

# ISET`s Microgrid Research

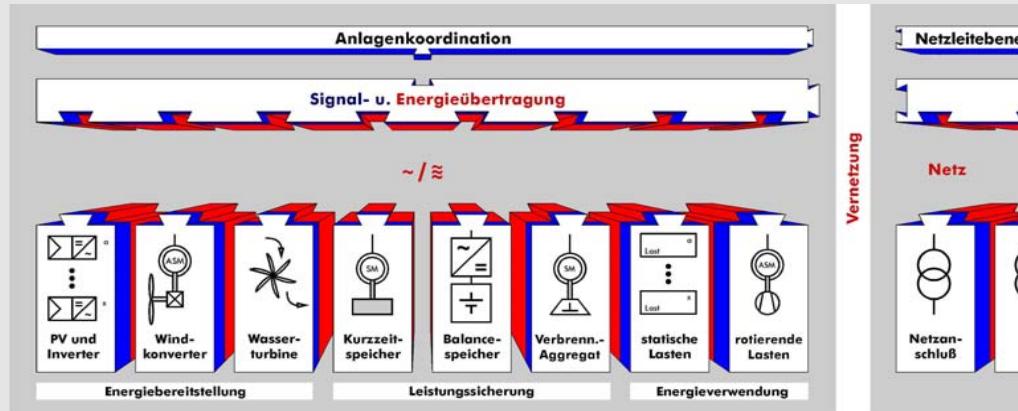
## Past, Present, Future

Dr.-Ing. A. Engler



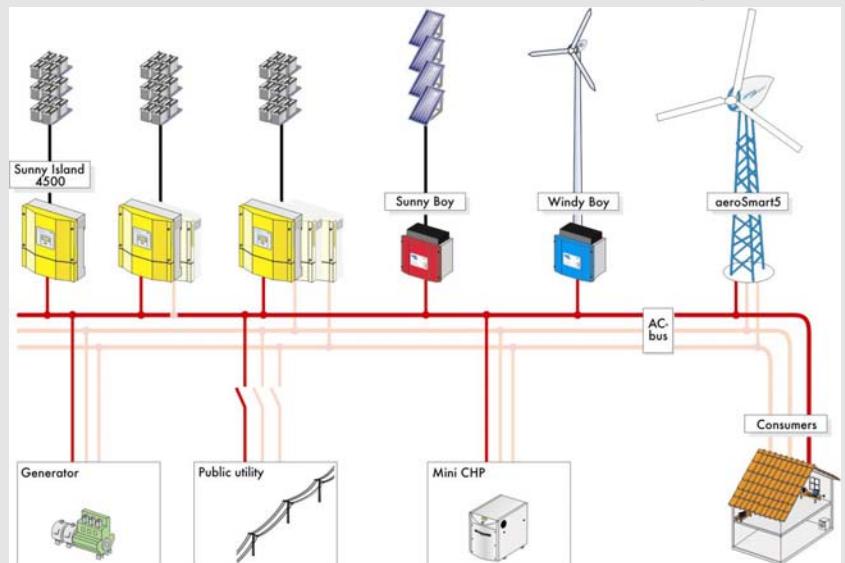


# Modular Systems Technology 1993 - 2005



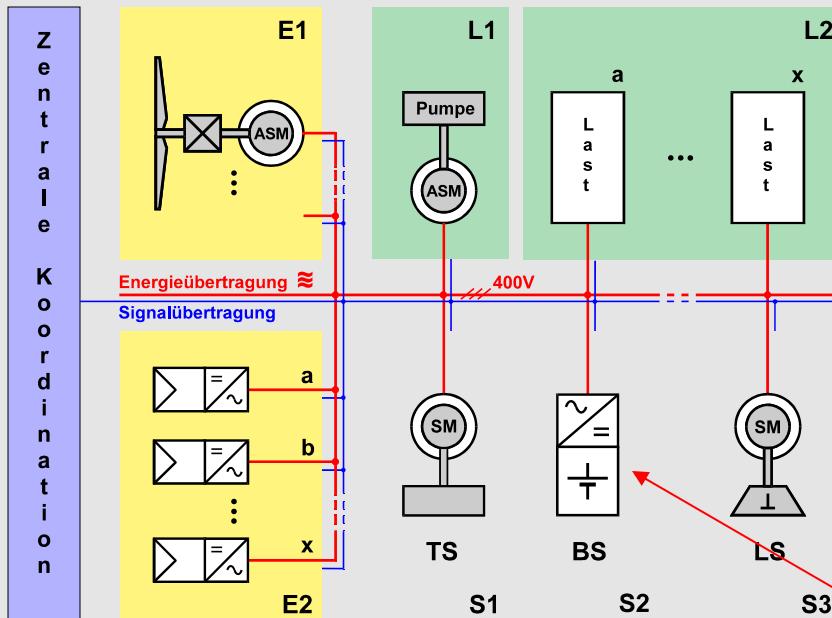
Concept, proof of concept  
1993 - 1998

Components, control  
1998 – 2001  
Source: SMA Technologie AG

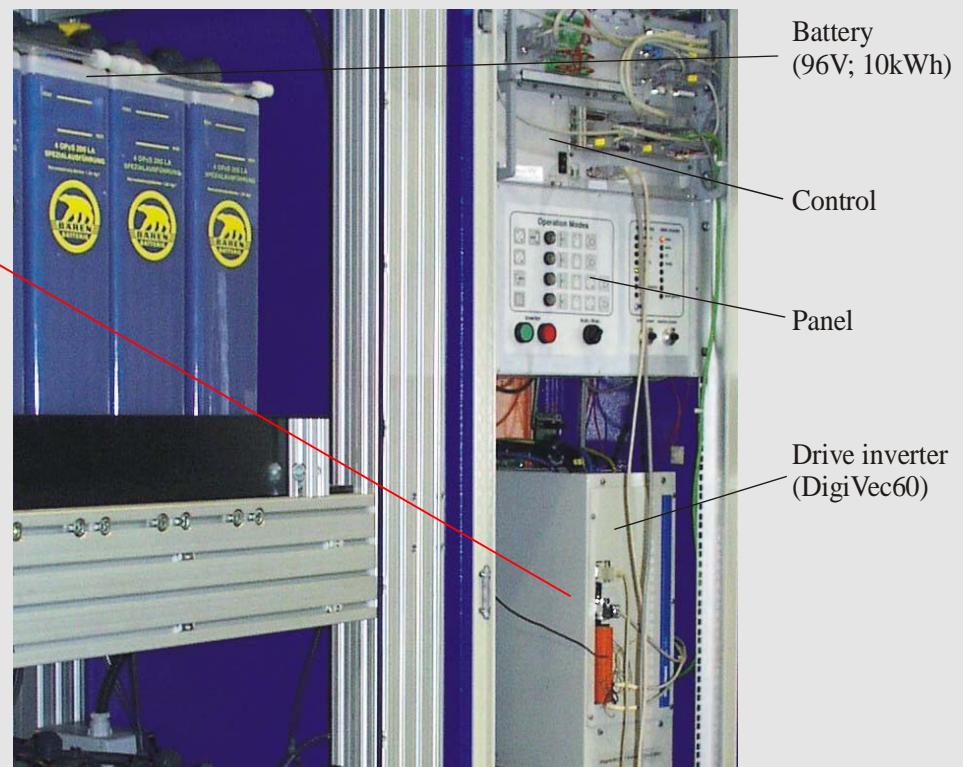


Interconnection, communication,  
