Resilient Community Microgrids with Dynamic Reconfiguration to Serve Critical Loads in the Aftermath of Severe Events

Building a Resilient Community Using DERs

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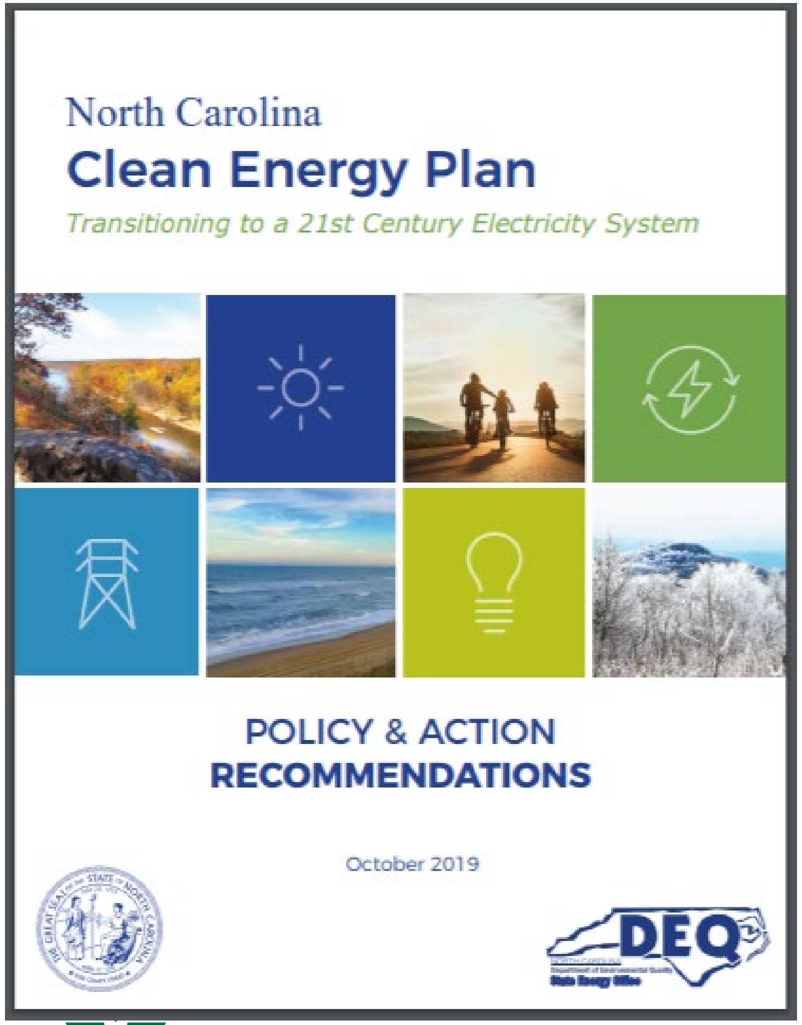
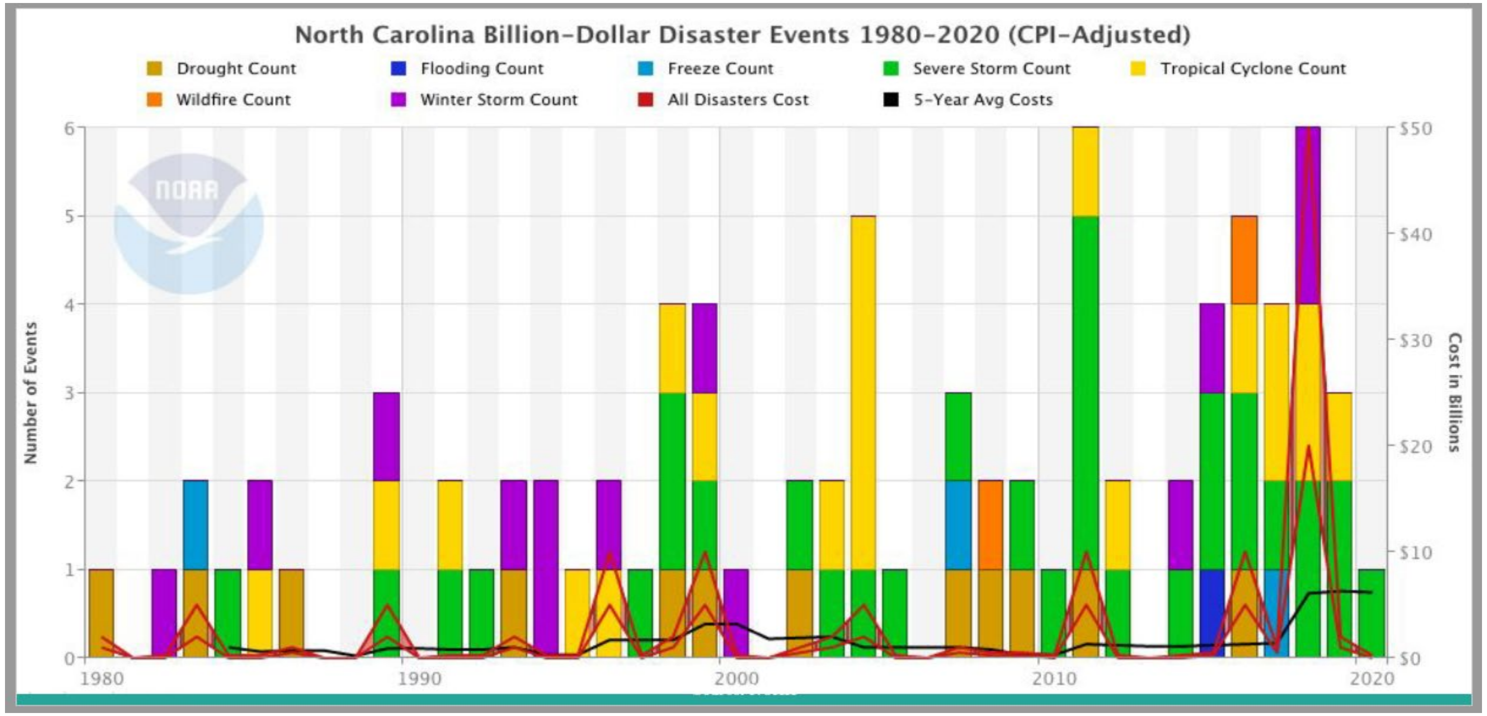
Outline

