Fraunhofer IFF

Smart electronic units for power system flexibility

An option for the future

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Agenda

1. Introduction & Motivation
2. Project RELINK
3. First results of potential and requirements analys
4. Selected UseCases
5. Conclusion

Project topics

- Power electronics to integrate RES in medium voltage grids
- Intelligent link between AC & DC networks
- Effect and potential analysis of future system services
- Guide for migration of existing systems

RELINK

Gefördert durch:

Bundesministerium für Wirtschaft und Energie

aufgrund eines Beschlusses des Deutschen Bundestages

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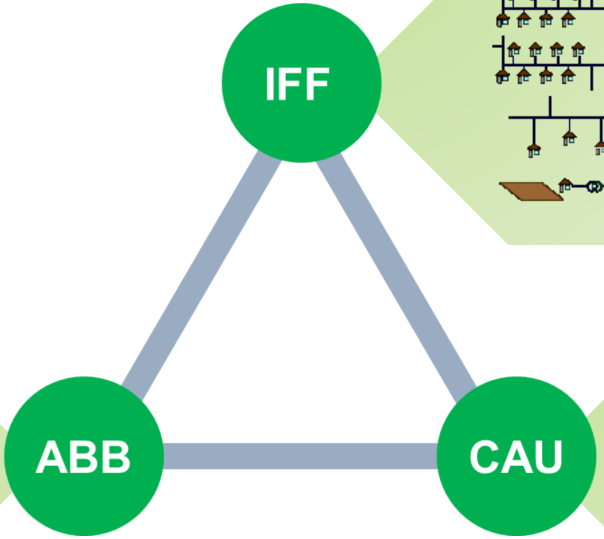
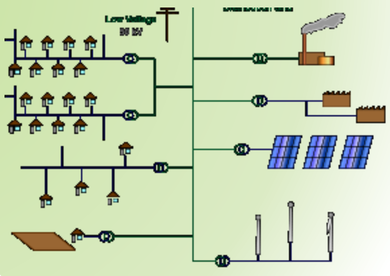
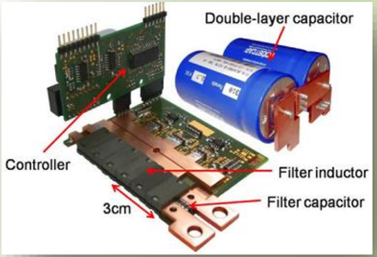
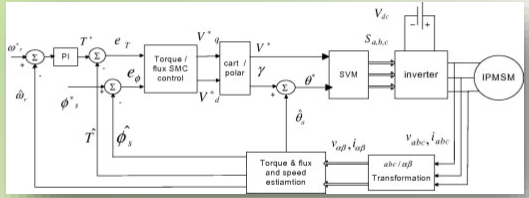
RELINK Partners and tasks

- Functions & Service
- Modularity
- Cost efficiency
- System integration



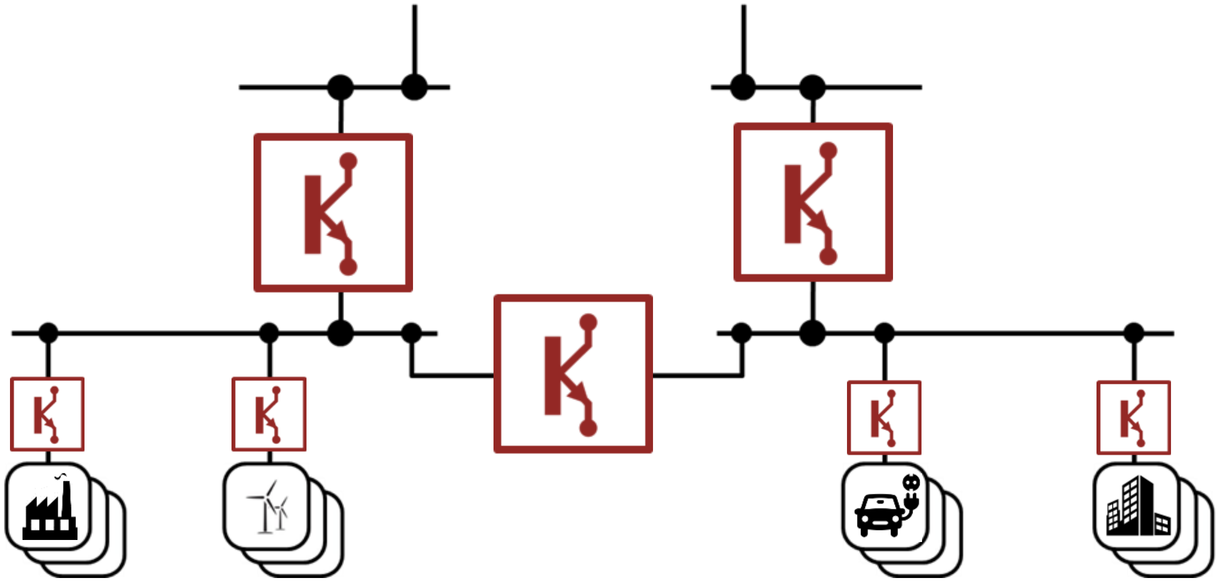






Christian-Albrechts-Universität zu Kiel

Smart electronic units in medium voltage systems



- **Requirements**
- **Potential**
- **UseCases**
- Costs
- Benefits

System services – now & perpective

Now

- Scheduling and dispatch
- Reactive power and voltage control
- Frequency control
- Loss compensation
- Load following
- System protection
- Energy imbalance