protection, EMS, 2001 - 2005

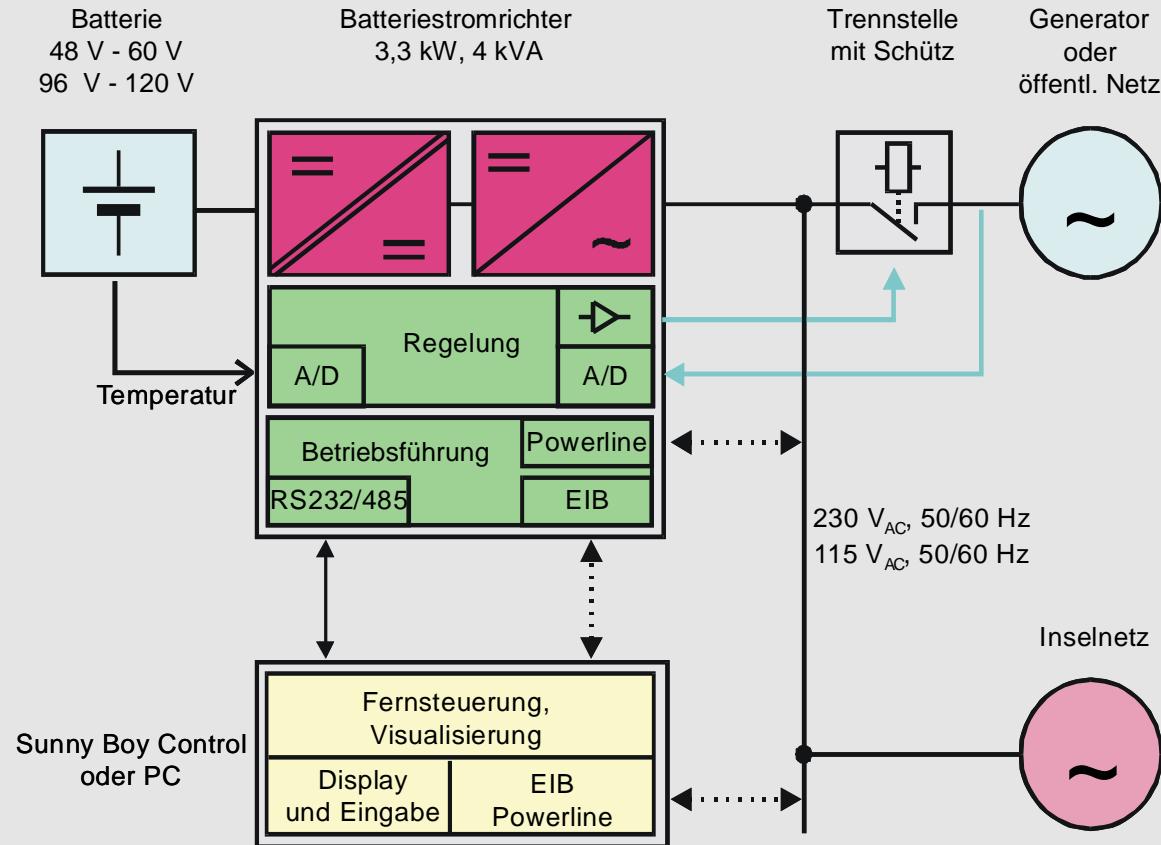
# EC-project MEGA-HYBRID 1994 - 1997



Three phase drive inverter adapted to use for island systems, droops have been planned for the supervisory control.



# Development of battery inverter 1997 - 1999

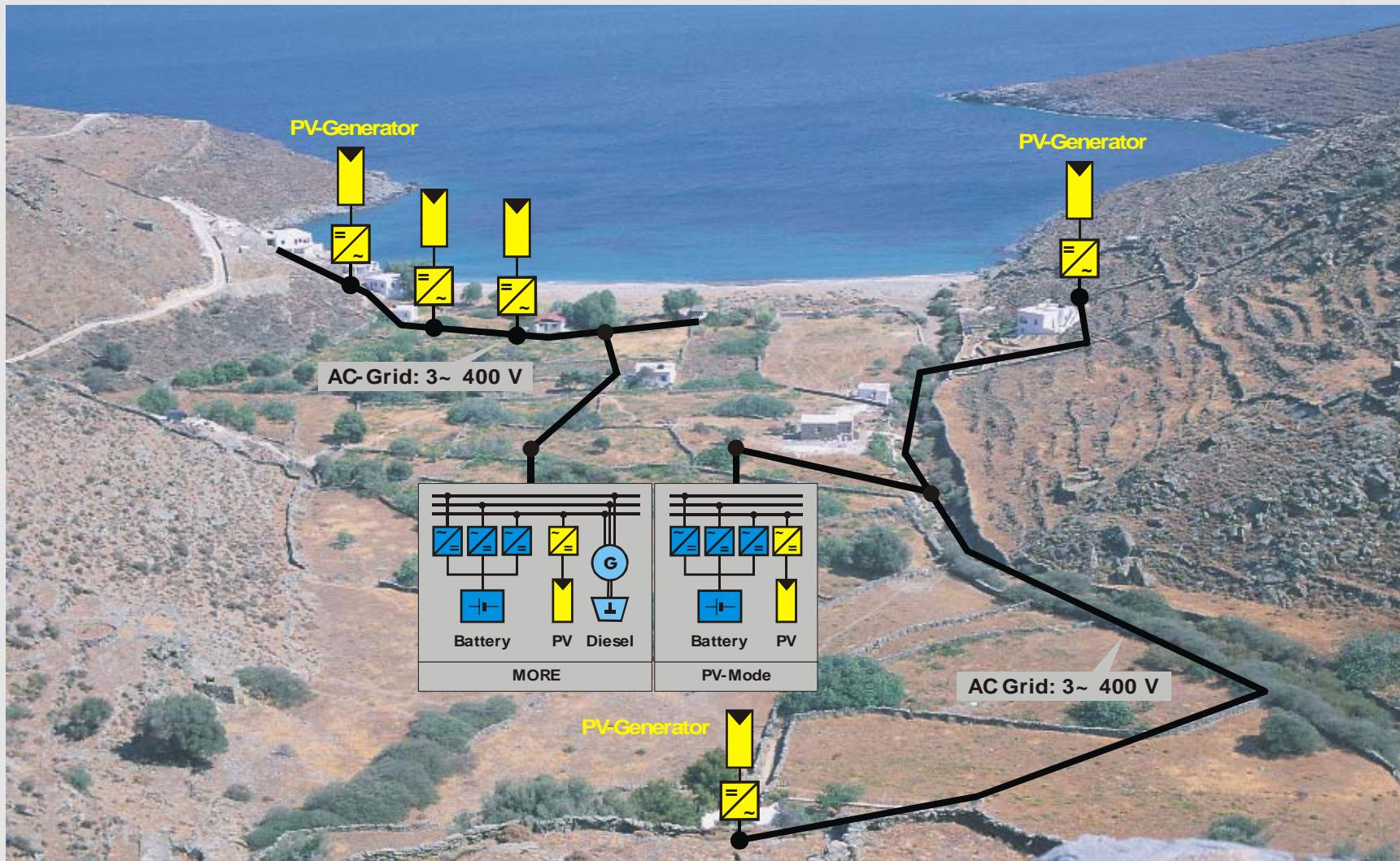


## Battery inverter Sunny Island



Principle of the Sunny Island (SMA) - prepared for expandable systems!

