



Cellular power grids for a 100% renewable energy supply

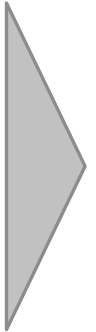
Eberhard Waffenschmidt
May 2015, IRENEC 2015



Climate change is hardly perceptible



100% Renewable Energy is possible



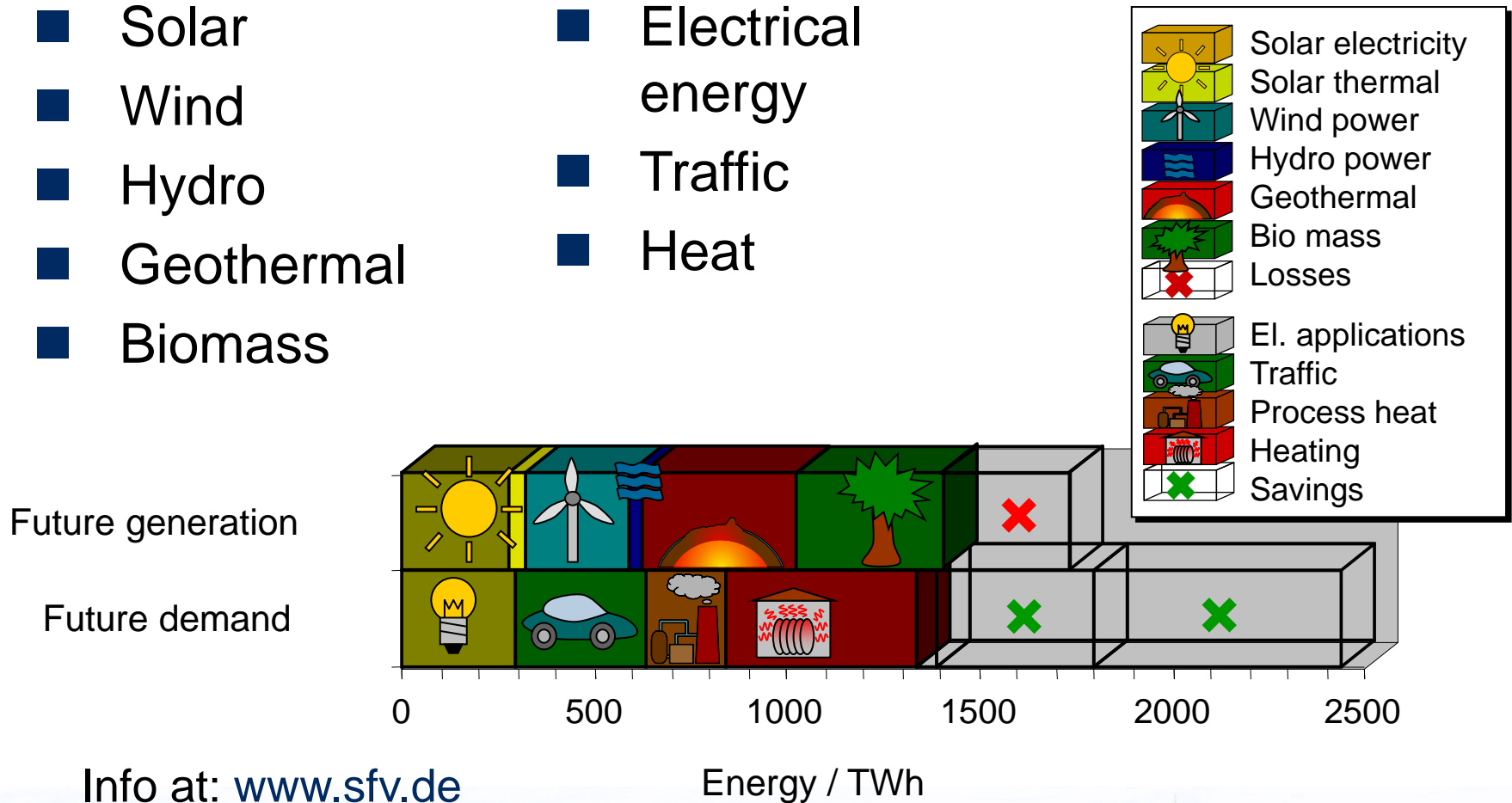
100% Renewable Energy is possible

Sources

- Solar
- Wind
- Hydro
- Geothermal
