

Design and Implementation of a Flexible Distributed Energy Management System to Investigate the Grid Integration of Controllable Distributed Energy Units



Source: IWES

Final Presentation for the
European Master of Renewable Energy
by
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Outline

- **Introduction to Grid Stability**
- Distributed Energy Management Systems (DEMS)
- Laboratory Equipment
- Motivation for Multi-tiered Aggregation of CDE's
- Experimental Procedure
- Results
- Conclusion

Electricity Grid Stability – The Double Balancing Act

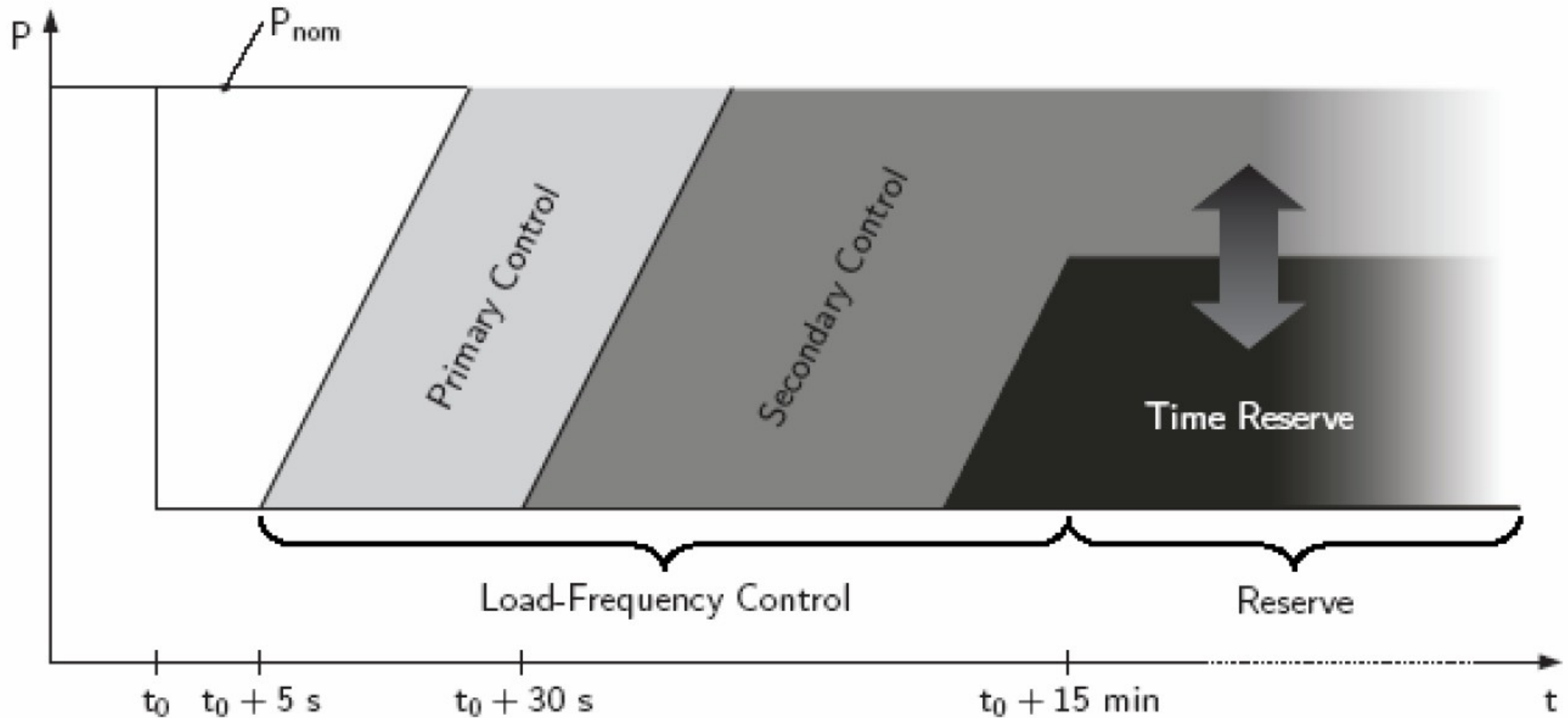
Frequency Control ~ Active Power Control

Voltage Control ~ Reactive Power Control

**Ancillary
Services**

My Focus = Active Power Control

What is Active Power Control?