# EC-project MORE and PV-Mode 1998 - 2001



Pilot plant on Kythnos: Supply of 11 buildings

Nagoya 2007 Symposium on Microgrids, 06.04.2007, Nagoya, Japan



# Greek Island Kythnos



Nagoya 2007 Symposium on Microgrids, 06.04.2007, Nagoya, Japan



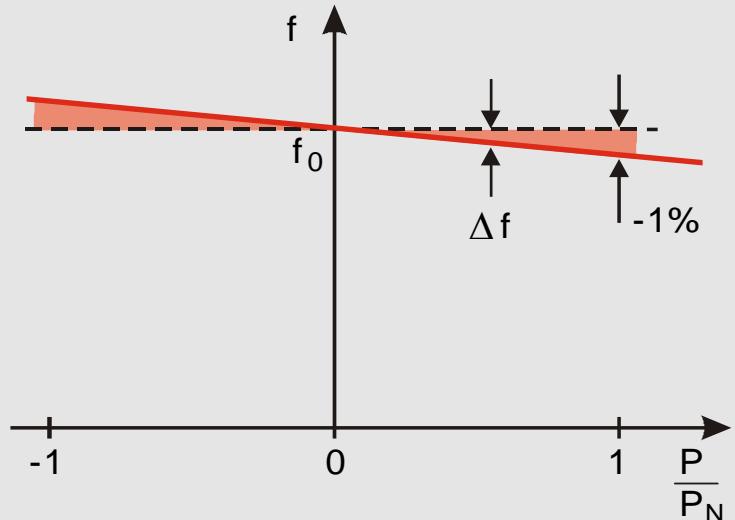
# Greek Island Kythnos



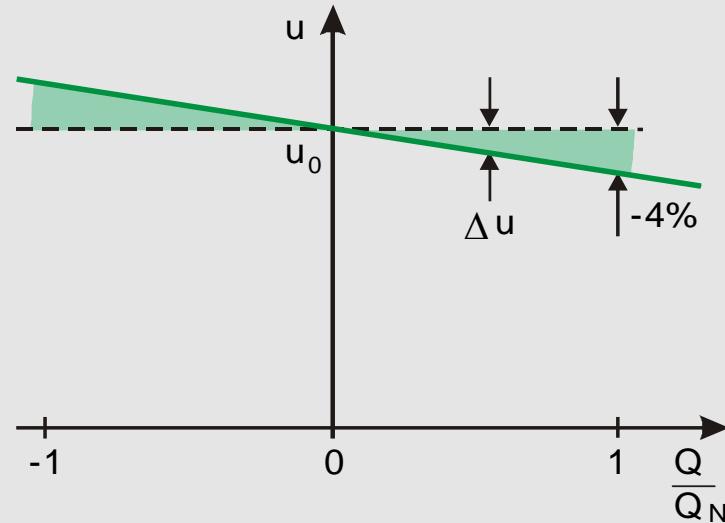
Nagoya 2007 Symposium on Microgrids, 06.04.2007, Nagoya, Japan

## selfsync®: Droop control for inverters (patented in Europe and US)

Inverters are controlled by droops:



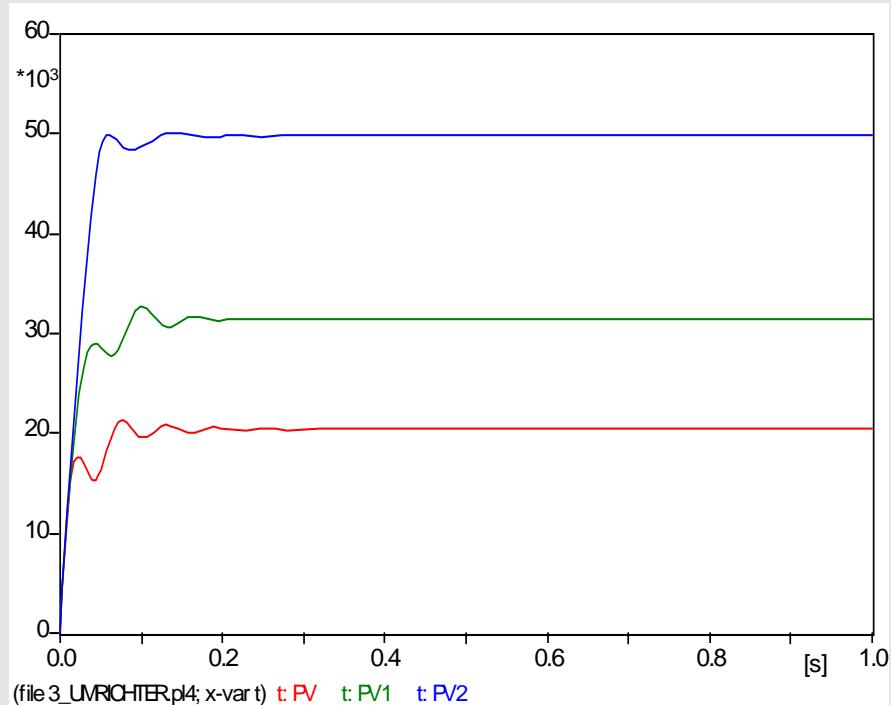
Frequency droop



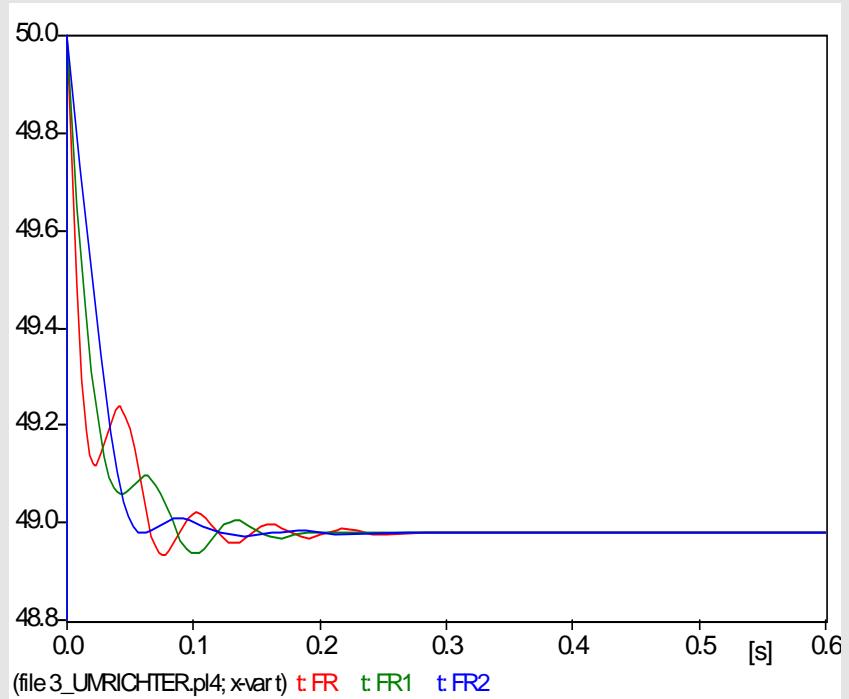
Voltage droop

The special implementation of droops with the **selfsync®** algorithm enables synchronisation and load sharing of inverters without communication!

