Microgrid Overview
SMUD Board Presentation

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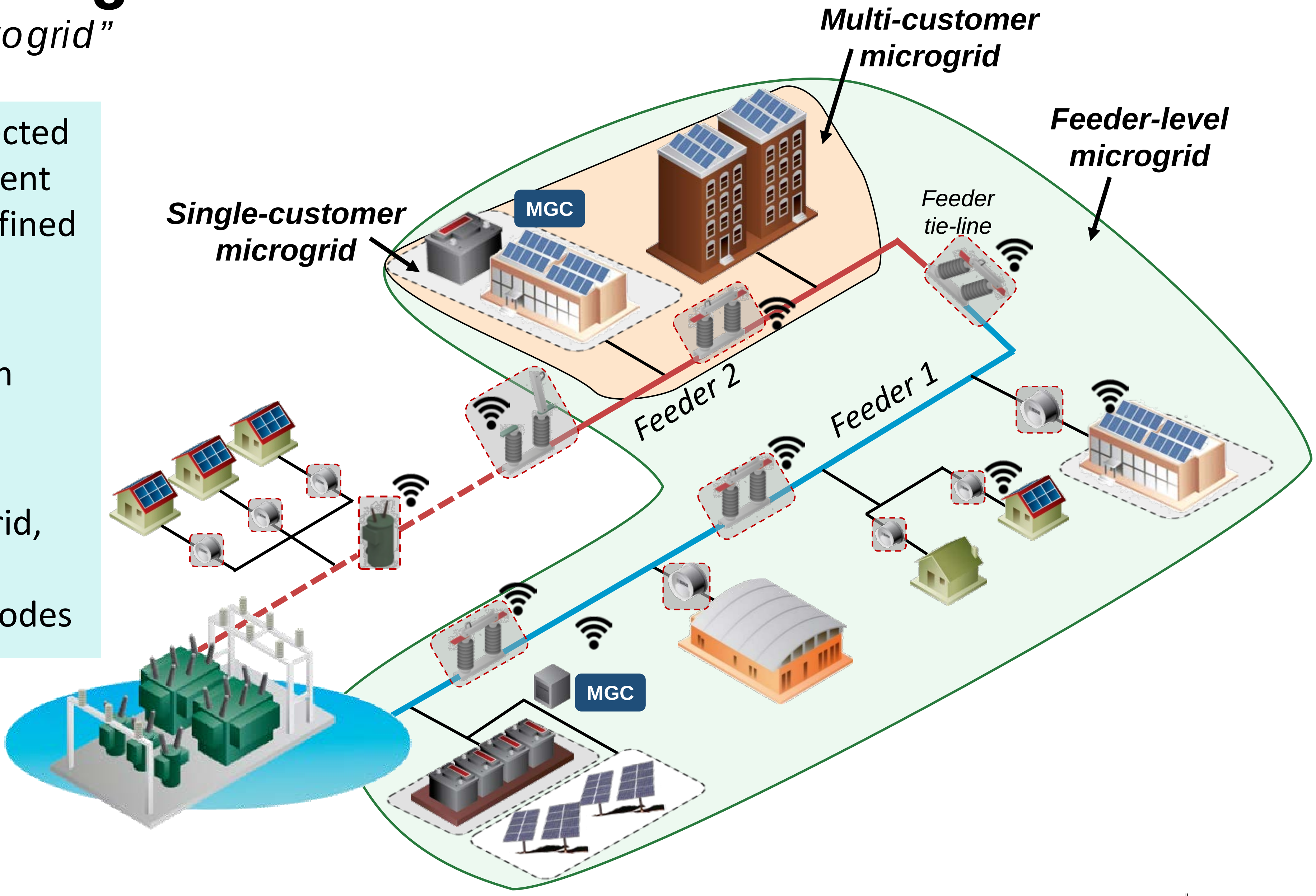
Definition of Microgrid

EPRI's Definition of "Microgrid"