- Team members
- Introduction and rationale
- Objectives
- Approach
- Anticipated outcomes

Introduction and rationale

SOLAR ENERGY TECHNOLOGIES OFFICE
U.S. Department Of Energy





- NC has significant exposure to tropical events; unique combination of vertically integrated utility and rural cooperatives

Objectives

An advanced microgrid control architecture will be designed

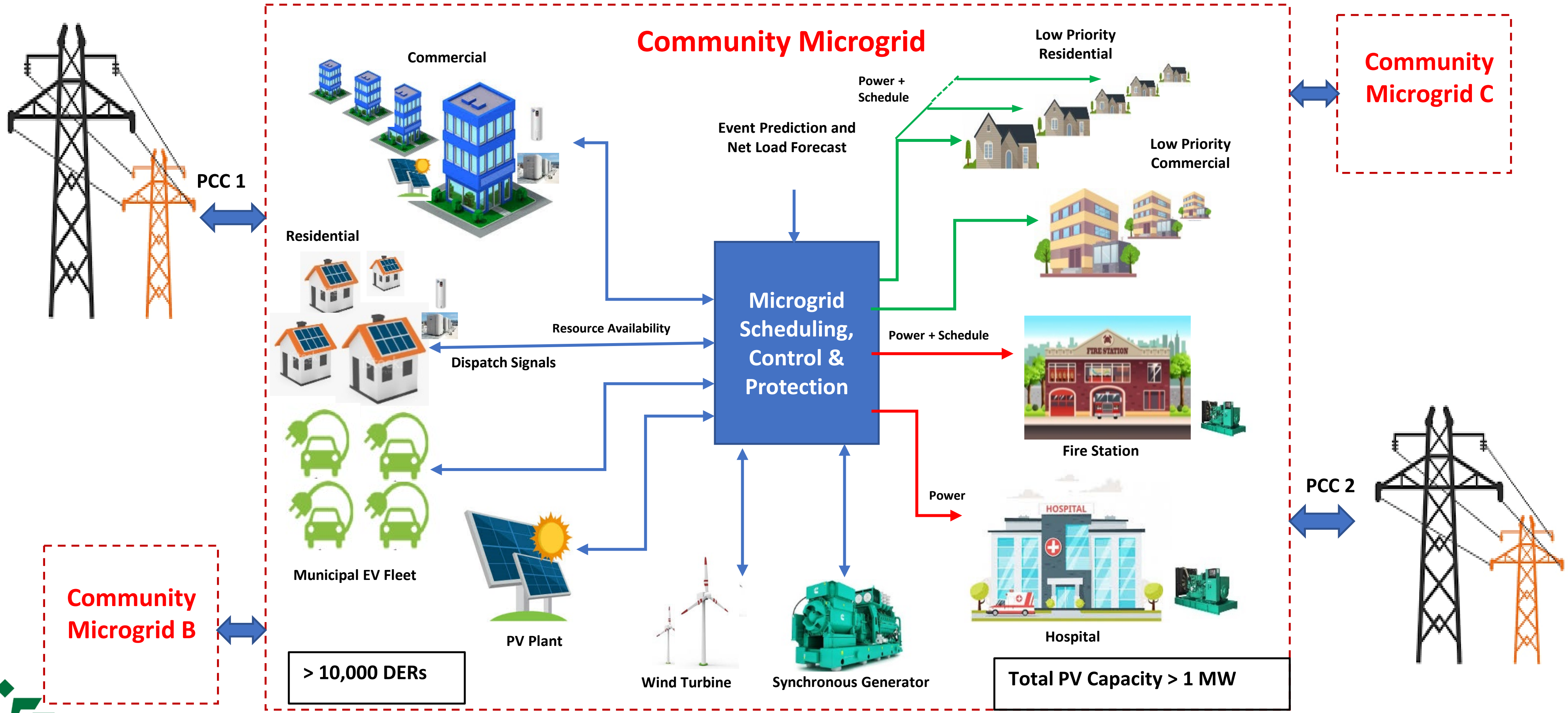
- Coordinate seamlessly with the grid at multiple PCC
- Communicate with DERs; automatically balance load/generation
- Provide critical energy service (hospitals, emergency shelters, etc.)
- Detect faulty conditions on a continuous basis
- Form networked microgrids with neighboring communities as needed
- Maintain safe operating conditions at all times

Control and protection testing utilizing a unique digital-twin approach.

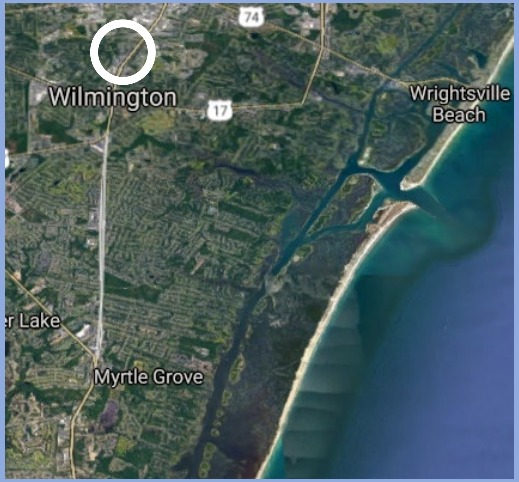
Simulate conditions with more than 10,000 DERs

