Overview of Microgrid R&D in Europe

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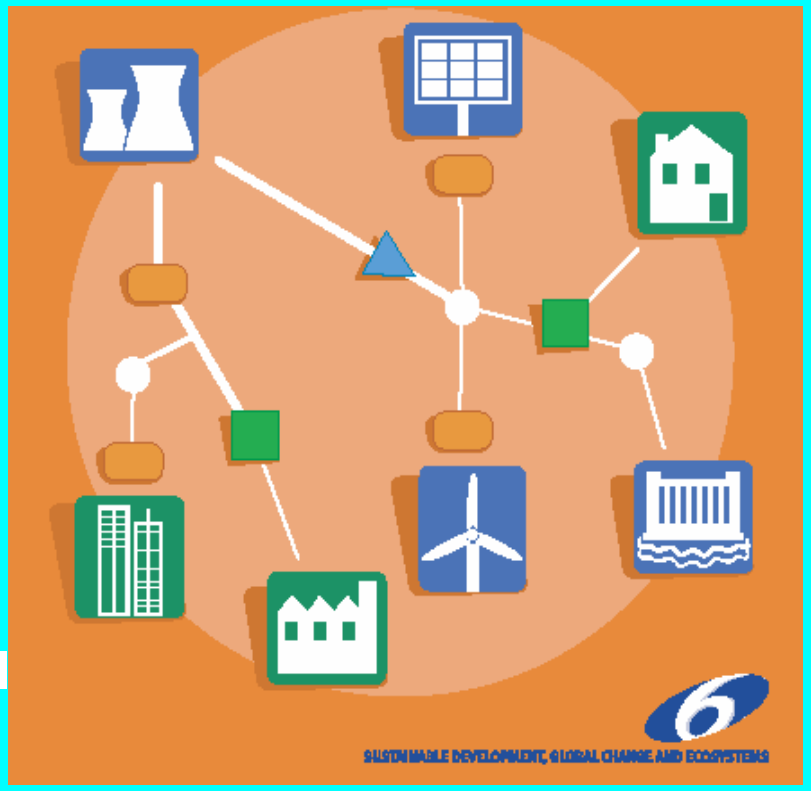
The EU concept of "Smart Power Networks"

- "Smart" coexistence of central and decentralised generation with lower carbon generation and efficient demand/response
- Load trading and cost optimisation by means of dialog towards time-variable tariffs and variable incentives depending on present load
- Customer integration based on bi-directional communication and large flow of information



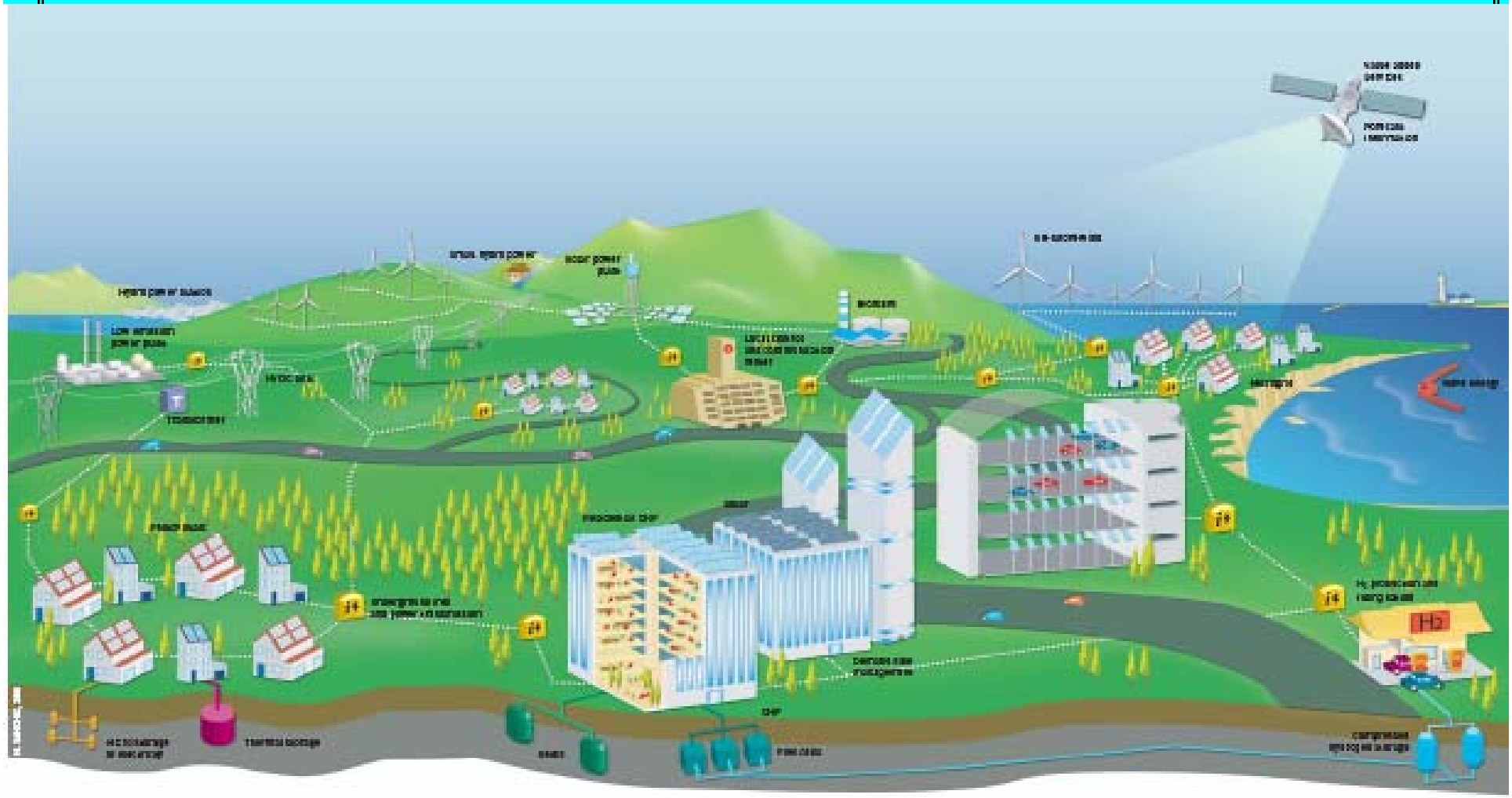
Key opportunities of "Smart Power Networks"

