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Microgrids –
The future of Small Grids

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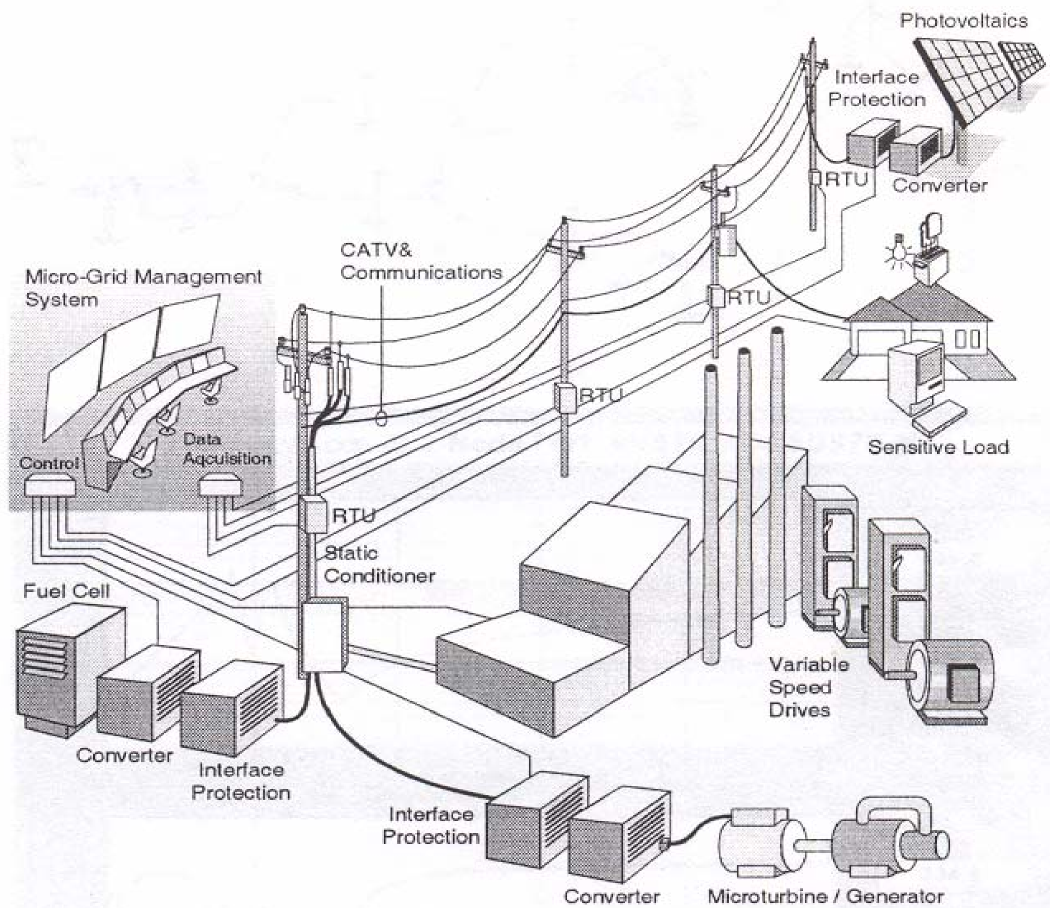
FPS 2005

What are MICROGRIDS?

Interconnection of small, modular generation to low voltage distribution systems forms a new type of power system, **the Microgrid**.

Microgrids can be connected to the main power network or be operated islanded, in a coordinated, controlled way.



Technical, economical and environmental benefits

- Energy efficiency
- Minimisation of the overall energy consumption
- Improved environmental impact
- Improvement of energy system reliability and resilience
- Network benefits
- Cost efficient electricity infrastructure replacement strategies

Energy Efficiency - Combined Heat and Power

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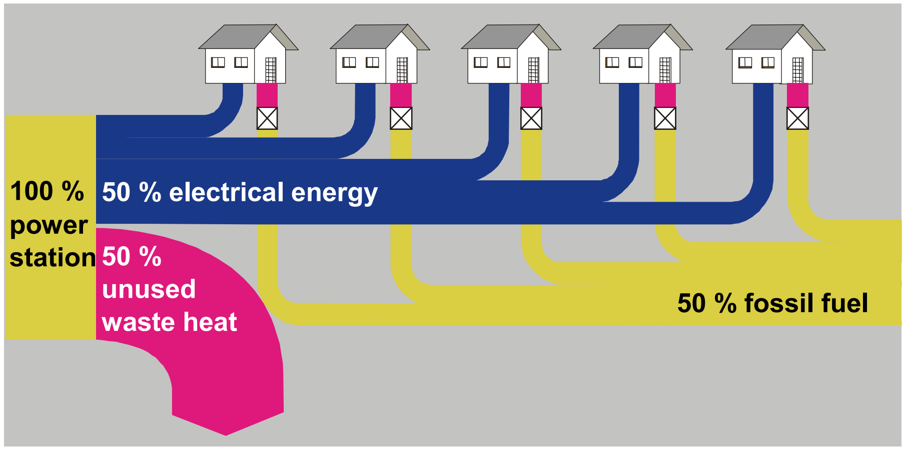

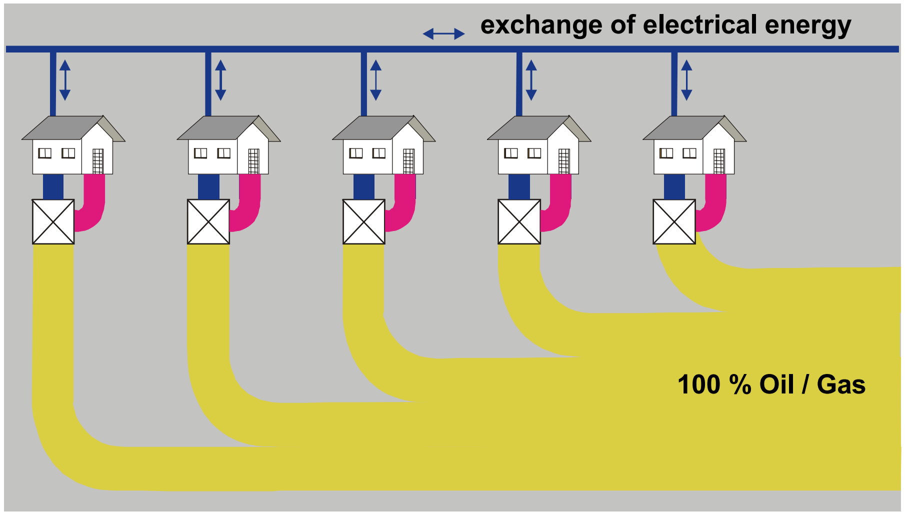

Prof. Dr. J. Schmid

Up to now:

- Central power stations
- Decentral heat production

In Future:

- Decentral combined heat and power

⇒ 1/3 less consumption of fossil sources of energy

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Climate & Power Disasters:

Normal in the future?

