Laboratory Demonstration od Microgrids With Storage
&
Senior Design Classes

Satish J. Ranade
New Mexico State University

Funded in part by the Energy Storage Systems Program of the U.S. Department Of Energy through Sandia National Laboratories

This work is partially supported by the Department of Energy, Energy Storage Systems and managed by Sandia National Laboratories. The support and encouragement of Dr. Imre Guyk is gratefully acknowledged

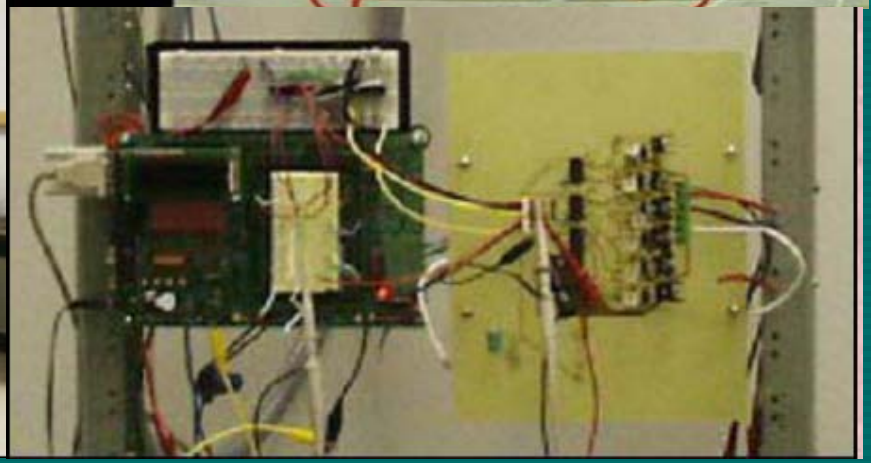
Project Background

- Investigating multiple applications of short term ESS in power systems
- Circa 2005
  - Increasing loadability of Inverter interfaced distributed energy resources (Patent received)
  - Sizing of ESS for transient (angle) stability and damping of oscillations
- Present
  - Application of ESS in Distribution Microgrids
  - Laboratory scale demonstration

Laboratory

Supports Senior Design Projects

Scale Model Power System
Renewables and Energy Storage
Microgrids

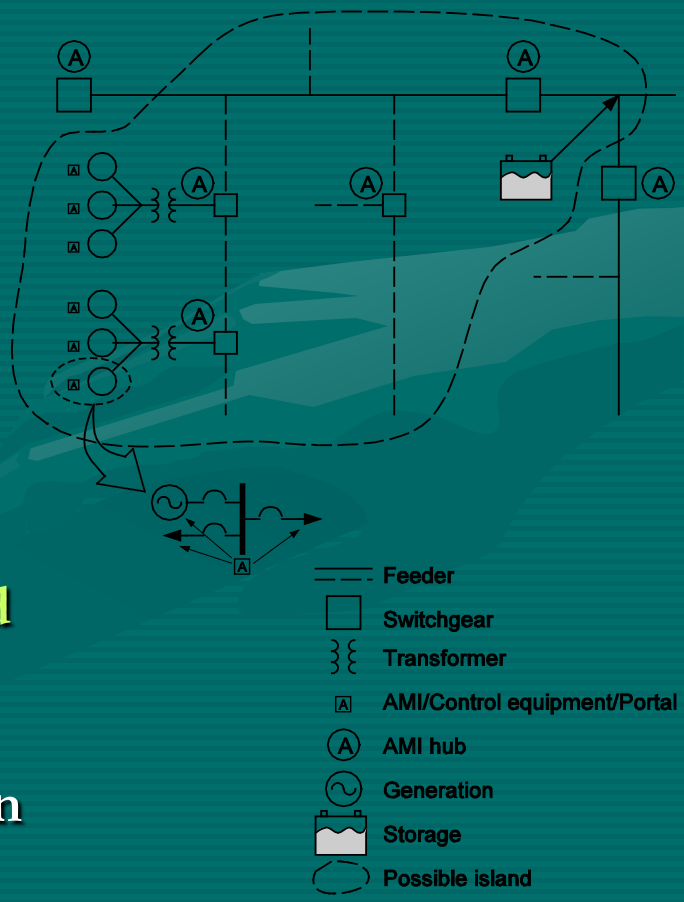


Customer Driven Microgrid

- Application focus – Residential/Small Commercial Customer

What is a customer-driven microgrid?

