Transforming Low Voltage Networks Into Small Scale Energy Zones

- Microgrids Symposium
- Professor Phil Taylor
- Durham University

Durham University

Overview

- Durham University/Energy Institute
- Small Scale Energy Zones
- Methodology
- Control Requirements
- Control Approach Selection
- Simulation Results
- Practical Results
- Conclusions
- Further Work

Durham University

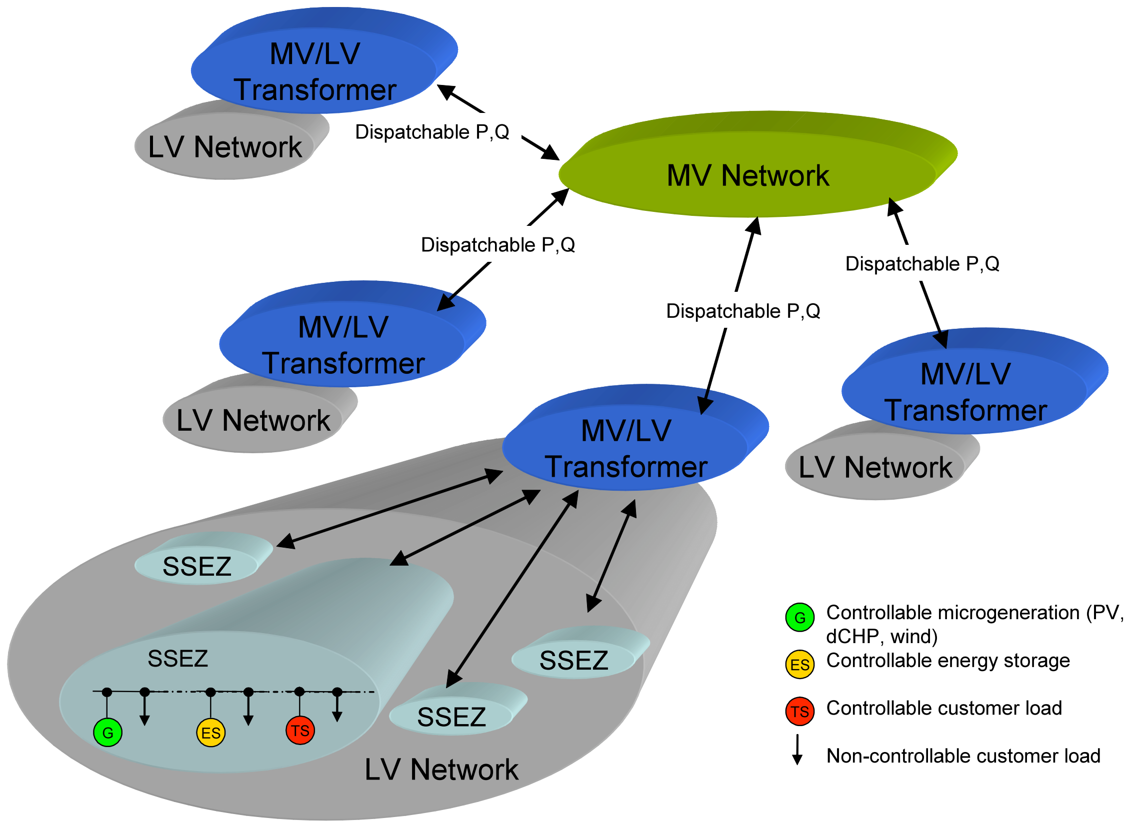
- Chancellor Bill Bryson
- Founded in 1832
- Collegiate University
- 15,000 students
- Ranked 5th in UK

- Engineering (Unified Approach)
- Ranked 3rd in UK
- 500 Undergraduates
- Research Groups Energy, Mechanics

Durham Energy Institute

- ‘Science and Society’
- 10 Departments (Engineering, Physics, Earth Sciences, Anthropology)
- Multi-disciplinary
- £36M Energy Funding last five years

Small Scale Energy Zones



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Methodology

- Micro-generation Growth
- Network Models
- Laboratory Design and Development
- Impact Studies (Passive, Grid Connected)
- Define Control Requirements
- Control Approach Selection
- Controller Implementation (Simulation and Lab)
- Controller Evaluation

SSEZ Control Requirements

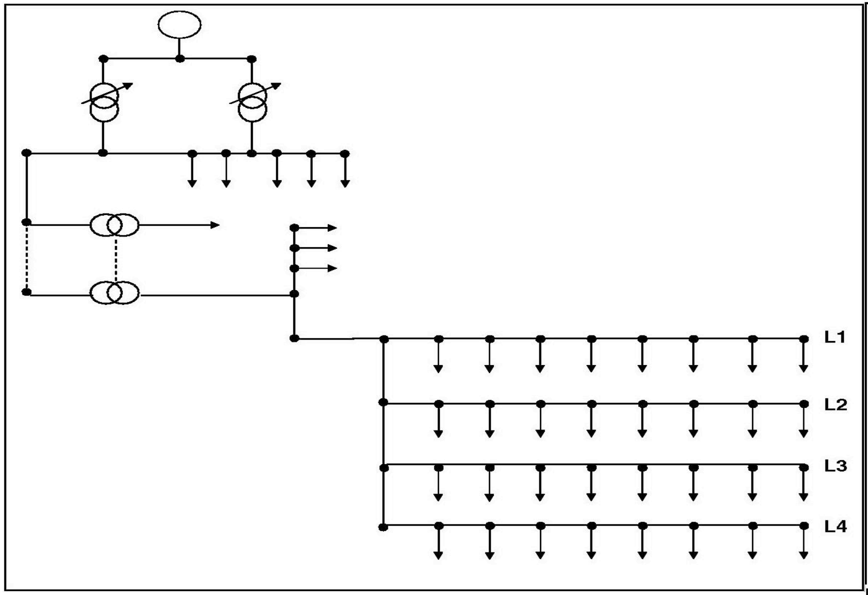
- Overcome Network Constraints
  - Voltage Limits
  - Voltage Unbalance
  - Thermal Limits
  - Reverse Power Flow Limits