- **Security of supply – efficient mix of centralised with decentralised operation allows the use of domestic energy resources, whilst maintaining a high level of reliability and quality of supply.**

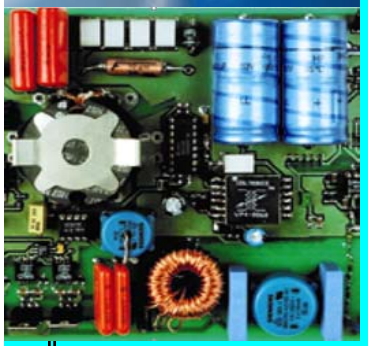
- **Climate change – higher efficiency in energy transport and use of RES and cleaner Distributed Generation, incl. CHP, results in a real contribution to reduce emissions.**

- **Competitiveness of European Industry – stimulate innovation of network and associated ICT represents a positive effect, both in the EU and worldwide.**

The Vision



FP5 (1998-2002) funded research
large-scale "integration" of RES+DG



Research Area: INTEGRATION DER	Number of projects	Total Budget [M€]	EC funding [M€]
Distributed Generation	8	34.29	18.99
Transmission	4	9.74	5.72
Storage	20	45.31	20.73
HT Superconductors	6	11.27	6.16
'Other'	17	29.12	15.21
TOTAL	55	129.73	66.81

MICROGRIDS Project

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

Contract : ENK5-CT-2002-00610

GREAT BRITAIN
- UMIST
- URENCO

PORTUGAL
- EDP
- INESC

SPAIN
- LABEIN

NETHERLANDS
- EMforce

14 PARTNERS,
7 EU COUNTRIES

GREECE
- NTUA
- PPC /NAMD&RESD
- GERMANOS

GERMANY
- SMA
- ISET

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

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

Budget 4.4 M€

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MICROGRIDS - Milestones

❖ Investigation, Development and Demonstration of the operation, control, protection, safety and telecommunication infrastructure of Microgrids,

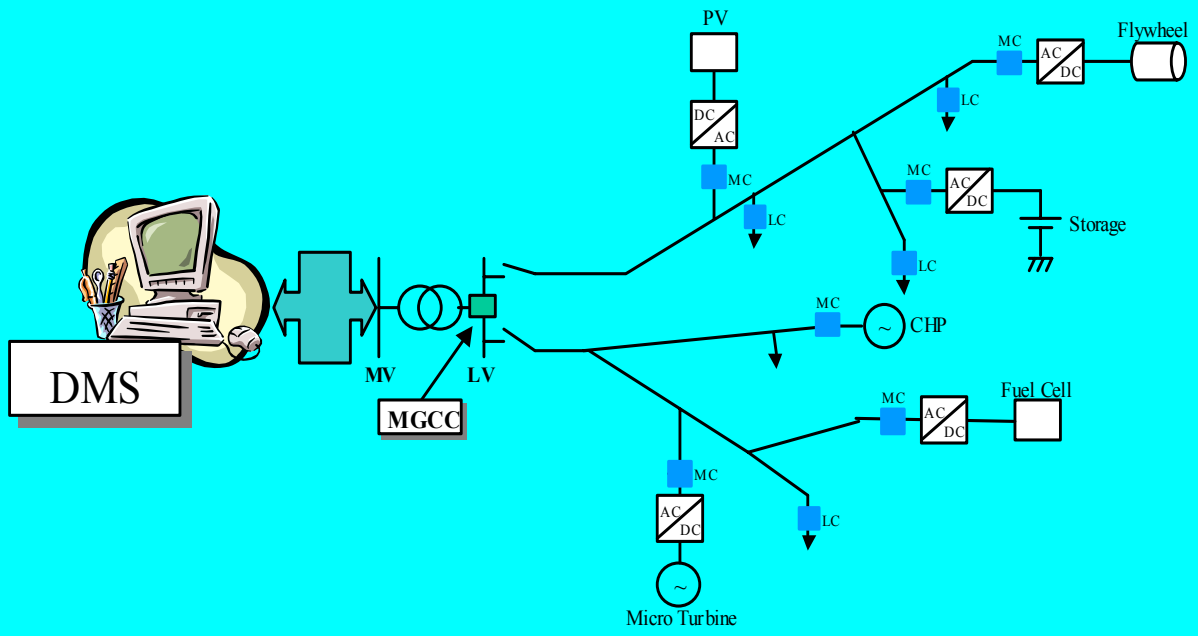
❖ Operation and Control concepts in both stand-alone and interconnected mode on Laboratory Microgrids will be demonstrated.