Source:
German Electricity Reserve Markets
Riedel, S., Weigt, H.

My Focus = Secondary Control

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Distributed Energy Management Systems (DEMS)

Types

- Micro-grids
- Cells
- Virtual Power Plants
- ...



**Aggregation of
CDE's**

Distributed Energy Management Systems (DEMS)

**Why
Aggregate
CDE's?**

**To Overcome the Challenges of
Decentralised Energy Generation**

- More Demanding Logistics
- Greater Need for Information
- Grid Stability – Who Will Do It?
- Trade Barriers

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Laboratory Equipment

12 kW Wind Turbine (G2)



Source: IWES

16 kW CHP (G1)



G = Generator
L = Load

15 kVA SG



80 kVA SG



14 kW Electric Vehicle Charging Station (L1)



11 kW Industrial Load (L2)

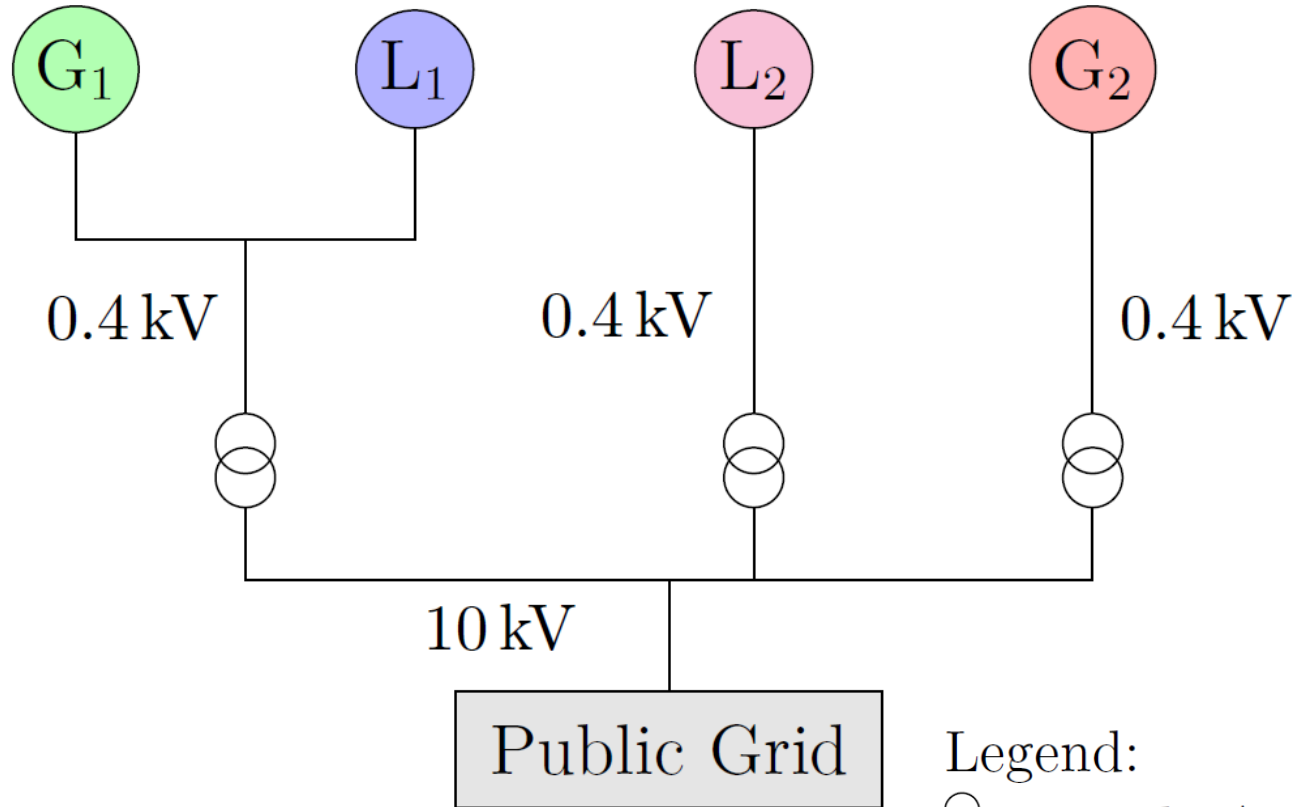


20 kVA
Generator



12 kVA
Load

Electrical Configuration



Legend:

 = 100 kVA Transformer

G_1 = 16 kW CHP

G_2 = 12 kW Wind turbine

L_1 = 14 kW Electric vehicle charging station

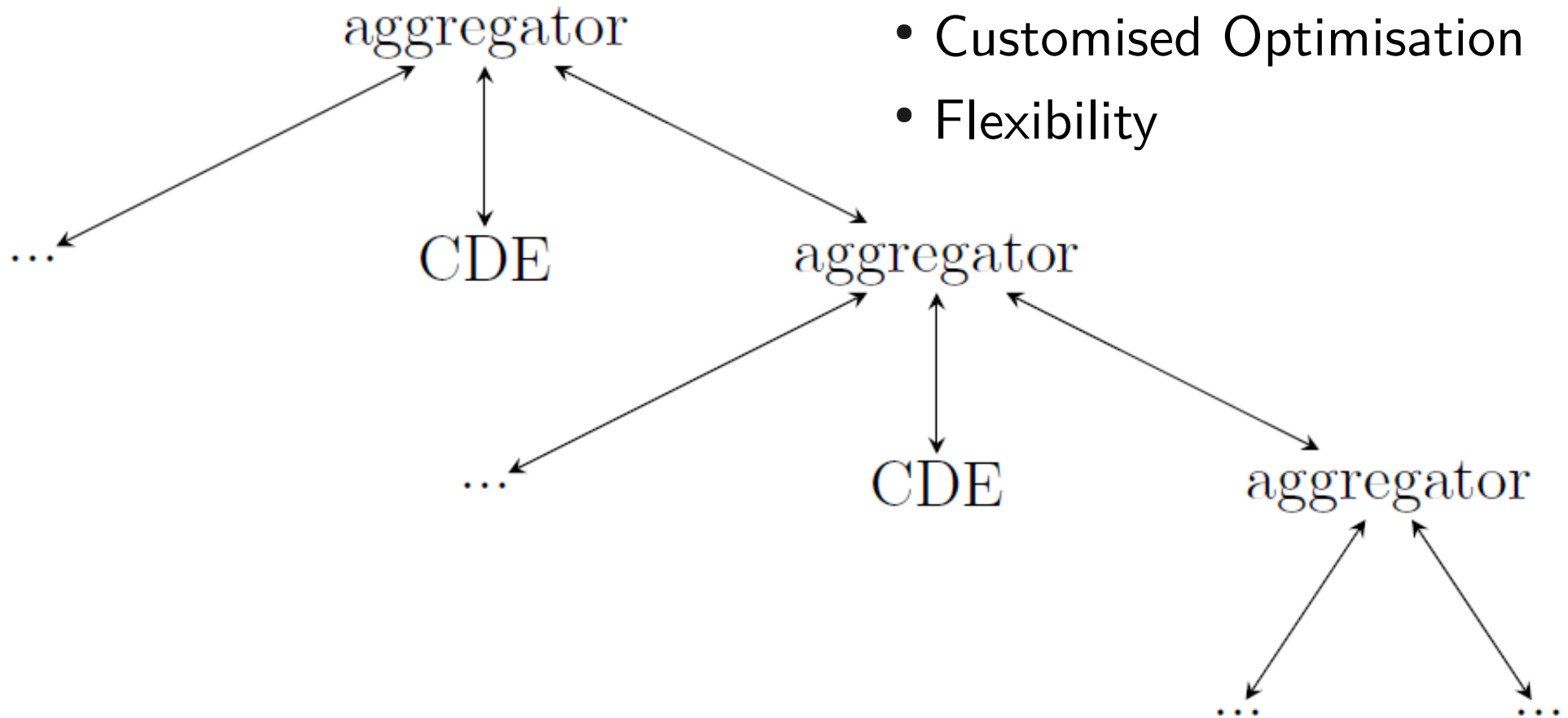
L_2 = 11 kW Industrial load

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Motivation for Multi-tiered Aggregation of CDE's

