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Sessões Técnicas OE

O Desafio da Microgeração e das Microredes

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Introduction

- Driving forces for the future development of the electric power systems:
  - 1) Environmental issues
  - 2) Replacement of old infrastructures (generation and grid)
  - 3) Security of Supply
  - 4) Increase quality of service (more automation and remote control)
  - 5) Electricity market liberalization (energy and services).

  ↓

  - 1) Increase renewable generation, **exploit clean coal technologies, CCGT and others**
  - 2) Increase Distributed Generation
  - 3) Built new central generation (increase efficiency and flexibility of operation)
  - 4) Interoperability of national grids: allow for a wider geographical market implementation, allow for long distance electricity transportation, efficient management of cross border flows, strength security of supply through enhanced transfer capabilities
  - 5) Demand Side Management (increase load consumption efficiency)
  - 6) Regulatory issues (harmonization of regulatory frameworks)

New Paradigmas

- The vision

From the SmartGrids document EU Commission

Microgeneration technologies

- Microwind generators (rural areas / urban environments)
- Solar PV
- Micro CHP (domestic Stirling engines, microturbines)
- Fuel cells
- +
- Storage energy systems: (batteries, flywheels)

Microgeneration technologies: Micro-wind turbines

Microgeneration technologies: Micro-wind turbines

Microgeneration technologies

- Solar PV

Microgeneration technologies: BIPV

Other solutions: surfaces coating (Glasses, Roofs, etc.) with thin films.

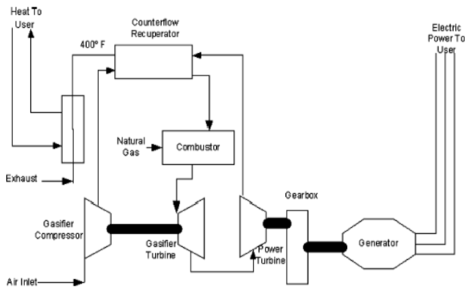
Micro CHP (Stirling engines)

- Packaged as a domestic boiler for mass market

Microgeneration - Microturbines

- Microturbine of 80 kW

In general the microturbine is connected to the grid through an electronic converter.

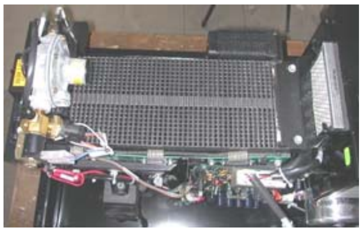


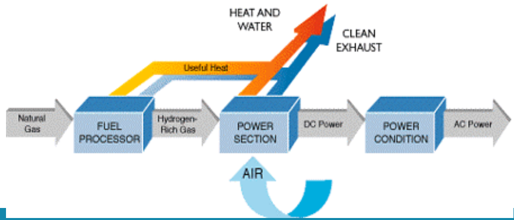
1,5 kHz to 4kHz

(single shaft)

Fuel-Cells

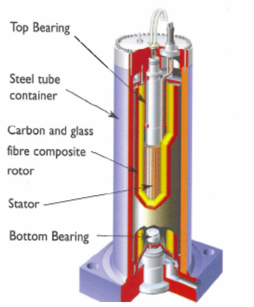
- Different Types (PEM, SOFC, Alkaline, PAC...)

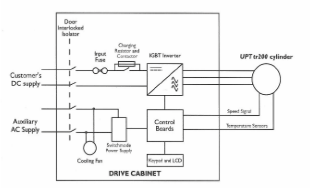


Energy storage - flywheels

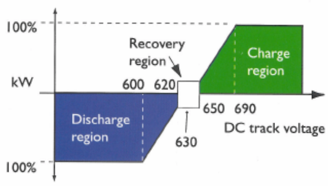
- Key element for the operation of a microgrid



Control Electronics



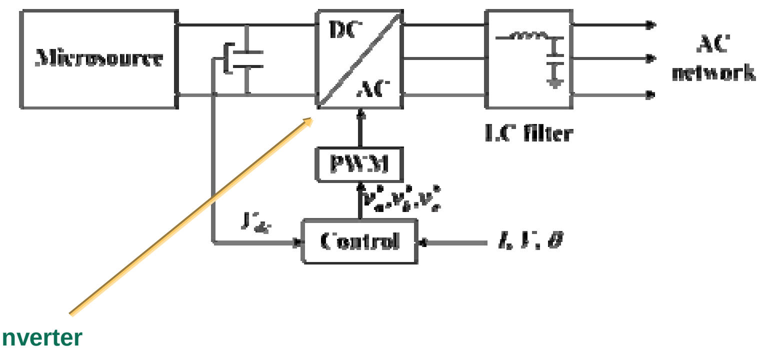
Control Schematic (Figure 2)