# Load sharing and frequency change (selfsync®)

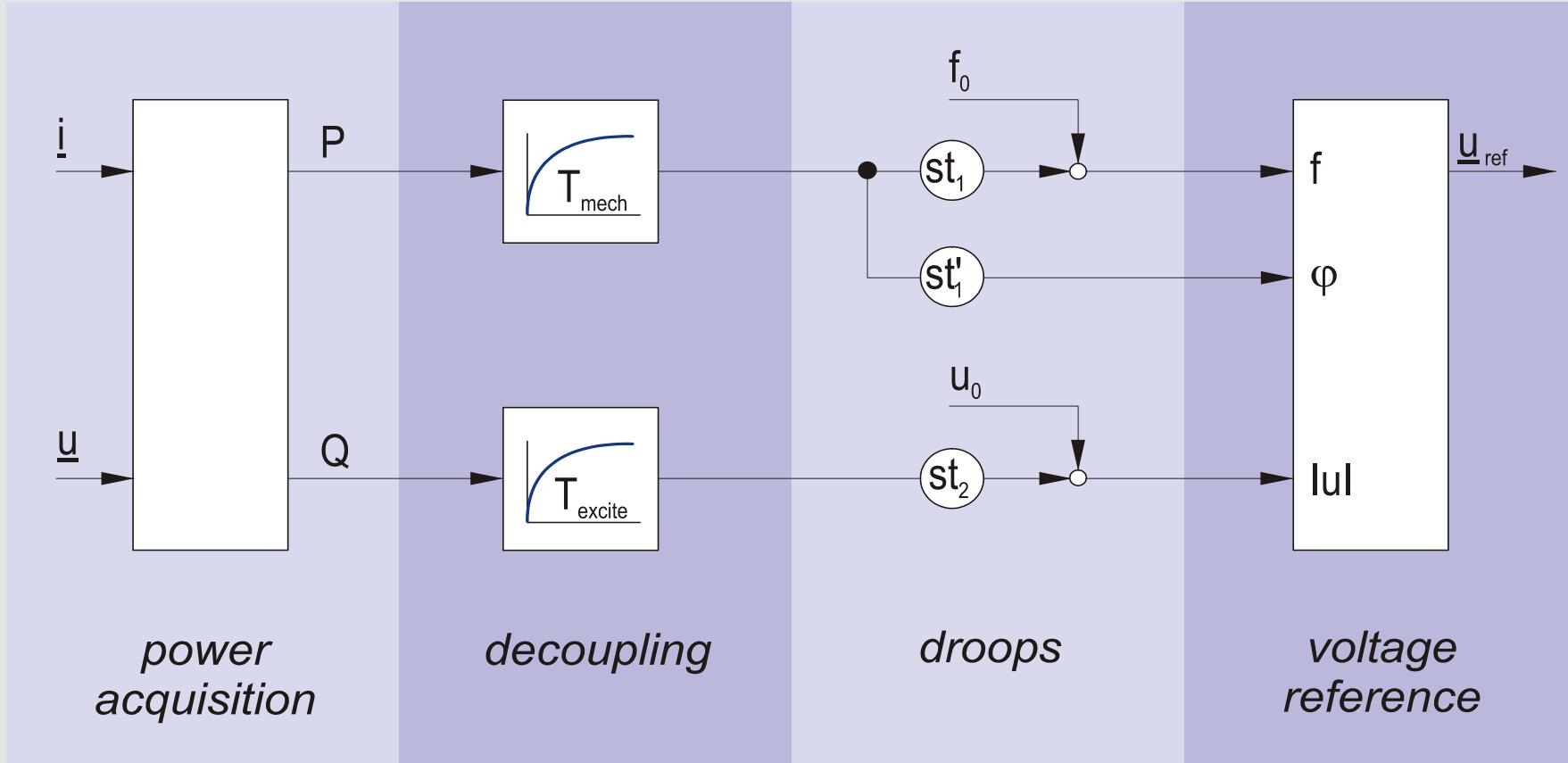


**Loadsharing: contribution depends on set-point of the idle frequencies**



**Synchronisation**

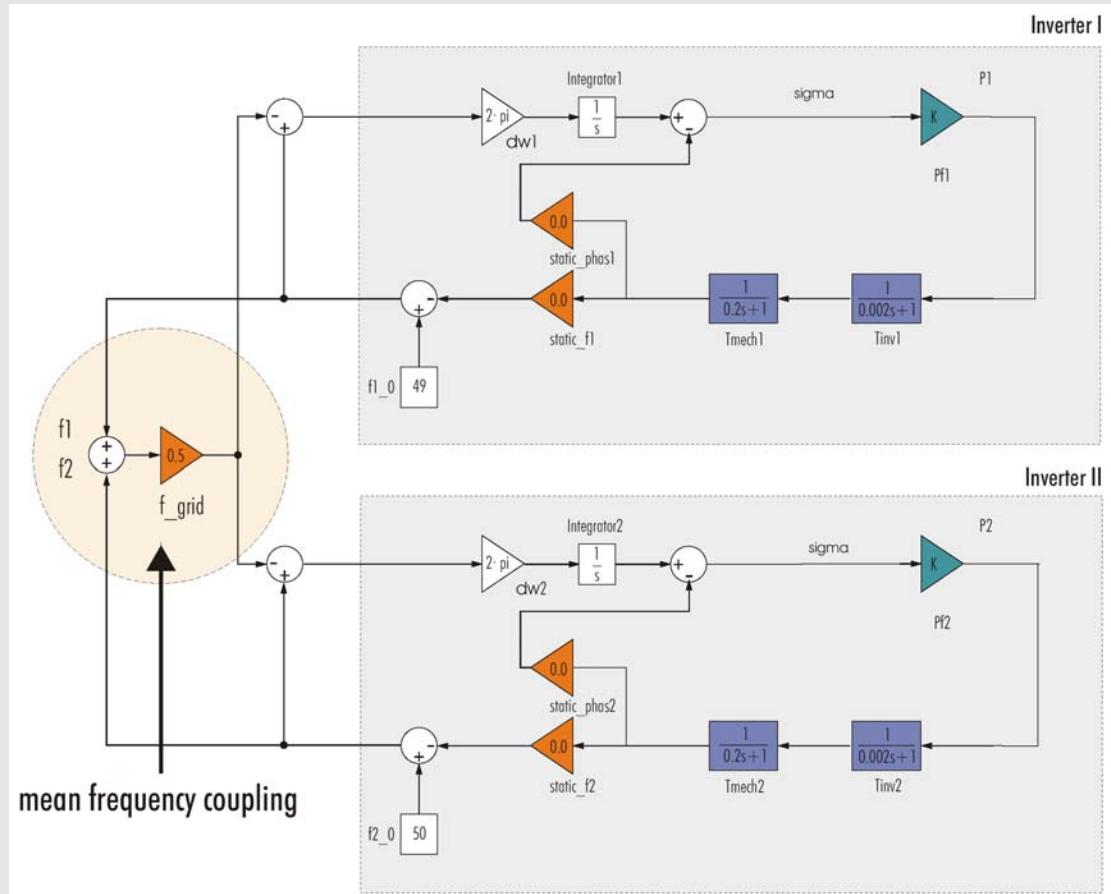
# selfsync®: Computation of set voltage for parallel operation of inductive coupled voltage sources (patented in US and Europe)



