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Electric Energy Systems Group

Electrical & Computer ENGINEERING

From Theory to Smart Grid Simulator for Assessing and Demonstrating The Potentials of New Technologies

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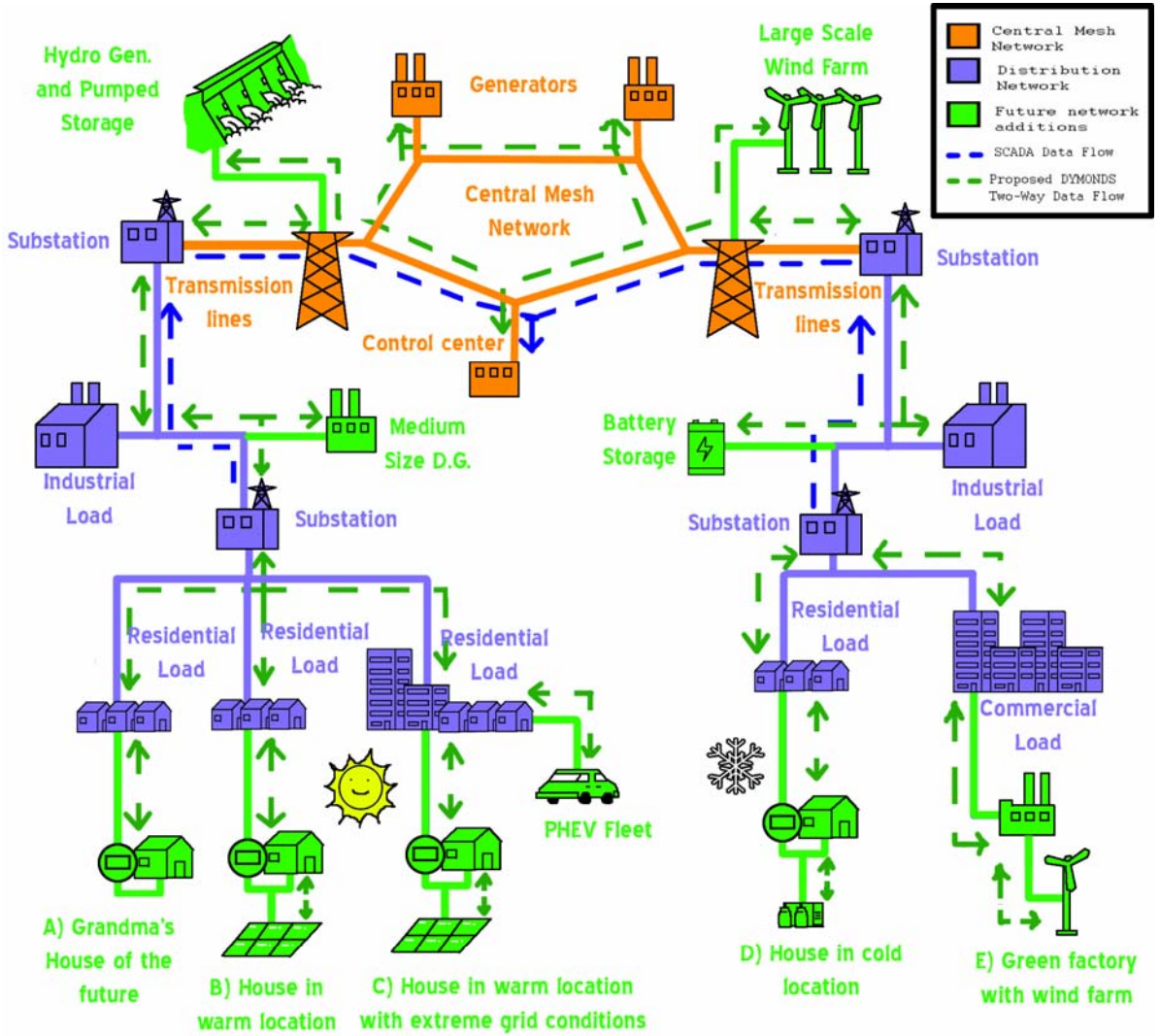
Acknowledgements

- **Le Xie**
  - Former PhD student, Assistant Professor at Texas A&M University
- **Marija Prica**
  - PhD student, EESG, ECE CMU
- **Niklas Rotering**
  - Former visiting Master's student, PhD student at RWTH Aachen, Germany

DYMONDS — Future electric energy system



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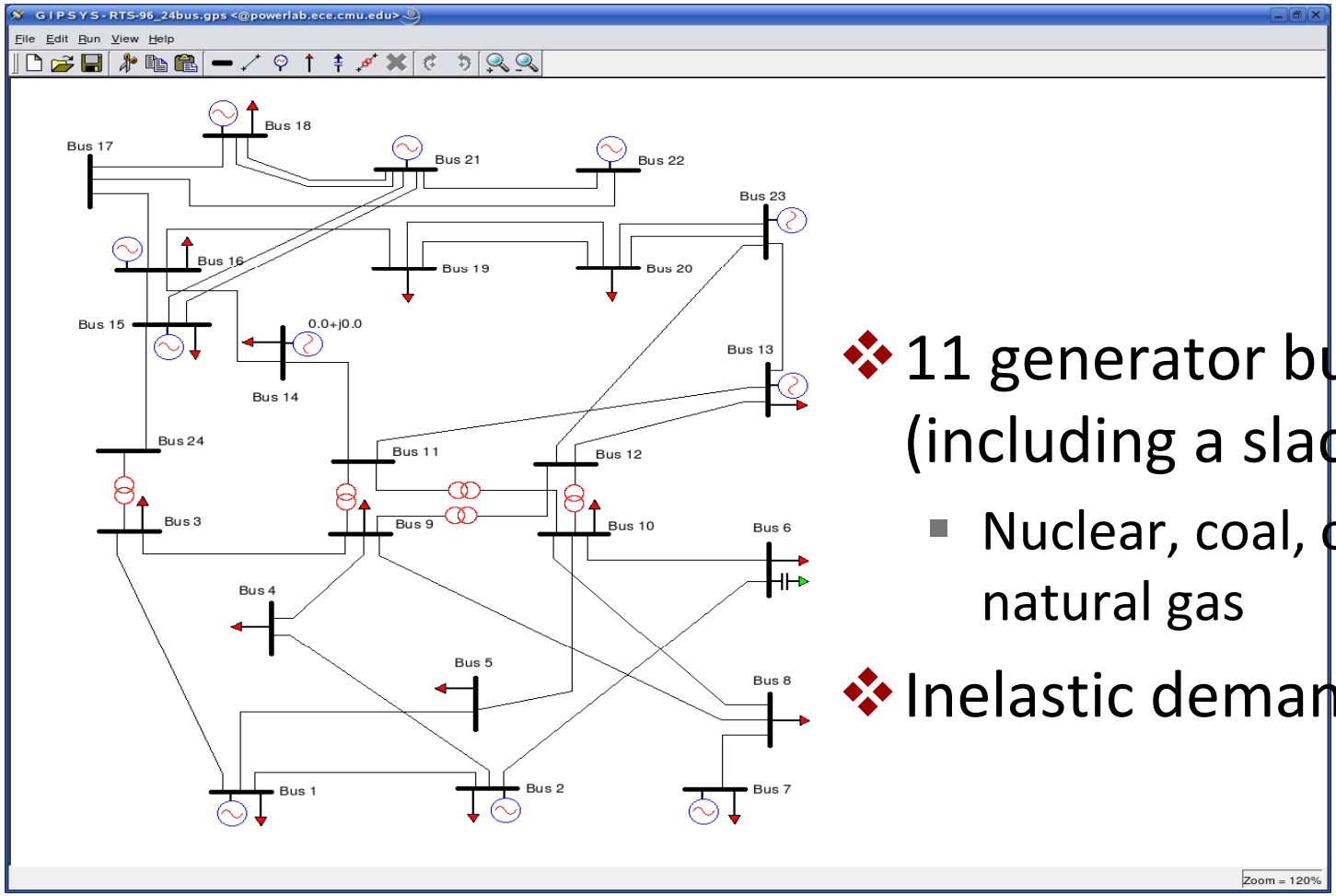
Dynamic Monitoring and Decision-making System (DYMONDS) [1]

- **Dynamic Monitoring Decision-making System (DYMONDS)**
  - Distributed decision making system
    - Computationally feasible
  - Individual decisions submitted to ISO (as supply/demand bids)
    - Individual inter-temporal constraints **internalized**

- **The pieces we've got**
  - System operator
  - Wind generation, price-responsive demand, PHEVs, planning and PMU(phasor measurement unit)s, and more