1. A group of inter-connected loads and DER equipment and devices, within defined electrical boundaries.
2. Acting as a single controllable entity with respect to the grid.
3. Able to connect and disconnect from the grid, operating in both grid-connected or island-modes



Types of Microgrids/Range of Objective

- **Commercial/Industrial Microgrids:** generally built with the goal of reducing demand and costs during normal operation, although the operation of critical functions during outages is also important, especially for data centers

- **Community/Utility Microgrids:** designed to improve reliability and to promote community participation

- **Campus/Institutional Microgrids:** many campuses already have DG resources, with microgrid technology linking them together. They are usually large and may be involved with selling excess power to the grid

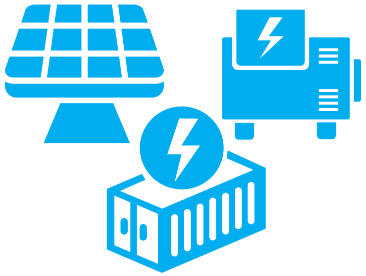
- **Military Microgrids:** critical loads, cyber and physical security, both for fixed bases and forward operating bases.

Most microgrids will be grid-connected >99% of the time

Microgrid Technology, Components and Costs

Components

- DER (Generation and Storage)
  - Diesel, natural gas, combined heat and power (CHP), biofuel, solar photovoltaic (PV), wind, and fuel cell and energy storage



- Microgrid Controller
  - Primary, Secondary, Tertiary
- Additional Infrastructure
  - Distribution system infrastructure (switchgear, protection equipment), information technology communications upgrades, metering
- Soft costs
  - Engineering, construction, commissioning, regulatory

Costs

- Leverage existing DER
- Lowest average cost in Community and Utility microgrid markets

Type	Typical Cost Range ($M/MW)
Campus/Institutional	$2.5 – $4.9
Commercial/Industrial	$3.4 – $5.4
Community	$1.4 – $3.3
Utility	$2.3 – $3.2

Source: NREL *“Phase I Microgrid Cost Study”* 2018

Why Build a Microgrid?