$$u_{\text{ref}} = |u| \cdot \sin(2 \cdot \pi \cdot f \cdot t + \varphi)$$



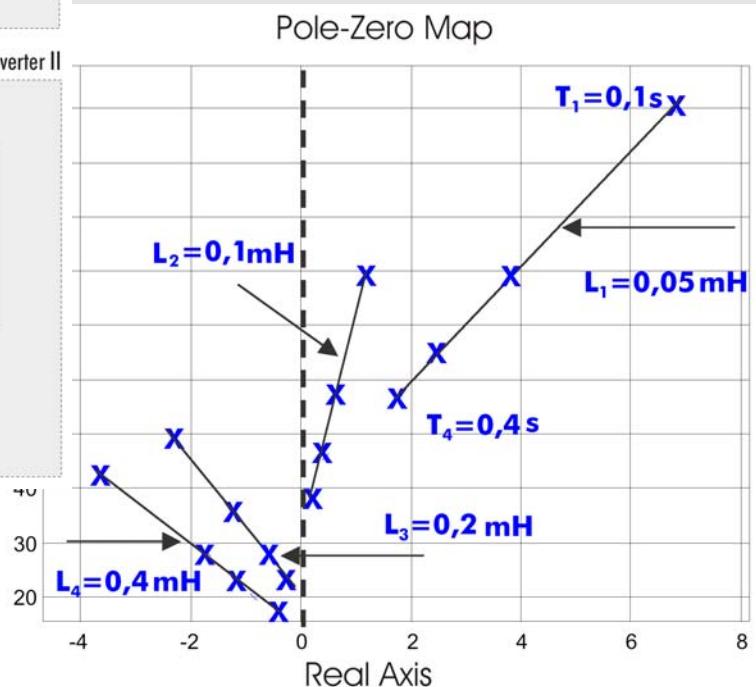
# Stability assessment of multi-inverter systems (selfsync®)