Field demonstrations

A Community microgrid



Potential community microgrid Wilmington, NC

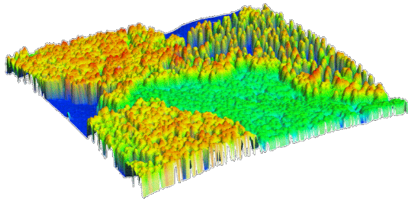


All facilities and complexes are within 5 miles of the Duke Energy substation

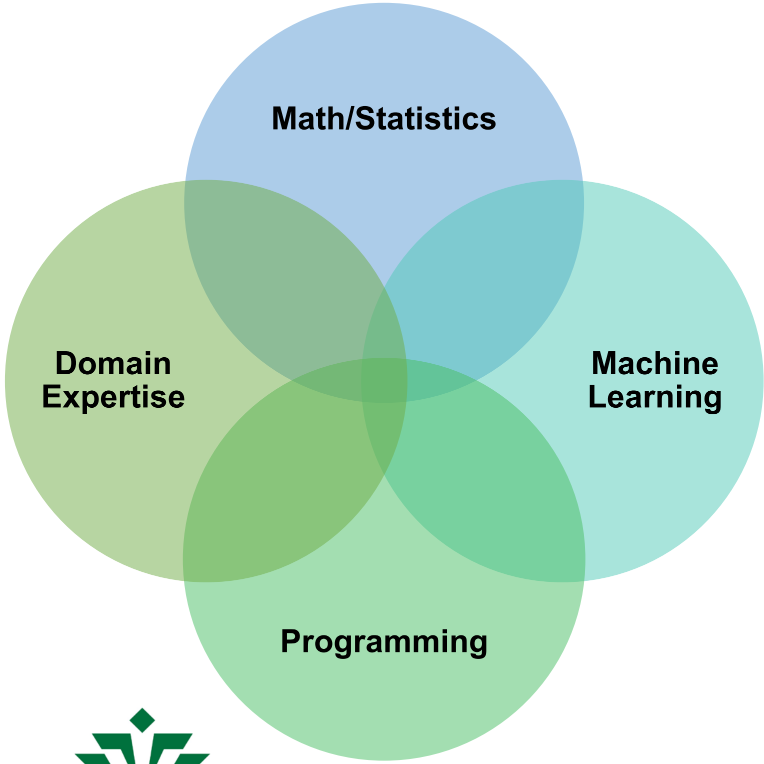
Pictures from google maps

Outage prediction & net load forecasting

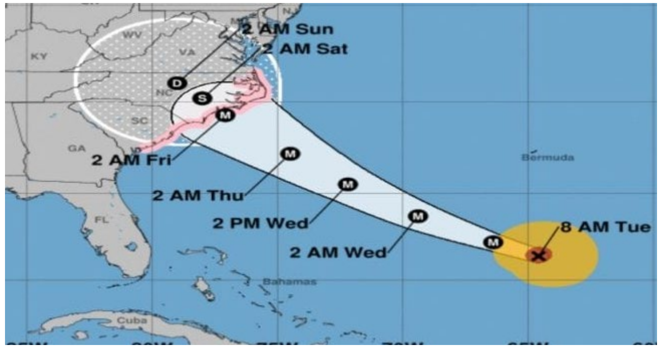
National Hurricane Center



The forecast model combined with weather forecasts predicts the number, sequence and location of vegetation-related outages after an extreme weather event



Statistical and machine learning tools:
- Multiple linear regression (MLR)
- Artificial neural networks (ANN)
- Support vector machine (SVM)



The forecast model also produces 24-hour-ahead forecasts from the numerical weather prediction (NWP) data, and the observed solar and load data.