- Customers install small distributed generators
- Utility maintains feeders that are generator friendly
  - Provides a market for load and renewable generation resource
  - Balancing energy from storage or CHP
  - Designed for reliability
  - Can be islanded in extreme



What could a customer-driven microgrid achieve?

- Economic benefit to customers
- New business model for the distribution company as an enabler of customer resources for profit and service quality
- Serve as a reliability resource for the grid

Storage (feeder or customer level) is key

Key Elements

Developing hardware to configure laboratory as microgrid

- Rotating machines and loads(DR)
- Storage
- Power Electronics
- distribution feeder

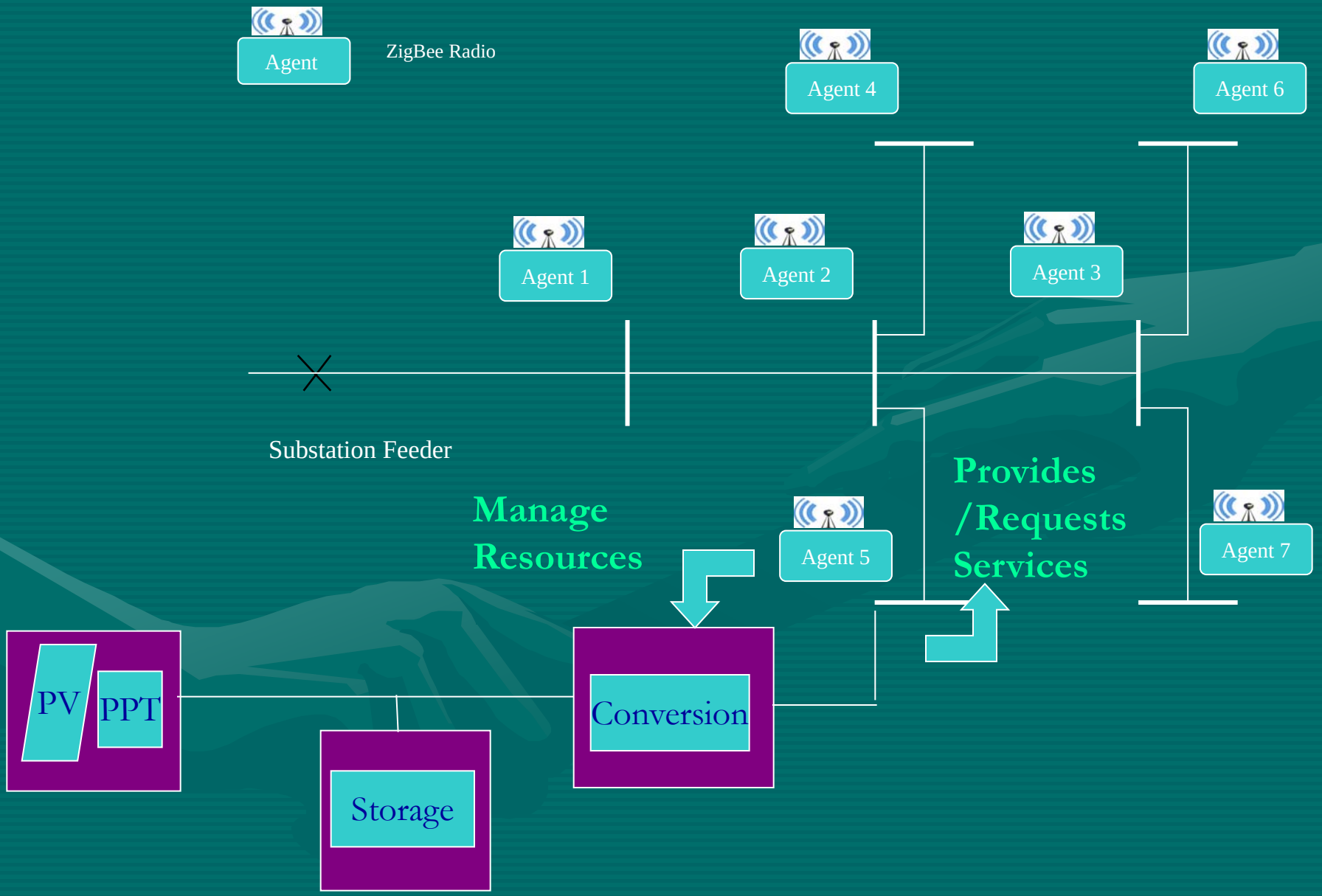
Agent-based distributed control algorithms for microgrid control