- Biomass

Savings

- Electrical energy
- Traffic
- Heat

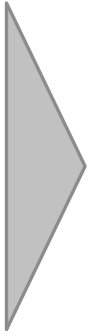


Info at: www.sfv.de

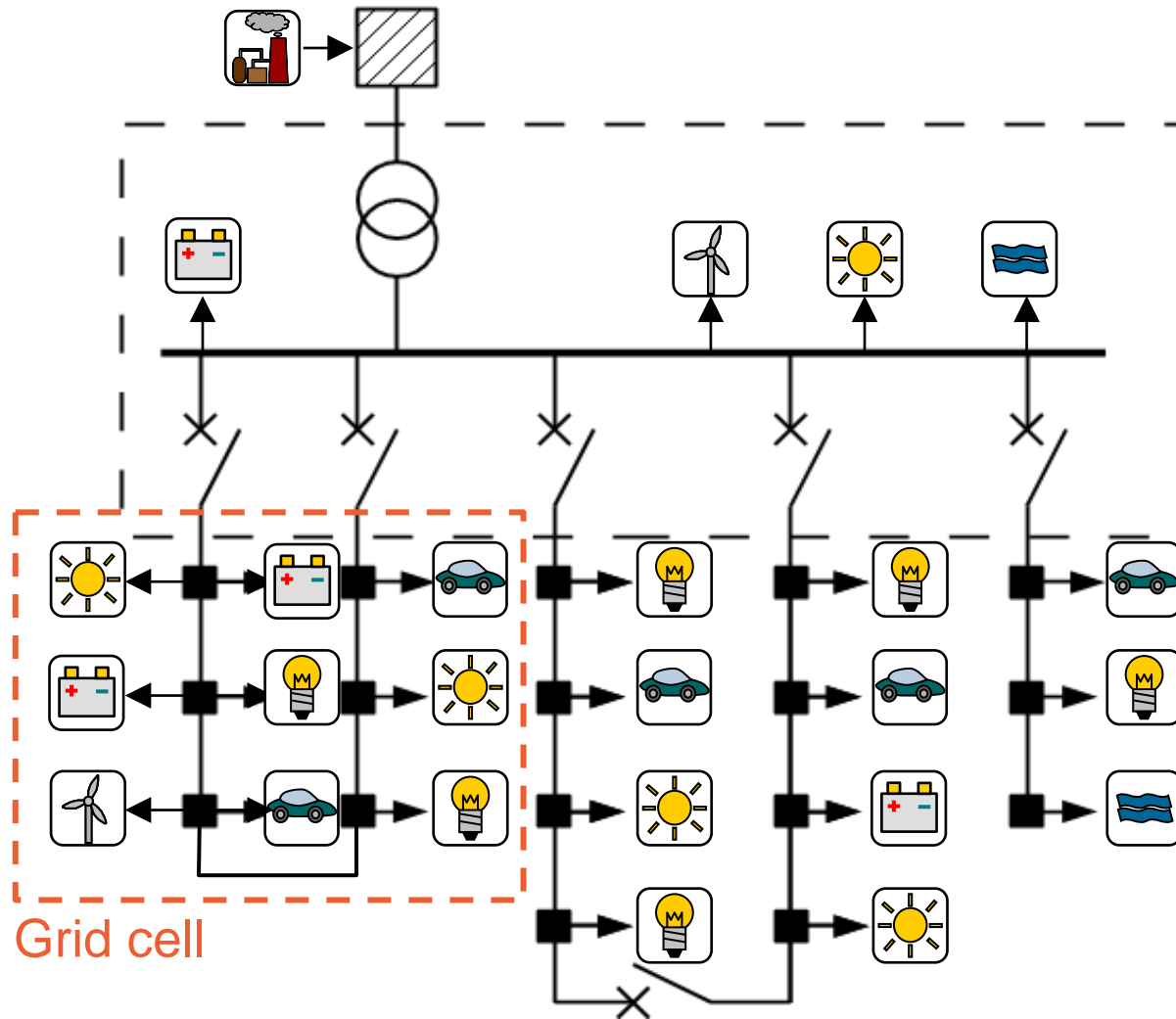
Energy / TWh



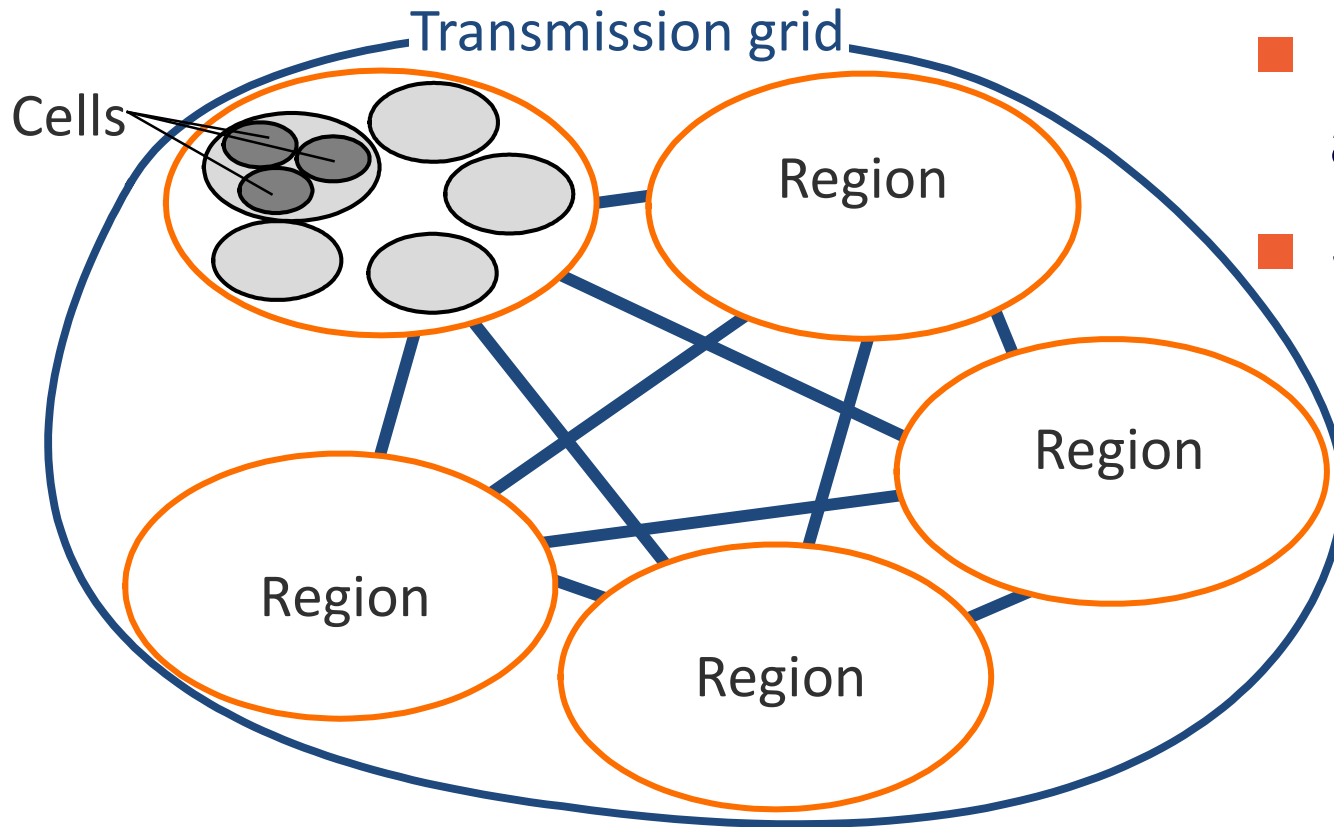
Cellular grid



Power grid with distributed renewables



Cellular grid



- Autarcic cells
- Bottom-up-approach