Energy Management and Control: Key Innovations

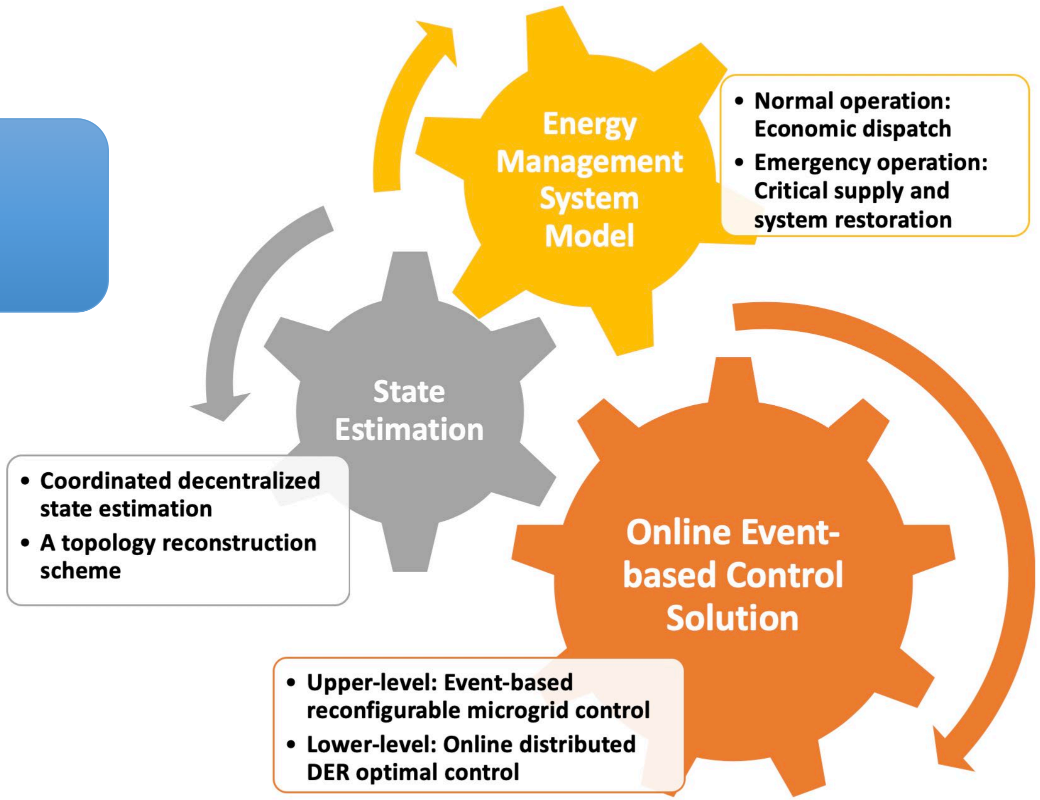
Scalable and reliable energy management

An event-driven proactive distributed management, control and opt.

