerging Focus Areas



Industry Trend – Breaking Down Silos

- Utility departments have historically operated relatively independently from each other, often with only minimal communication and coordination
- Increasing complexity, new technologies, and higher expectations are driving a **breakdown of historical silos**



Flexible Interconnection – Planning + Operations

- Historically, load and DER interconnections have been studied by Planning (or DER Interconnection Engineering), then treated as “set it and forget it” with minimal coordination with Operations
- “Static” Flexible Interconnection methods are more complex, but still function in a “set it and forget it” fashion
- **Dynamic Flexible Interconnection** allows Operations to manage load or DER real power input/output capabilities in real-time to respond to grid needs, requiring initial and ongoing coordination

FOUNDATION	STATIC METHODS		ADVANCED METHODS
IMPORT/EXPORT LIMITATIONS	STAGGERED CONNECTIONS	SCHEDULE-BASED CONNECTIONS	DYNAMICALLY MANAGED CONNECTIONS
Customers are assigned a single import or export cap (e.g., 250 kW max demand), fixed at time of interconnection. No variation with time.	Customer’s import/export limits are fixed at time of connection and ramp up per the staggered connection timeline and capacity amount agreed to in the contracting process.	Customer’s import/export limits vary by time (e.g., hourly, seasonal), according to a pre-defined and contractually approved schedule. Enables alignment with known system constraints.	Customer’s import/export limits are set in real-time or via forecast (e.g., day-ahead), based on current or projected system constraints. May require DERMS, AMI, or other systems.

Flexible Grid Connection Methods ([CHARGED Initiative](#))



Resiliency Planning – Planning + Reliability + Design + Operations

Reliability vs Resiliency

- Reliability – day-to-day outage occurrences from routine events
- Resiliency – ability to withstand, recover from, and reduce the magnitude and duration of major disruptive events

Resiliency Planning

- Preparedness and capabilities for anticipated types of major disruptions
 - e.g., extreme heat wave, polar vortex / winter storm, hurricane
- Includes vulnerability assessment, restoration planning, grid hardening, operational continuity, load shed planning, and other elements

Resilience Phase	Description	Metric Type
Anticipate	The ability of the system to anticipate threats and hazards and be ready to take mitigation actions.	Situational awareness - wind
		Situational awareness - ignition
		High fire threat
		Communications protocols
Withstand	The electrical system's capacity to avoid being affected by a hazard.	Asset condition
		Asset ratings
		Asset hardening status
Adapt	The ability of the grid to respond to asset damage or the community to change behavior to minimize impacts to customers.	Automation and topology
		Emergency power
		Social indicators
		Community resilience
Recover	The ability to restore normal grid operation after a disruption.	Accessibility
		Power restoration
		Mutual aid agreements

Resiliency Phases and Attribute Metrics

Source: [NARUC Resilience Framework](#)



Integrating Resilience Planning with Distribution System Planning

The following levels of integration apply to threat assessments, solution identification and prioritization, consideration of other grid needs, and metrics

Stated Plans for Future Integration

- Distribution system plans mention or discuss utility efforts to integrate resilience planning in the future

Enhanced Reliability Analysis

- Distribution system plans address major event days by leveraging methods for resilience threat analysis
- Utility uses worst performing circuits and root cause analyses for assessing circuits, but also incorporates data from extreme events

Resilience Integration in Distribution System Plans

- Distribution system plans incorporate long-term resilience planning components

Source: Collins, M., A.M. Dias, P. De Martini, L. Schwartz (forthcoming Berkeley Lab report; see [preview for NASUCA](#))



Proactive Investment – Planning + Customer Service

- Distribution capacity investments typically are executed when their certainty of need is very high
 - ▣ Short-term load growth or specific large load addition triggering thermal equipment overload
 - ▣ Minimizes risk of imprudent investments, but can delay connections due to multi-year construction times
- Proactive investments are executed further in advance, when needs are relatively less certain
 - ▣ Used to improve customer experience, increase long-run investment efficiency or help meet state energy goals

RISK FACTOR	CURRENT INVESTMENT APPROACHES	PROACTIVE INVESTMENT APPROACHES
Lifecycle Cost Impact	▣ higher unit costs, recurring work/ revisit assets, and lost synergies between investments	▣ minimizes potential repeated work and prevents urgency-based inefficiencies
Stranded/ Underutilized Asset Risk	▣ investments made after growth is known	▣ risks driven by potential for forecast inaccuracies
Utility Cost Recovery Risk	▣ investments justified by known load growth	▣ depends on Regulatory Process Design
Dissatisfaction of Customers Adopting Electrification Measures	▣ delays in new connections likely due to lack of capacity	▣ capacity available for new / upgraded connections without delays
Policy Alignment Risk	▣ lags policy timelines	▣ removes barriers to achieving policy goals
Execution Complexity	▣ simpler planning, but requires rapid mobilization under pressure; fewer complex forecasting models	▣ requires complex forecasting, integrated processes, and robust project justification

Risk Factor Comparison Between Existing and Proactive Investment Practices
(Source: [CHARGED Initiative](#))

▣ Low ▣ Medium ▣ High



Q&A



Disclaimer

This document was prepared as an account of work sponsored by the United States Government. While this document is believed to contain correct information, neither the United States Government nor any agency thereof, nor The Regents of the University of California, nor any of their employees, makes any warranty, express or implied, or assumes any legal responsibility for the accuracy, completeness, or usefulness of any information, apparatus, product, or process disclosed, or represents that its use would not infringe privately owned rights. Reference herein to any specific commercial product, process, or service by its trade name, trademark, manufacturer, or otherwise, does not necessarily constitute or imply its endorsement, recommendation, or favoring by the United States Government or any agency thereof, or The Regents of the University of California. The views and opinions of authors expressed herein do not necessarily state or reflect those of the United States Government or any agency thereof, or The Regents of the University of California.

Ernest Orlando Lawrence Berkeley National Laboratory is an equal opportunity employer.

Copyright Notice

This manuscript has been authored by an author at Lawrence Berkeley National Laboratory under Contract No. DE-AC02-05CH11231 with the U.S. Department of Energy. The U.S. Government retains, and the publisher, by accepting the article for publication, acknowledges, that the U.S. Government retains a non-exclusive, paid-up, irrevocable, worldwide license to publish or reproduce the published form of this manuscript, or allow others to do so, for U.S. Government purposes



Contact

Cody Davis

cdavis@epeconsulting.com

For more information

Download publications: <https://emp.lbl.gov/publications>

Sign up for our email list: <https://emp.lbl.gov/mailling-list>

Follow us on social media: @BerkeleyLabEMP.bsky.social and [@BerkeleyLabEMP](https://twitter.com/BerkeleyLabEMP)

Acknowledgements

This work was funded by the U.S. Department of Energy under Contract No. DE-AC02-05CH11231.

The views and opinions of authors expressed herein do not necessarily state or reflect those of the United States Government or any agency thereof, or The Regents of the University of California.