Power Profile (Figure 3)

Microgenerators grid interface

- The general model of a microgenerator can be of the following type

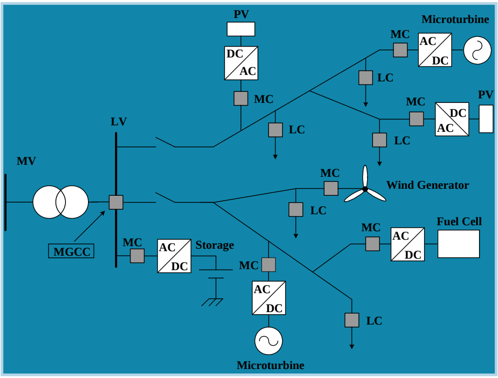


MicroGrid: A Flexible Cell of the Electric Power System

MG Hierarchical Control:
- MGCC, LC, MC
- Communication infrastructure

The MicroGrid Concept

- A Low Voltage distribution system with small modular generation units providing power and heat to local loads
- A local communication infrastructure
- A hierarchical management and control system

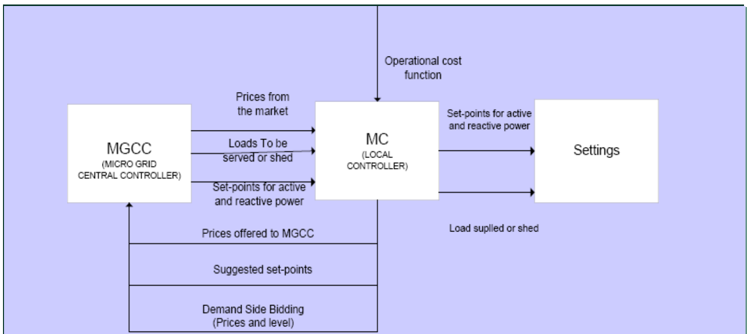


Operation Modes:

- **Interconnected Mode**
- **Emergency Mode**

Normal interconnected mode

- Managing the microgrid



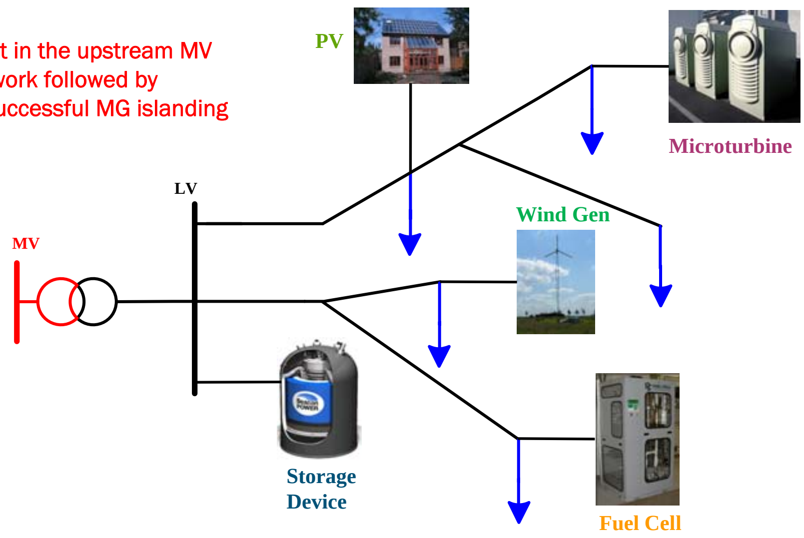
Two market policies :

1.Microgrid as a good citizen-maintains zero reactive power serving its own customers needs