- Swarm control



Autarkic Cell

Control



Power balance

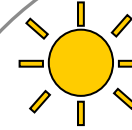


Storage

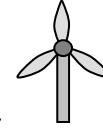


Virtual inertia

Generation



Solar power



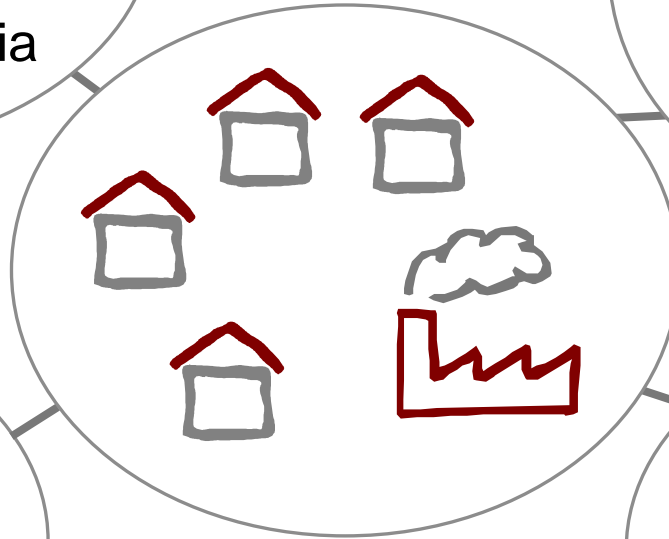
Wind power



Bio energy



Hydro power



Fault Management



Short Circuit



Blackstart

Organisation