MatLab/Simulink model based on mean frequency coupling

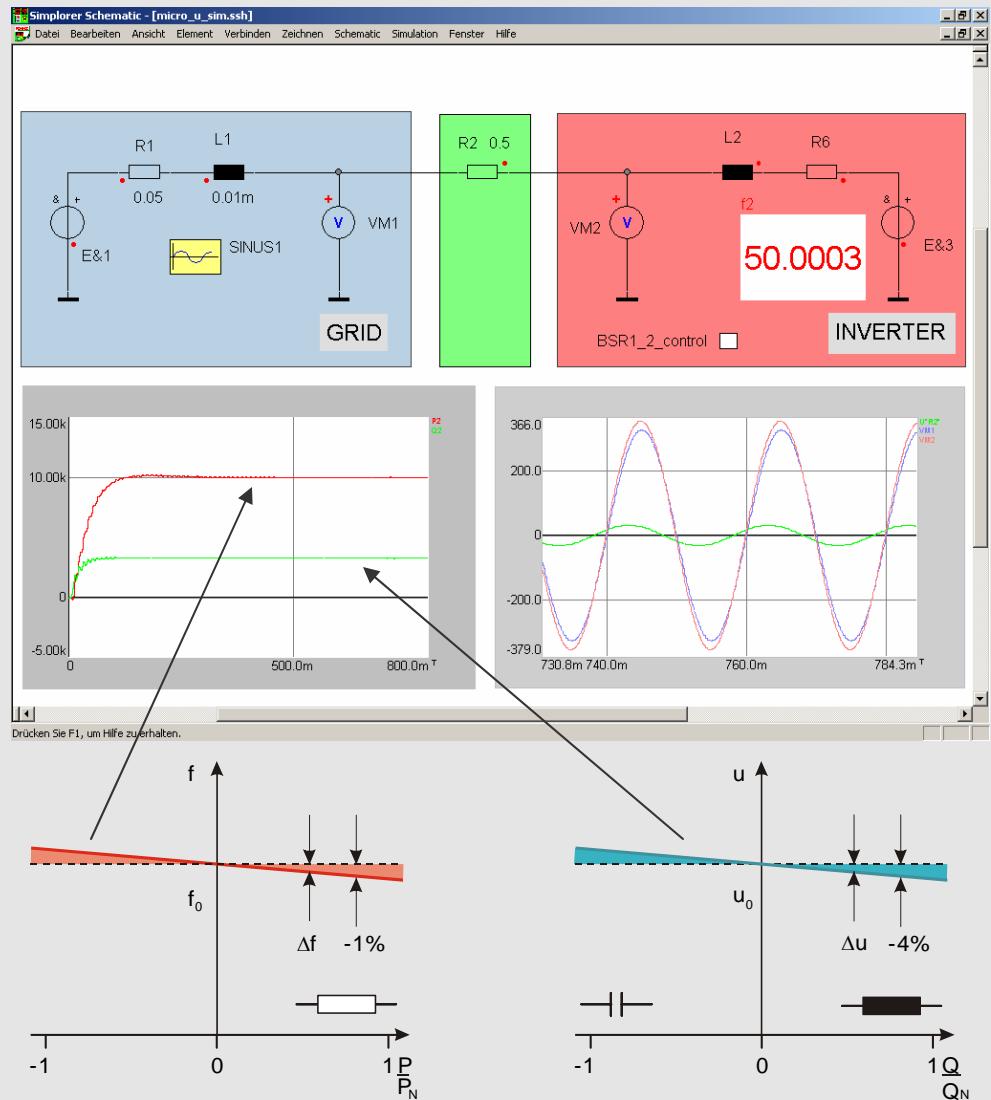
- Stable
- Scalable

Stable and unstable operating points



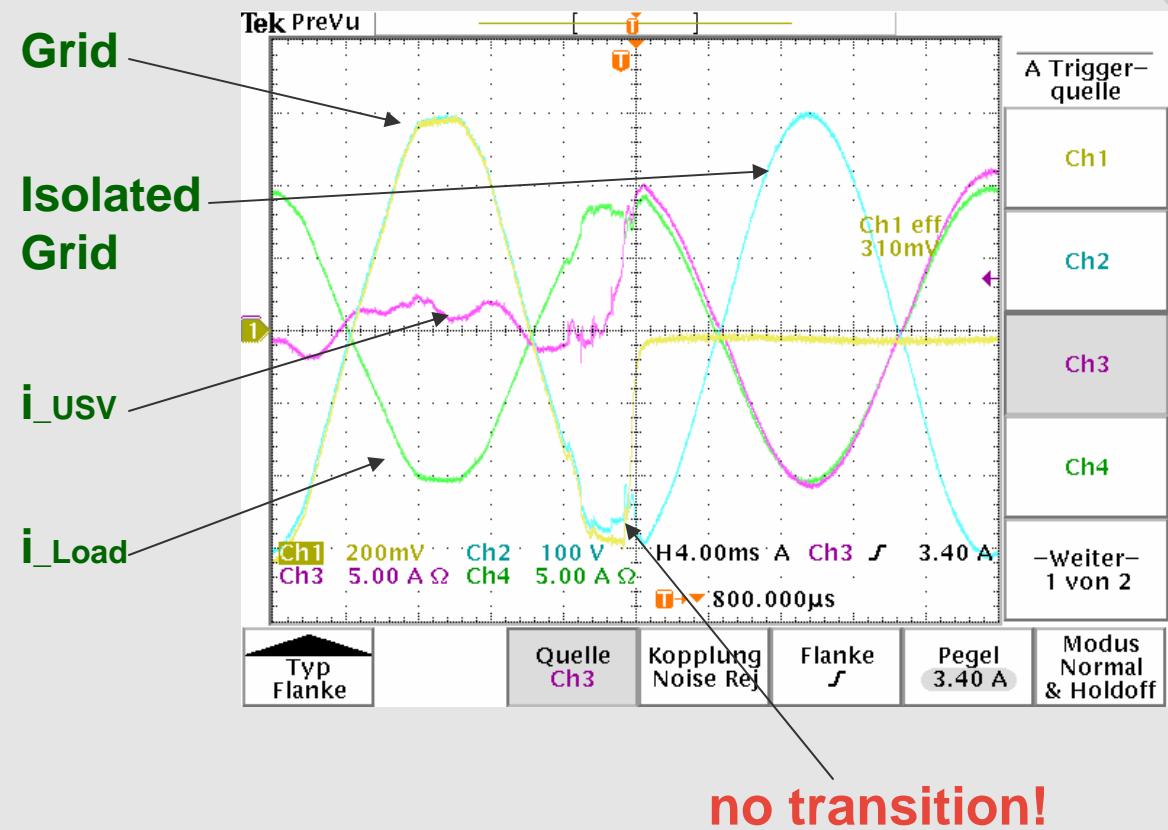


## „Indirect operation“ of droops in case of resistive coupling (LV-case)



- Applied droop concept is based on inductive coupled voltage sources.
- In a LV-grid components are coupled resistively, thus voltage determines the active power distribution
- There are two effects of droops
  - direct (inductive coupling)
  - indirect (resistive coupling)
- The „indirect“ effect requires droops, which have the same sign for the frequency as well as the voltage droop and therefore the stable operation point is „in phase“.

# High Impedance Grid fault (selfsync®)



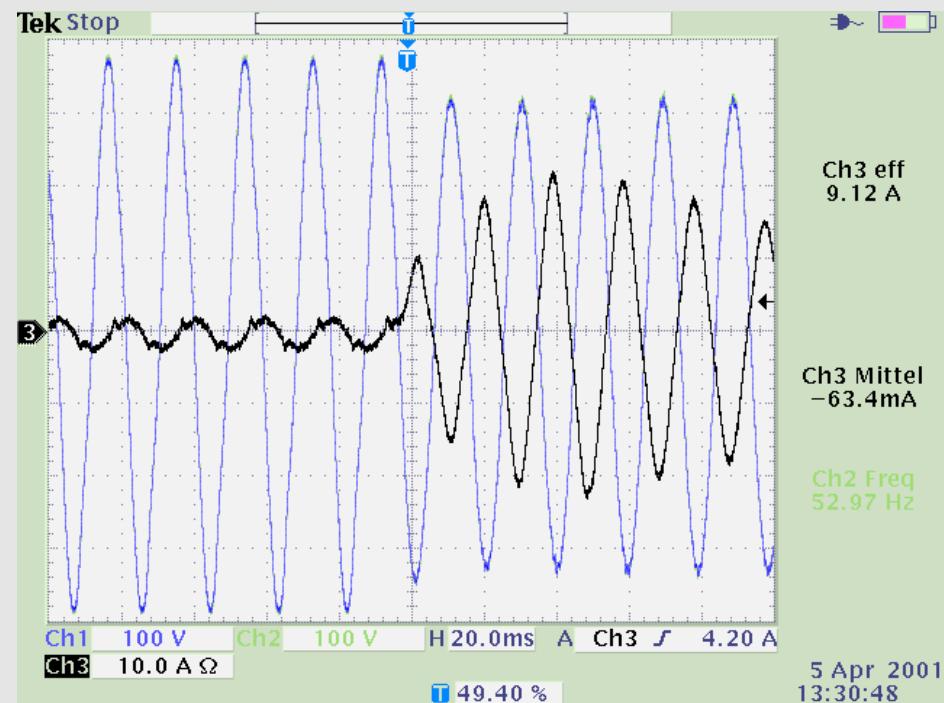
Principally the suggested control mode also continuous operation even in case of a line interruption. A **grid failure** mostly results not in an interruption but in a **short-circuit** and therefore motivates the development of a **disconnection device**!

# Parallel operation of an ASG and Sunny Islands (selfsync®)

Load sharing between Sunny Island and genset is possible due to the inherent frequency / active power characteristic of the genset (slip, mechanical controller)

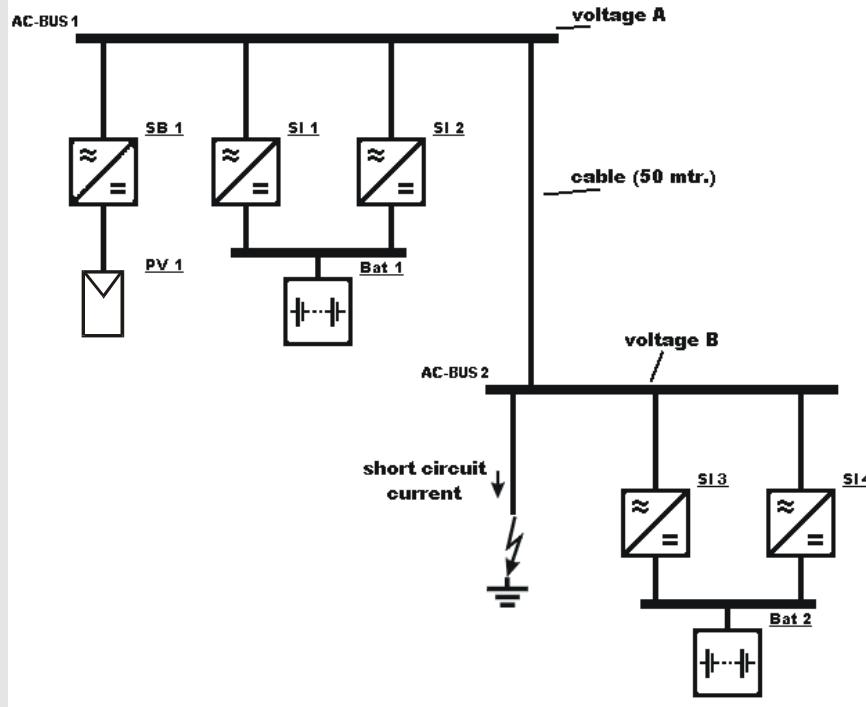


Single phase genset with ASG and capacitor (Fa. Kirsch)



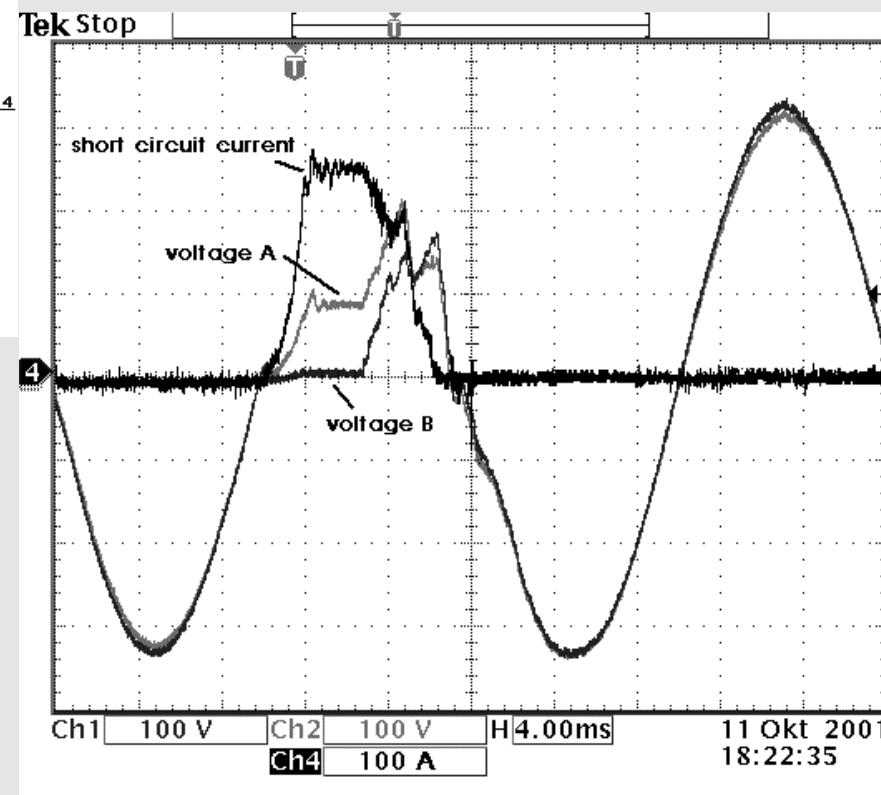
Synchronising a Sunny Island onto the genset (idle frequency set for charging)