- Key issue –
  - very large number of resources
  - autonomy v. plug-n-play

Fully decentralized with only neighbor-neighbor communication

-

Distributed control



Distributed control

Key issues

- Market creation/management
- Ancillary Services

- Islanding
- Identification/Creation/Configuration
- Control (Frequency, voltage), Restoration

Identify 'kernel problems'

- Capacity Discovery
- Price discovery
- Power Flow
- …

Establish baseline of what can be done with decentralized neighbor-neighbor communication

Determine optimum design – heterarchical (hybrid)

Distributed control

Capacity discovery

Simple algorithm

Proved to have guaranteed finite convergence

Hardware implementation demonstrated

Power Flow

Demonstrated Convergence
A natural multi-agent system

Islanding

Demonstrated Island Identification

Continuing Work

Capacity discovery

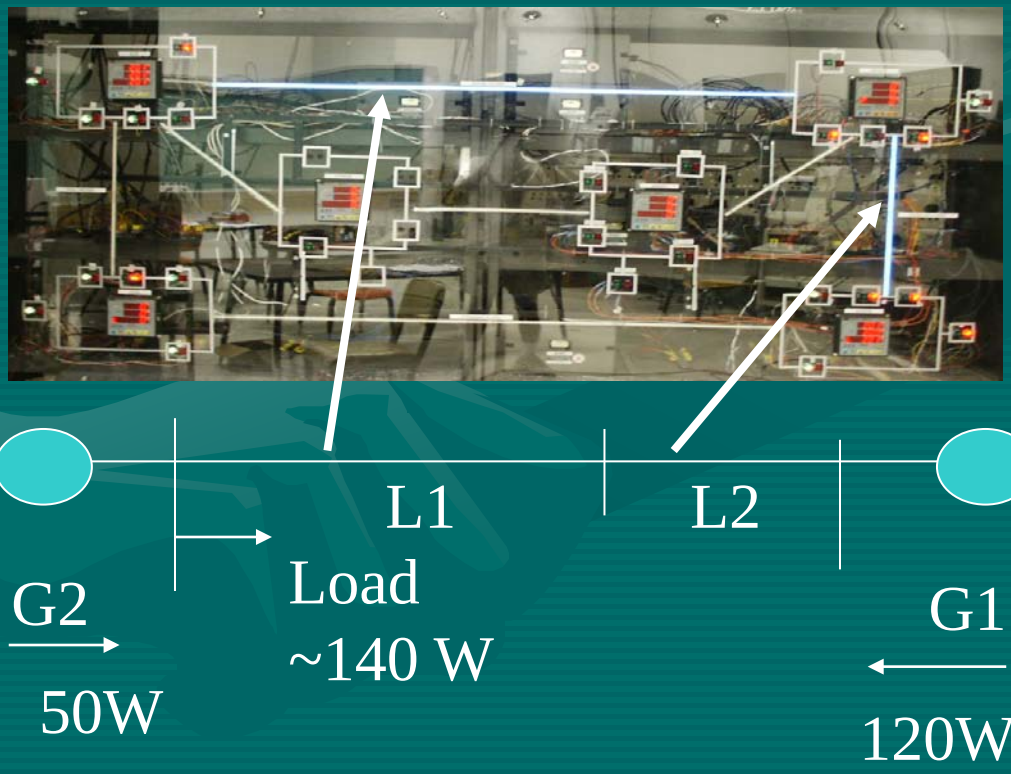
Hardware implementation

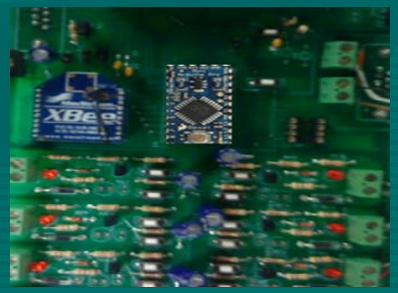
Power Flow

Island Identification

Integrate with Laboratory

Demonstrate Microgrid Operation





Conclusion

Progressing towards demonstration of laboratory scale micrgid with storage

Provide fundamental insights into distributed control and management

Integrated development with Senior Design Classes

- PV+Storage System Design
- Inverter Design
- Other applications (e.g., smart outlets)

This NMSU Program Gratefully Acknowledges the Advice and Support of Stan Atcitty at Sandia National Laboratories in Albuquerque, NM.