Concepts of DYMONDS Simulator

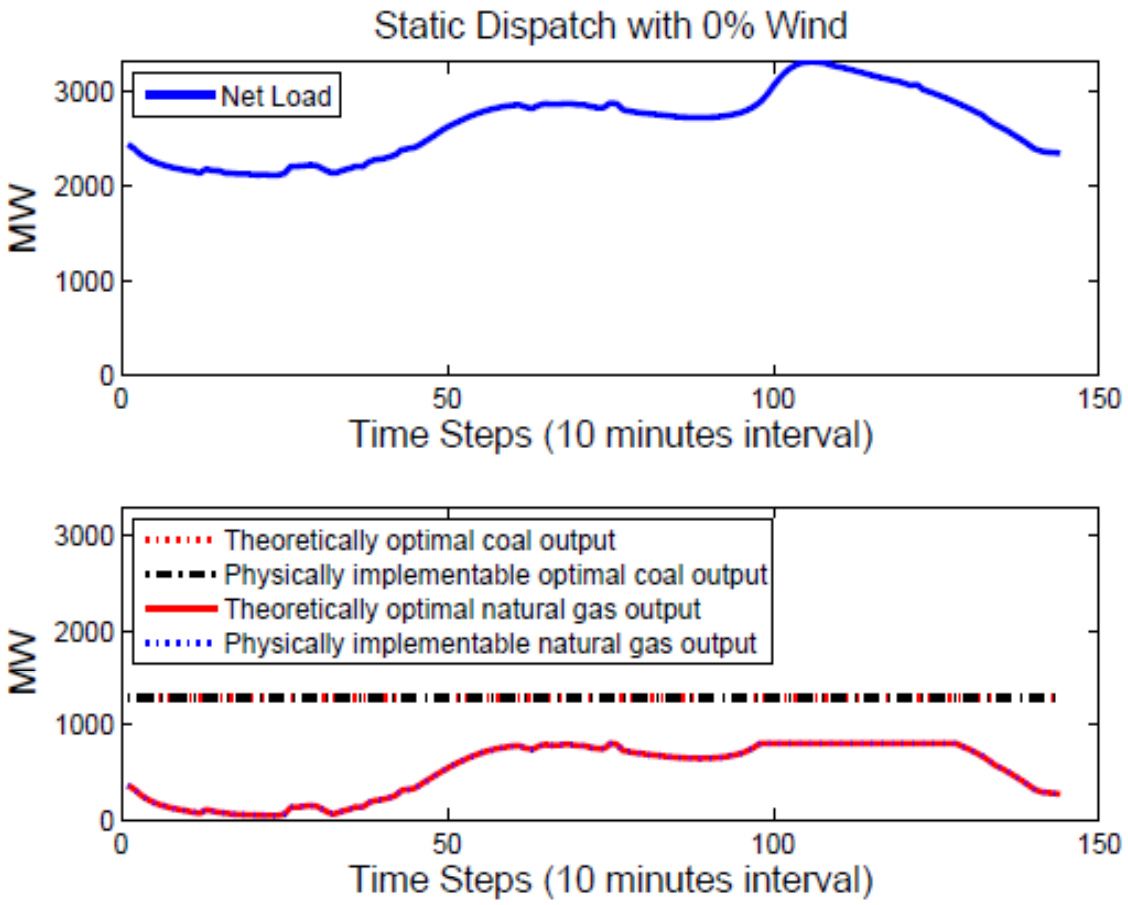
IEEE 24-bus Reliability Test System (RTS) in GIPSYS [2]



Jovan Ilić

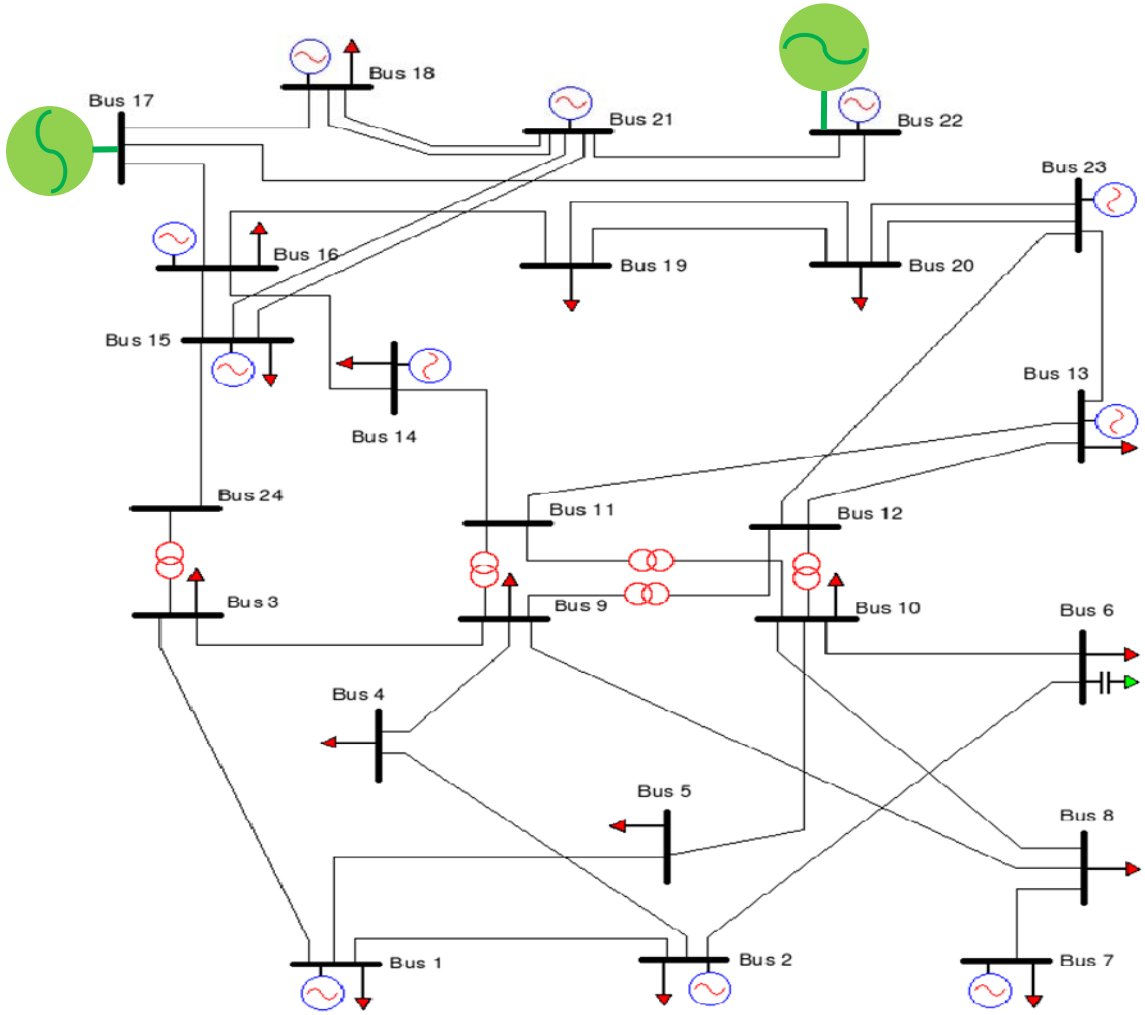
- 11 generator buses (including a slack bus)
  - Nuclear, coal, oil, natural gas
- Inelastic demand

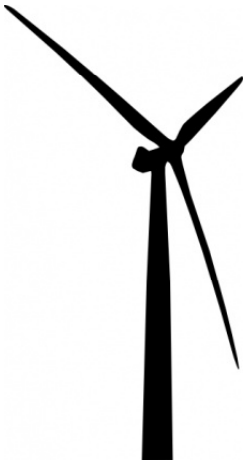
Current electric power systems



DYMONDS Simulator

Scenario 1: + Wind generation [3,4]