# Increasing short circuit power (selfsync®)



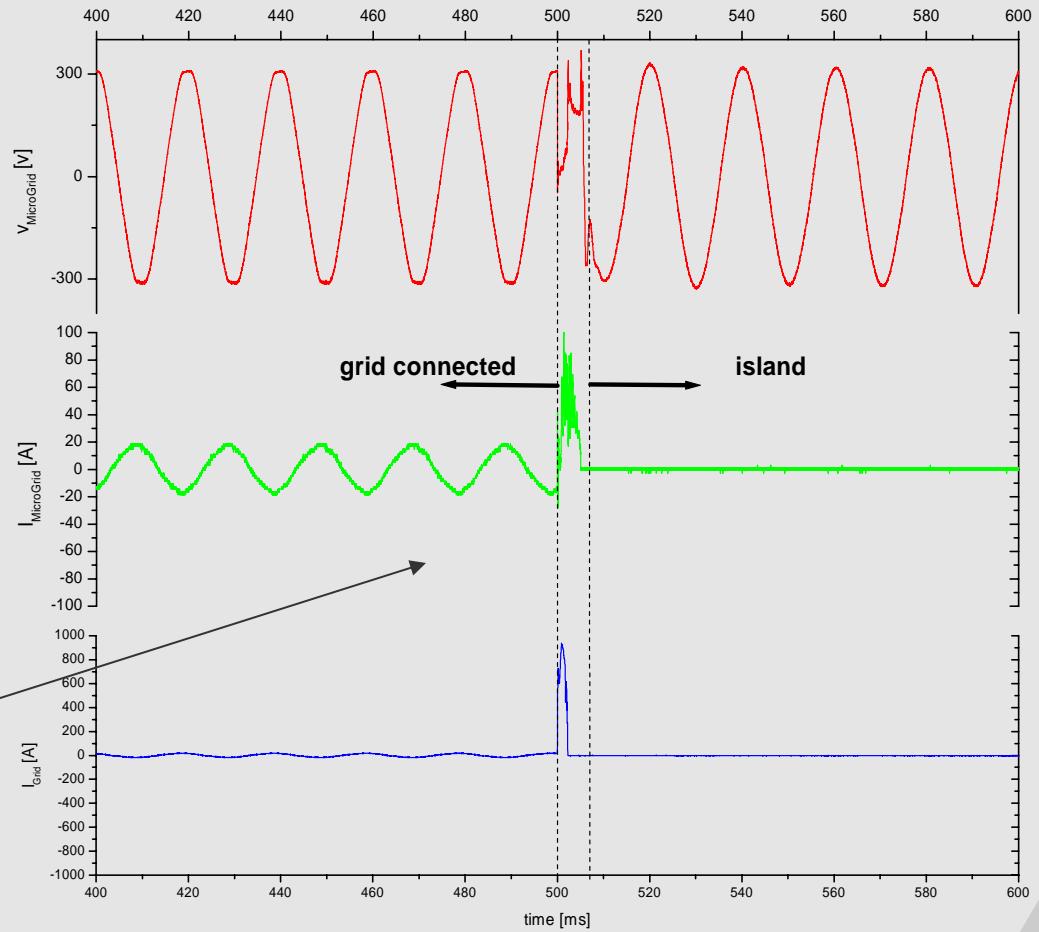
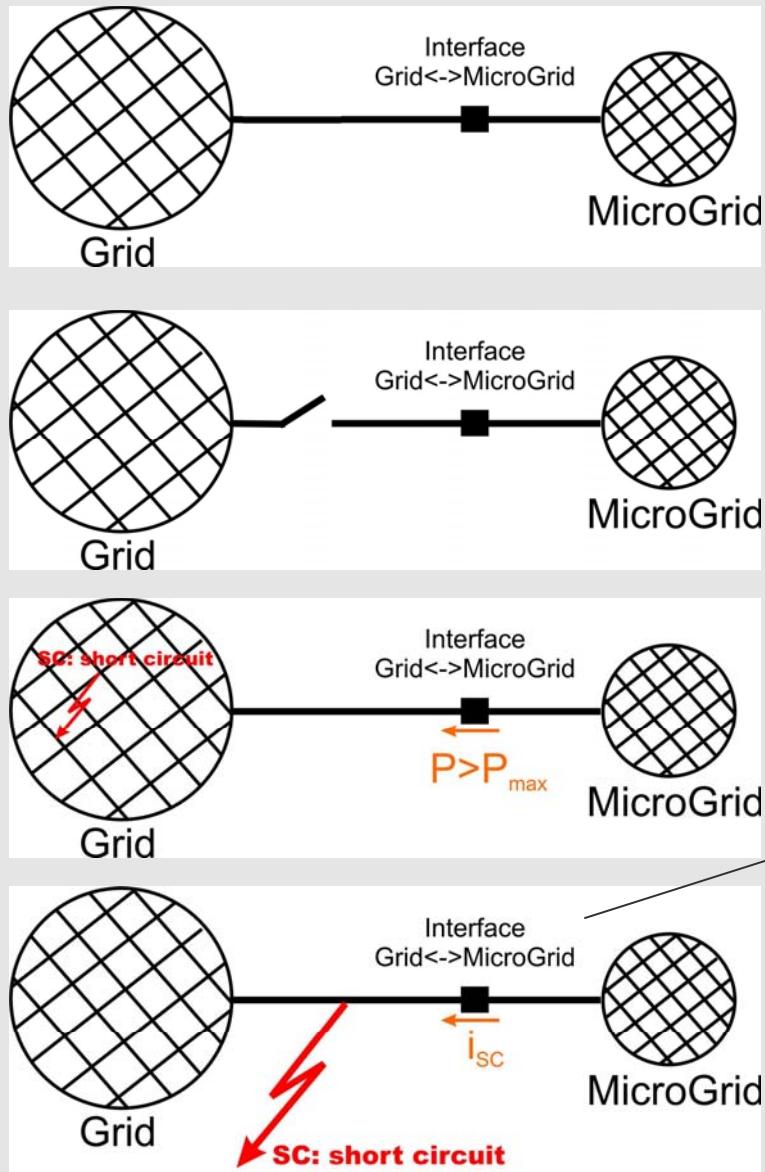
**Short circuit:  
triggering a circuit breaker**