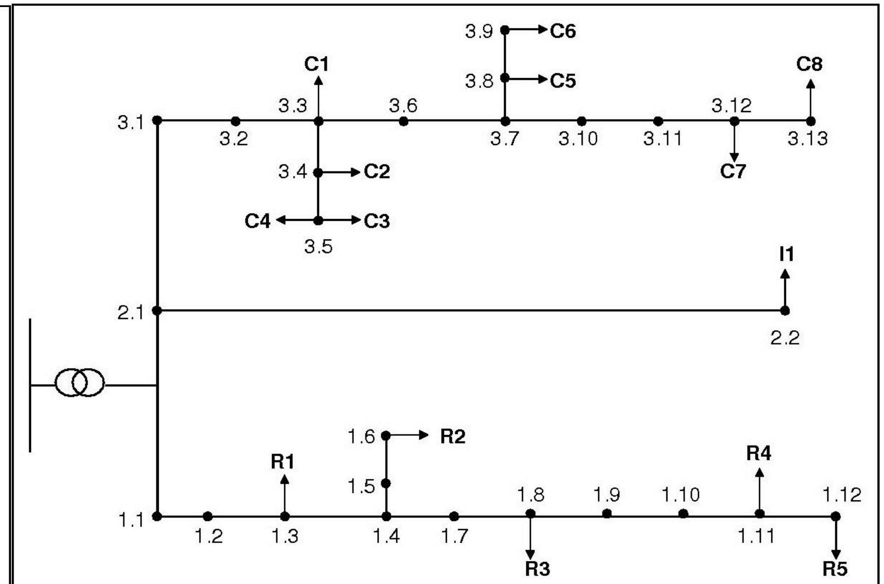
- Achieve Operational Goals
  - Zero Export
  - Zero Import
  - Self Sufficiency
  - Constant power import
  - Dispatchable power output

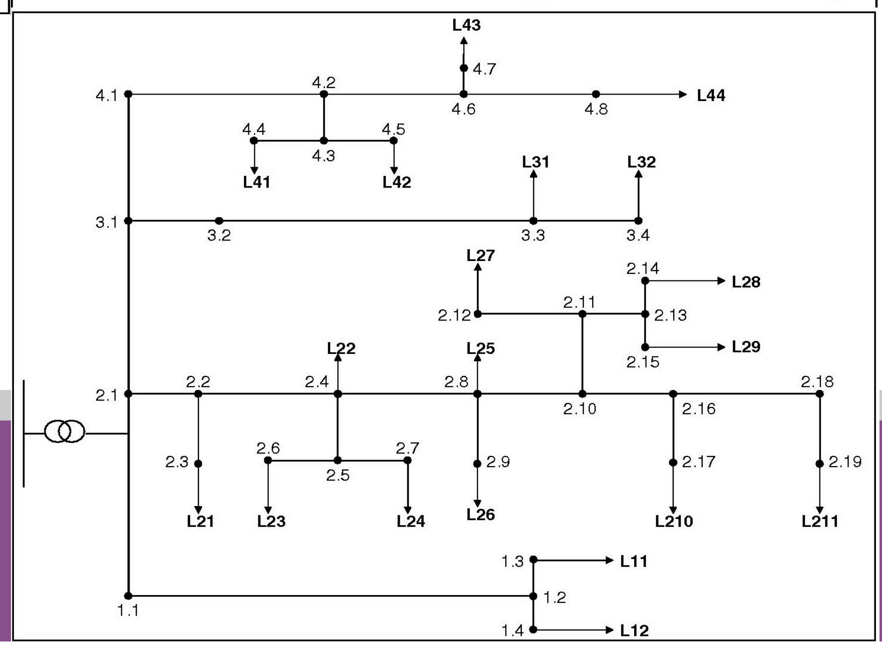
Network Models

- Low voltage
- UK Generic
- EU Generic
- Real UK
- Steady state 3 wire
- Dynamic 4 wire
- Validated with UK DNOs

Generic UK/EU and Real UK Networks







Impact Studies

	UK	EU
Voltage Regulation	770	325
Voltage Rise	185	535
Voltage Unbalance	47.8/ph	27/ph
Transformer Thermal Limits	610	505
Cable Thermal Limits	1,045	340
Increase in Losses	80	180

Table 1: Allowable SSEG volumes [kW] for the UK and European generic network.