Understanding Microgrid Objectives

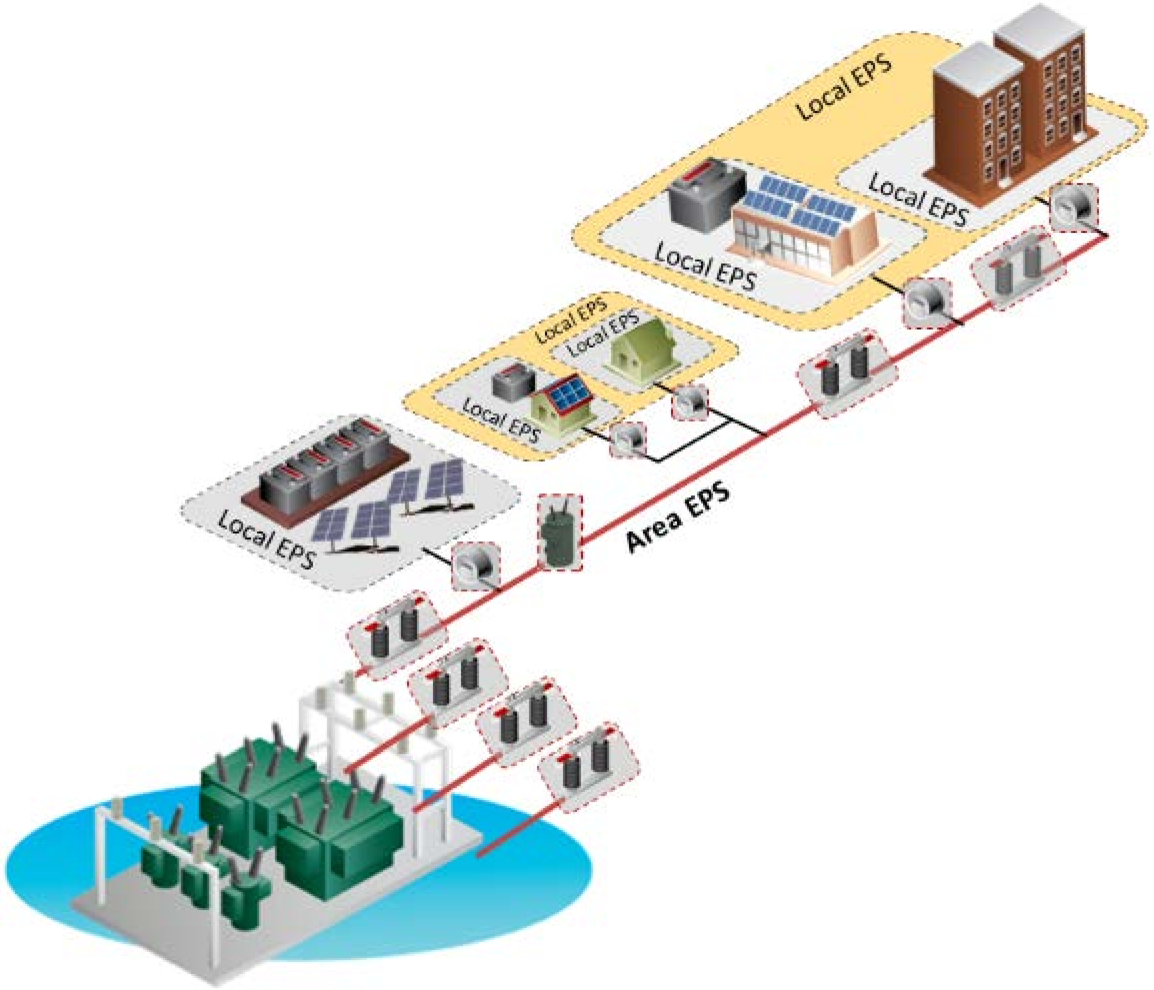
Objective	Solutions…
Integrating more renewables (hosting capacity)	Infrastructure upgrade, smart inverters, energy storage
Reducing local emissions	Grid-tied renewables, CHP, building and transportation electrification
Defer / Avoid Utility Upgrade (non-wires alternative)	Smart inverters, energy storage, flexible load – coordinated by DERMS/ADMS/etc.
Enable building and transportation electrification	Aggregation of local controllers, flexible load management
Improve Local Resilience / Reliability	Infrastructure upgrade, backup generators, energy storage, **microgrid**

Microgrids as part of Resilience Strategies – Key Drivers

- Expanding T&D expensive and difficult
- Hardening of grid can be expensive
- Local resilience sources can be strategic

Hardening Measures	Recovery Measures	Survivability Measures
Higher Design & construction standards	Faster restoration management and damage assessment	Resilient technologies namely microgrids utilizing DER technologies for outage mitigation

Rising Expectations



- The vision of grid interactive community resilient solutions is to leverage existing DER and create "community microgrids" to begin a more decentralized restoration from outages, and then connect these to the full electric grid
  - Reduces the likelihood and impact of power outages from major events;
  - Improves the restoration of grid power along with the capability of customers to receive that power; and
  - Strengthens the customer's and community's ability to address prolonged outages.

Grid, Customer, and Community Resilience

The Utility Challenge: Integration of Microgrids

Regulatory Challenges:

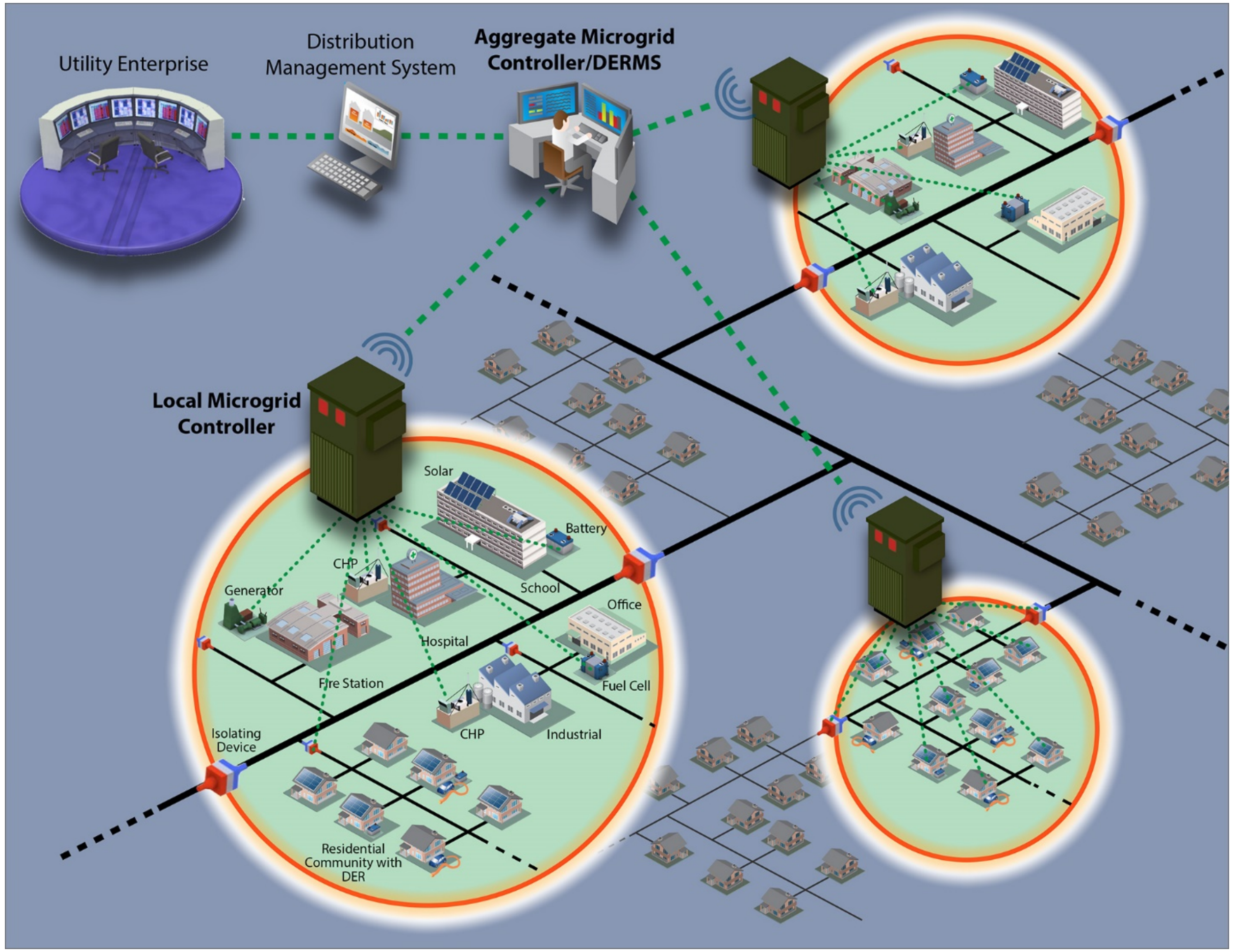
- Ownership of generation
- Administrative burden of regulation

Technical Challenges:

- Bi-directional power flows
- Fault current contribution
- Unit Level Volt/VAR support
- Islanded Operation

Economic Challenges:

- DER technologies still costly and with uncertain lifetimes
- Business model still undeveloped
- Utility rate structures in early implementation