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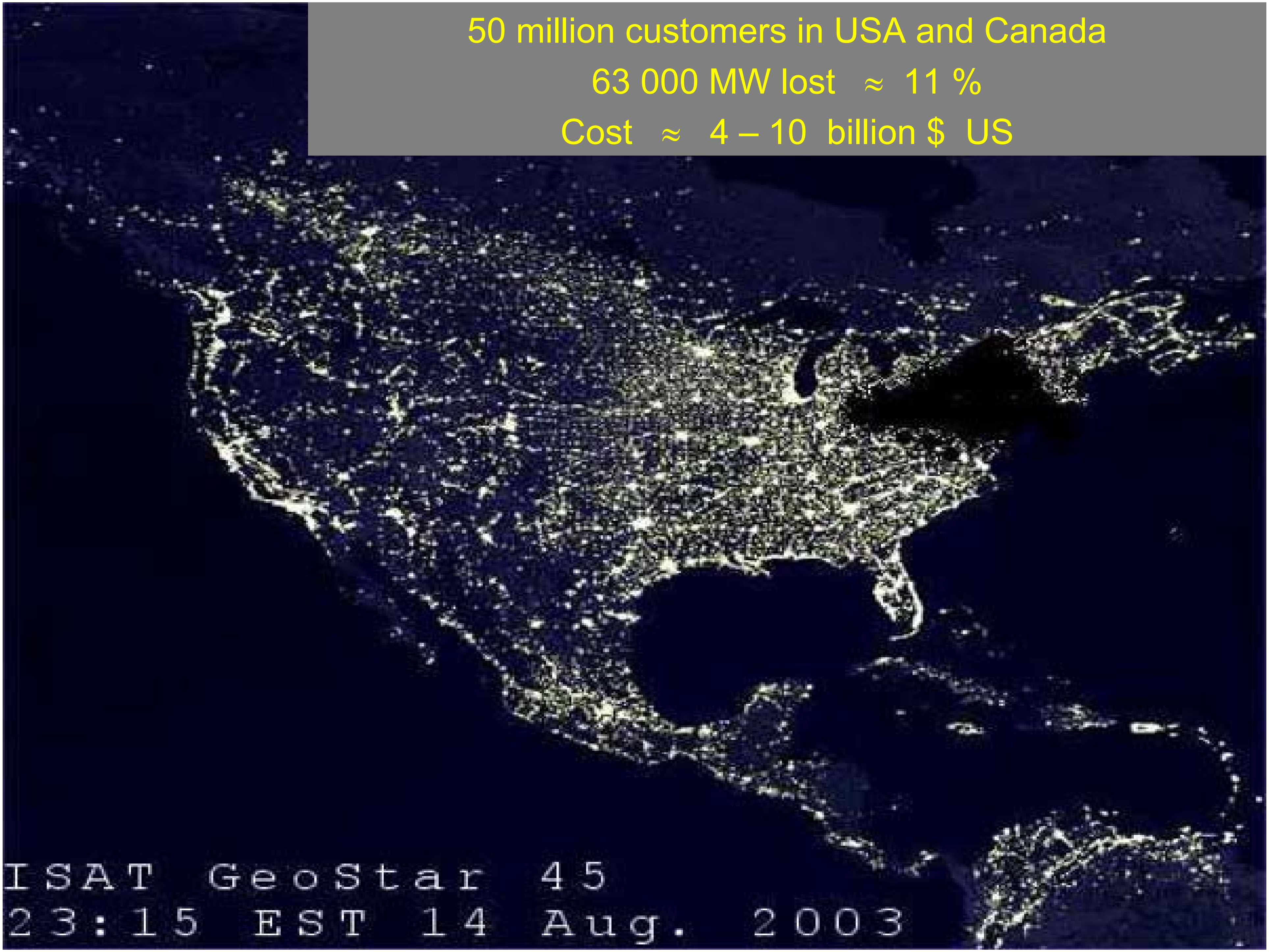
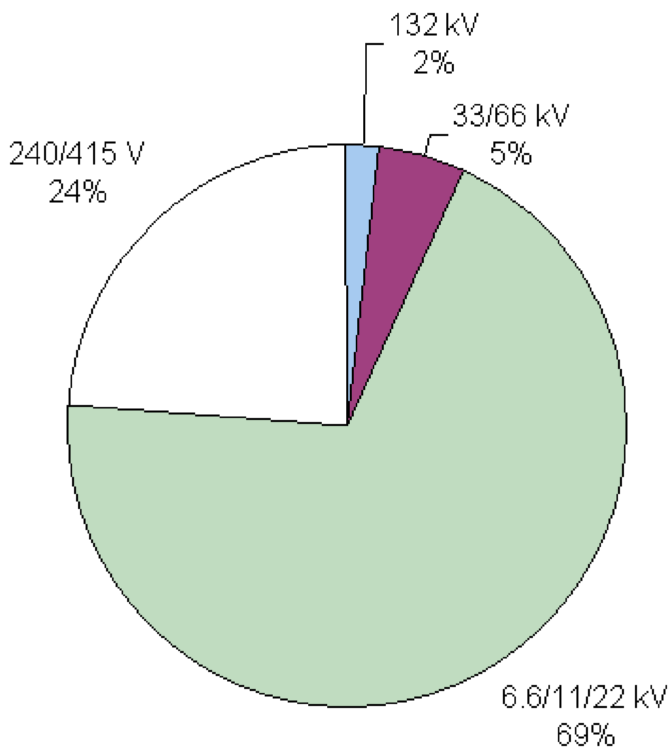
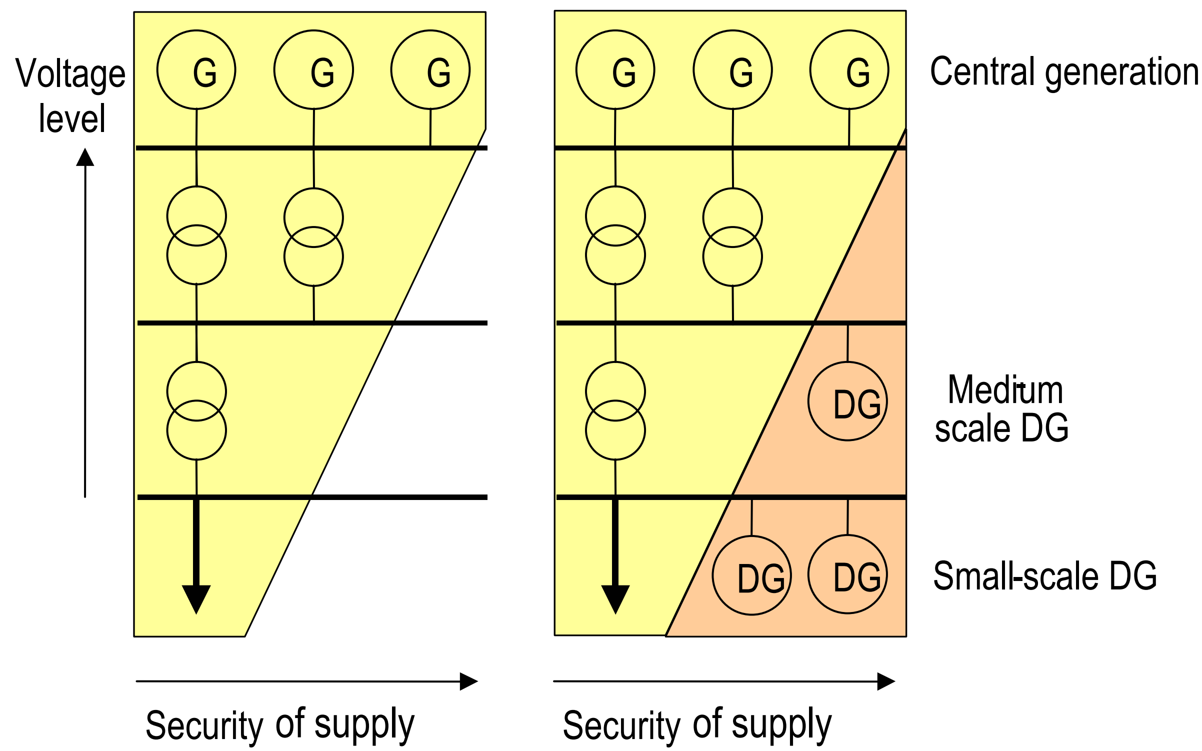

50 million customers in USA and Canada
63 000 MW lost ≈ 11 %
Cost ≈ 4 – 10 billion $ US
ISAT GeoStar 45
23:15 EST 14 Aug. 2003