Microgrids Project Highlights

- Control philosophies (hierarchical vs. distributed)
- Energy management
- 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

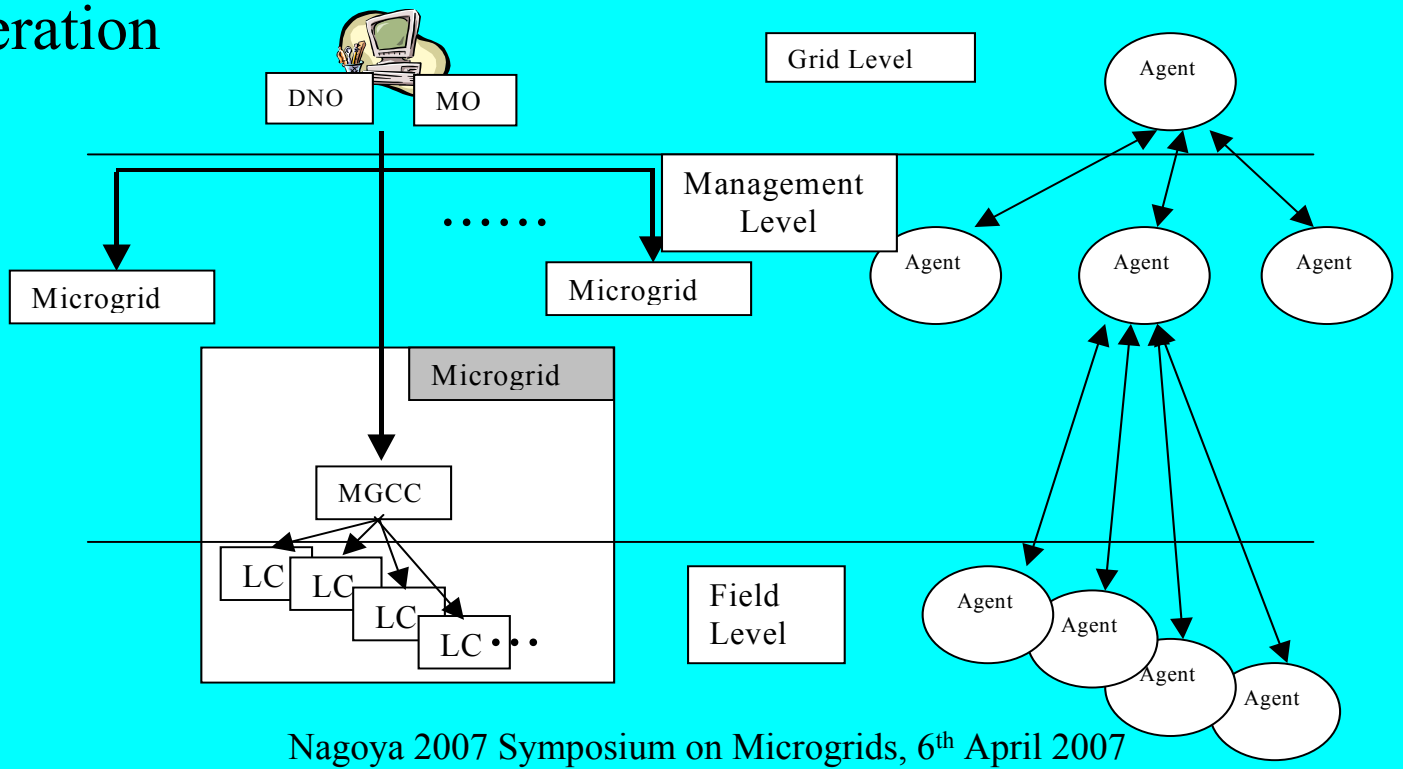


Centralized vs. Decentralized Control

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



MAS Architecture

Agent → Layered Learning Approach

Target