- Energy management system model
- Decentralized state estimation

Event-based objective

Online event-based scalable solution algorithms

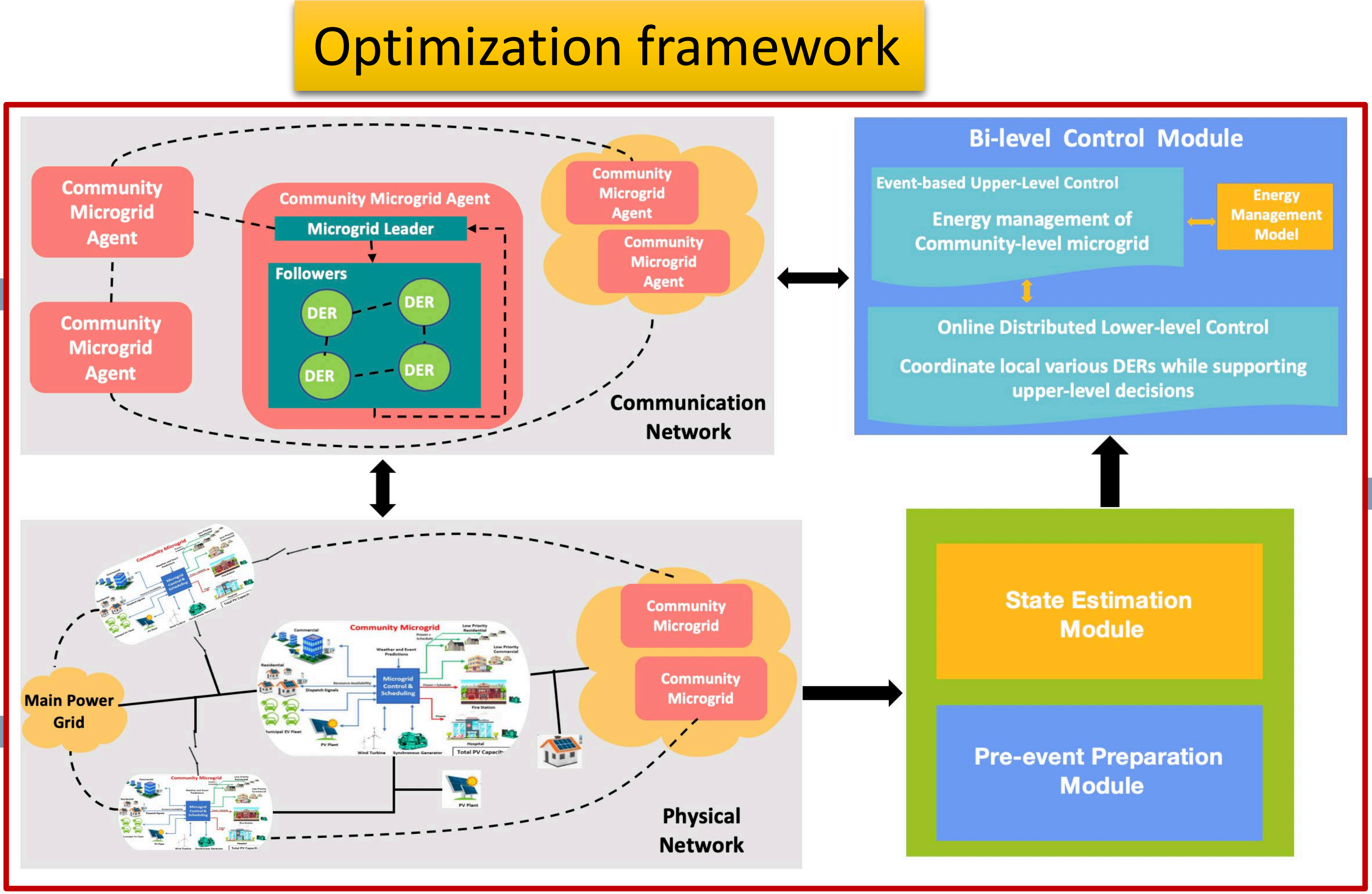


Source: SMU

Energy Management and Control: Technical Approach

Microgrid agent:
- Bi-level control
- Hybrid upper-level objectives
- Lower-level online distributed control

Physical network:
- In response to dispatch and operation commands



A dynamic feedback-based framework to guarantee control accuracy

Source: SMU

Adaptive reconfiguration/restoration

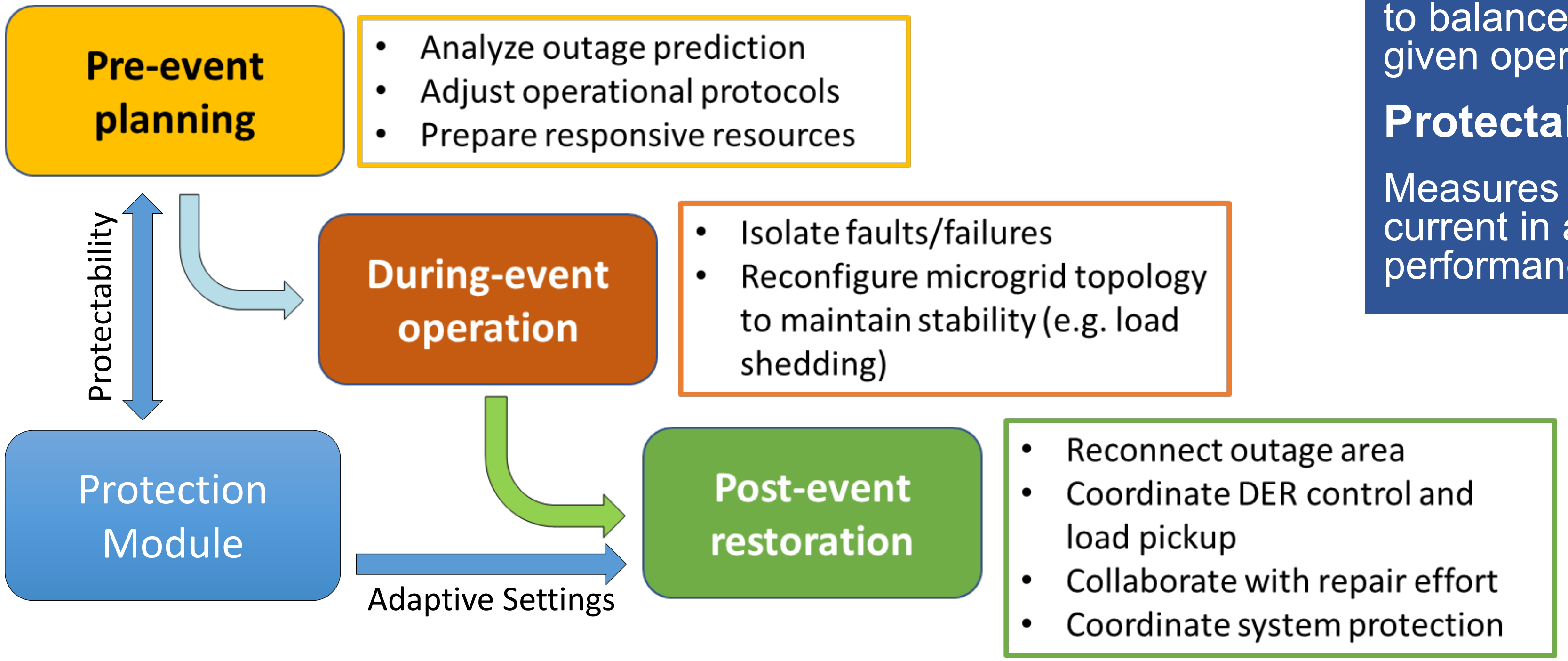
- The *Reconfiguration/Restoration Module* ensures that the network is both adequate and protectable using information about impending or occurring emergencies