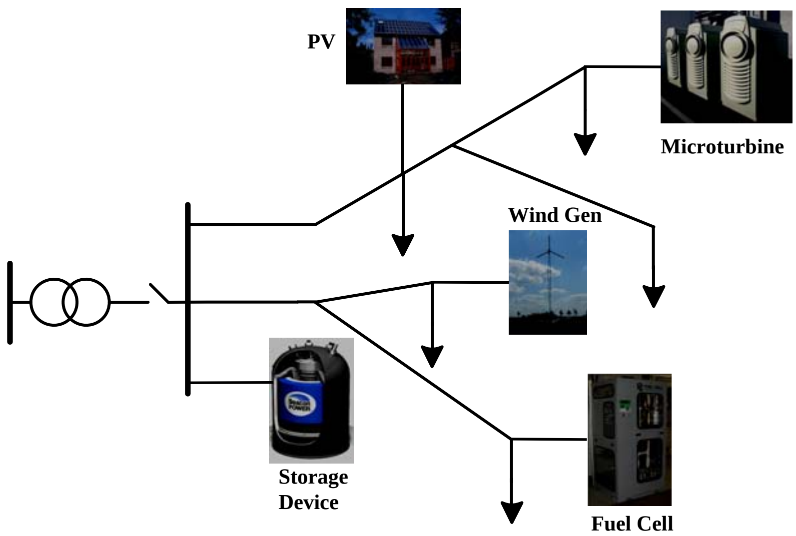
2.The Microgrid buys and sells power to the grid

MicroGrid Black Start

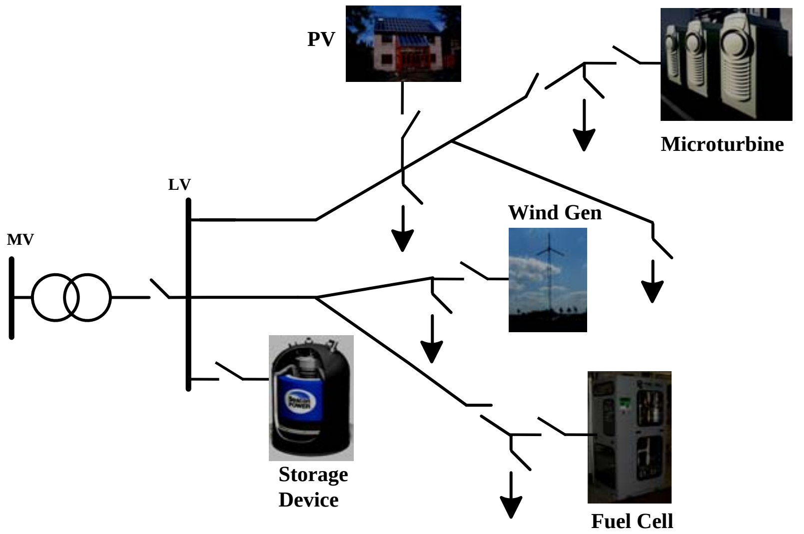
Fault in the upstream MV network followed by unsuccessful MG islanding