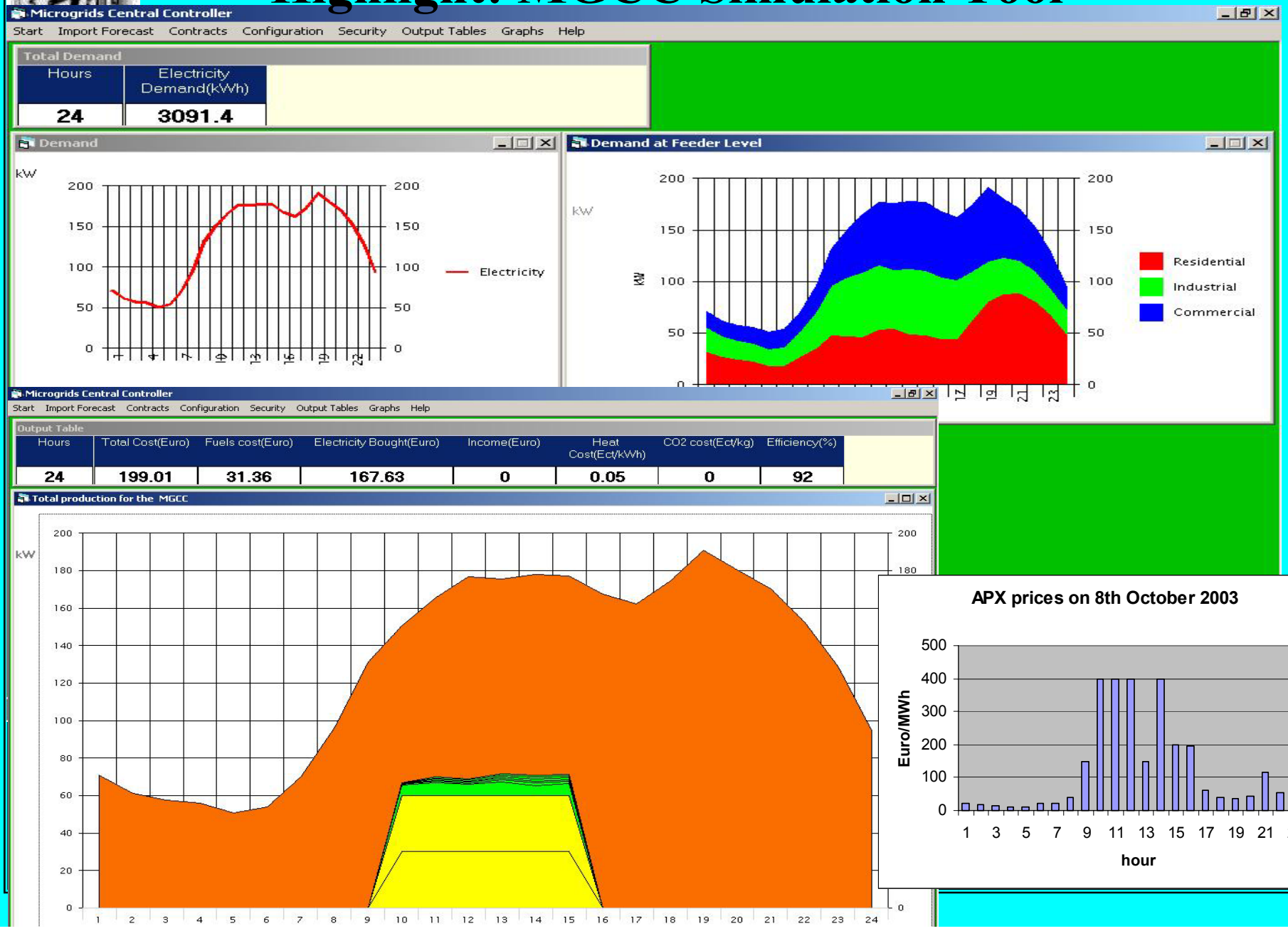
Perform Multiple Operations like Active Power Control, Market Participation or black start. These Operations require different types actions

Organization of Actions and Behaviors

Level	Behavior	Agents	Example
1	Single Agent	Single	Battery management
2	Multi Agent	Many	Switching Operations
3	Team	Many/All	Market Participation