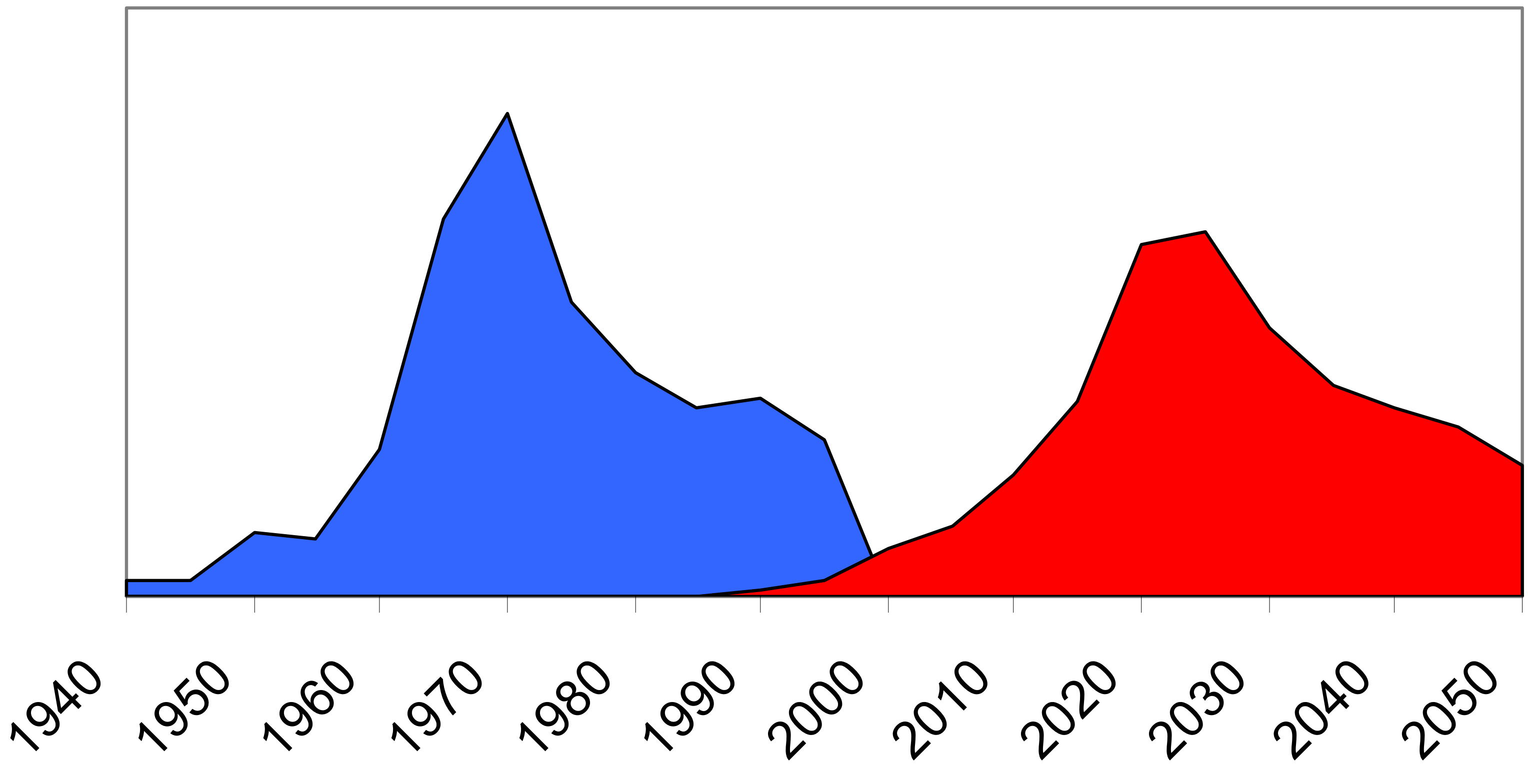
Potential for DG to improve service quality



Distribution of CMLs



Installation and Replacement time Distributions of Substation Equipment



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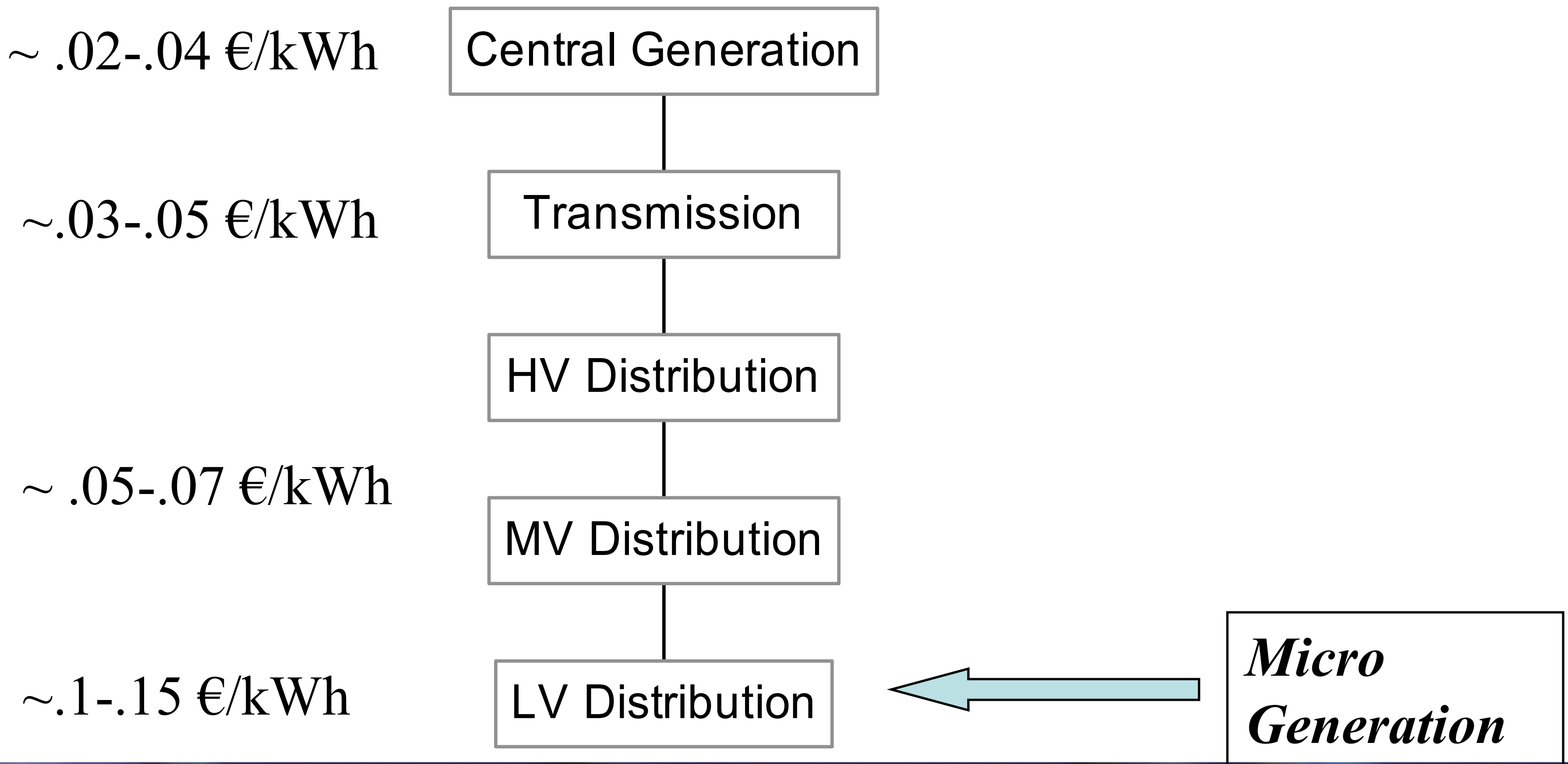
Network Benefits –
Value of Micro Generation



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Technical Challenges for Microgrids

- Relatively large imbalances between load and generation to be managed (significant load participation required, need for new technologies, review of the boundaries of microgrids)
- Specific network characteristics (strong interaction between active and reactive power, control and market implications)
- Small size (challenging management)
- Use of different generation technologies (prime movers)
- Presence of power electronic interfaces
- Protection and Safety

Market and Regulatory Challenges

- coordinated but decentralised energy trading and management
- market mechanisms to ensure efficient, fair and secure supply and demand balancing
- development of islanded and interconnected price-based energy and ancillary services arrangements for congestion management
- secure and open access to the network and efficient allocation of network costs
- alternative ownership structures, energy service providers
- new roles and responsibilities of supply company, distribution company, and consumer/customer