- Research
- New Business Models
- Customised Optimisation
- Flexibility



Outline

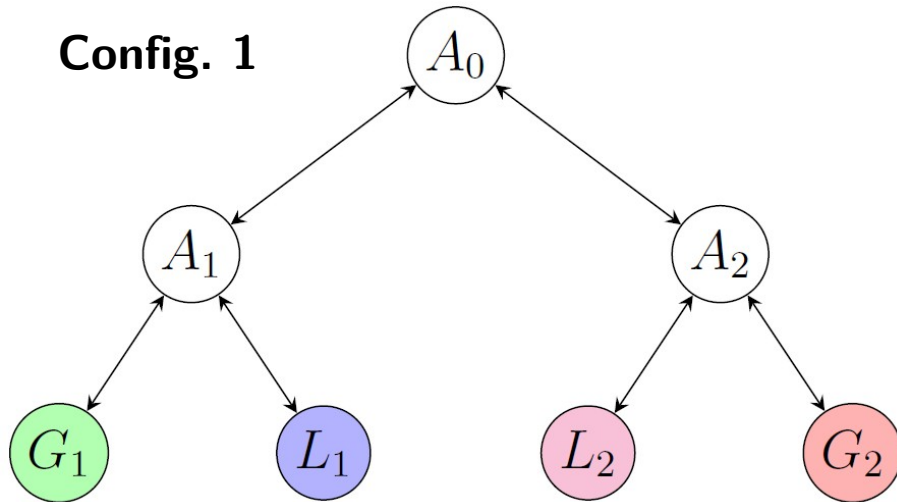
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Assumptions

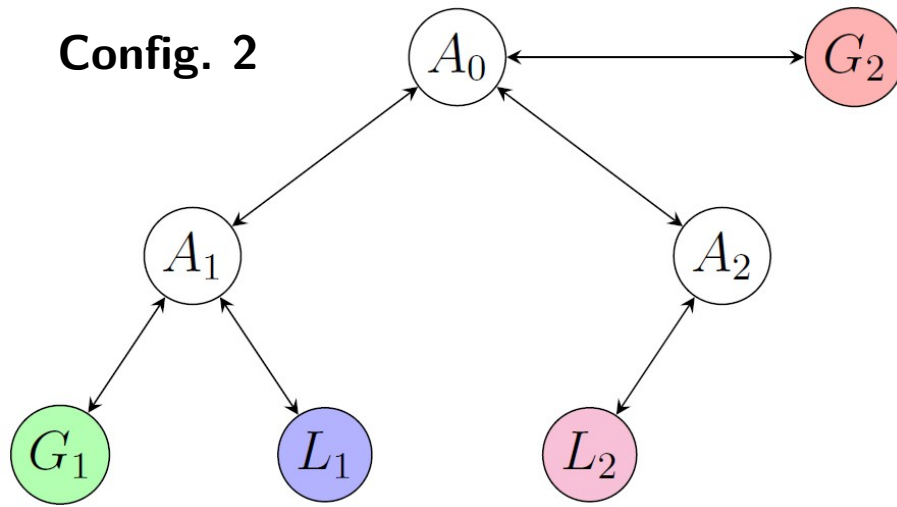
- Market flexibility
- Primary remuneration from German Feed-in tariff
- Obligated by law to provide active power control.
Remunerated at a lower rate

Comparing Two Communication Configurations

Config. 1



Config. 2



Aims

- Create a software based DEMS
- Flexible Design
- Hierarchically Independent
- User Friendly
- Active Power Output Independent of CDE Configuration
- Possible to Incorporate Other Optimisation Algorithms and Simulation Packages

Legend:

↔ = TCP/IP connection

A₀ = Root agent

A₁ = Agent 1

A₂ = Agent 2

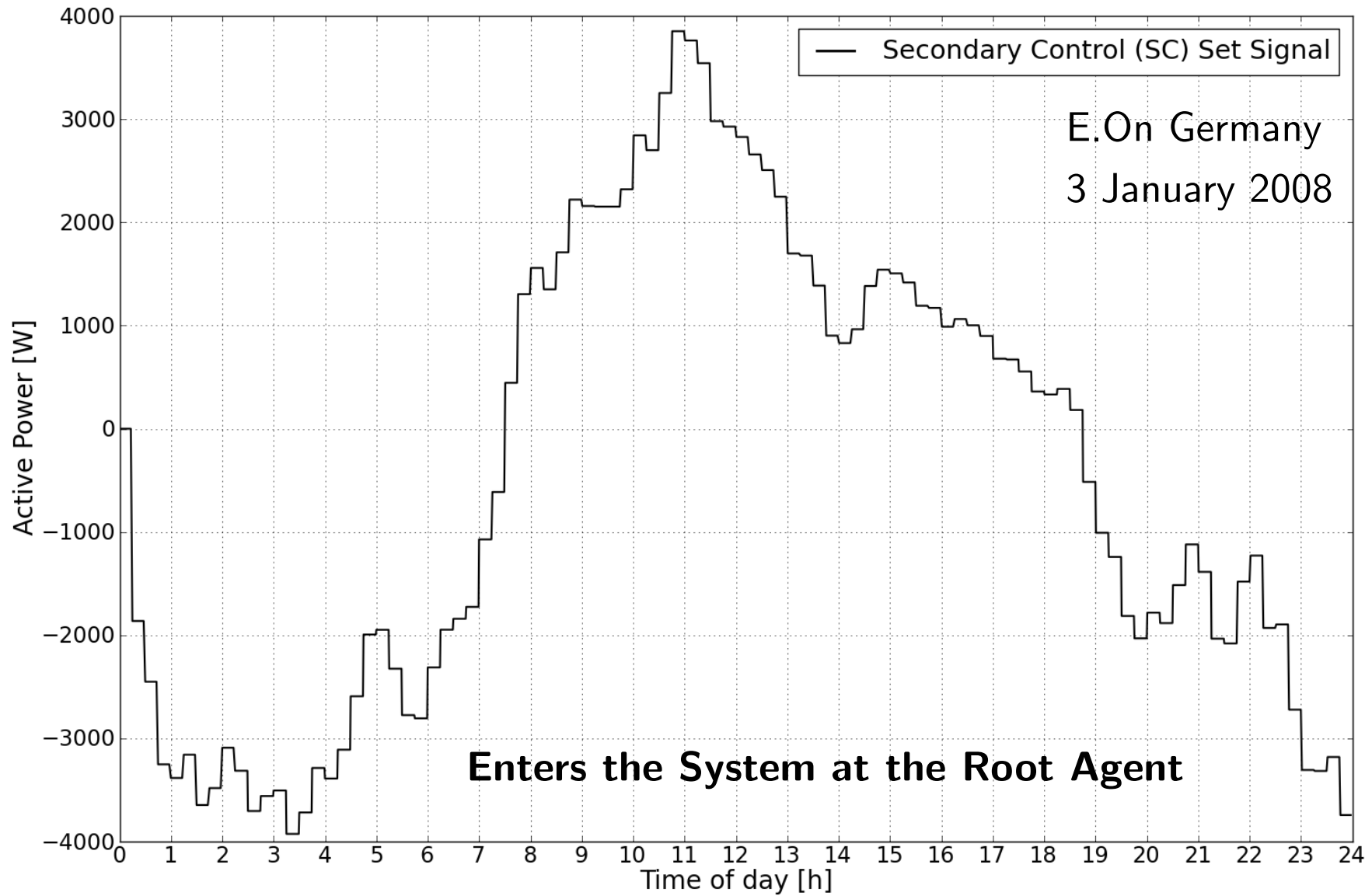
G₁ = 16 kW CHP