Le Xie

- 20% / 50% penetration to the system

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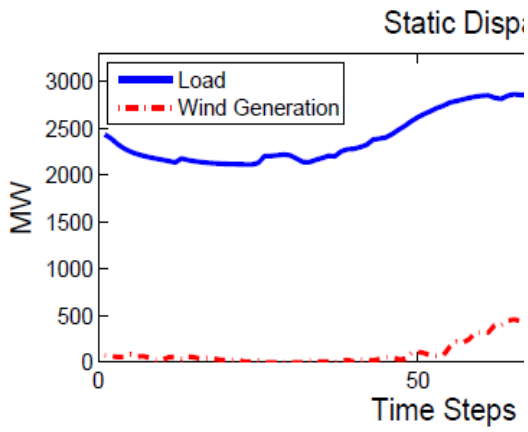
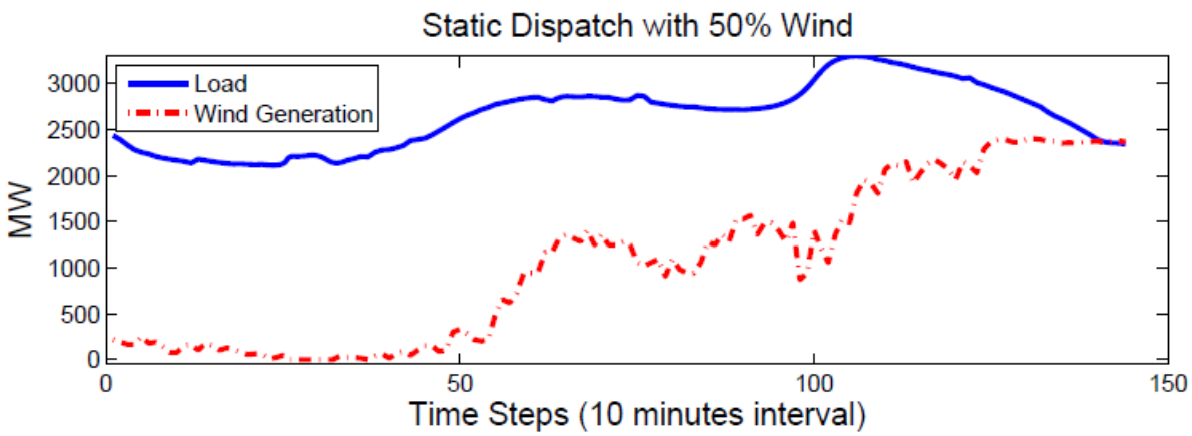
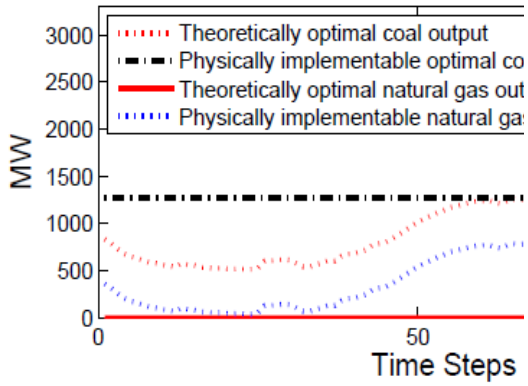
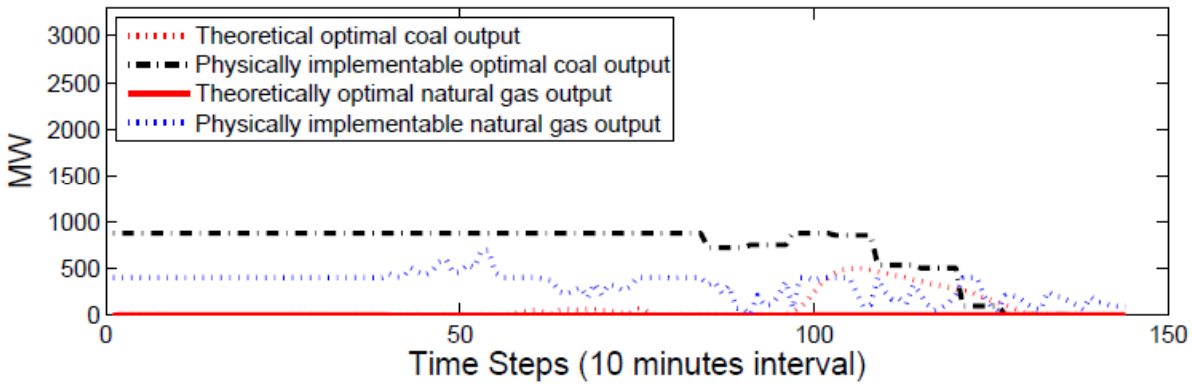
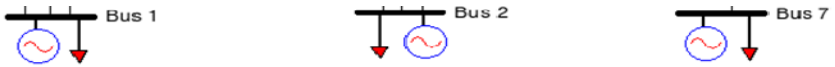
DYMONDS Simulator
Scenario 1: + Wind generation





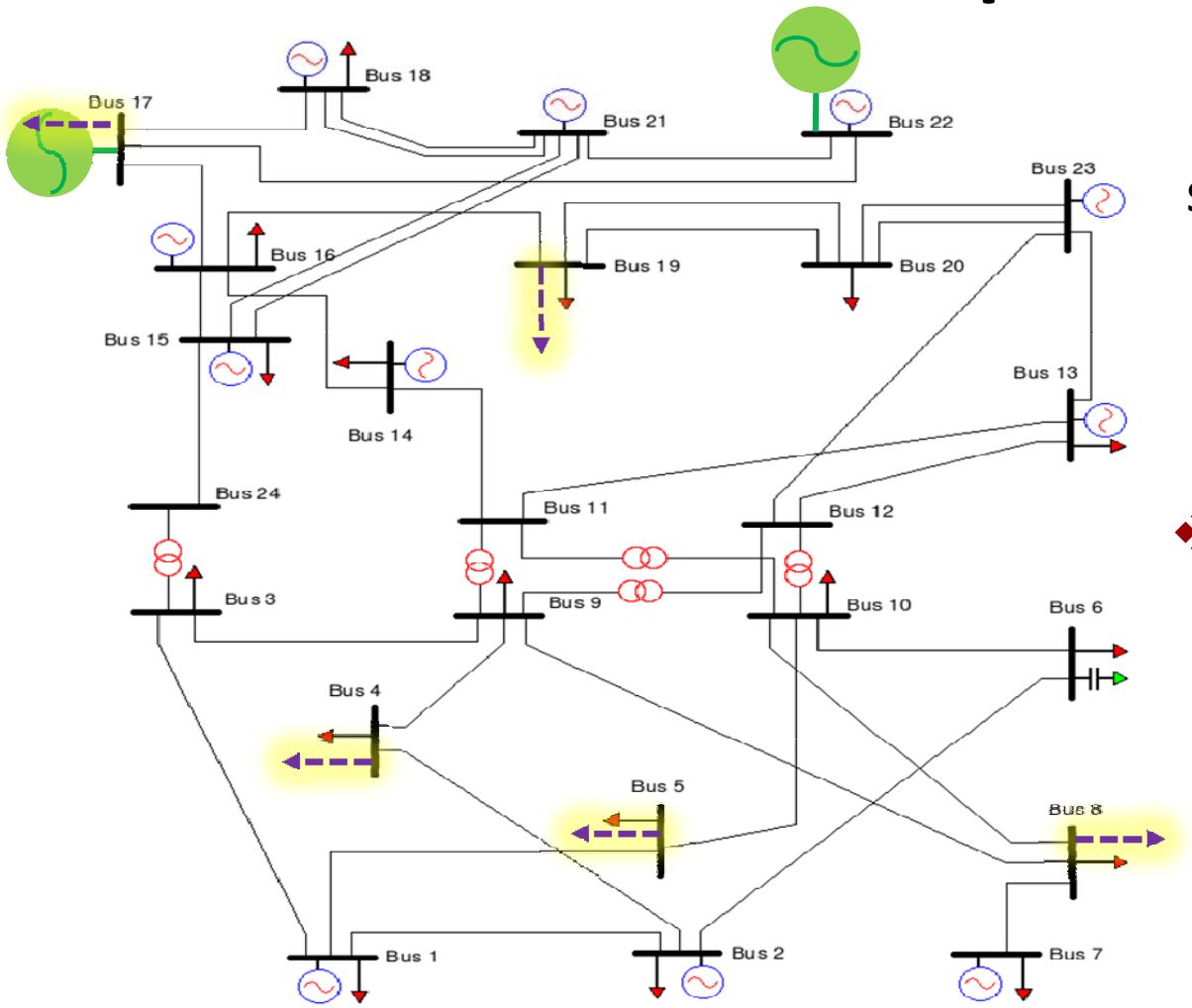


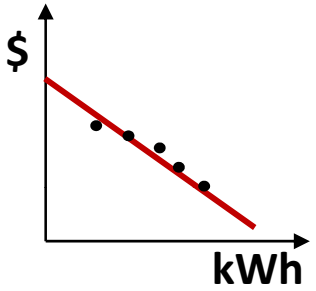




DYMONDS Simulator

Scenario 2: + Price-responsive demand [3-5]