EC MICROGRIDS Project

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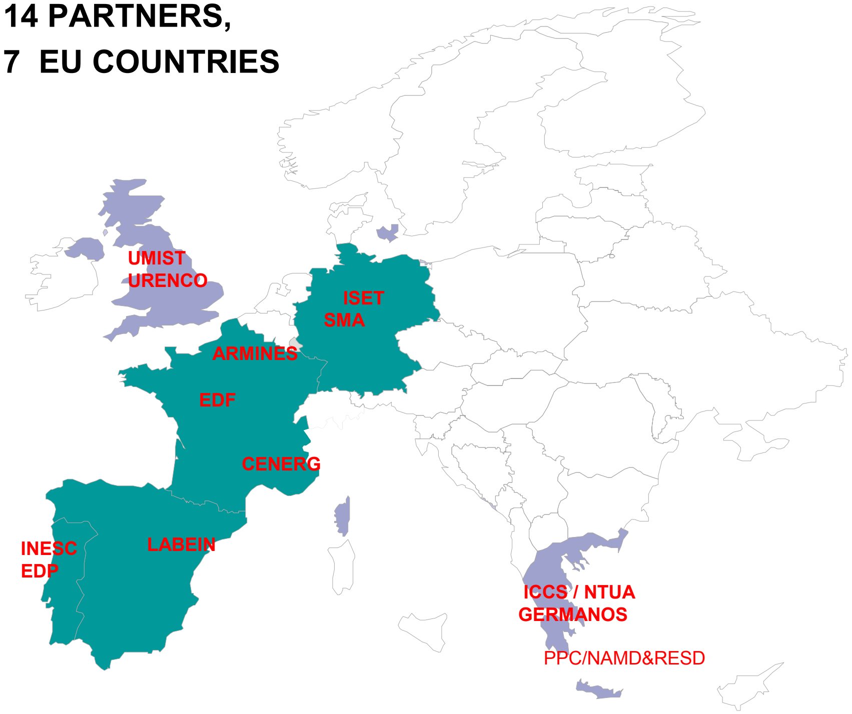
"Large Scale Integration of Micro-Generation to Low Voltage Grids

Contract : ENK5-CT-2002-00610

14 PARTNERS,

7 EU COUNTRIES



GREAT BRITAIN
- UMIST
- URENCO

PORTUGAL
- EDP
- INESC

SPAIN
- LABEIN

NETHERLANDS
- EMforce

GREECE
- NTUA
- PPC /NAMD&RESD
- GERMANOS

GERMANY
- SMA
- ISET

FRANCE
- EDF
- Ecole des Mines de Paris/ARMINES
- CENERG

http://microgrids.power.ece.ntua.gr

R&D Objectives

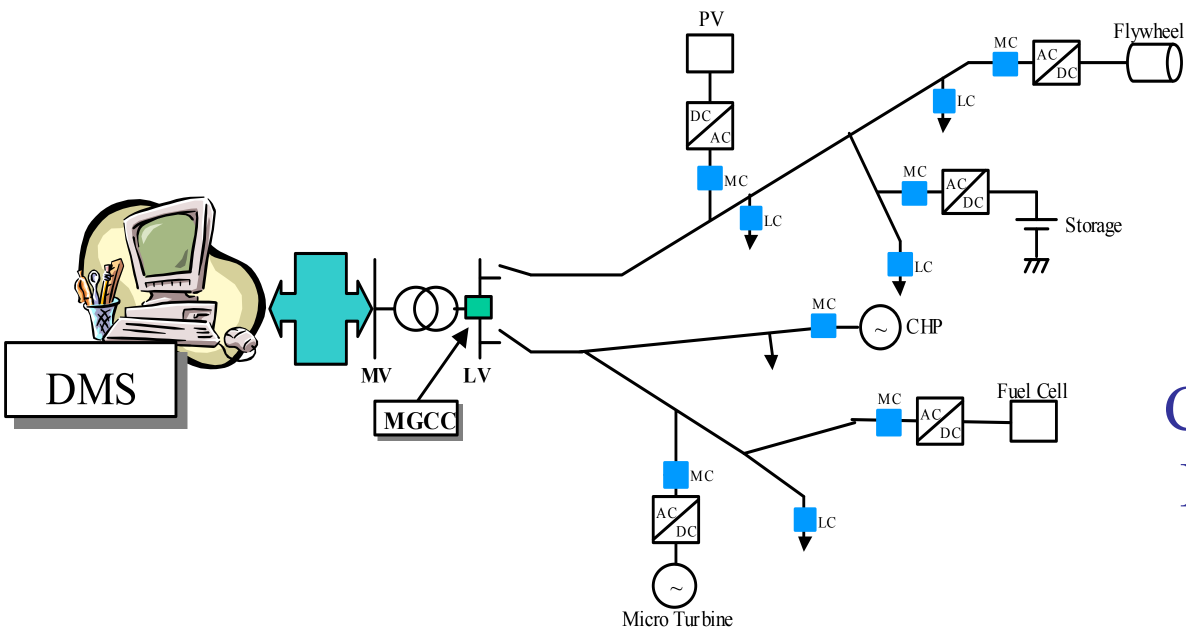
- Contribute to increase the share of renewables and to reduce GHG emissions;
- Study the operation of Microgrids in normal and islanding conditions;
- Optimize the operation of local generation sources;
- Develop and demonstrate control strategies to ensure efficient, reliable and economic operation;
- Simulate and demonstrate a Microgid in lab conditions;
- Define protection and grounding schemes;
- Define communication infrastructure and protocols;
- Identify legal, administrative and regulatory barriers and propose measures to eliminate them;

Microgrids Highlights

- Control philosophies (hierarchical vs. distributed)
- Energy management within and outside of the distributed power system
- Device and interface response and intelligence requirements
- Quantification of reliability benefits
- Steady State and Dynamic Analysis Tools
- Laboratory Microgrids

Microgrids – Hierarchical Control

MicroGrid Central Controller (MGCC) promotes technical and economical operation, interface with loads and micro sources and **DMS;** provides set points or supervises LC and MC; **MC and LC Controllers**: interfaces to control interruptible loads and micro sources