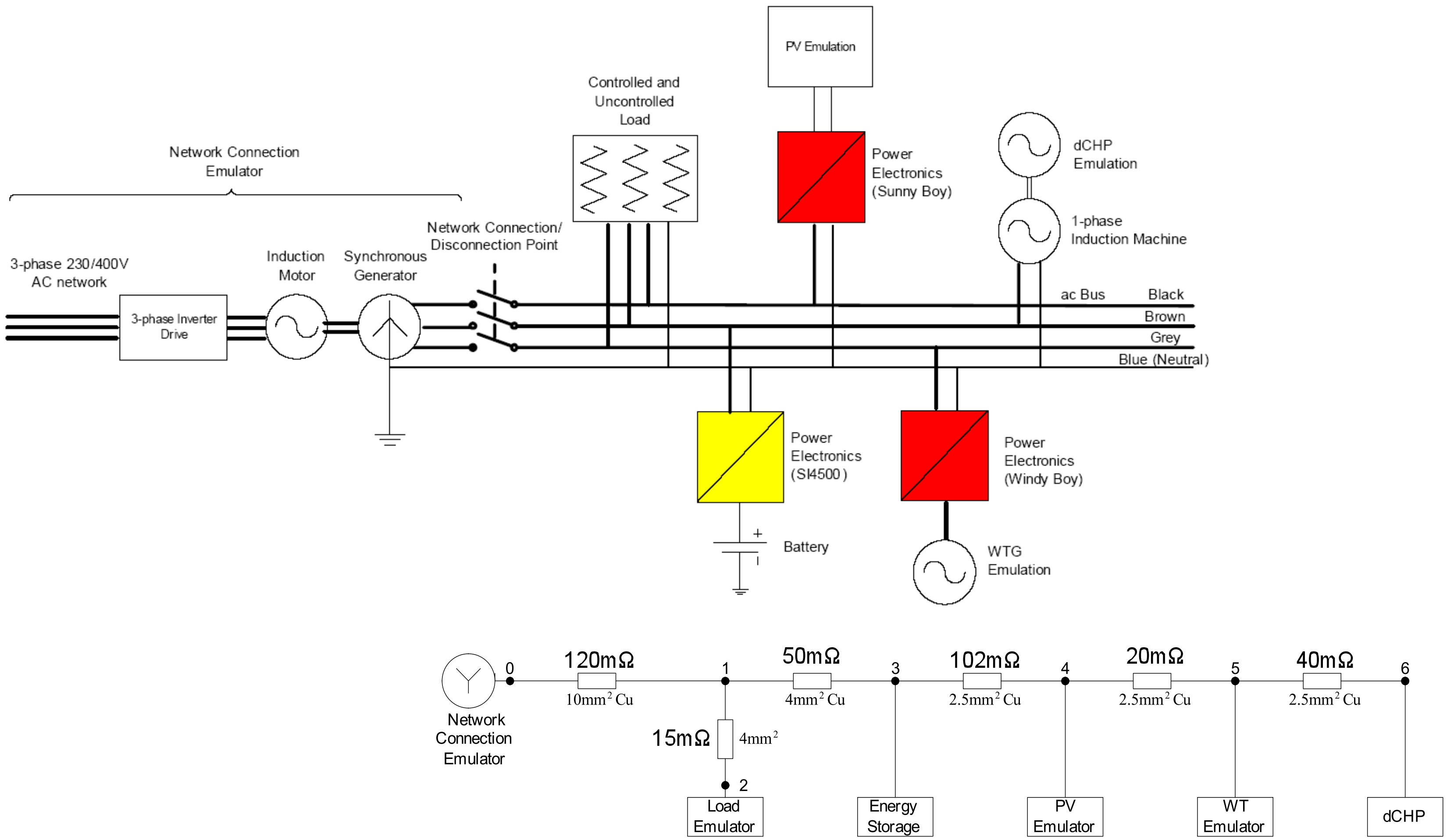
Laboratory Development

- Requirements
  - Assess the impact of micro-generation on distribution networks.
  - Validate models.
  - Implement, test and refine the control algorithms developed during research programs.

- Network 4 wire
- Load (single phase)
- Generation (single phase)
- Energy Storage (single phase)
- Instrumentation
- Controllability (Repeatable Tests)