Microgrids & Resilience Technology & Demonstration Landscape

Customer-Owned Community

Utility Managed Community

Solar+ES+EV Charging Microgrid

EV as Dispatchable Assets

Utility-Operated
in Front of the Meter DERs

Utility Operated DERs during PSPS

Together…Shaping the Future of Energy

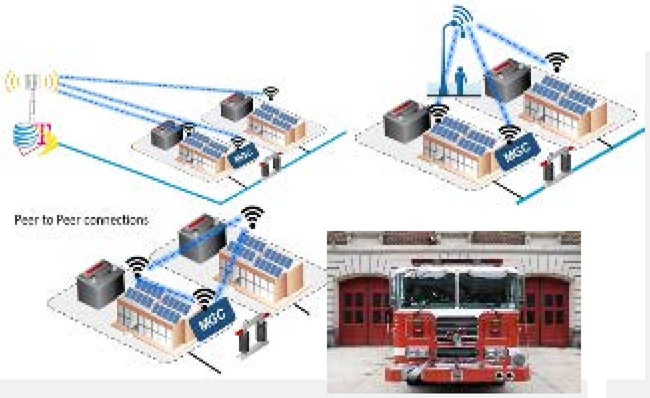
Additional Material

Enable Resiliency through Community Design

Microgrid as Part of a Traditional Utility System
Source: EPRI, 2016

Integrate with and repurpose existing Infrastructure and DERs

Improve restoration through community control, grid-forming inverters, & interconnection practices



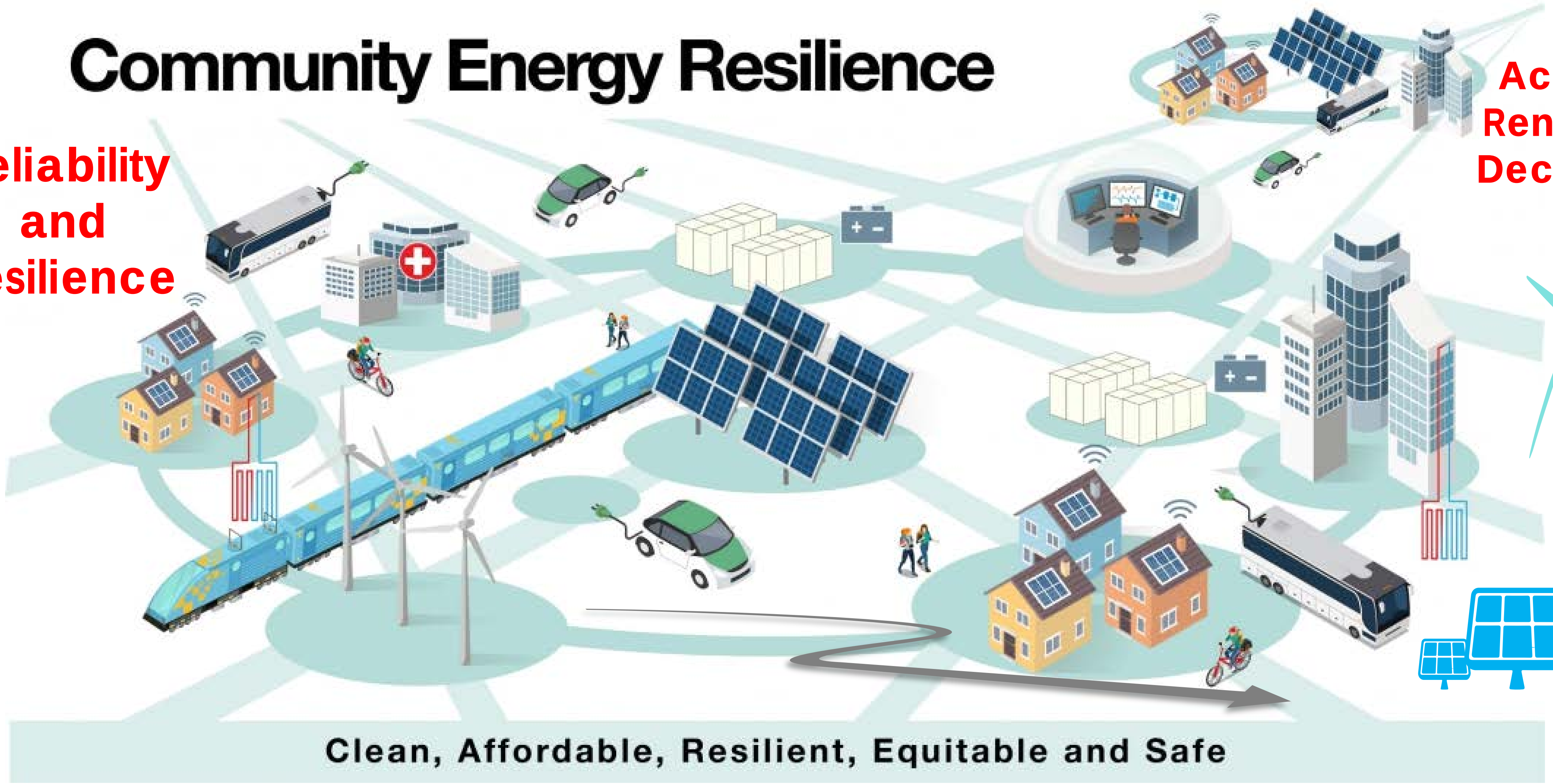
Enable independent communication systems for critical infrastructure