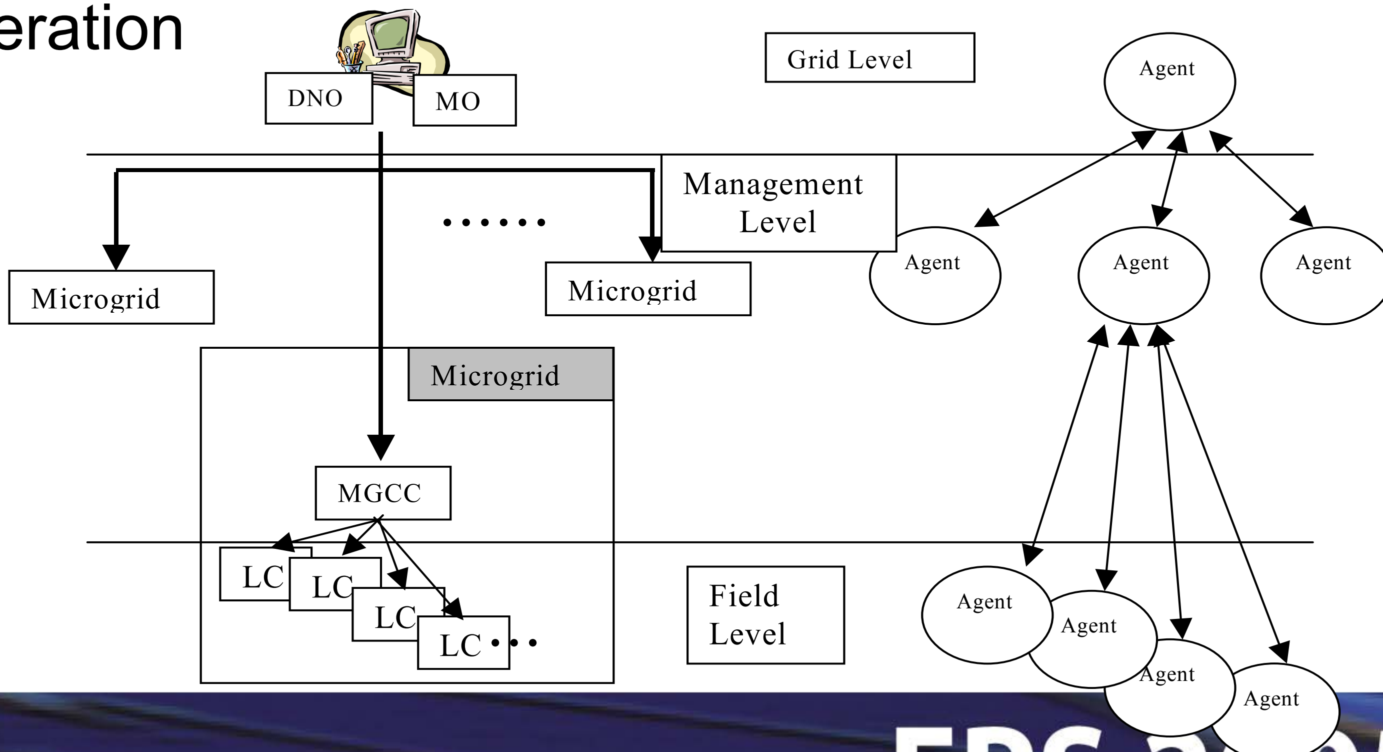


Centralized vs. Decentralized Control

MultiAgent System for Microgrids

- Autonomous Local Controllers
- Distributed Intelligence
- Reduced communication needs
- Open Architecture, Plug n' Play operation

- FIPA organization
- Java Based Platforms
- Agent Communication Language



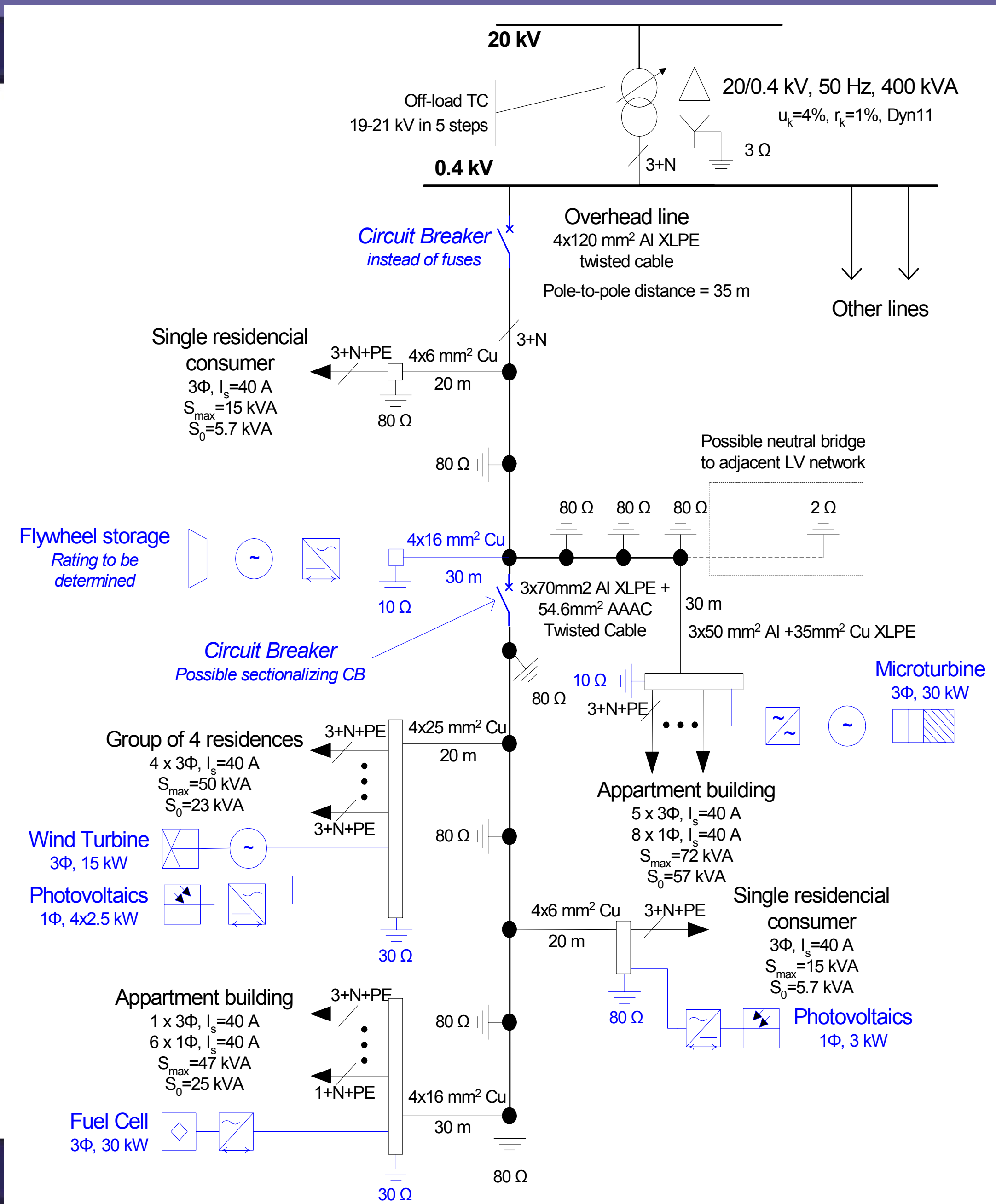
Participation of Microgrids in Energy Markets

- **Microgrid Serving its own needs using its local production, when beneficial (Good Citizen)**

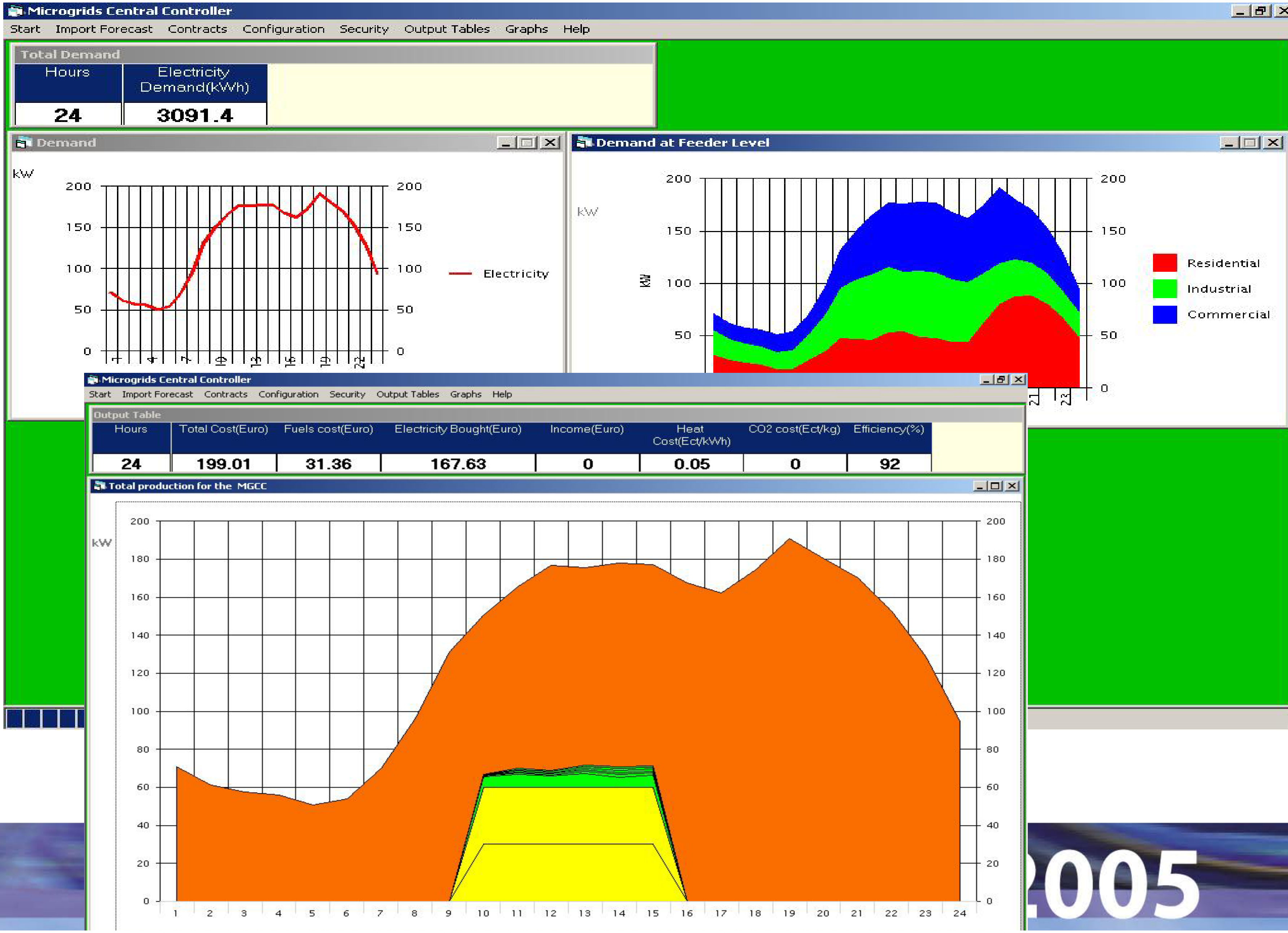
  MGCC minimises operation costs based on:
  - Prices in the open power market
  - Forecasted demand and renewable power production
  - Bids of the Microgrid producers and consumers.
  - Technical constraints
- **Microgrid buys and sells power to the grid via an Energy Service provider (Ideal Citizen)**