Complex System Hierarchically Organized

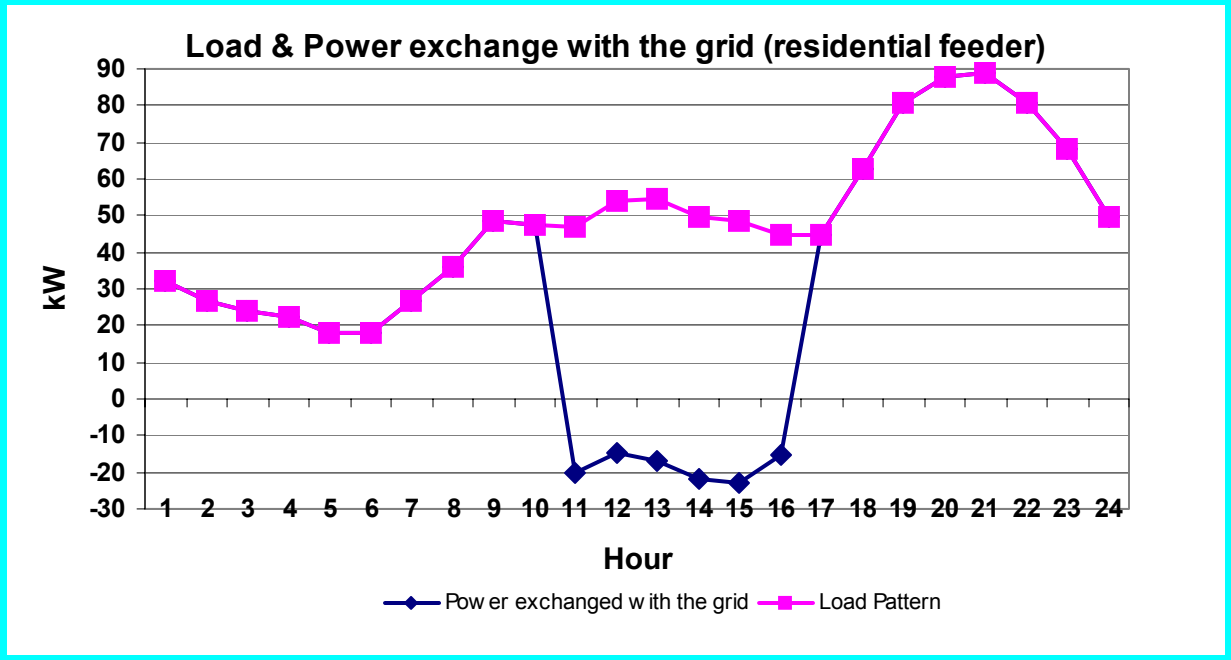
Highlight: MGCC Simulation Tool



Residential Feeder with DGs

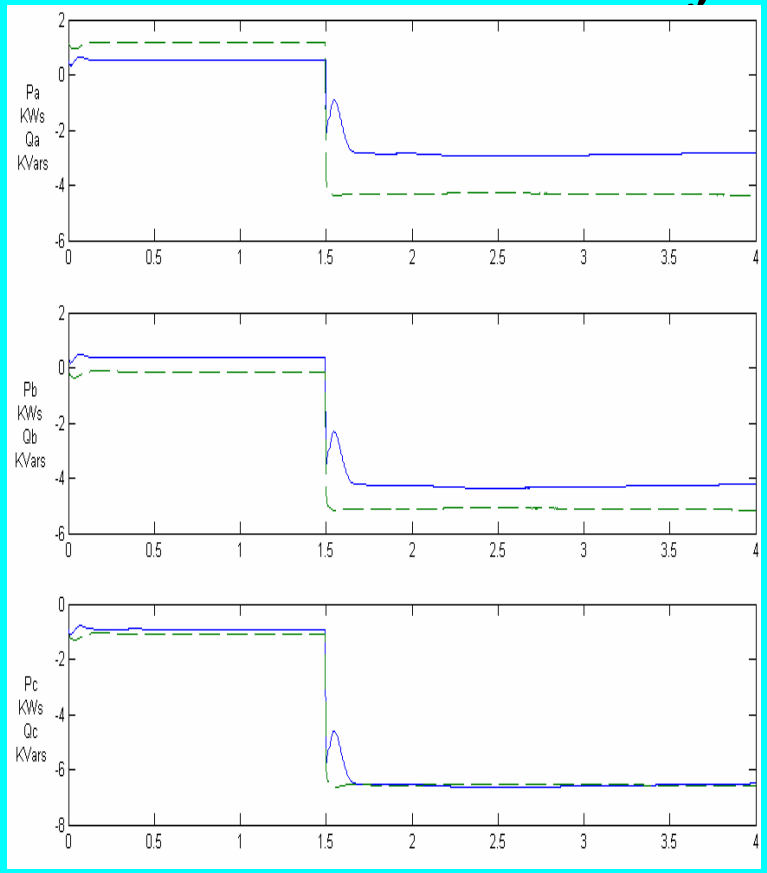
Good Citizen Cost Reduction : 12.29 %
27% reduction in CO_2 emissions