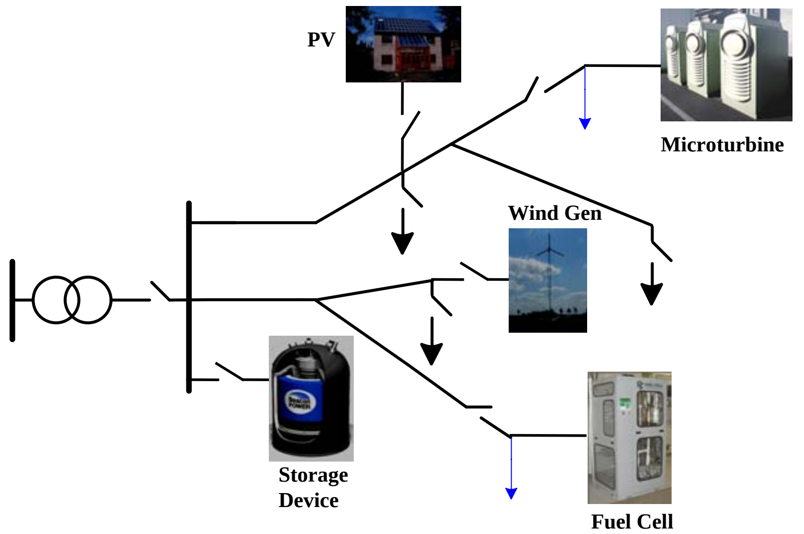
MicroGrid Black Start



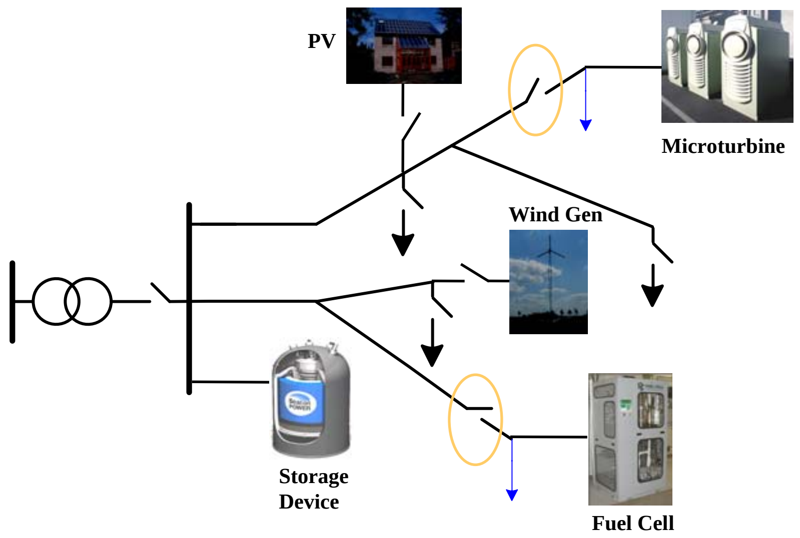
MicroGrid Black Start



MicroGrid Black Start

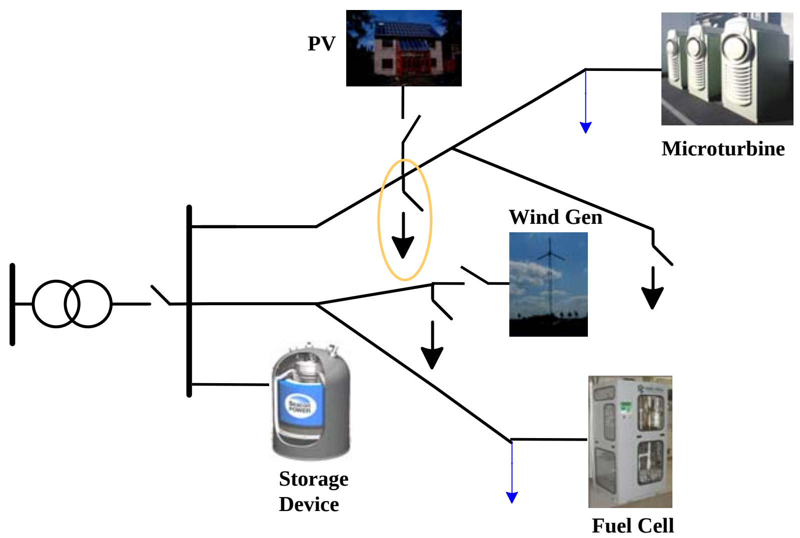


MicroGrid Black Start

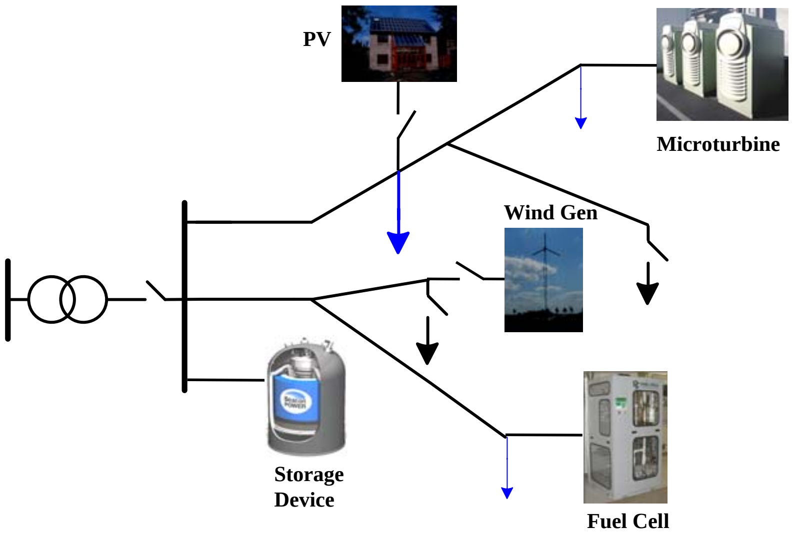


LV

MicroGrid Black Start

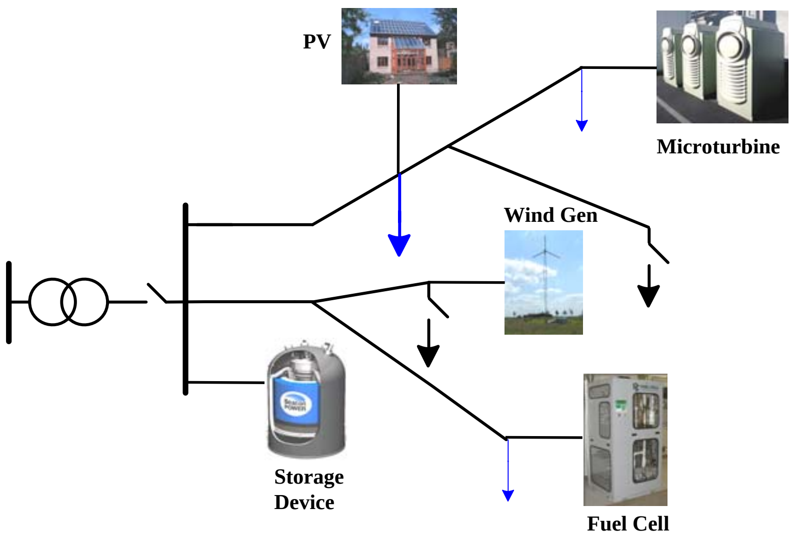


MicroGrid Black Start

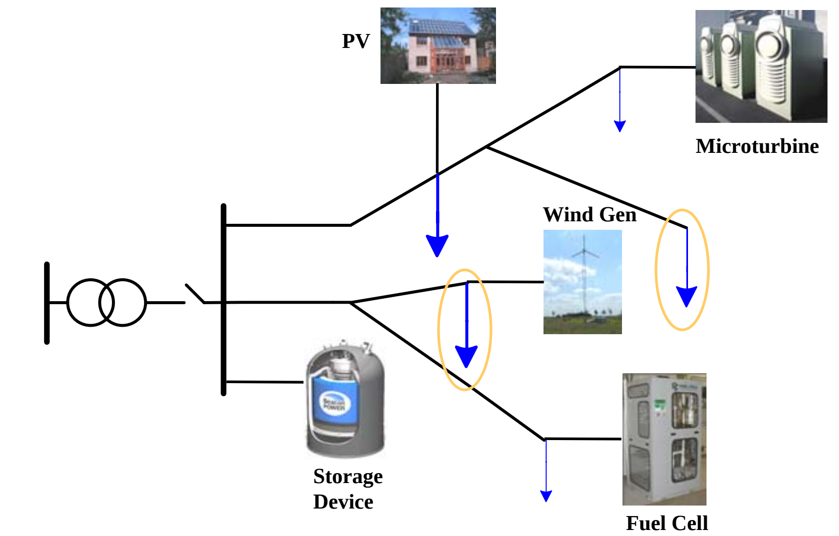


LV

MicroGrid Black Start

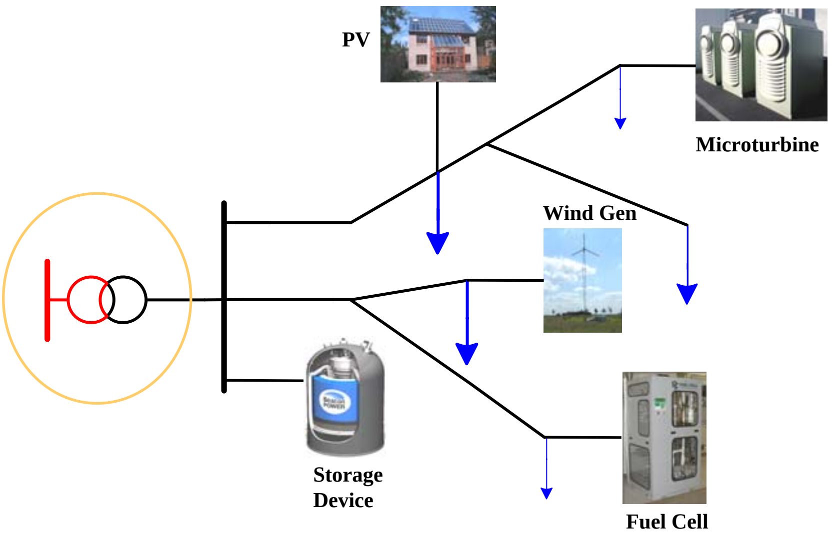


MicroGrid Black Start



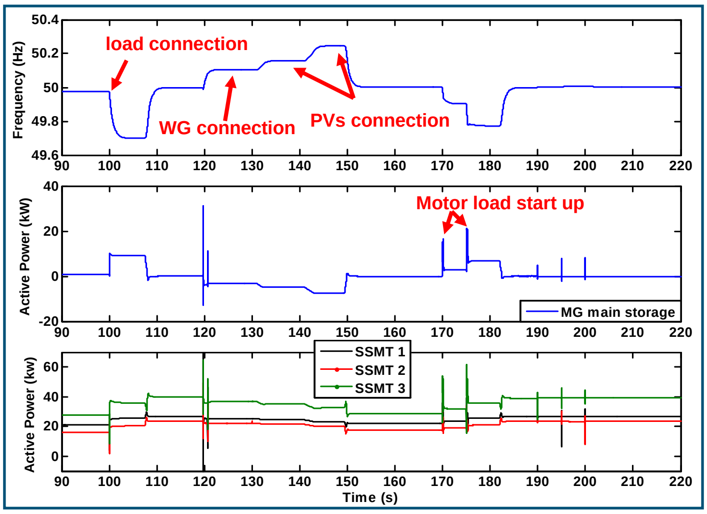
LV

MicroGrid Black Start



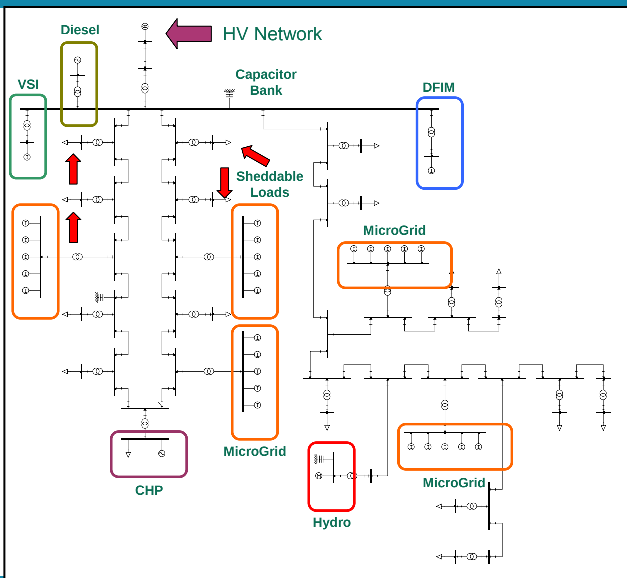
Results from Simulations – Long Term Dynamics

- An Overview of the Service Restoration Procedure