Experimental SSEZ

Schematic Layout



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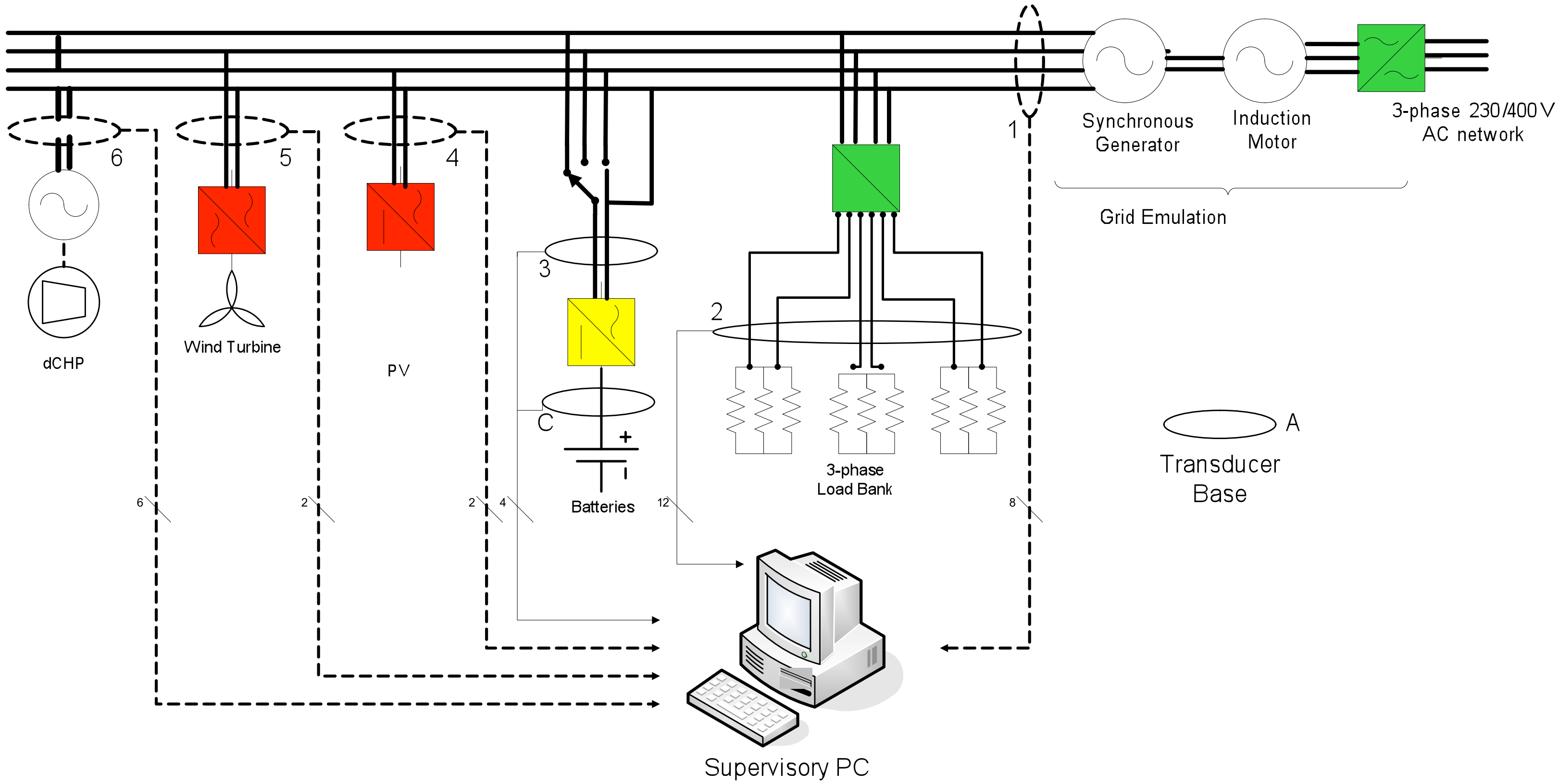
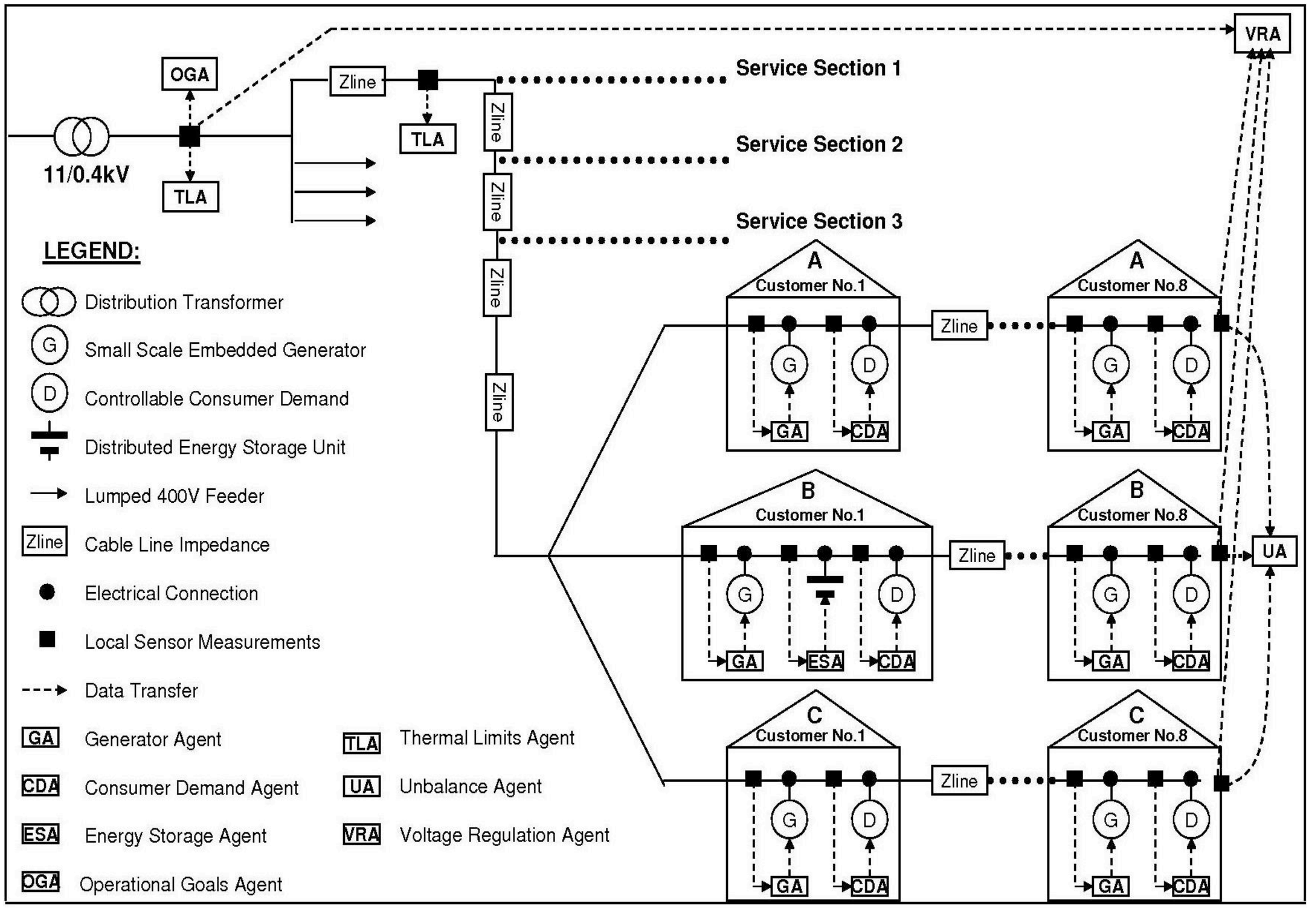
Data Acquisition