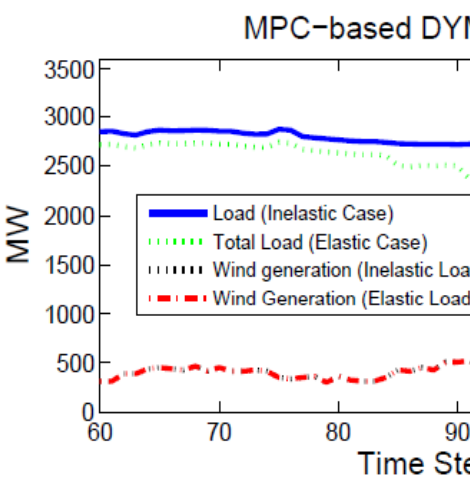


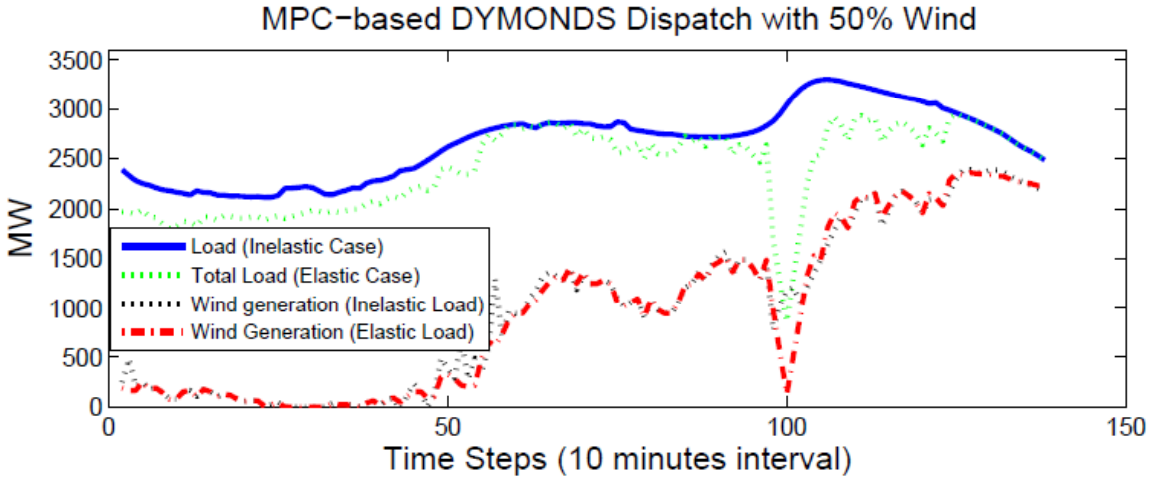


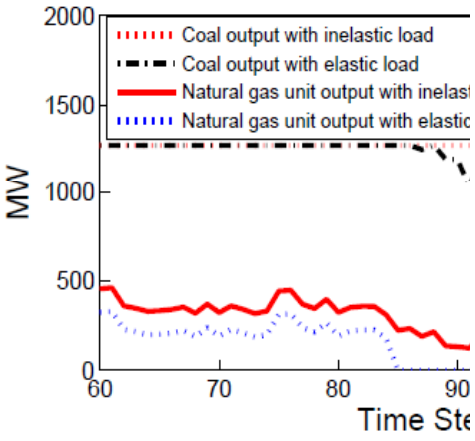
J.Y. Joo

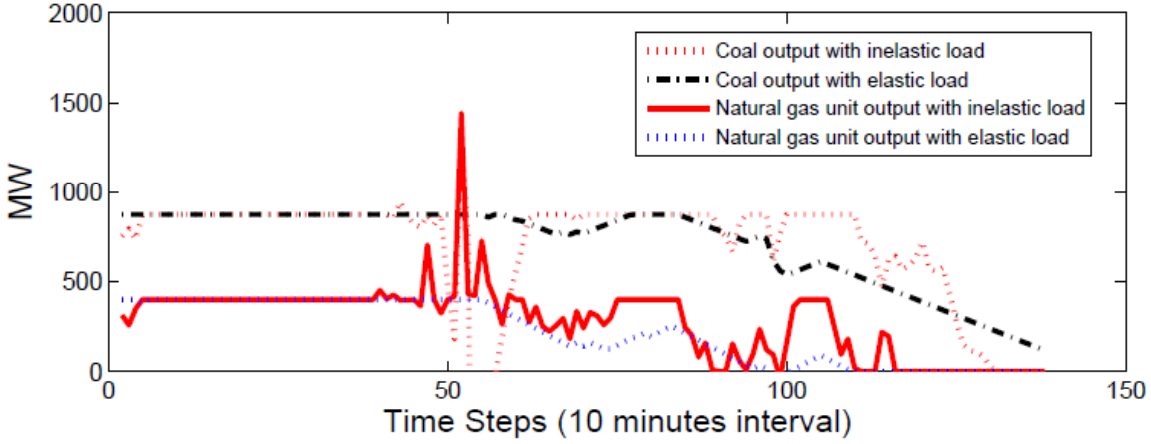
- Elastic demand that responds to time-varying prices

DYMONDS Simulator
Scenario 2: + Price-responsive demand









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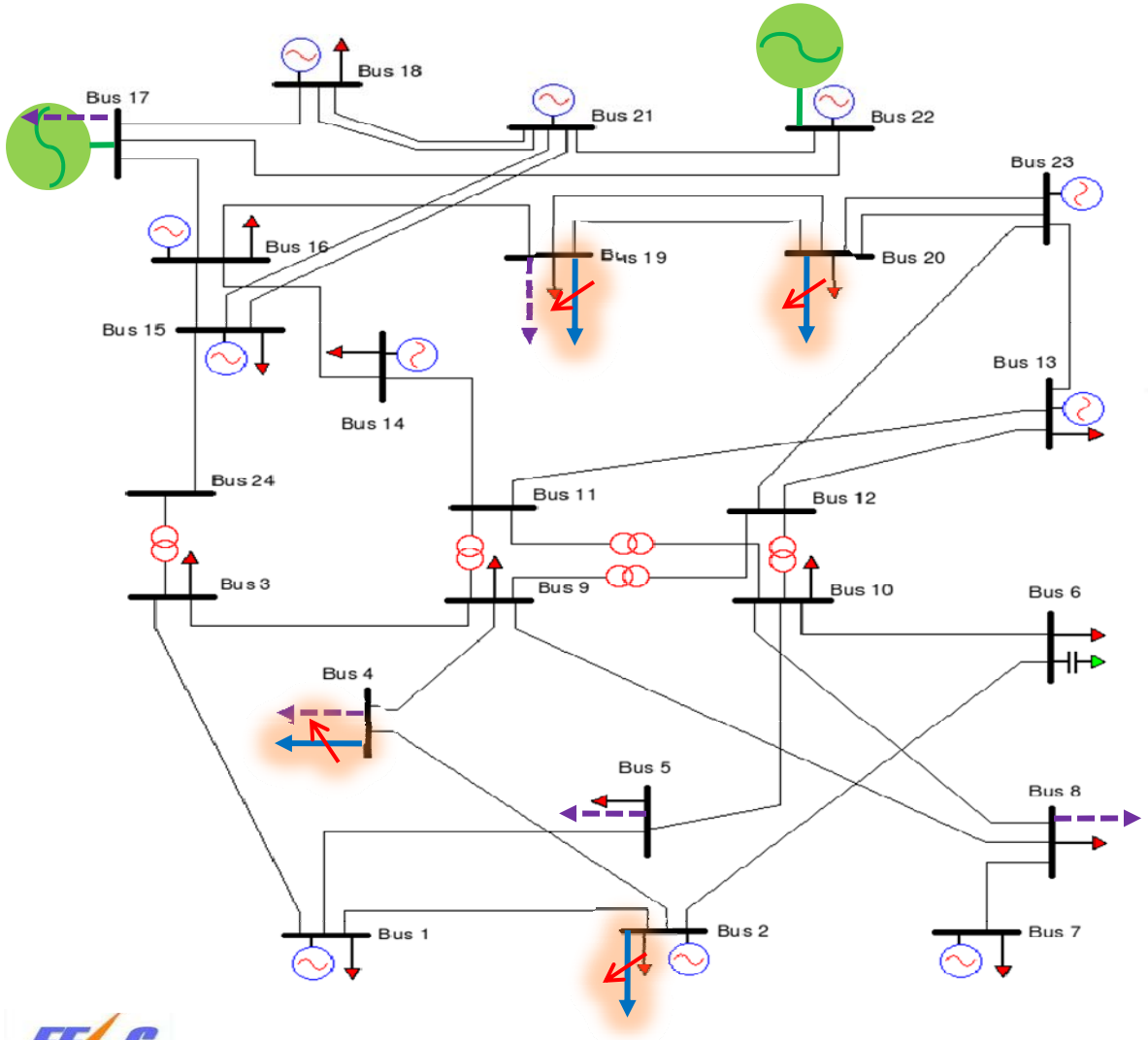
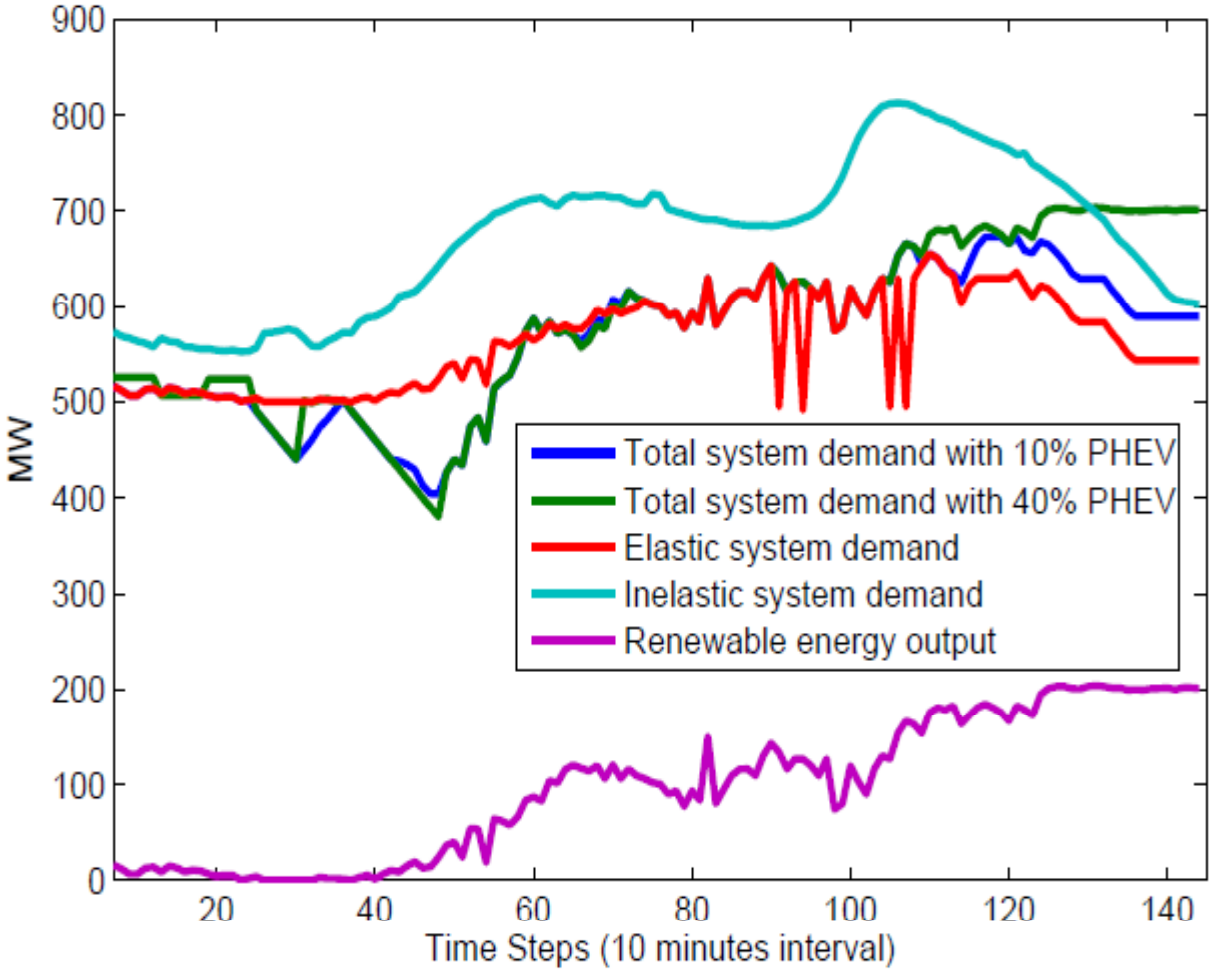
DYMONDS Simulator
Scenario 3: + Electric vehicles [6]