Demonstrations validate decarbonization and resilience co-benefits!

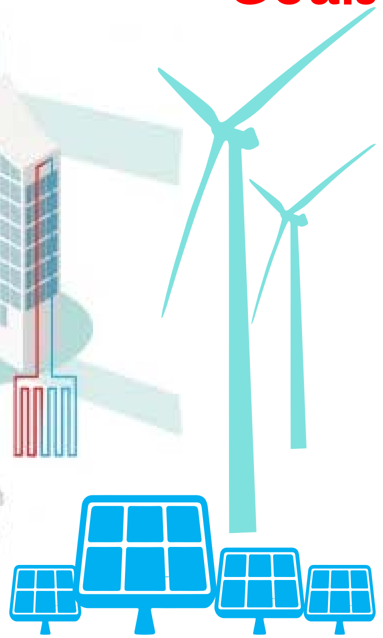
Balancing decarbonization goals, energy affordability, equity considerations, and sustainability commitments

Achieving Resilience and Carbon Reduction Goals

Reliability and Resilience



Achieve 100% Renewable and Decarbonization Goals



Can Community Microgrids Enable Both These Goals?

EPRI Integrated Grid Demonstrations

Blue Lake Rancheria & Humboldt County Airport Microgrids

Project Lead
Schatz Energy Research Center (SERC)

Technology Demonstrated
Community Solar PV
Community Battery Storage
Electric Vehicle
Microgrid
Distributed Resource Management System
Distribution Management System

Demonstration Objectives
Resiliency
Reliability Improvement
Generation Capacity
Distribution Planning
DER Operations and Maintenance

Related EPRI Programs
P94 Energy Storage and Distributed Generation
P174 Integration of Distributed Energy Resources
P193C Solar Generation
P200 Distribution Operations and Planning

Project Type
Field Deployment

Connected Projects
N/A

Last Modified

Multiple Customer

Duke Energy Mount Holly Microgrid Test Facility

Project Lead
Duke Energy

Technology Demonstrated
Residential Solar PV
Utility-scale Solar PV
Community Solar PV
Commercial Battery Storage
Utility-scale Battery Storage
Community Battery Storage
Sensor Technology
Electric Vehicle
Microgrid

Demonstration Objectives
Voltage Regulation
Power Quality
DER Operations and Maintenance

Related EPRI Programs
P161 Information and Communication Technology
P174 Integration of Distributed Energy Resources

Project Type
Laboratory Testing
Cost-Benefit Assessment

Connected Projects
N/A

Last Modified

Single Customer

Bronzeville Community Microgrid (SHINES)

Project Lead
Commonwealth Edison (ComEd)

Technology Demonstrated
Utility-scale Solar PV
Utility-scale Battery Storage
Microgrid
Operational Forecasting
Distributed Resource Management System
Smart Inverter

Demonstration Objectives
Resiliency
Reliability Improvement
Power Quality

Related EPRI Programs
P94 Energy Storage and Distributed Generation
P174 Integration of Distributed Energy Resources
P193C Solar Generation