  MGCC maximizes value of the Microgrid, i.e. maximizes revenues by exchanging power with the grid based on similar inputs

Study Case LV Feeder with DG sources



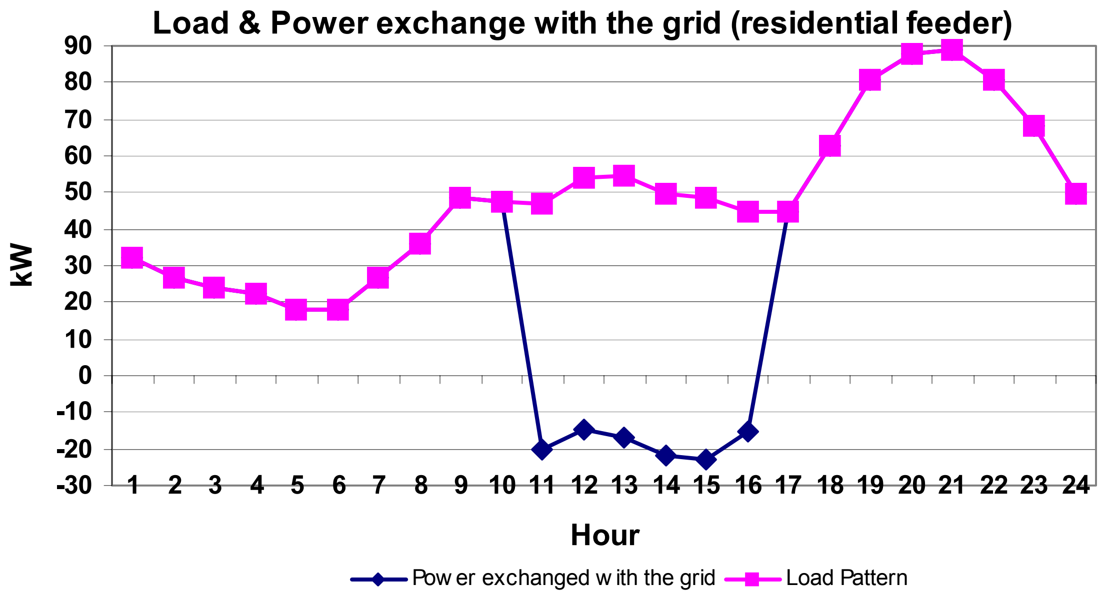
Highlight: MGCC Simulation Tool



Residential Feeder with DGs

Good Citizen Cost Reduction : 12.29 %
27% reduction in CO_2 emissions

Model Citizen Cost reduction : 18.66%



Highlight: Reliability Assessment

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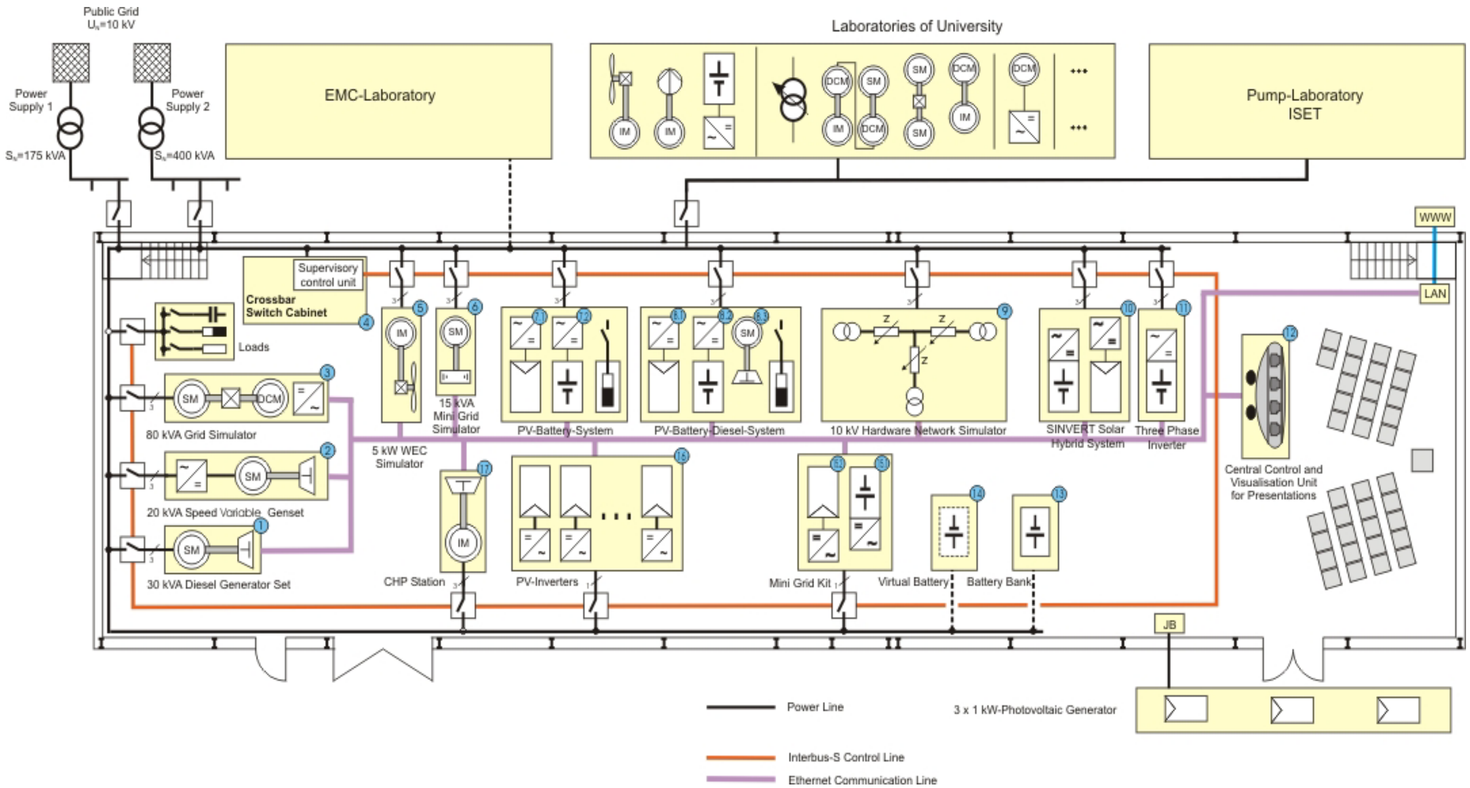
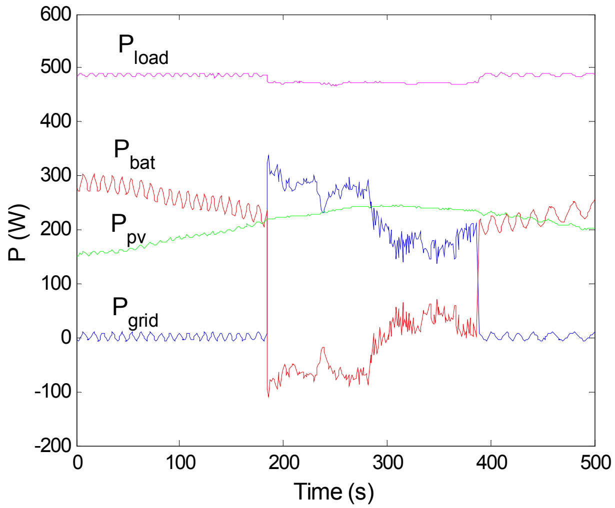
- System Maximum Load Demand: 188 kW
- Capacity of System Infeed: 210 kW (100%)
- Installed DGs: 15 kW Wind, 13 kW PVs, 30 kW Fuel Cells, 30 kW Microturbines