Niklas Rotering

- Interchange supply / demand mode by time-varying prices

DYMONDS Simulator
Scenario 3: + Electric vehicles [4]



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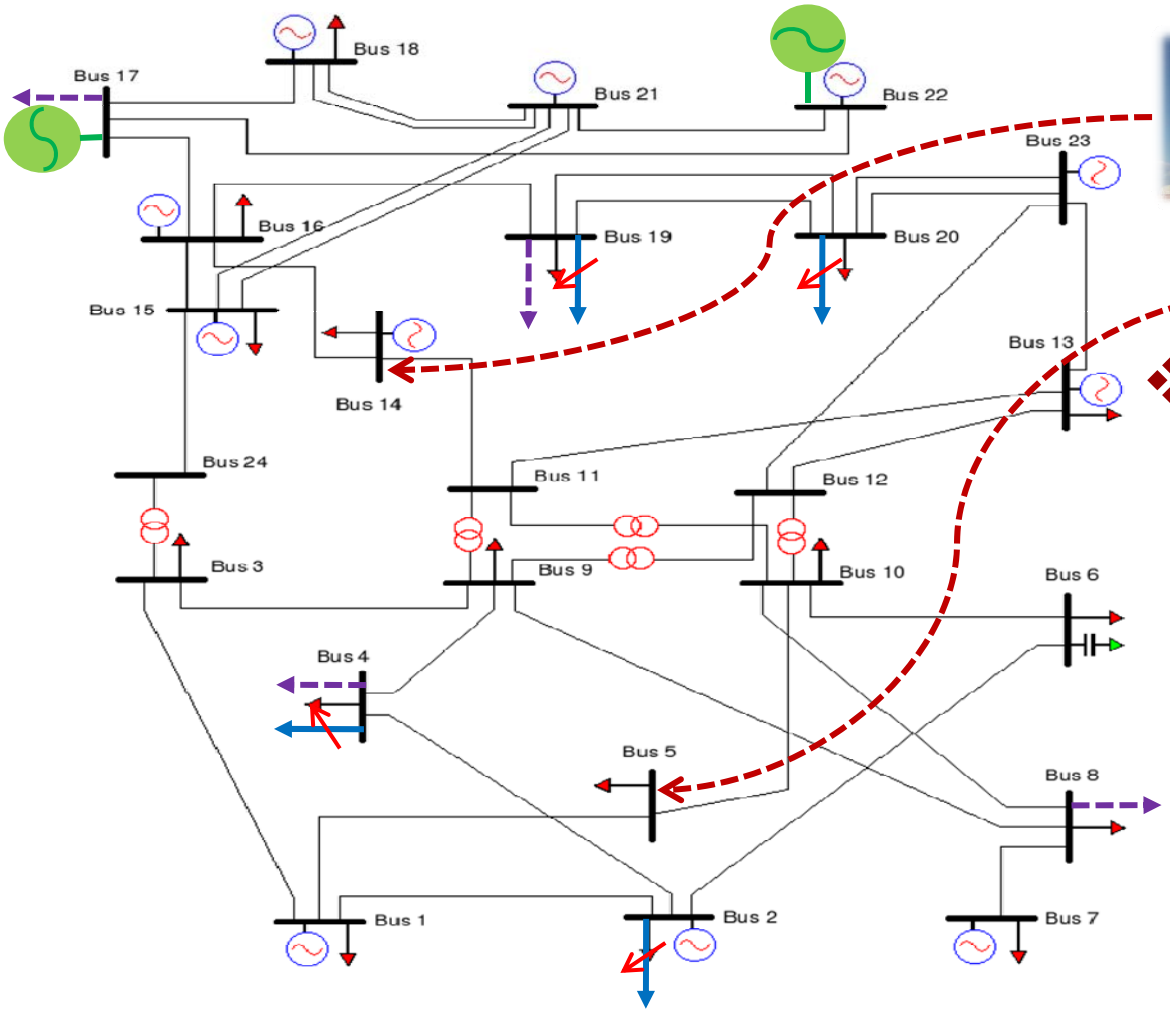
DYMONDS Simulator
Scenario 4: + long-run decision making [4]



Marija Prica

- Long-run planning of new generation capacity installation
  - Long-run marginal bids
  - For the next 10 years

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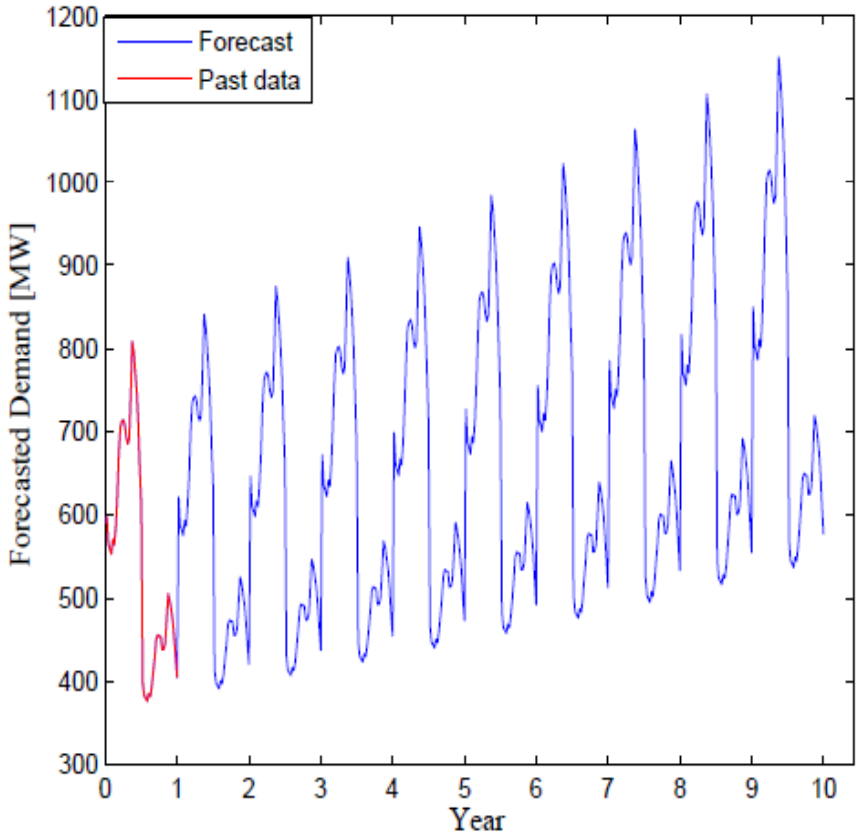
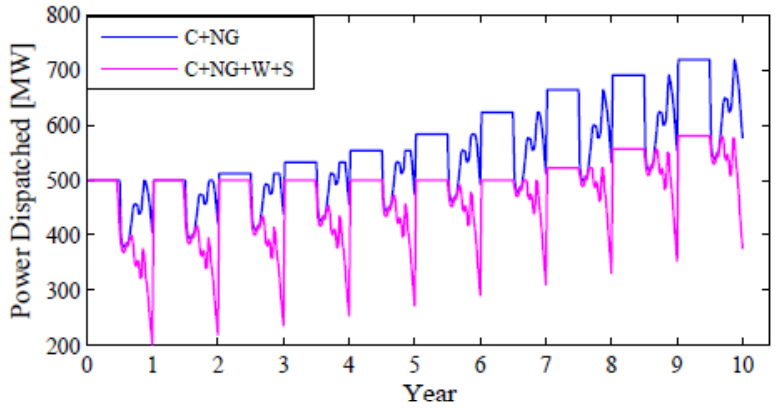
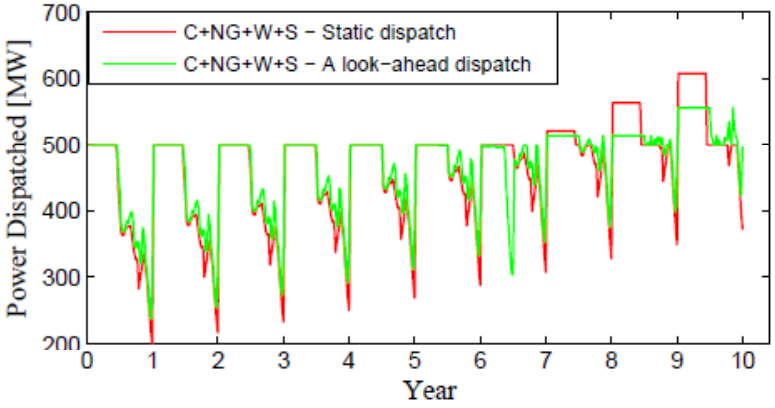
DYMONDS Simulator
Scenario 4: + long-run decision making