Adequacy:

Measures the ability of the power system to balance its load and generation in the given operating conditions

Protectability:

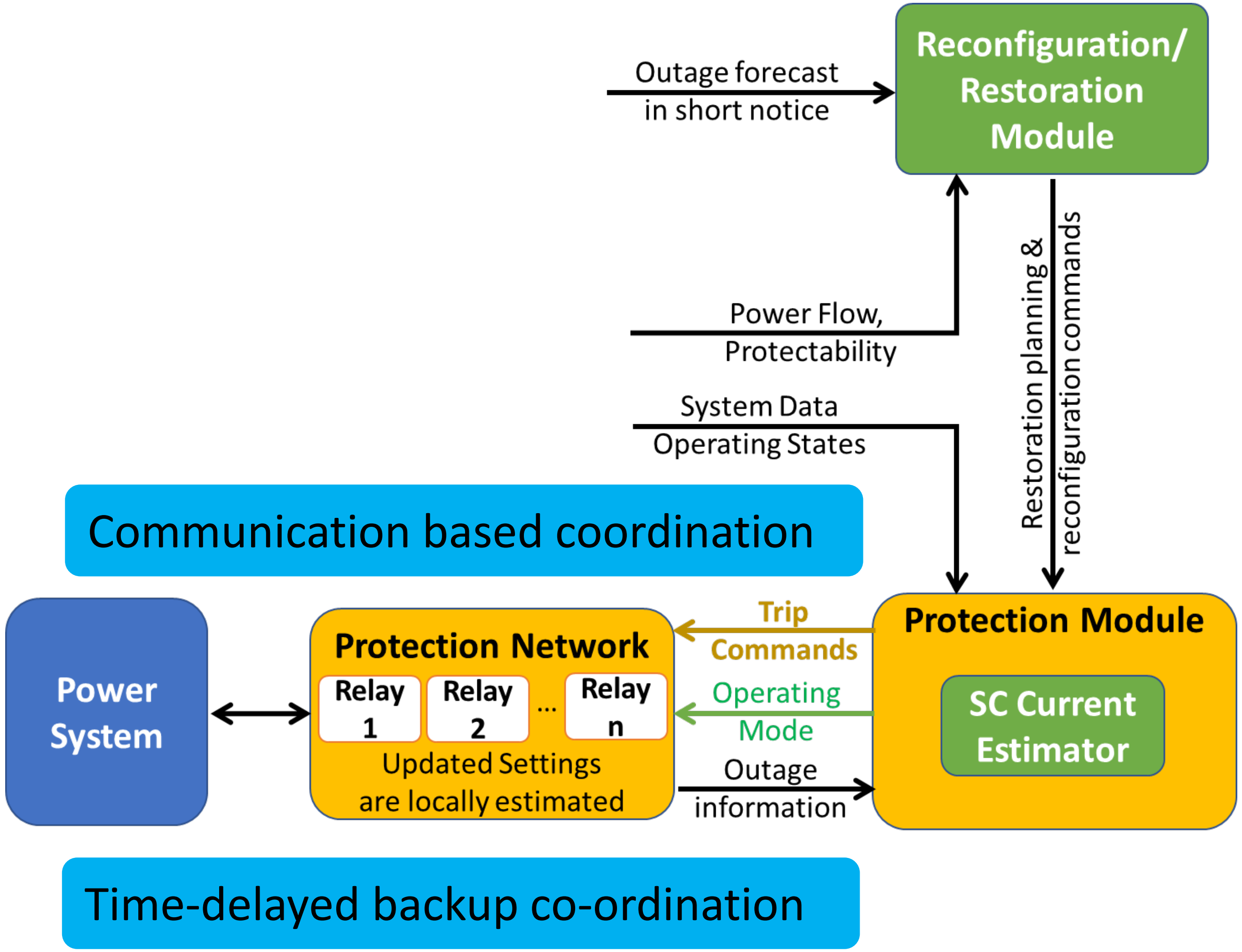
Measures the relative availability of fault current in a system topology for reliable performance of protection schemes