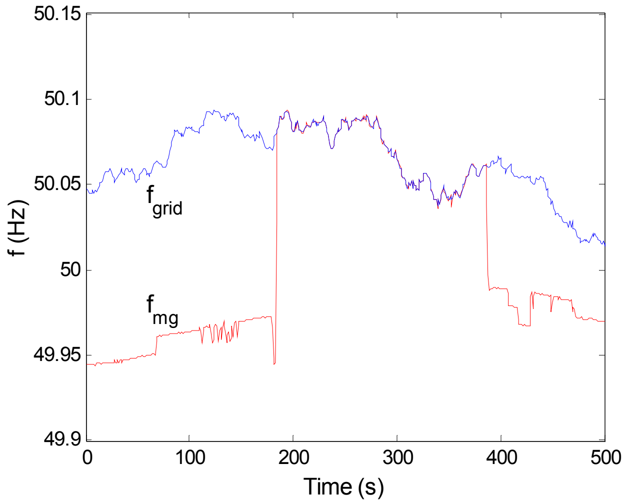
	FLOL (ev/yr)	LOLE (hrs/yr)	LOEE (kWh/yr)
Infeed Capacity 100% (no DGs)	2,130	23,93	2279,03
Infeed Capacity 80% (no DGs)	58,14	124,91	3101,52
Infeed Capacity 80% (with Wind + PV)	14,02	41,67	2039,41
Infeed Capacity 80% (all DGs)	2,28	15,70	716,36

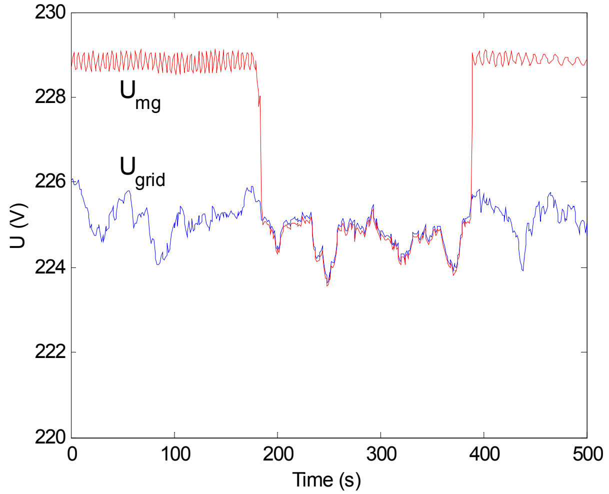
DeMoTec at ISET



Laboratory installation at NTUA

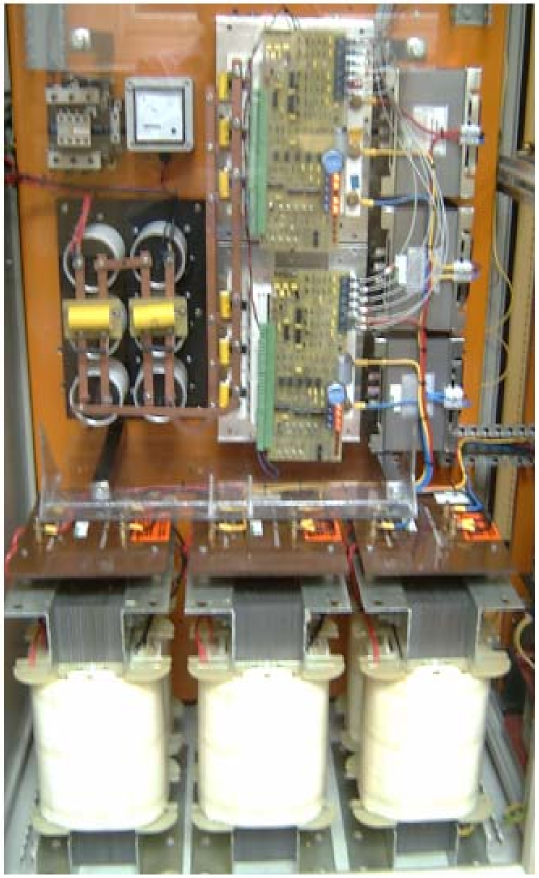






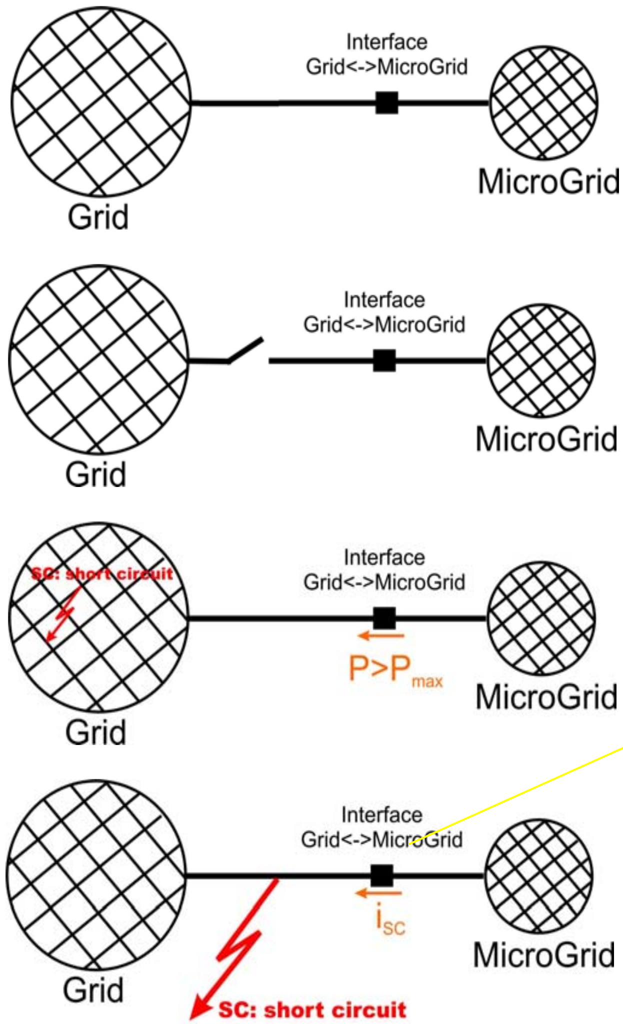
Implementation of the flywheel energy storage system by UM