- Long-term load forecast



- Coal power plant

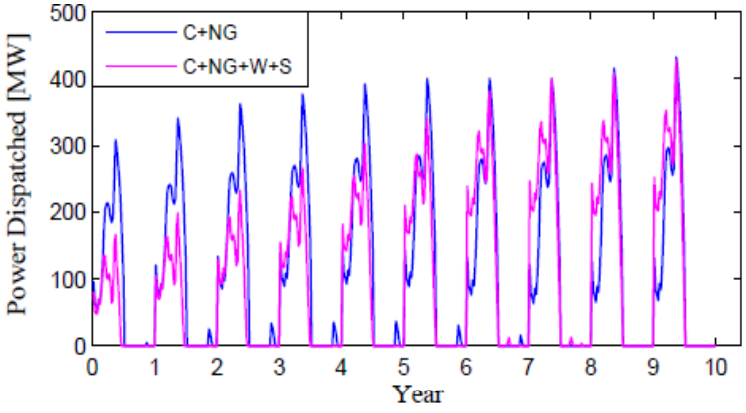


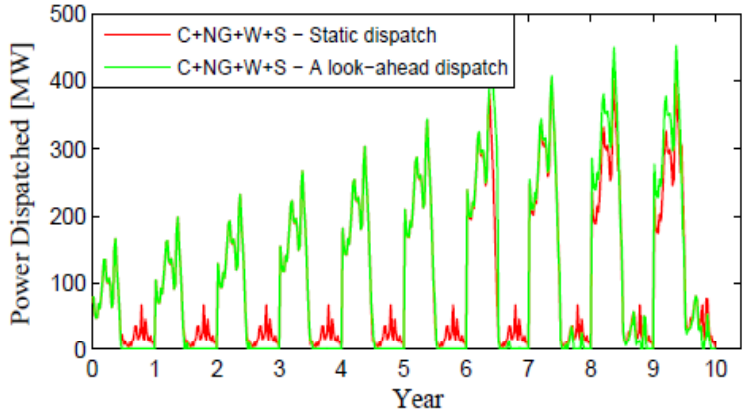


DYMONDS Simulator

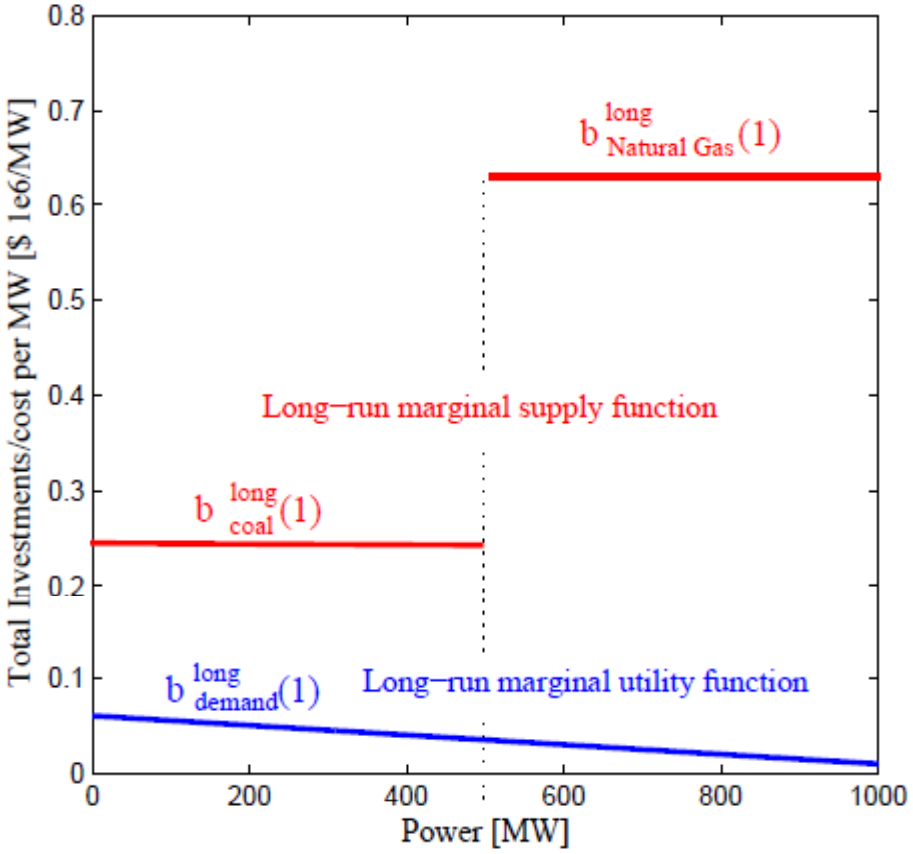
Scenario 4: + long-run decision making

- Natural gas power plant





- Long-run bidding functions



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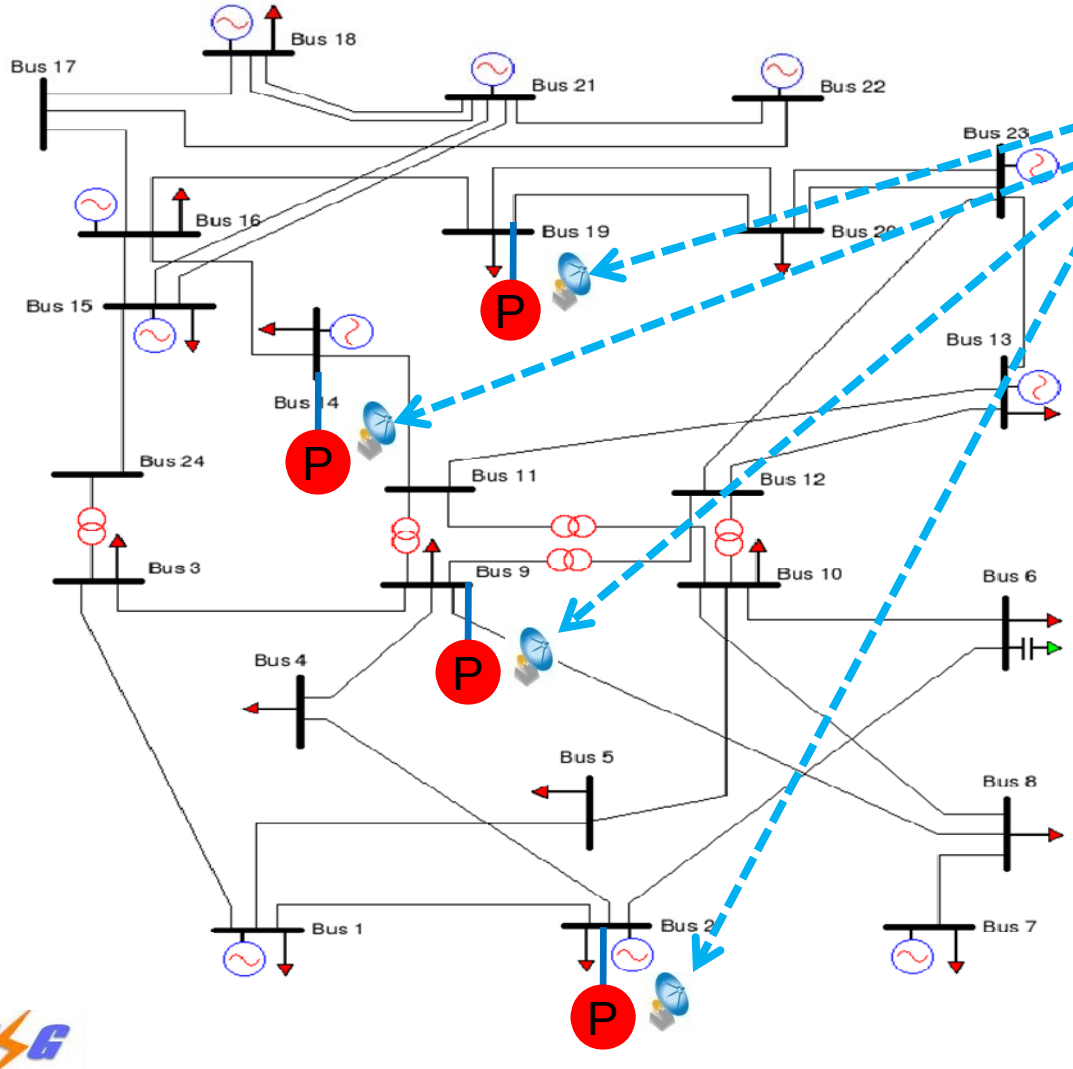
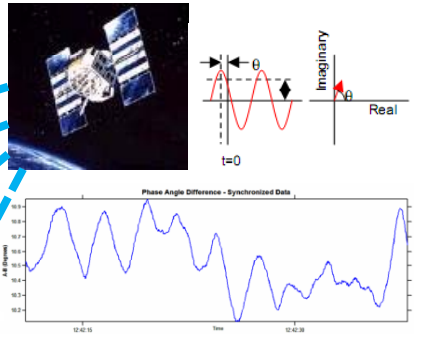
DYMONDS Simulator