Model Citizen Cost reduction : 18.66%

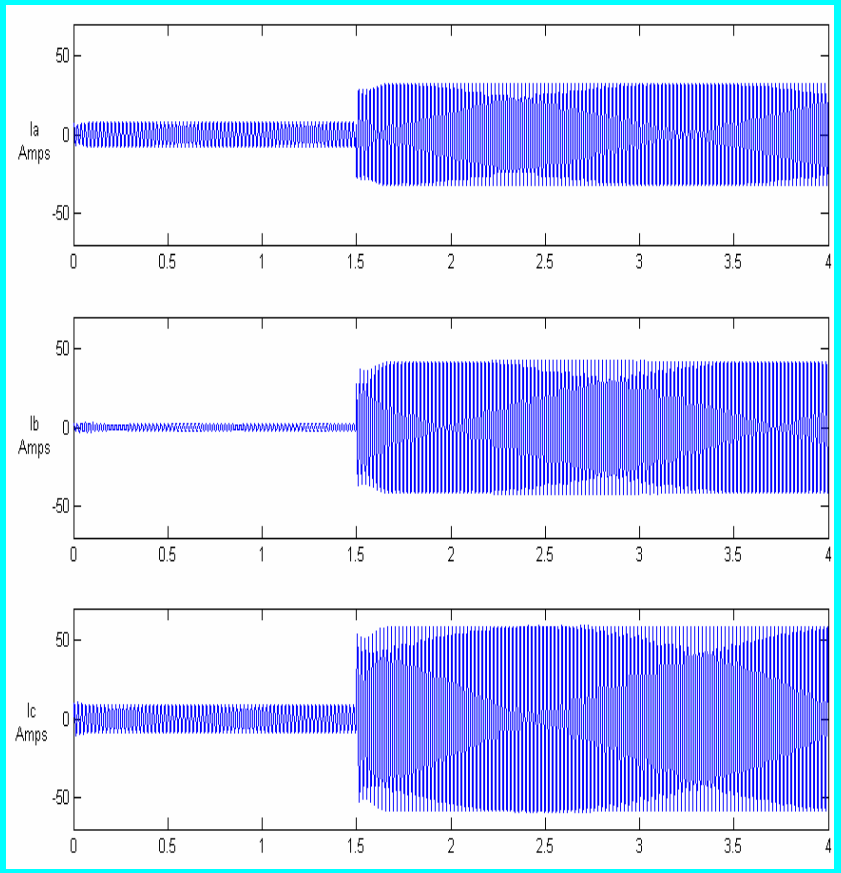


Highlight: Modelling and Simulation

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



P,Q per phase Battery Inverter A



I per phase Battery Inverter A

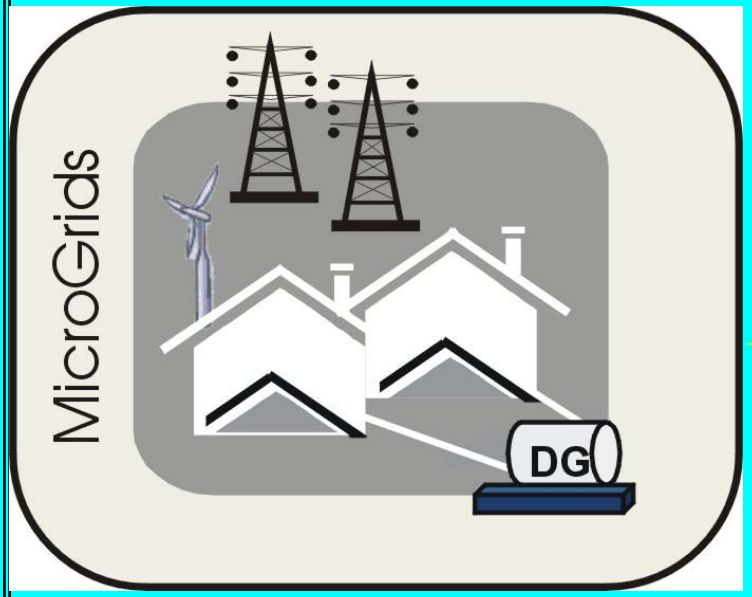
Further Needs Identified

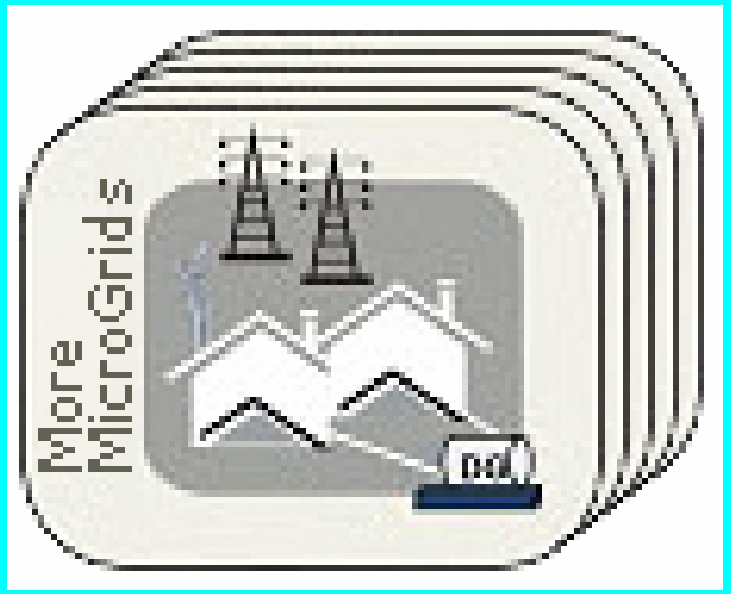
- More sophisticated control techniques and devices for Distributed Resource and Load controllers to implement
- Study of integration of several Microgrids into operation and development of the power system. Interaction with DMS.
- Need for standardization and benchmarking.
- **Field trials to test control strategies on actual Microgrids**
- **Need for quantification of Microgrids effects on Power sysetm operation and planning**
- Need for cooperation and learning from alternative, complementary approaches, under development in US, Canada and Japan

FP6 (2002-2006) funded research
large-scale Integration of RES+DG

Research Area: INTEGRATION DER	Number of projects	Total Budget [M€]	EC funding [M€]
Advanced Architectures and Operation concepts	7	65.50	33.35
Transmission	2	7.07	4.95
Storage	1	5.87	5.00
HT Superconductor Devices for networks	2	7.82	3.35
Advanced Power Electronics	2	5.25	3.41
TOTAL	14	91.51	50.06