G₂ = 12 kW Wind turbine

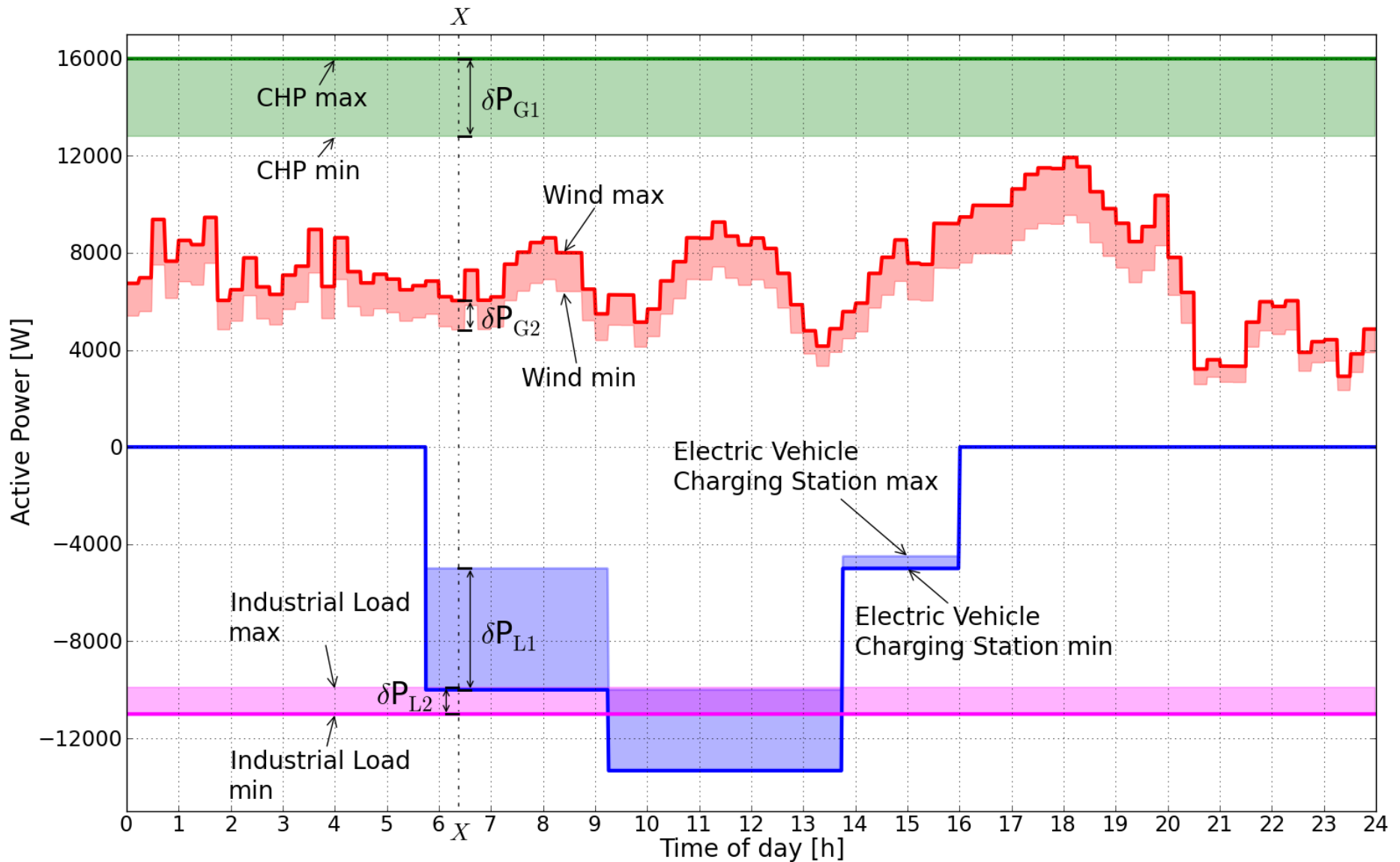
L₁ = 14 kW Electric vehicle charging station