Source: NREL

Dynamic adaptive protection

- In-built 'Protection Module' evaluates the protectability of a given topology
  - Novel parameters estimate the fault current contribution from the remote DERs.
- 'Dynamic adaptive fault detection block will be a modified overcurrent-based algorithm to account for local (measured) and remote data to reliably detect faults
- Protection module also determines the adaptive settings for relays



Source: NREL

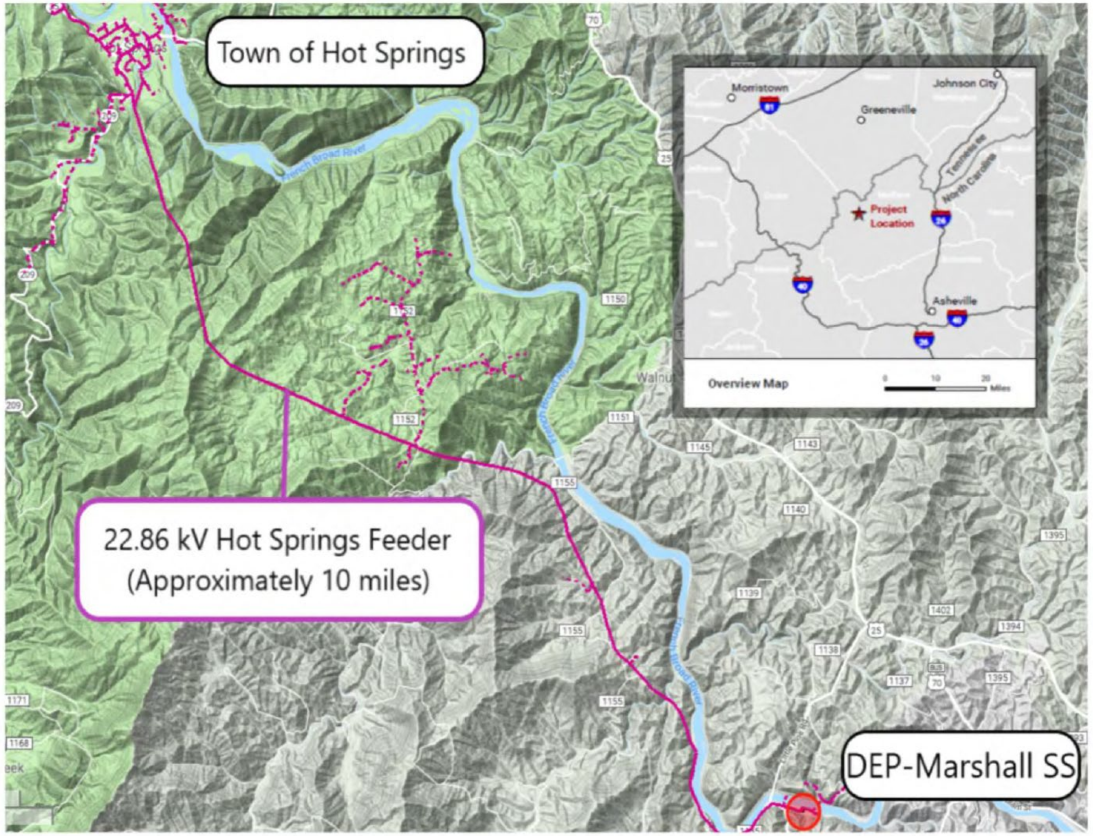
Field testing
Hot Springs microgrid

Conduct a field test intended to deploy several of the innovations at the Hot Springs Microgrid owned and operated by Duke Energy.

- Test adaptive protection scheme
- Test methods for improving islanded black start
- Test methods for improving stability during islanded mode when grid-forming inverters are used.

Real-time data will be streamed with UNCC, likely via PI connect

Testing several scenarios assuming that large numbers of third-party DERs were also installed on the same feeder



Anticipated outcomes/innovations

- Resilient community microgrids that:
  - Should be able to handle more than 10,000 DERs (solar, wind, and energy storage assets)
  - will be supported by mostly both FTM/BTM DERs and flexible loads

- The project will develop new distributed approaches for energy management.

- Major improvements: automatic response during events and hybrid solutions after events.
  - Hybrid control prevents the re-design of controllers along with the pre-designed event-based objective.

Thank you!

Questions?