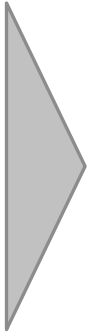


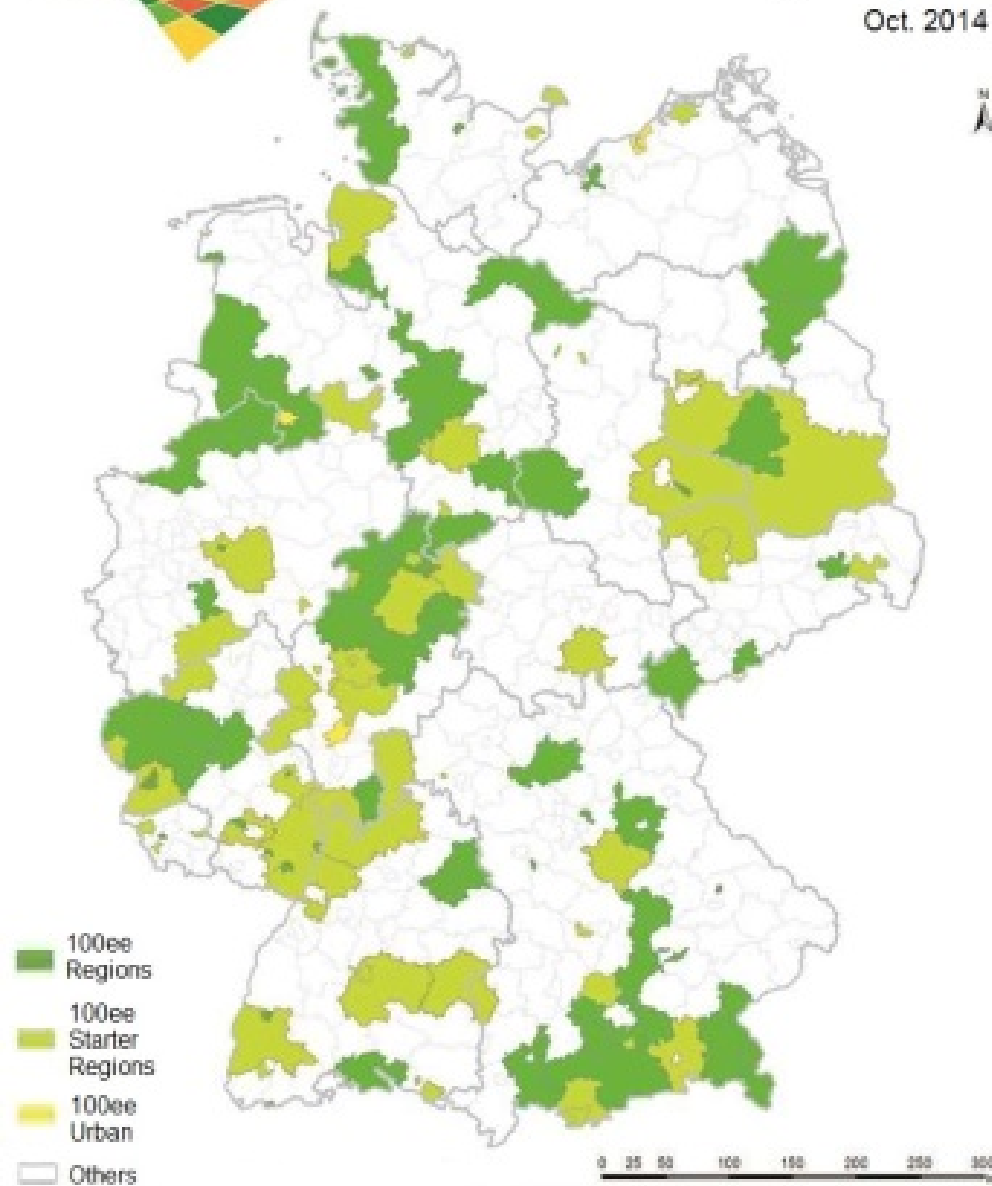
Business



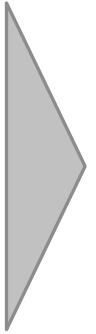
Legal

Autarky vs. Autonomy





Blackout



Blackout



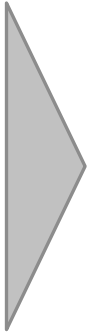
Whole Europa
is hit by a
Blackout.

Whole Europa?
Nope!
One smart
village is able
to fight the
darkness...