Multi-microgrids

- Microgrids
  - DFIM
  - Fuel Cell
  - Microturbine
  - Storage (VSI)
  - PV
- Large VSI
- Large DFIM
- Hydro
- CHP
- Small Diesel
- Sheddable Loads



Some results from an impact analysis study

- Investigation of the impact of microgeneration on the Portuguese Electrical Distribution System
  - quantify overall benefits of microgrids in terms of energy losses and avoided CO_2 emissions
  - quantify the impact of a widespread deployment of microgrids on the future replacement and investment strategies → investment deferral

Methodology

- Hence, typical networks at the distribution level were identified (HV, MV and LV)
- For each network it was necessary to define:
  - load scenarios
  - microgeneration scenarios
- For each network, load and microgeneration do:
  - Calculate losses, by solving load-flows (with and without microgeneration integration)
  - Estimate the amount of avoided CO_2 emissions

  } For 1 year
  - Evaluate benefits from investment deferral } For 25 years

Results

- 10% Microgeneration Penetration

	Energy Loss Reduction (%)	Energy Loss per Network Type (without µG) (GWh)	Energy Loss per Network Type (with µG) (GWh)	Diferential
HV	5,15	134	127	7
UMV	7,35	456	422	33
RMV	4,79	304	289	15
ULV	11,35	1237	1097	140
RLV	7,55	825	763	62
Total	8,72	2956	2698	258
	Loss Rate (%)	7,0	6,4	0,6
	CO_2 (ton)	1093653	998330	95324

Considering:
370 $tonCO_2/GWh$
(ERSE reference value)