Control Approach Selection

- Centralised versus Distributed ?
- Criteria
  - Scalability and Openness
  - Efficient Communications
  - Resilience and Reliability
- Attributes
  - Autonomy
  - Social Ability
  - Reactivity
  - Pro-activeness

Envisaged Implementation



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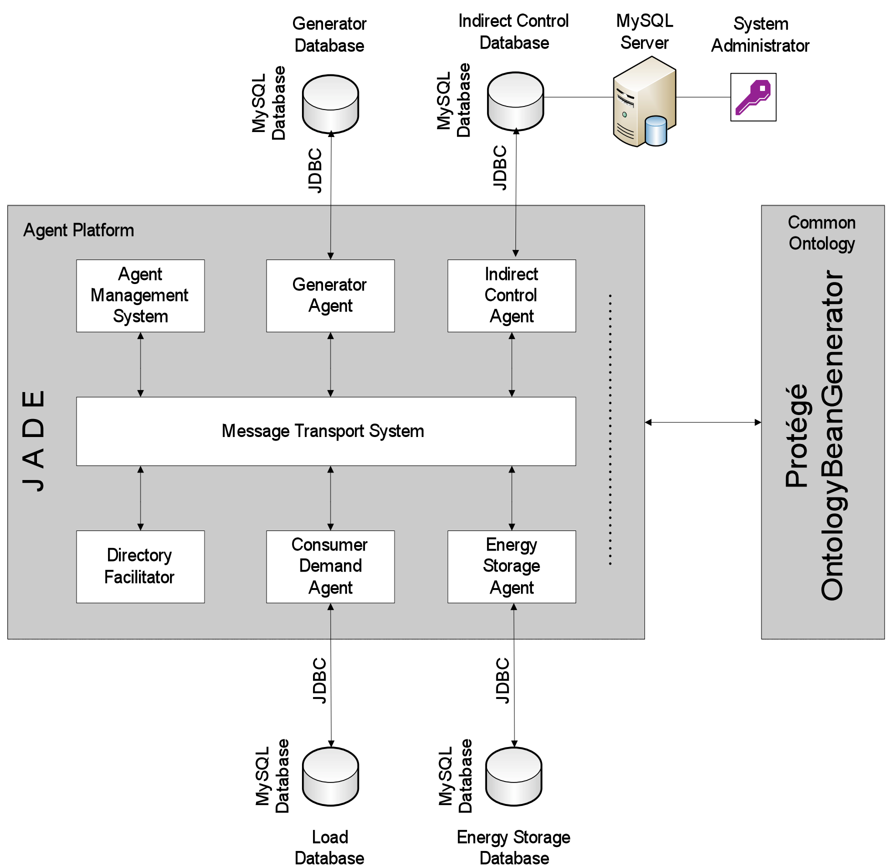
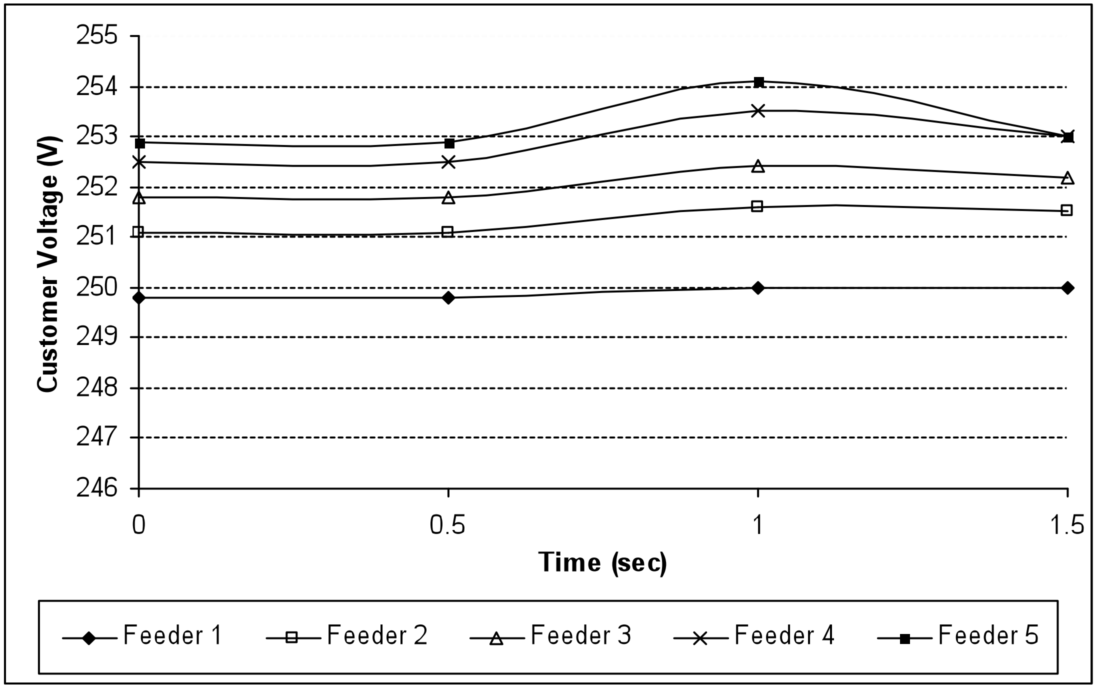
Controller Evaluation- Simulation