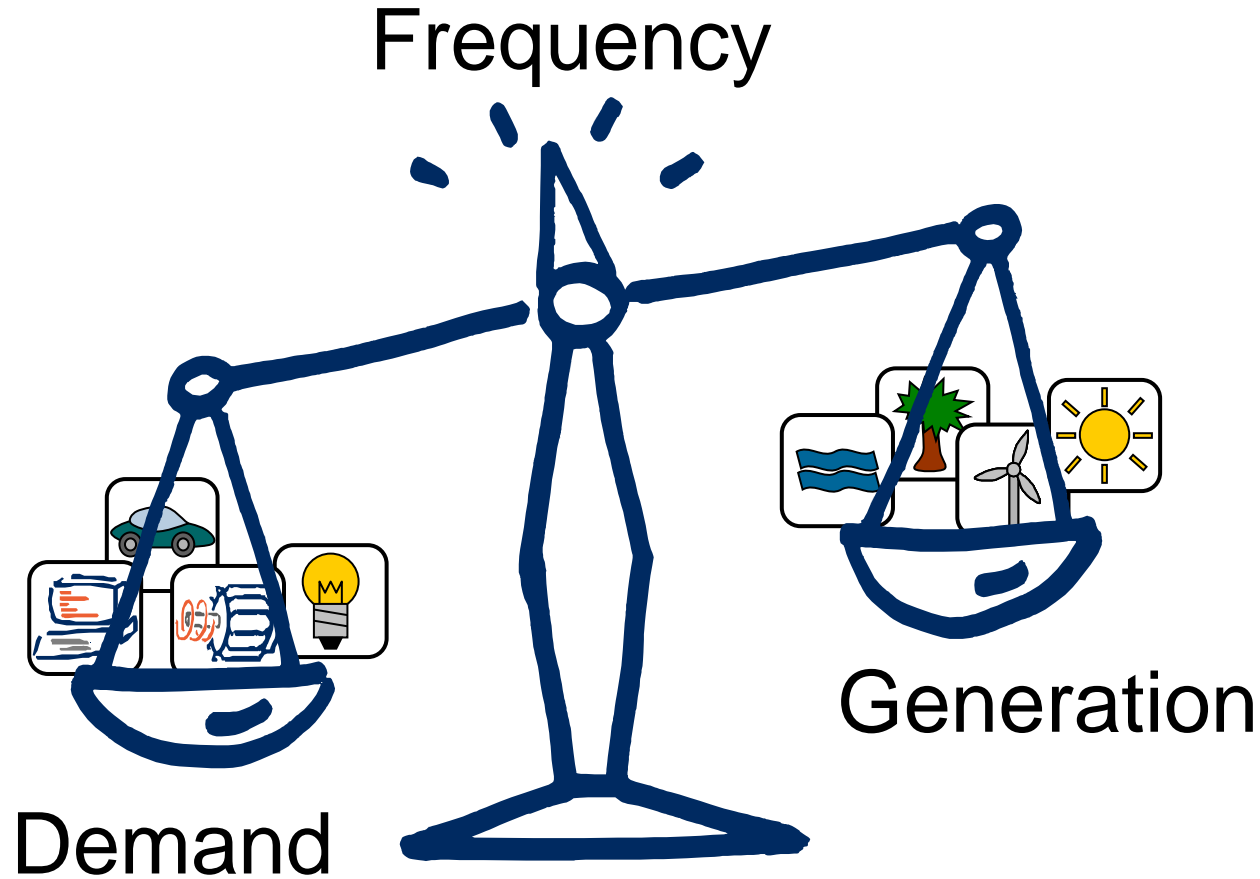
And there will
be more!