LOGOS



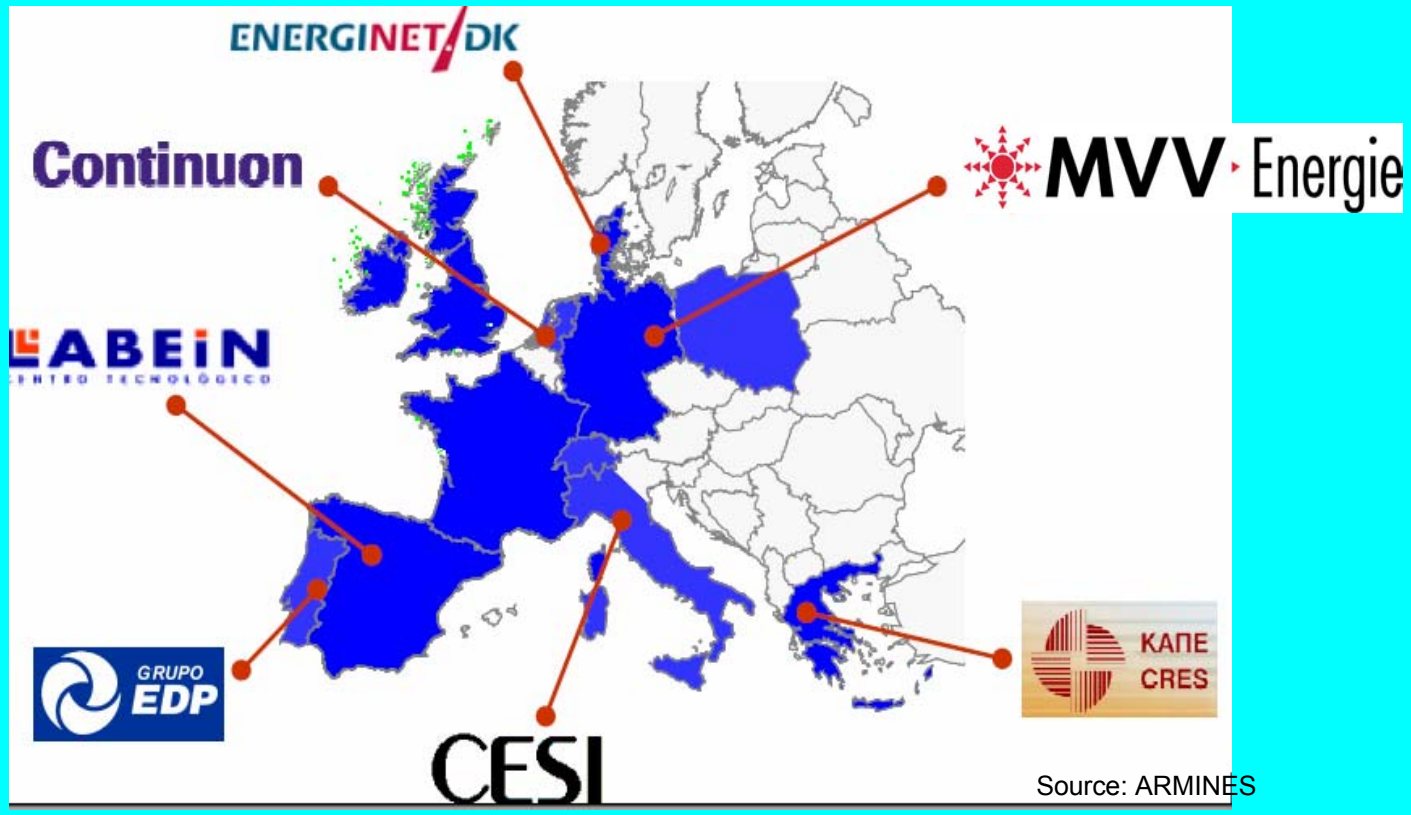


MORE MICROGRIDS Project

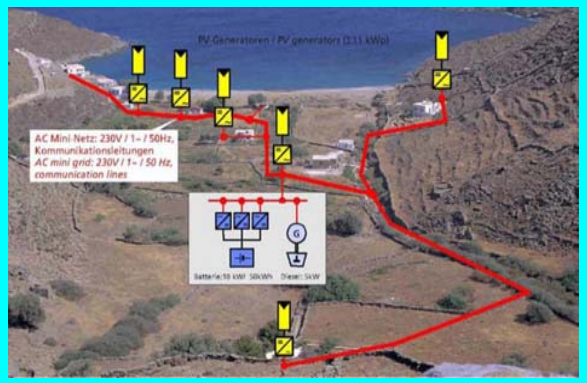
"Advanced Architectures and Control Concepts for More Microgrids

Contract : **PL019864**

Demonstration Sites in the MoreMICROGRIDS project:

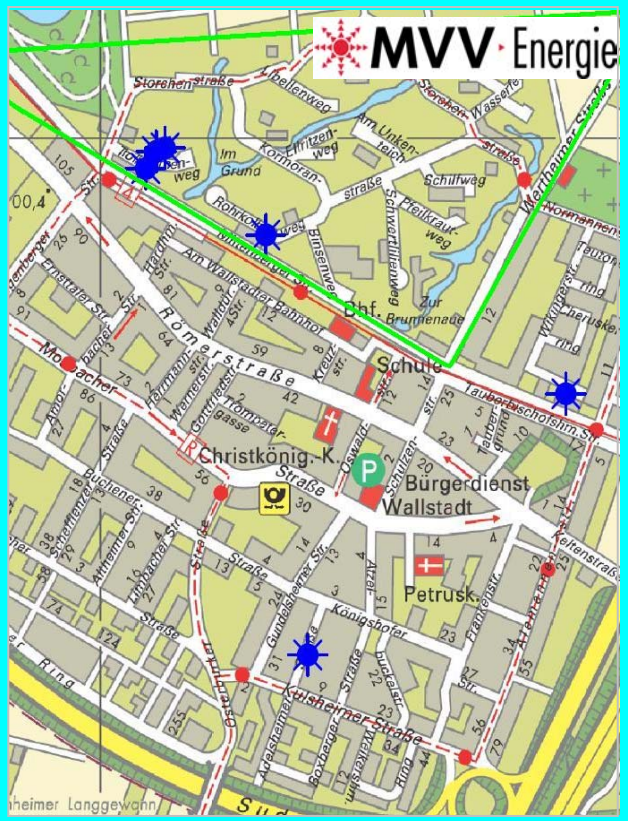


Pilot installation: Kythnos Island, Greece



Duration	**Since 2003**
Pilot profile	■ **DG capacity el.** **22 kWp** ■ **DG Technology** **PV, battery, diesel-gen** ■ **Classification** **rural, off-grid** ■ **Grid Operator** **CRES**
Tasks	■ **Microgrid operation** ■ **Multi master control method for improvement of available peak power and system reliability**

Pilot installation: Residential Area „Mannheim-Wallstadt“, Germany



Duration	**Starting August 2006**
Pilot profile	■ **DG capacity el.** **ca. 40 kWp** ■ **DG Technology** **PV, CHP** ■ **Classification** **residential** ■ **Grid Operator** **MVV Energie**
Tasks	■ **Microgrid operation** ■ **Socio-Economic evaluation**

Pilot installation: Bronsbergen Holiday Park, The Netherlands

Duration	**Starting August 2006**
Pilot profile	■ **DG capacity el. 315 kWp** ■ **DG Technology PV, storage** ■ **Classification residential, 210 cottages** ■ **Grid Operator Continuon**
Tasks	▪ **Islanded operation, automatic isolation and reconnection** ▪ **Harmonic voltage distortion** ▪ **Energy management and lifetime optimization of storage system** ▪ **Black start**

Pilot installation: Swimming Pool in Portugal

Pilot profile		Tasks	
	■ DG Technology Microturbine, Capstone 60 ■ Grid Operator EDP		• Starting and Shutdown of the MT • Operation in Island and Interconnected Mode and transitions .

Conclusions

- Microgrids : New paradigm for future power systems
- Distinct advantages regarding efficiency, reliability, network support, environment, economics
- Challenging technical and regulatory issues

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