**Single phase inverter grid  
(DeMoTec, ISET)**



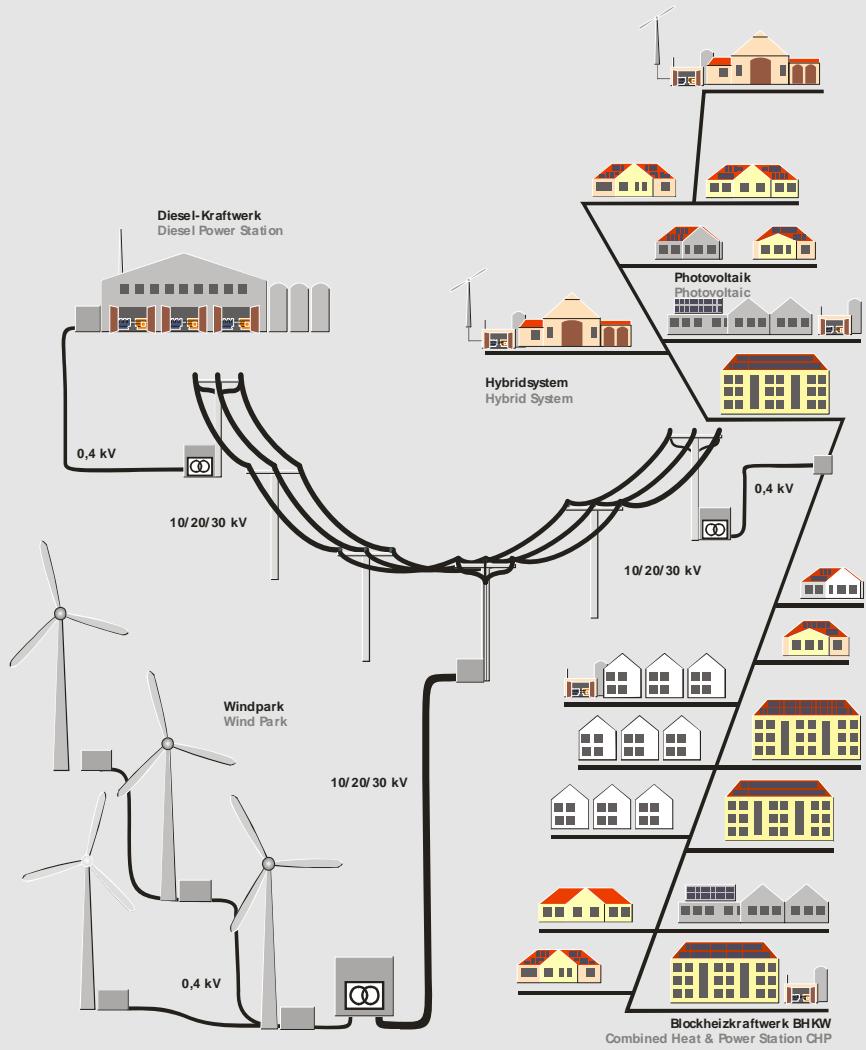


## Electronic switch: possible faults (selfsync®)





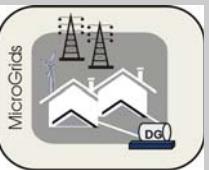
# Interconnecting distribution systems (MV- and LV-Grids)



Medium-voltage grid emulator

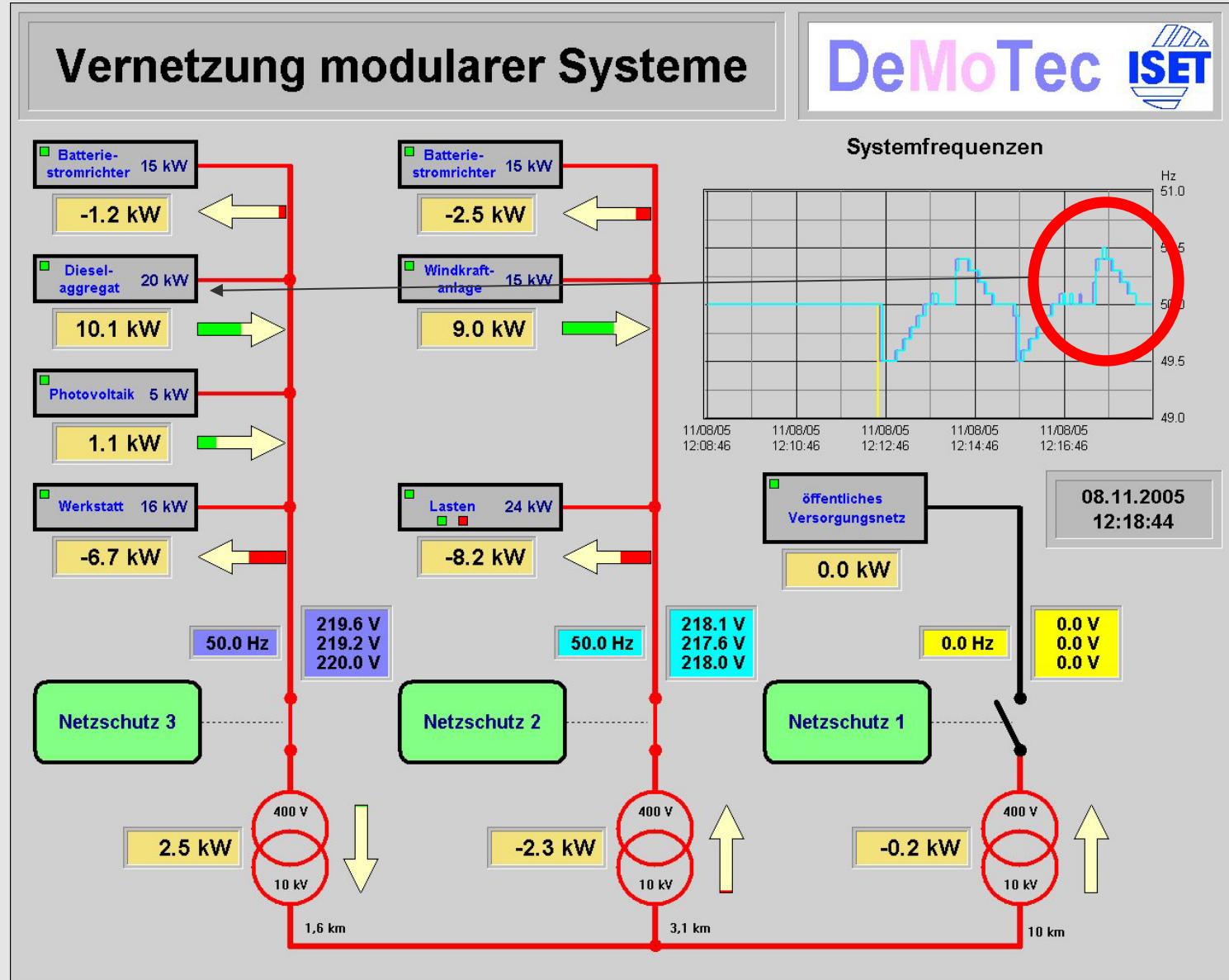


Line equivalent



# Laboratory demonstration

## - Starting diesel genset (tertiary control) -



Nagoya 2007 Symposium on Microgrids, 06.04.2007, Nagoya, Japan

## Future Work

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- Innovative Protection Systems combining EMS and online-monitoring on MV-level
- Multi-microgrids (participation in EC-project More Microgrids)
- SCADA-systems and standardisation of communication
- Meshed grids

## Conclusion

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**Microgrids is a viable concept. This is mainly due to the effective use of power electronics!**

**THANK YOU!**