Project Type
Laboratory Testing
Field Deployment

Connected Projects
N/A

Last Modified

Utility Operated

37 demo projects
https://techportal.epri.com/demonstrations/ig

Example Utility Reliability/Resilience Applications

Xcel Energy

Community Resiliency Initiative

Solar plus Storage based microgrids to support community resiliency

- Community partner defines “critical” infrastructure
- Xcel Energy brings battery storage and islanding capability
- Solar and other generation provided by the site

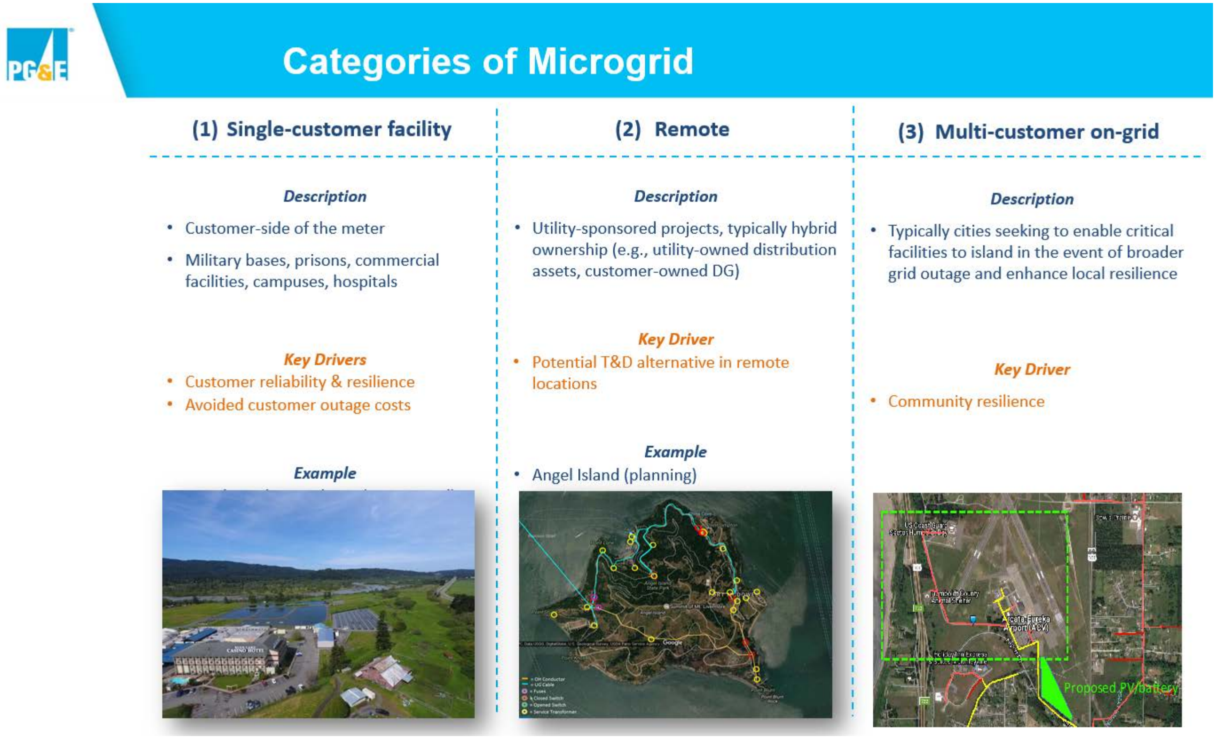
Benefits:

- Improves resiliency
- Supports Xcel Energy’s clean energy transition
- Provides grid benefits

Enabling Legislation:

- HB18-1270 (http://leg.colorado.gov/bills/hb18-1270)

PG&E Arcata Microgrid



Alabama Power

SMART NEIGHBORHOOD™

Objective:

Design and build a first of a kind high performance community and residential microgrid to learn how to better serve changing customer needs.