- MAS approach
- FIPA Compliant
- Jade My SQL
- Link to PSCAD

MAS Implementation



Simulation Results



Controller Evaluation - Laboratory

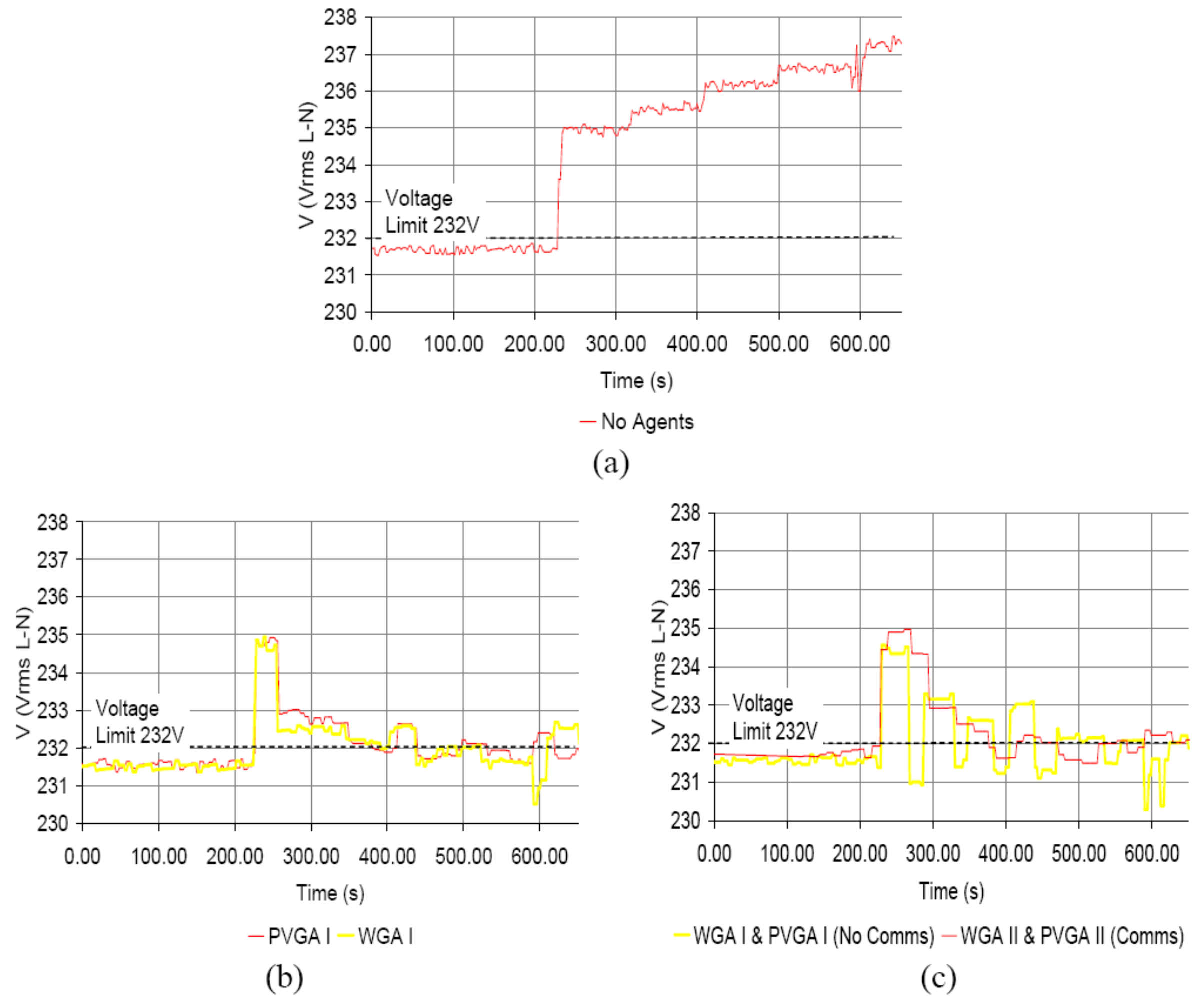


Figure 6: Operation of over-voltage agents in the Experimental SSEZ.