Balance of power



Balance of power



Control types

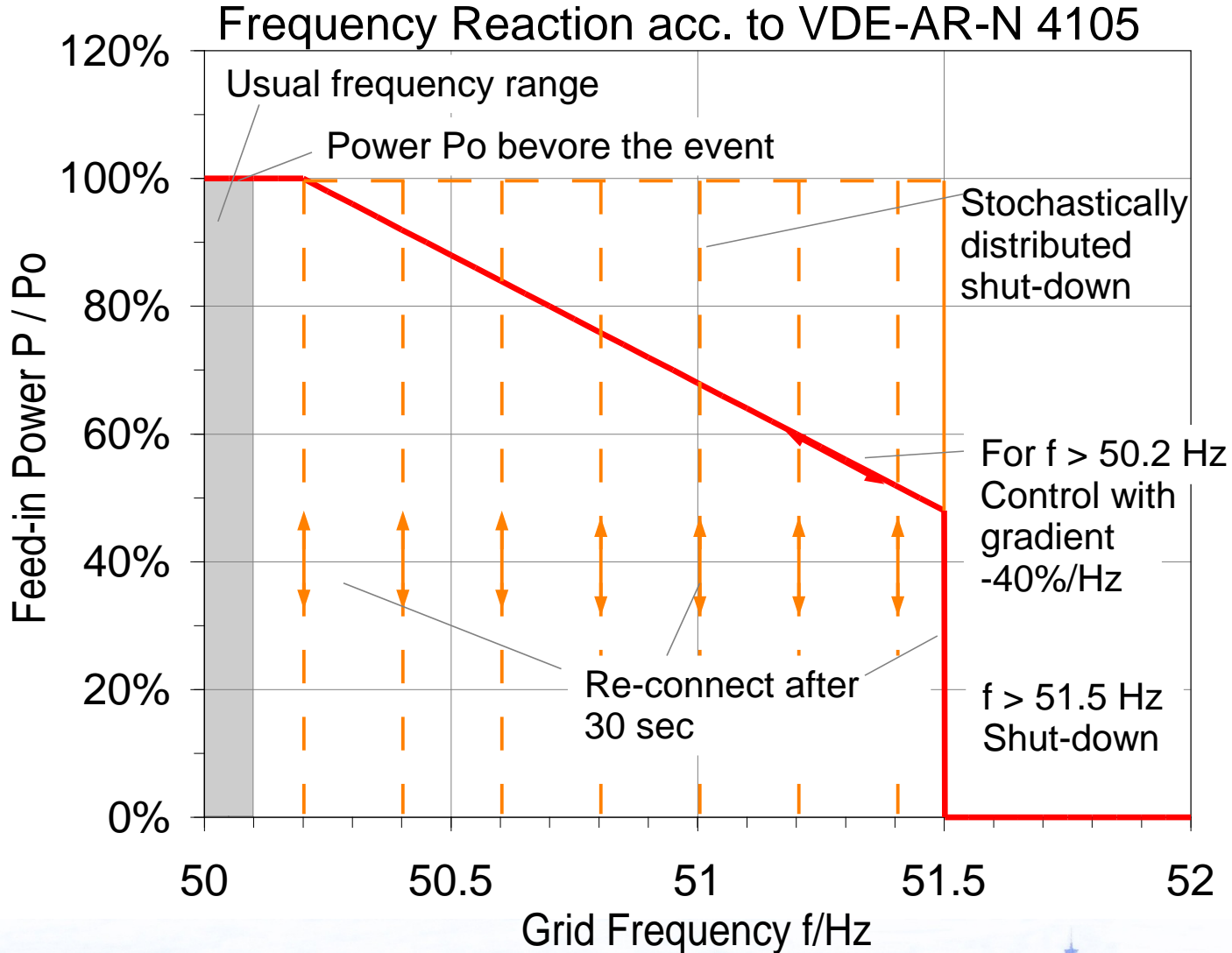


Master control

Foto: AP



Frequency response at low voltage grid



Control types

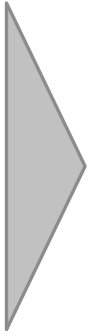


Master control

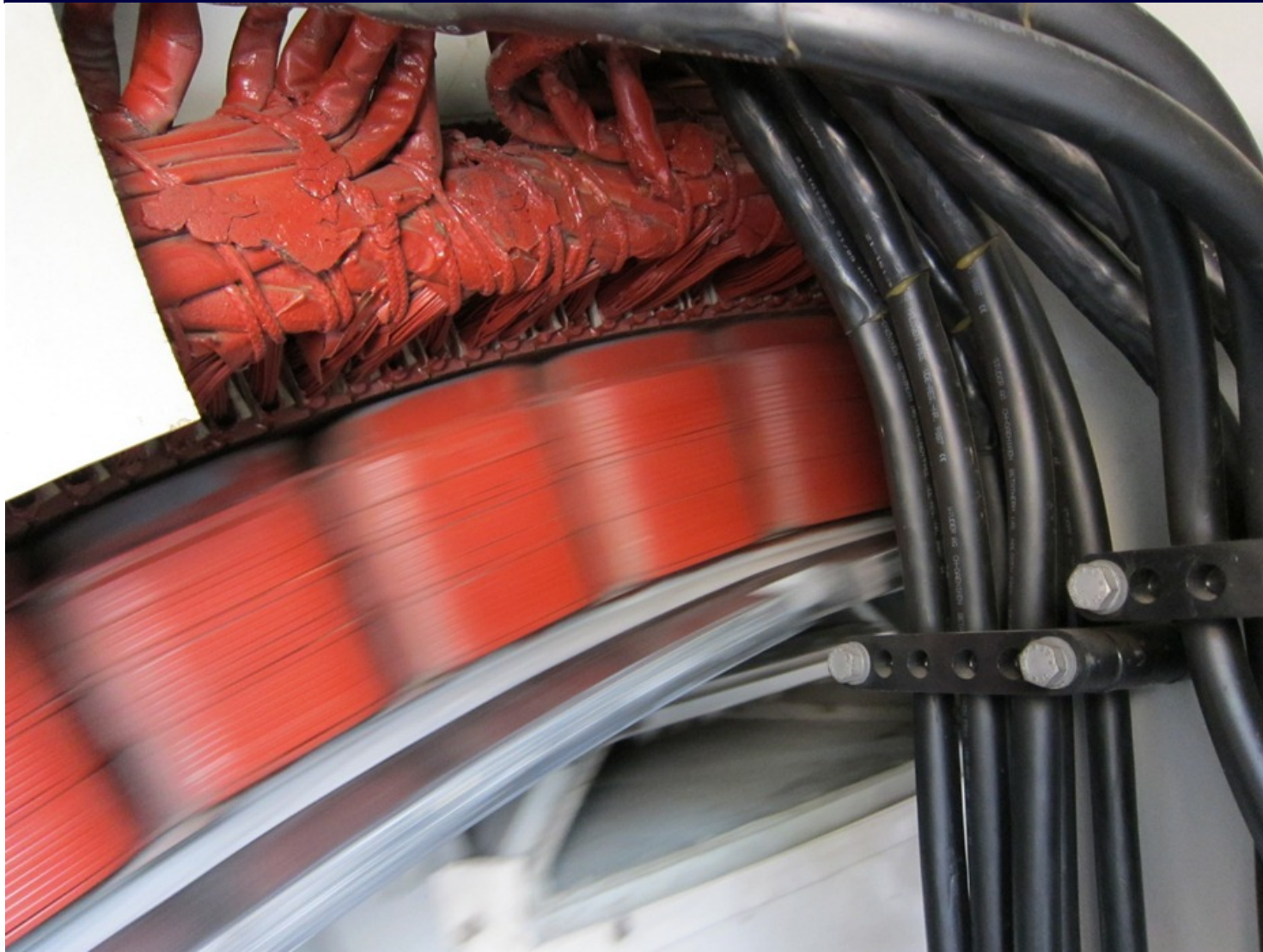


Swarm control

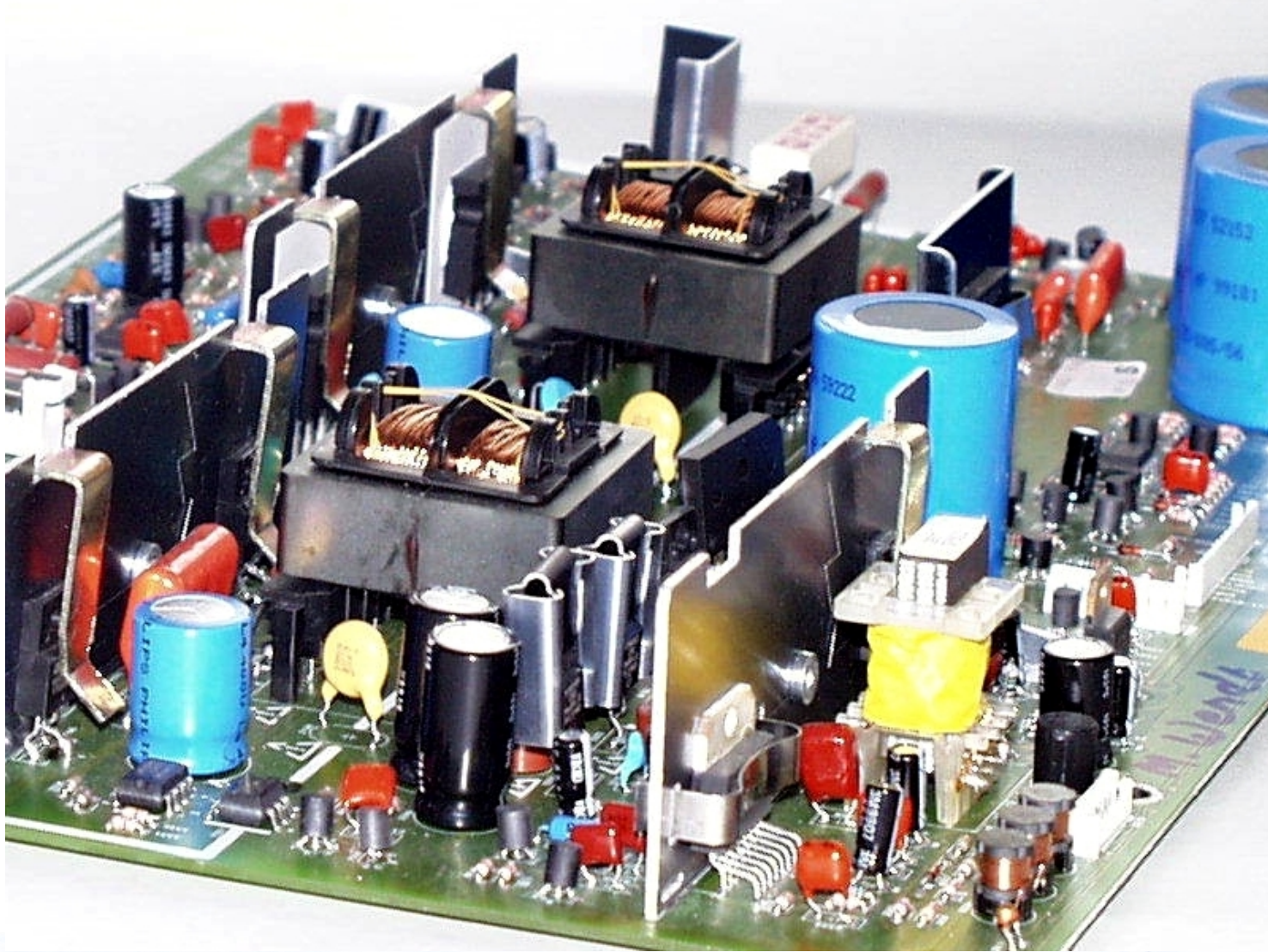
Grid control



Rotating masses of generators



Electronic has no inertia