0.05 €/kWh
(average energy cost) → 12,9 M€ avoided costs in losses

Results

- 10% Microgeneration Penetration

Year	Energy Loss Reduction (10^6 euros)	Line Loading Reduction Year 1 (10^6 euros)	Line Loading Reduction (10^6 euros)	
1	12,882	0,207		
2	12,924		0,000	
3	12,967		0,199	
4	13,010		0,000	
5	13,053		0,191	
6	13,096		0,000	
7	13,140		0,184	
8	13,183		0,000	
9	13,227		0,177	
10	13,271		0,000	
11	13,315		0,171	
12	13,359		0,000	
13	13,403		0,164	
14	13,448		0,000	
15	13,492		0,158	
16	13,537		0,000	
17	13,582		0,152	
18	13,627		0,000	
19	13,672		0,147	
20	13,718		0,000	
21	13,763		0,141	
22	13,809		0,000	
23	13,854		0,136	
24	13,900		0,000	
25	13,946		0,131	**Total**
Total	335,181	0,207	1,953	**337,3403**

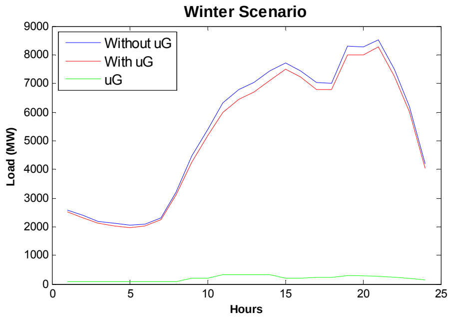
$$\sum_{i=1}^{n}\left[C_0\cdot\frac{(1+t_c)^{i-1}}{(1+t_a)^{i-1}}+\frac{I_{i-1}\cdot t_a}{(1+t_a)^{i-1}}\right]$$

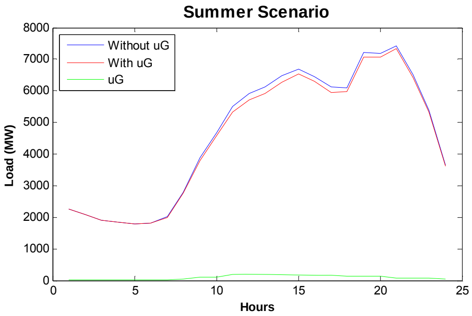
Savings resulting from the reduction in the average annual energy losses for a time span of 25 years, at the present time

Avoided interests due to postponing for 25 years the line and transformer investments

Daily Load Diagram

- 10% Microgeneration Penetration





Maximum μG contribution: 337 MW

μG contribution at peak load: 248 MW

Maximum μG contribution: 204 MW

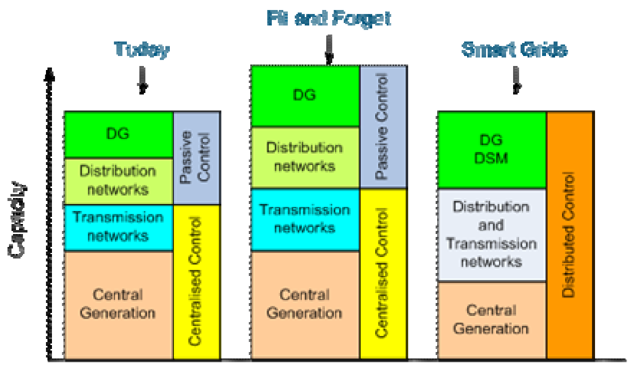
μG contribution at peak load: 86 MW

Avoided energy generation : 1272 GWh (in year 2005)

With 534 MW of installed capacity in μG (100.000 - 150.000 installations)

Conclusions - Benefits

- Consequences of the SmartGrid concept



From Goran Strback

Conclusions - Benefits

- Large technical, economic and environmental benefits can be achieved by using microgeneration:
  - Considerable amount of loss network reduction;
  - Better voltage profiles;
  - Reliability improvements;
  - Increased economic performance of the distribution activity
    - investment deferral network reinforcement costs;
    - avoided costs in network losses.
  - Avoided CO2 emissions

Specific and fair new remuneration schemes must be identified

Beneficiaries: Microgenerators, consumers, DSOs, society

Conclusions - Benefits

- Society benefits (less tangible benefits related to energy policy):
  - increased security of power systems,
  - diversification of primary energy sources,
  - reduction on energy external dependence),
  - potential economic benefits (new economic activities, increase in job creation, improvements in social cohesion and environmental sustainability).
- Additional opportunities for electric power manufacturers will be created:
- Competitiveness in the electric power industry will increase
- Research is the Key element for the development of this SmartGrid concept