Controller Evaluation - Laboratory

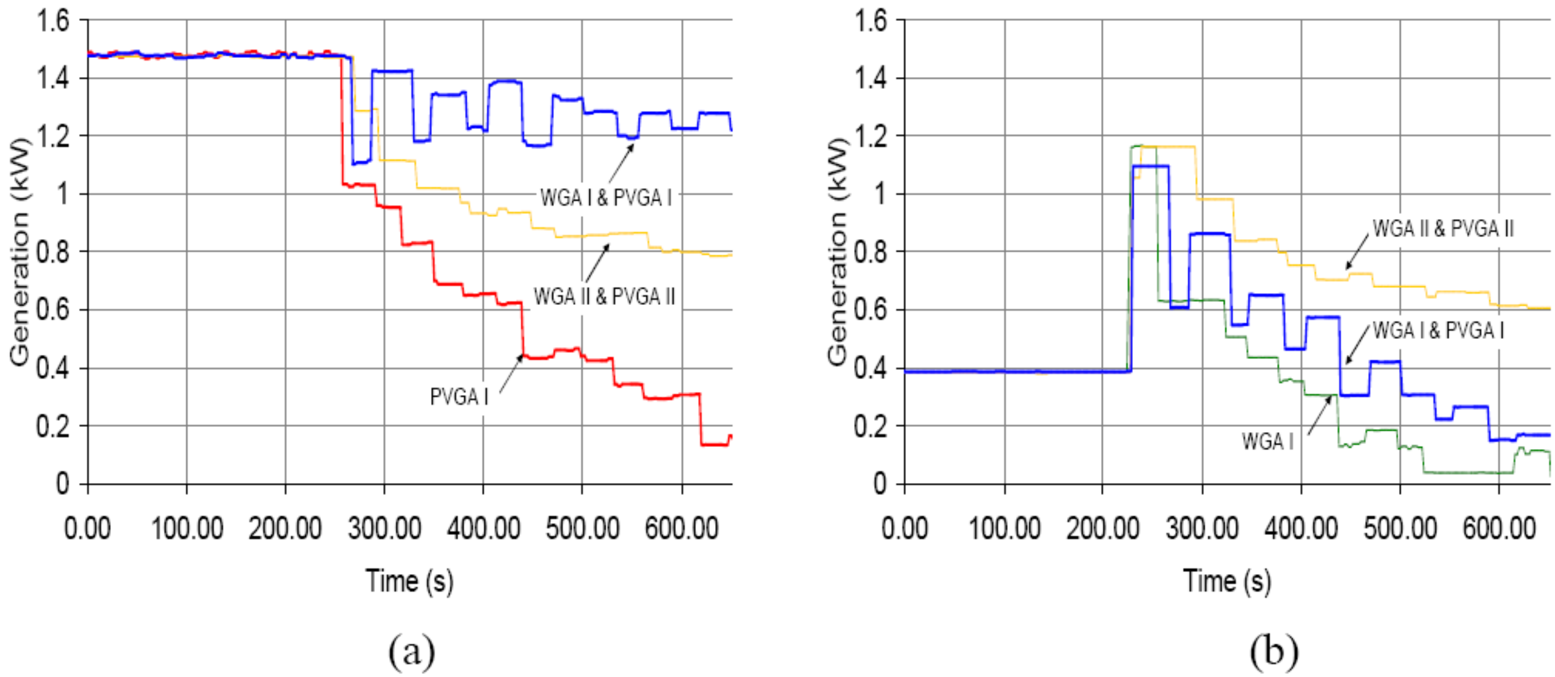


Figure 7: Generation output of (a) PV generator and (b) Wind Turbine Generator during operation of overvoltage agents on Experimental SSEZ.