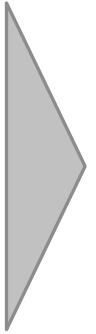


Frequency control with renewables

- VSYNC-Projekt:
 - Frequency control with PV-inverters
- Virtual synchronous generator
 - Inverter behaves like a synchronous generator
- Enercon wind turbines
 - Frequency control for wind power inverters
- Kombikraftwerk 2
 - Control distributed across Germany



Examples



Examples

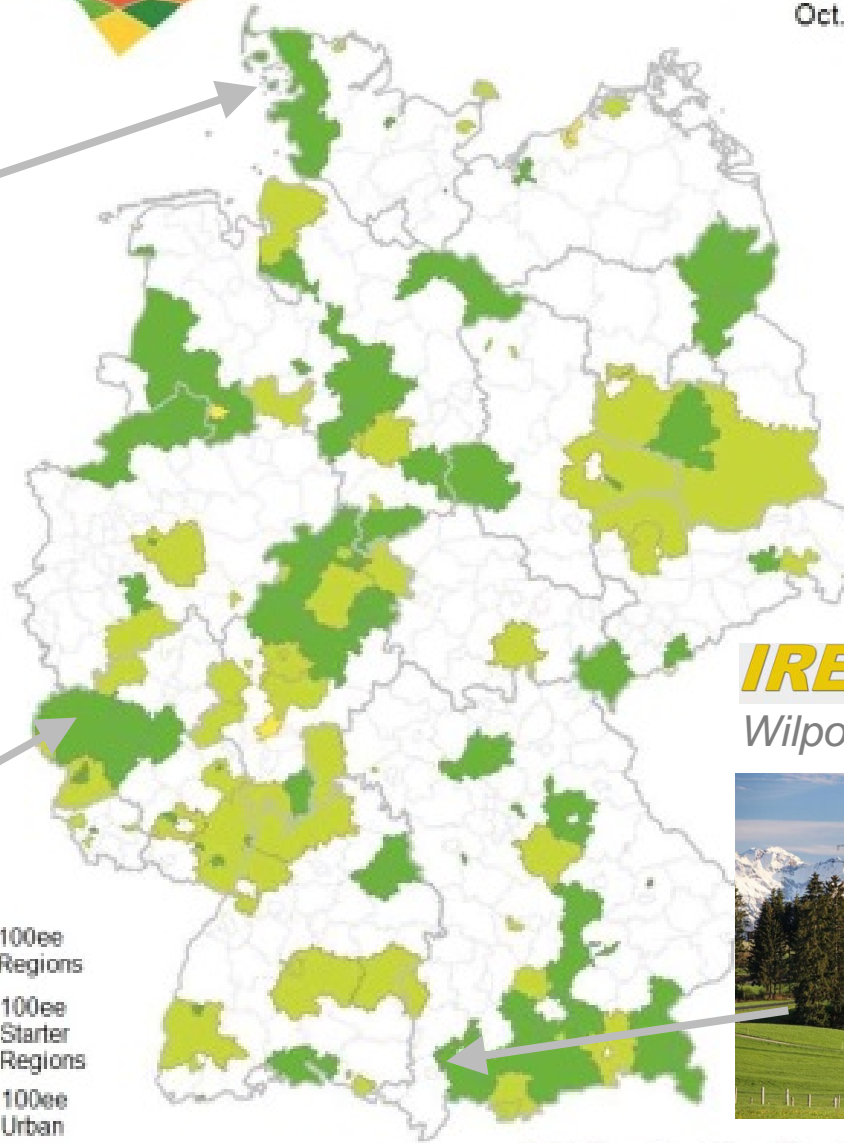


100% Renewable Energy Regions

Oct. 2014



- 100ee Regions
- 100ee Starter Regions
- 100ee Urban
- Others



Towards 100% Renewable Energies

With a cellular grid...

- electrical power becomes more resilient.
- we learn how to operate our future grid.



Contact

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[eberhard.waffenschmidt/index.html](http://www.f07.fh-koeln.de/fakultaet/personen/p_eberhard.waffenschmidt/index.html)