Scenario 5: + PMU-Based Robust Control [7]





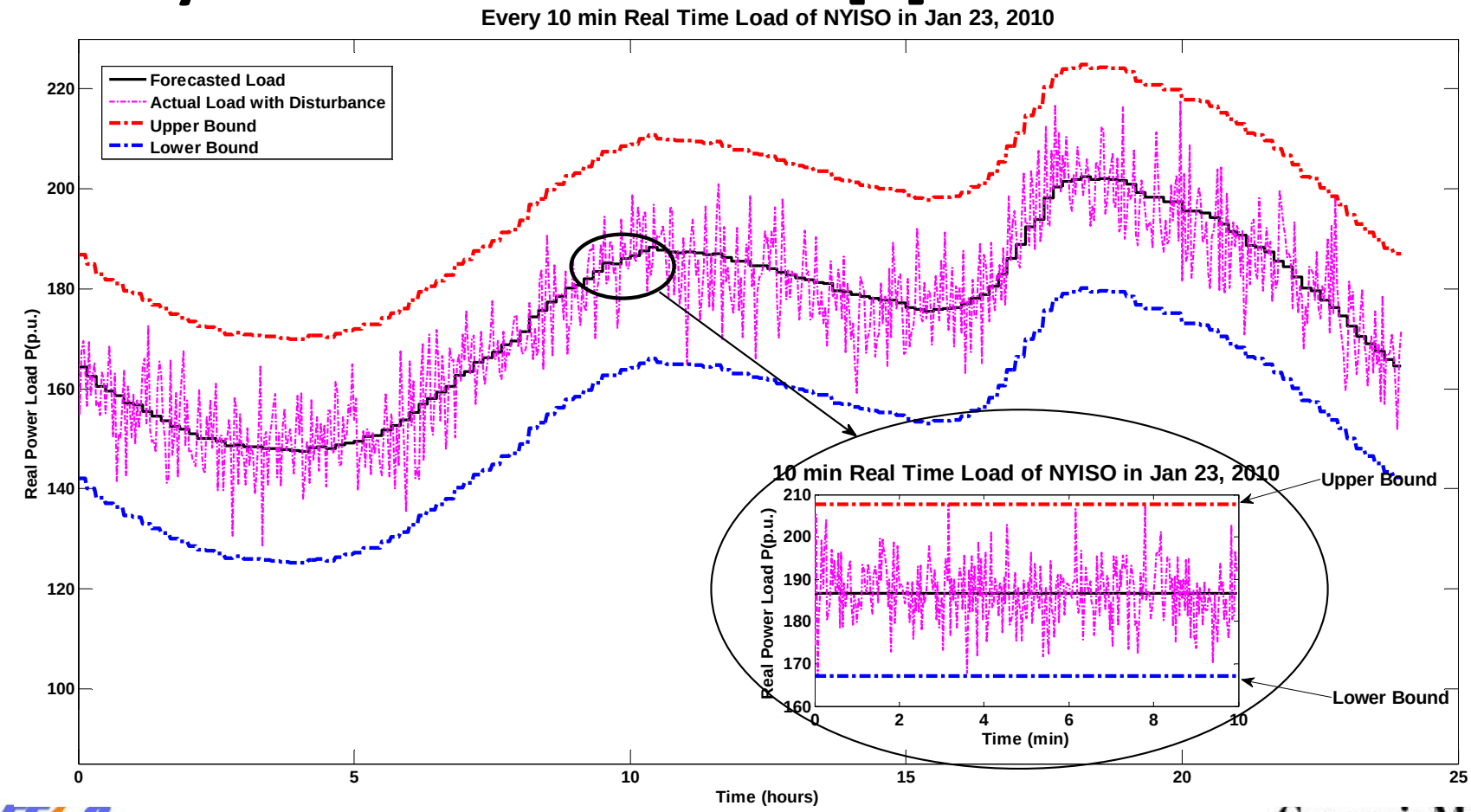
Zhijian Liu

Automated Voltage Control (AVC) and Automated Flow Control (AFC)

- Design Best Locations of PMUs
- Design Feedback Control Gains

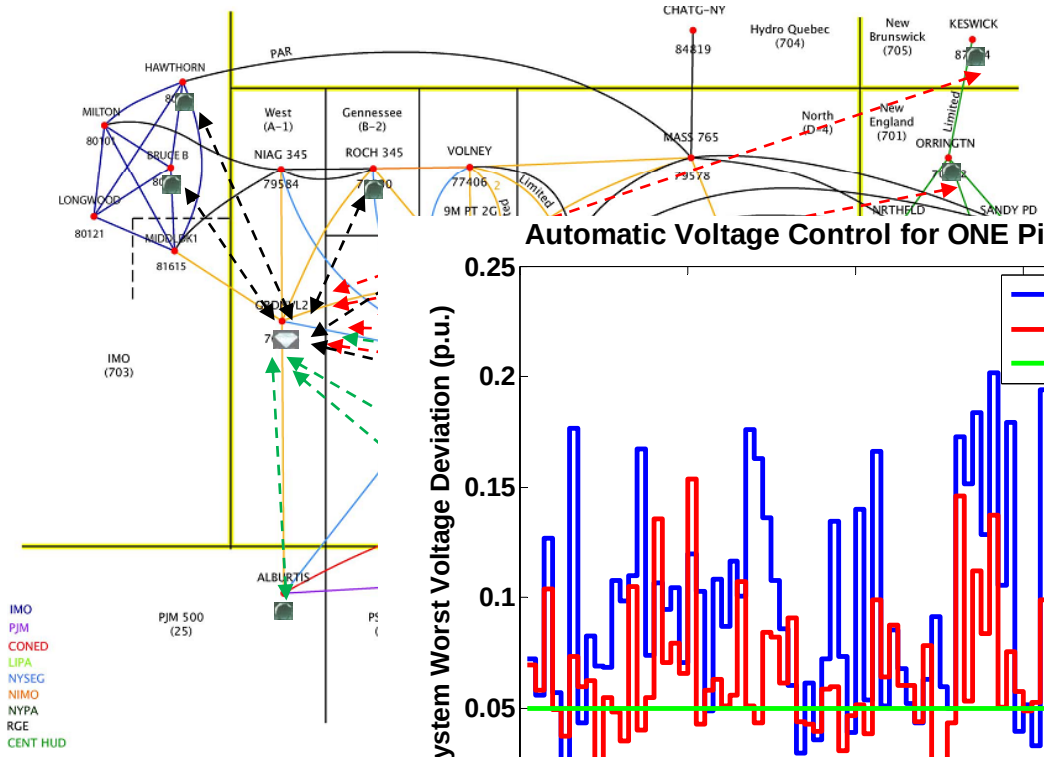
PMU-based Automatic Voltage and Flow Regulation

❖System Demand Curve [8]



PMU-based Automatic Voltage and Flow Regulation

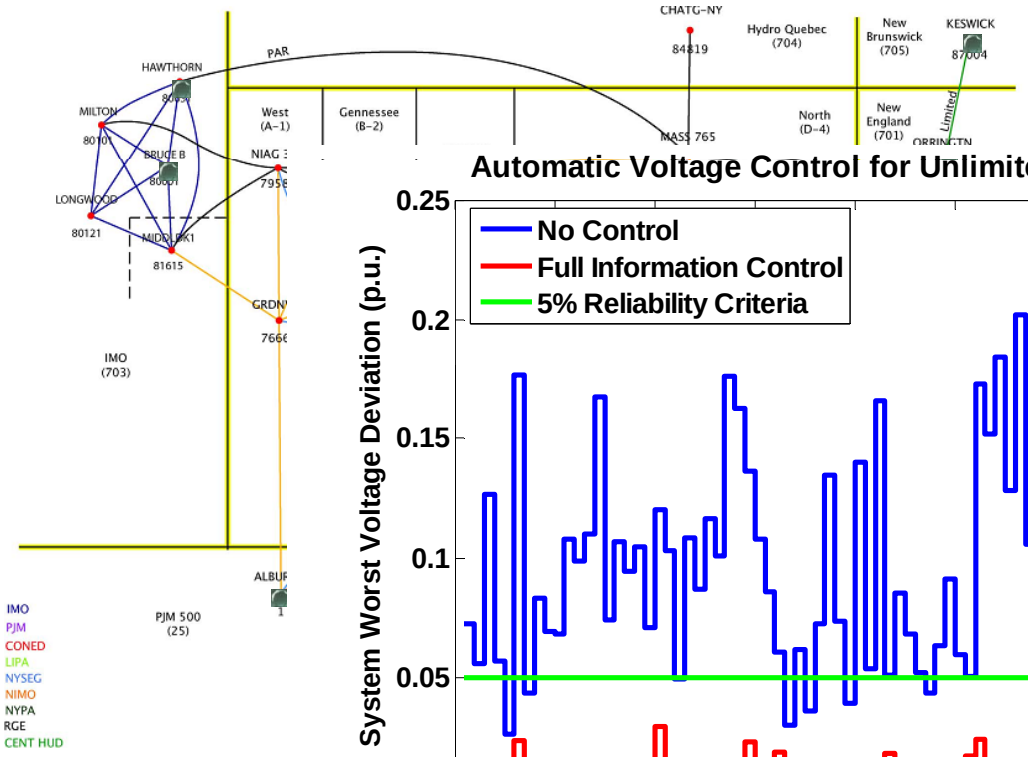
- **Robust AVC Illustration in NPCC System [7, 9]**