Controller Evaluation - Laboratory

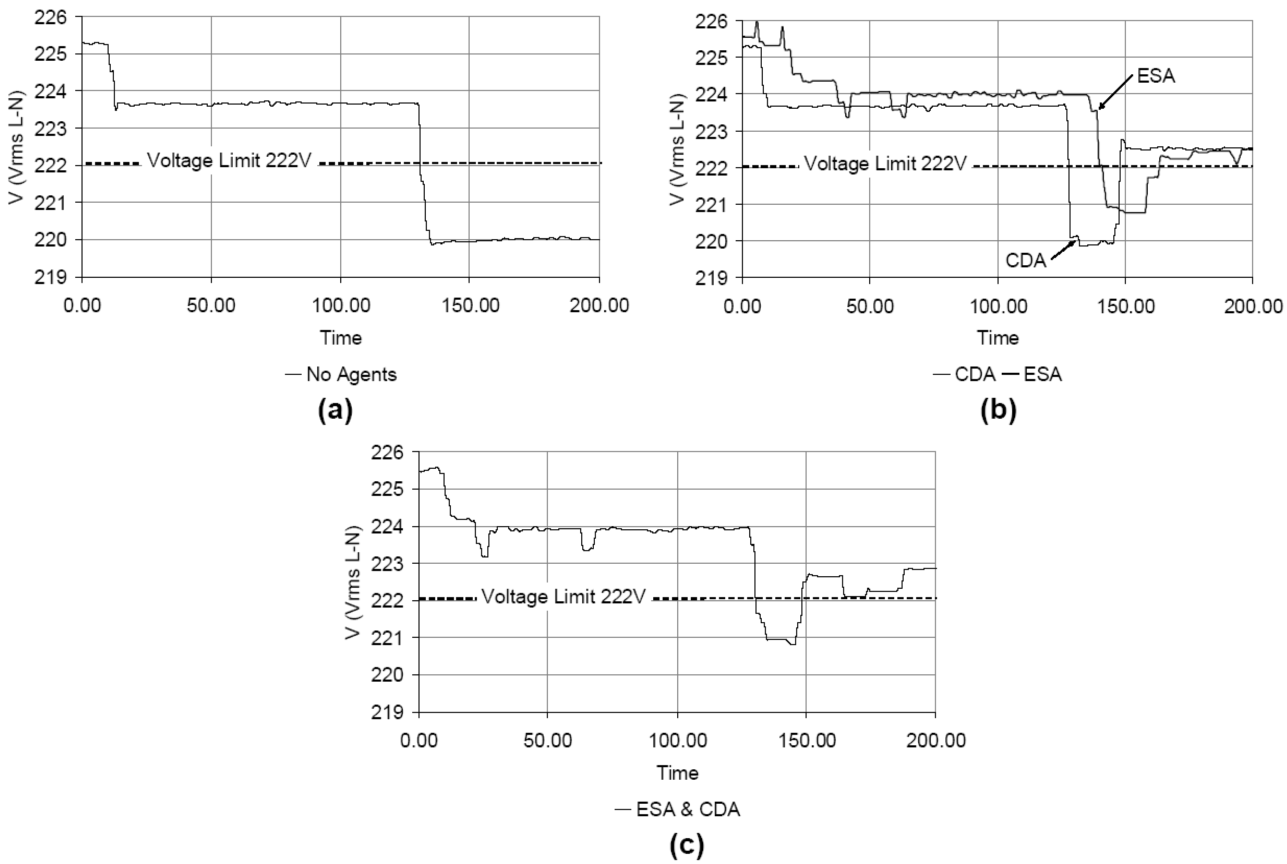


Figure 6: Effect of agent deployment in undervoltage conditions

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Controller Evaluation - Laboratory

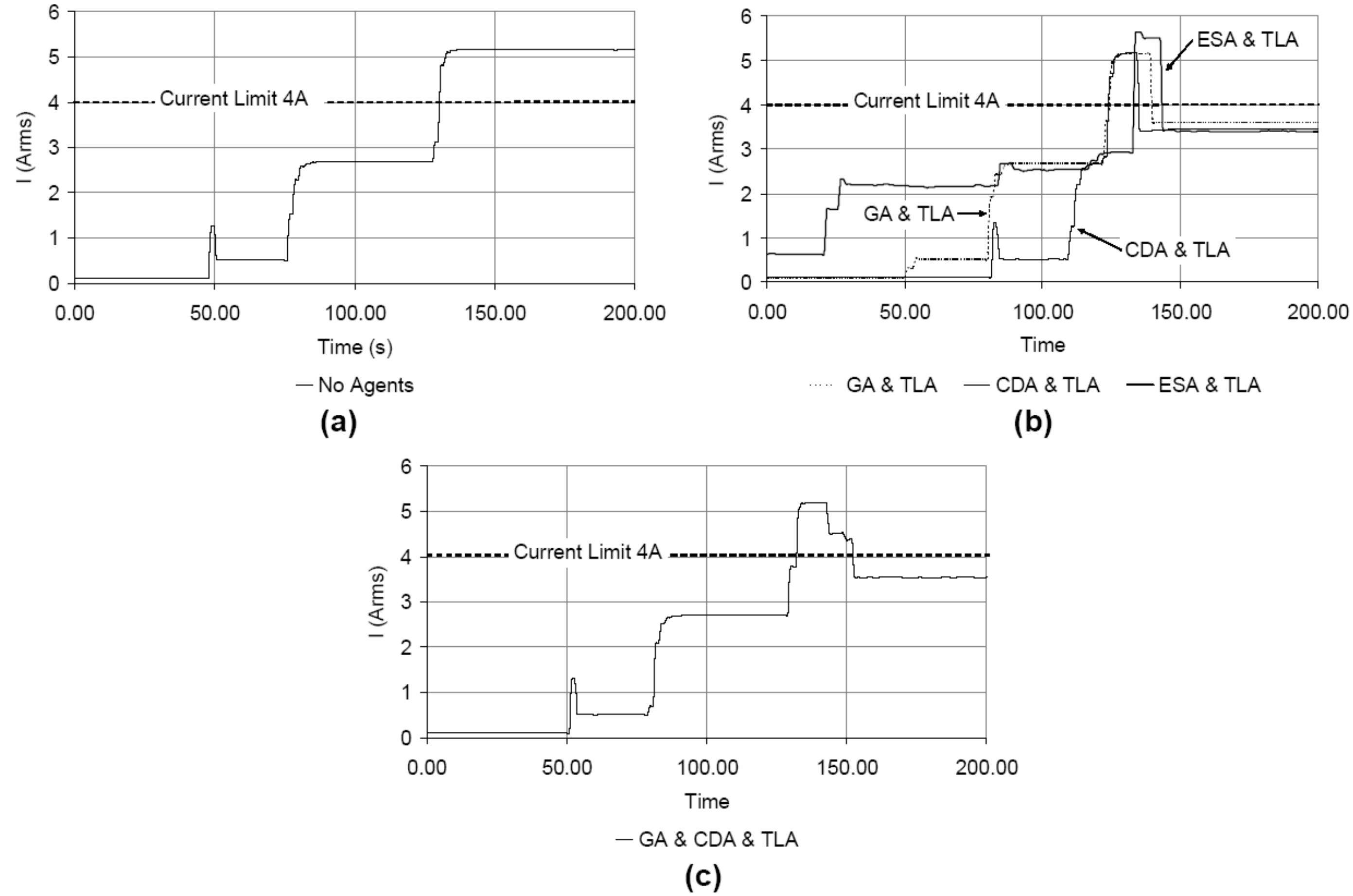

Figure 7: Effect of agent deployment in overcurrent conditions

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Conclusions

- SSEZ Concept
- Simulation and Laboratory Developments
- Distributed Control Approach- MAS
- Evaluated through Simulation and Laboratory
- Encouraging results