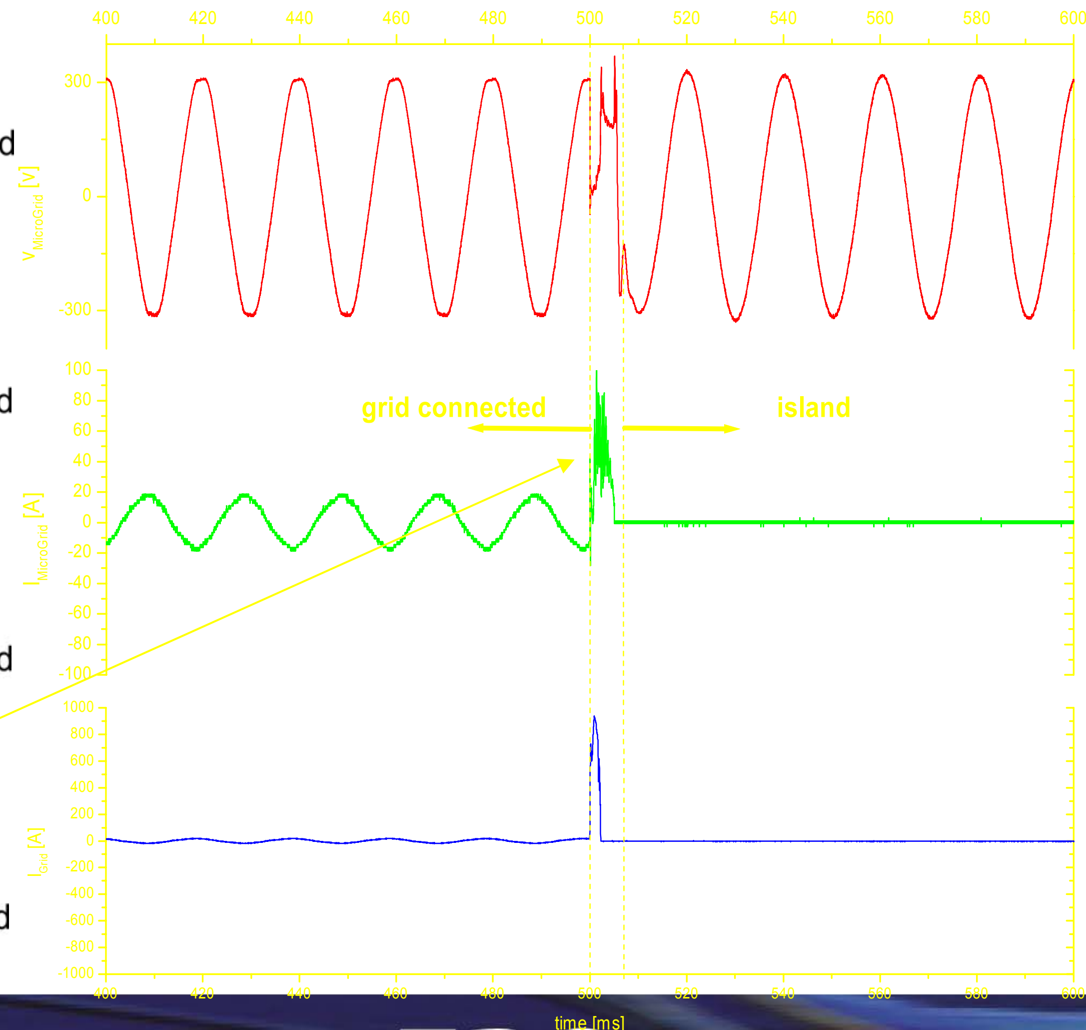
Flywheel



Inverter interface

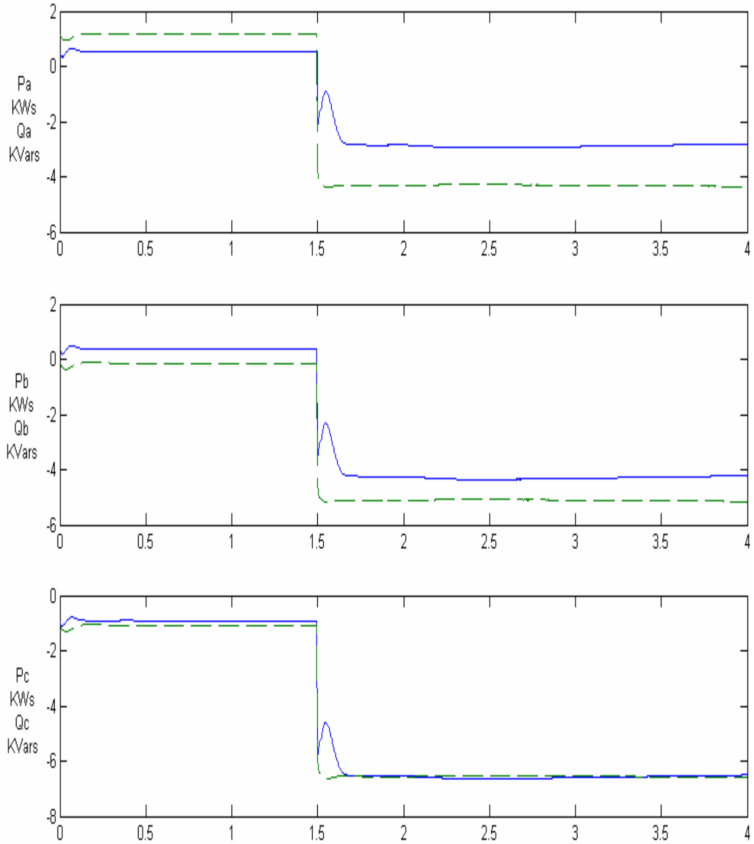
Development of Electronic Switch



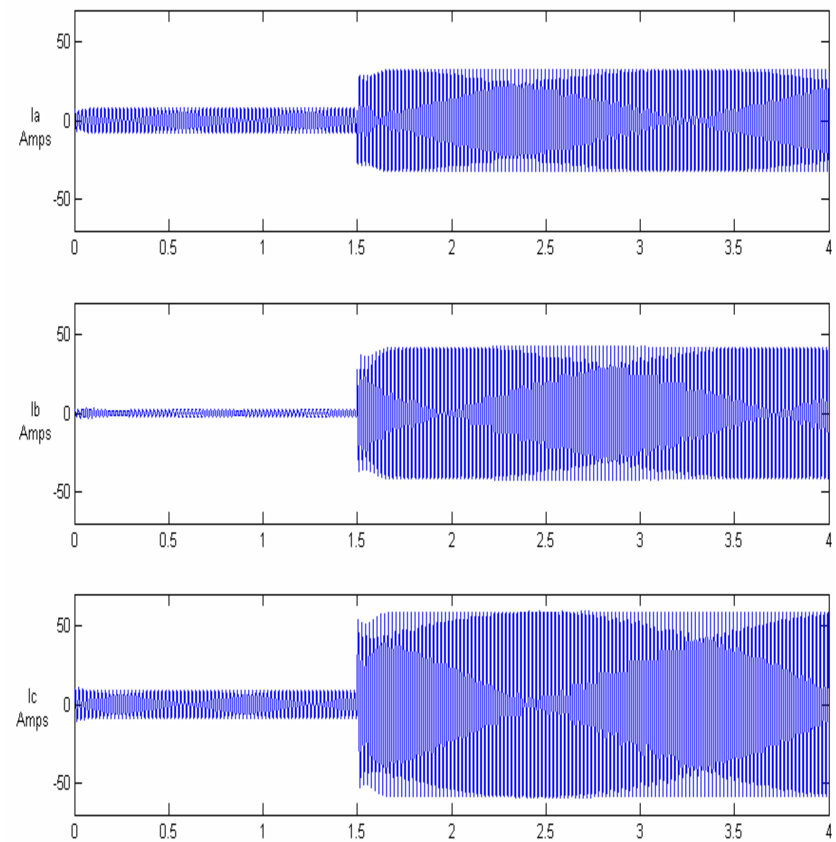


Highlight: Modelling and Simulation

Two battery invs + two PVs + one WT - Isolation + wind fluctuations



P,Q per phase Battery Inverter A



I per phase Battery Inverter A

Conclusions

- Microgrids: A possible paradigm for future LV power systems
- Distinct advantages regarding efficiency, reliability, network support, environment, economics
- Challenging technical and regulatory issues
- Promising solutions, needs for field demonstrations

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