- **Limited System Observability**
- **Pilot Point: Bus 76663**

PMU-based Automatic Voltage and Flow Regulation

❖ Robust AVC Illustration in NPCC System



- Full System Observability

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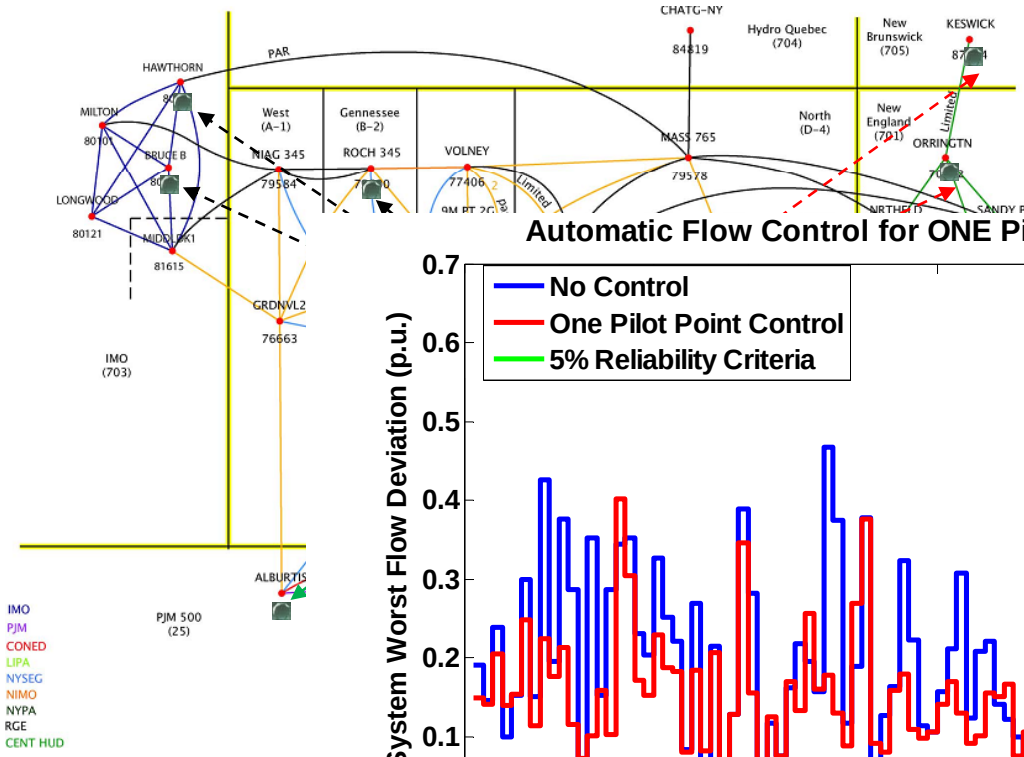
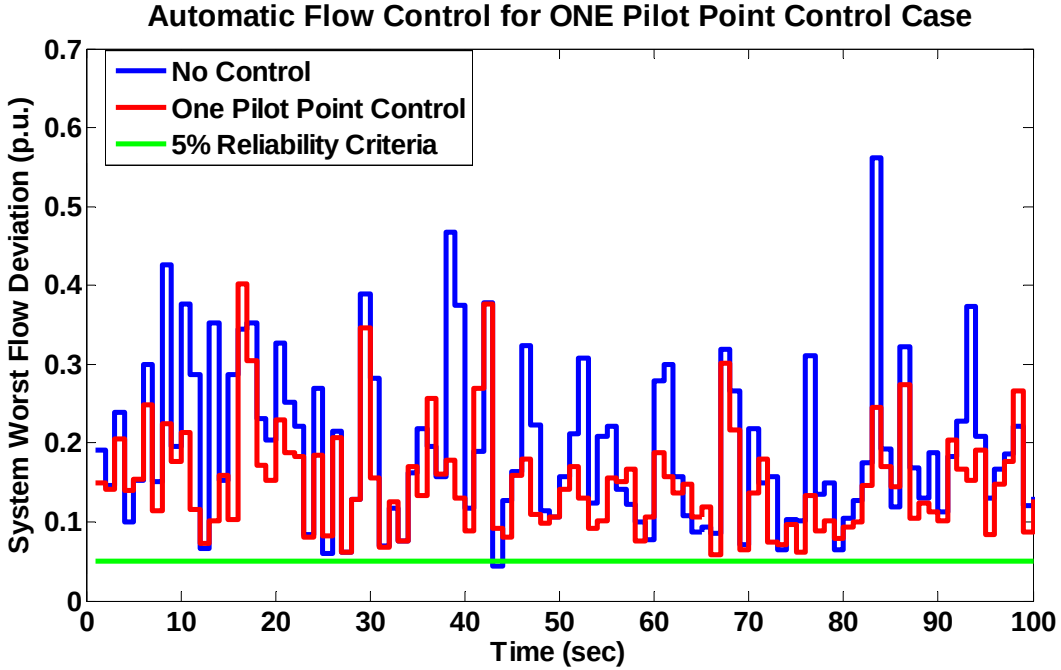
PMU-based Automatic Voltage and Flow Regulation

- **Robust AFC Illustration in NPCC System [7, 9]**



- **Limited System Observability**
- **Pilot Point: Bus 75403**



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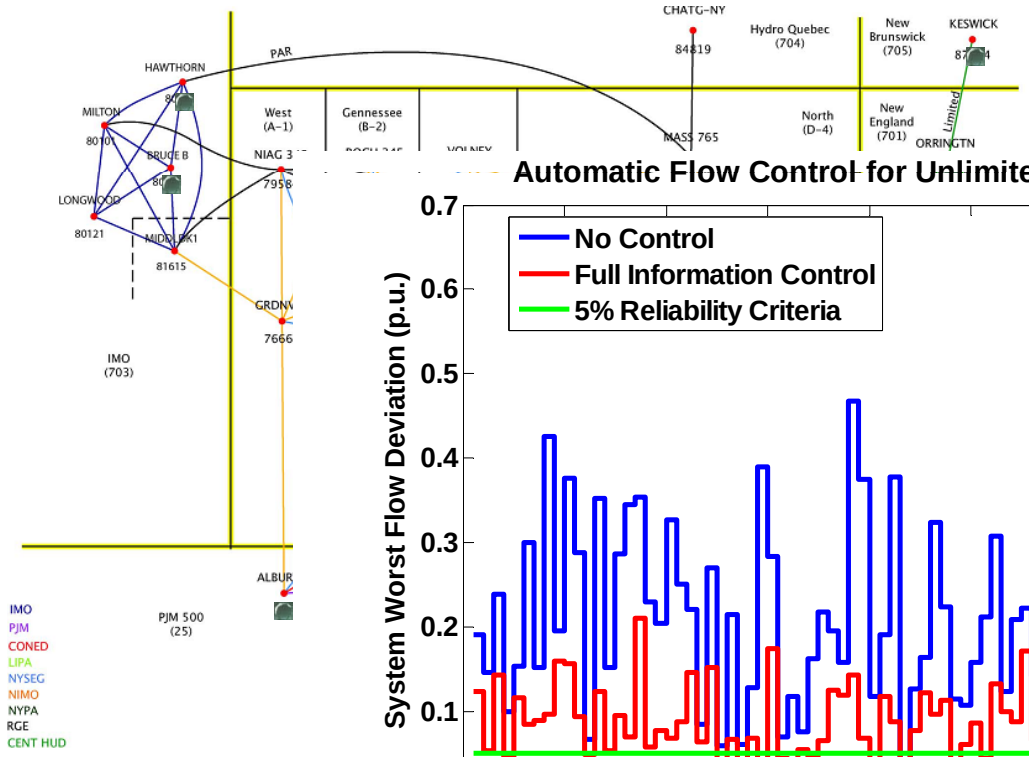
PMU-based Automatic Voltage and Flow Regulation

❖ Robust AFC Illustration in NPCC System



❖ Full System Observability

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Concluding remarks

- **Current power systems simulator**
  - Centralized optimization
  - Information and decision-making concentrated on ISO

- **Future energy systems simulator (DYMONDS)**
  - Distributed optimization
    → **modularized** components and decision-makings
  - Appropriate **information exchange** between the components
  - Balance of the system by ISO

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