L₂ = 11 kW Industrial load

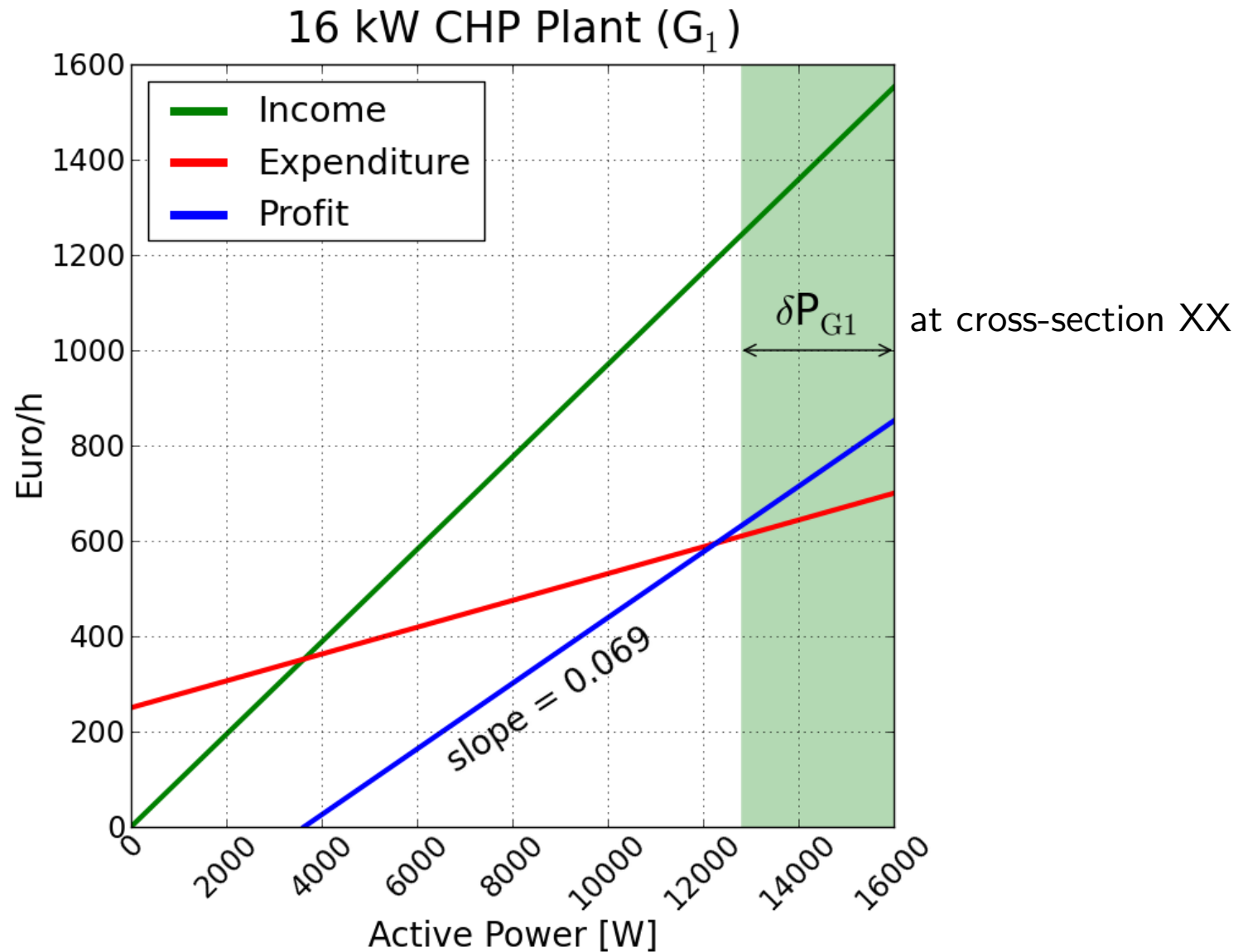
Secondary Control Signal



Active Power Profiles & Operating Ranges



Decision Making Criteria – Profit & Power

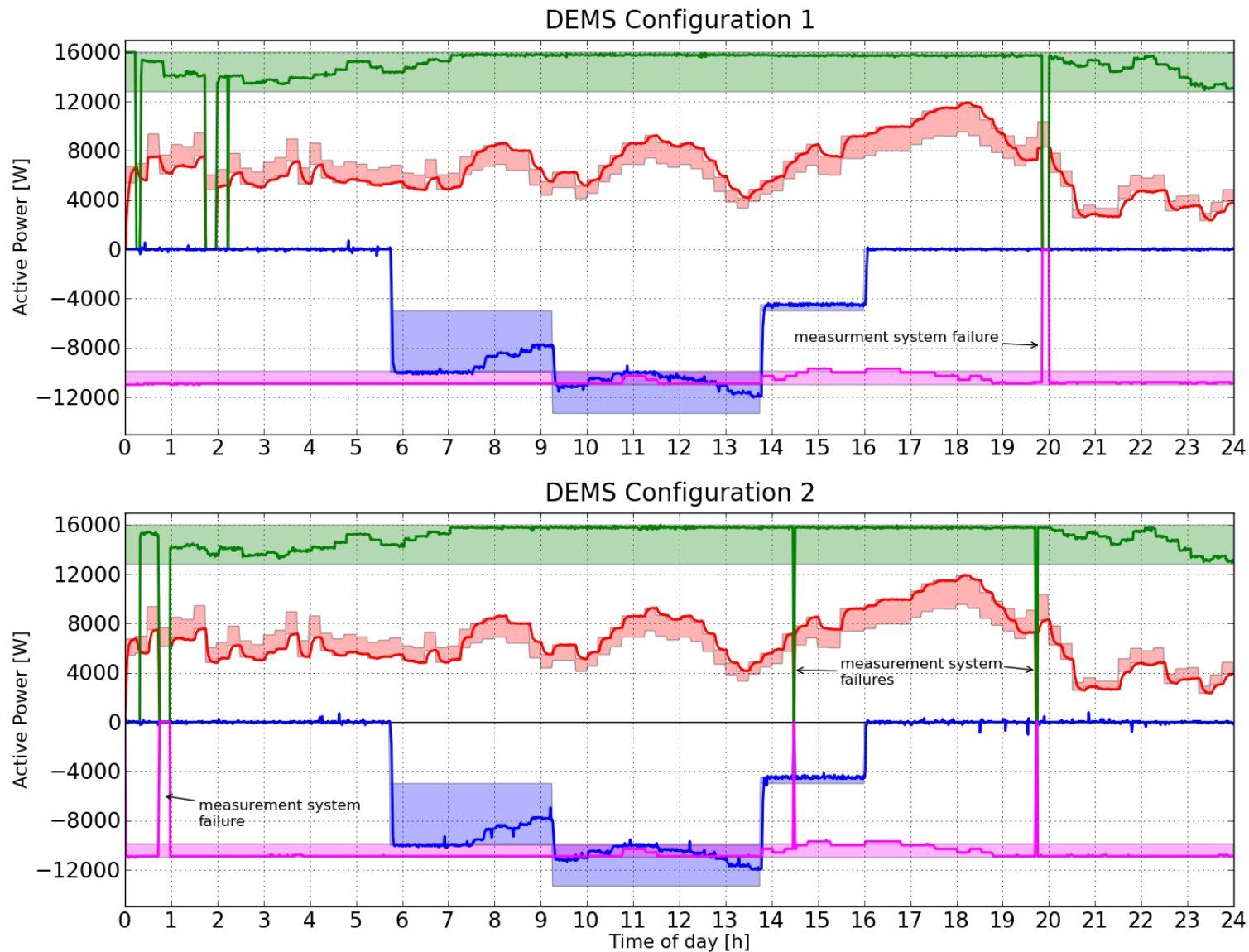


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Show External DEMS Animation

Comparison of Output from Config. 1 & 2



Conclusions

- Flexible Design ✓
- Hierarchically Independent ✓
- User Friendly ✓
- Active Power Output Independent of CDE Configuration ✓
- Possible to Incorporate Other Algorithms and Simulation Packages ✗

The End

Thank You
For
Your Attention

Questions Please

Scaling the Secondary Control Signal