Additional future services

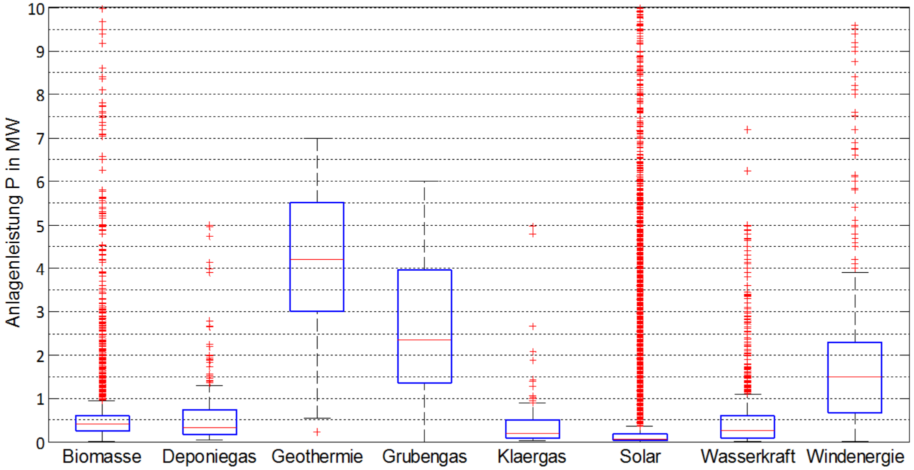
- Phase balancing
- Voltage quality
- Active voltage control / support
- Provision of short circuit power
- Momentary reserve (synthetic inertia)
- … to be continued …

Potential analysis of existing power units

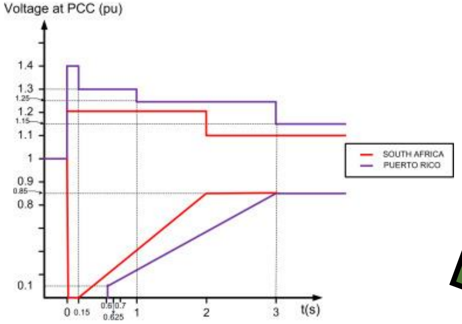
Installed power in MV level per balancing zone (2017)

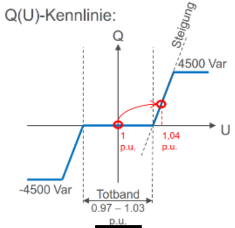
	Amprion	50Hertz	TenneT	Transnet	Total
Wind power	6,34 GW	6,71 GW	13,90 GW	1,07 GW	**28,02 GW**
Solar	3,02 GW	6,06 GW	5,02 GW	1,47 GW	**15,57 GW**
Biomass	1,19 GW	1,62 GW	2,64 GW	864 MW	**6,31 GW**
Hydropower	311 MW	135 MW	411 MW	257 MW	**1,11 GW**
Geothermal	7,8 MW	220 kW	30,9 MW	550 kW	**39,49 MW**
Mine gas	191 MW	--	--	--	**191 MW**
Landfill gas	68 MW	65 MW	33,4 MW	19,1 MW	**185,5 MW**
Sewer gas	23,4 MW	8,9 MW	22 MW	20,6 MW	**74,9 MW**
Sum	**11,2 GW**	**14,6 GW**	**22,1 GW**	**3,7 GW**	**51,5 GW**

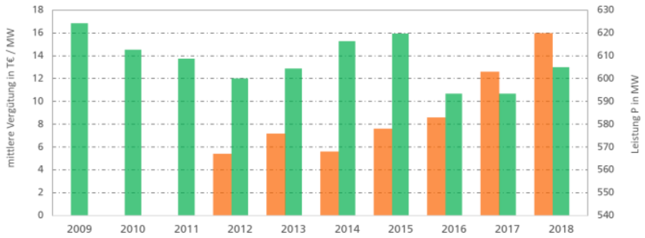
Distribution of electric power per unit (across balancing energy zones in Germany)



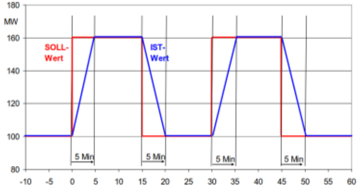
Requirements analysis

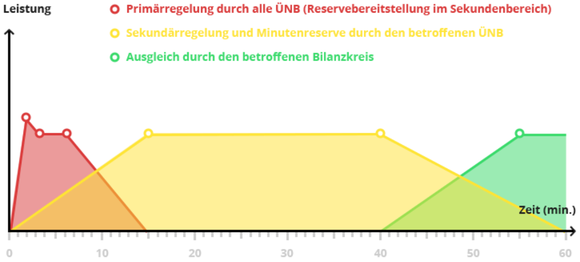






	Mittlere Leistung	kumulierte Leistung	Deckung %	
			T_A = 2s	T_A = 10s
Windkraft	1,5 MW	28,02 GW	3,11	15,57
Solar	78,4 kW	15,57 GW	1,73	8,65
Biomasse	400 kW	21,88 GW	0,70	3,51
Wasserkraft	270 kW	1,11 GW	0,12	0,62
Geothermie	4,2 MW	39,47 MW	0,00	0,02
Grubengas	2,7 MW	191 MW	0,02	0,11
Deponiegas	337 kW	185,5 MW	0,02	0,10
Klärgas	187,5 kW	74,9 MW	0,01	0,04
Summe			0,88	4,39





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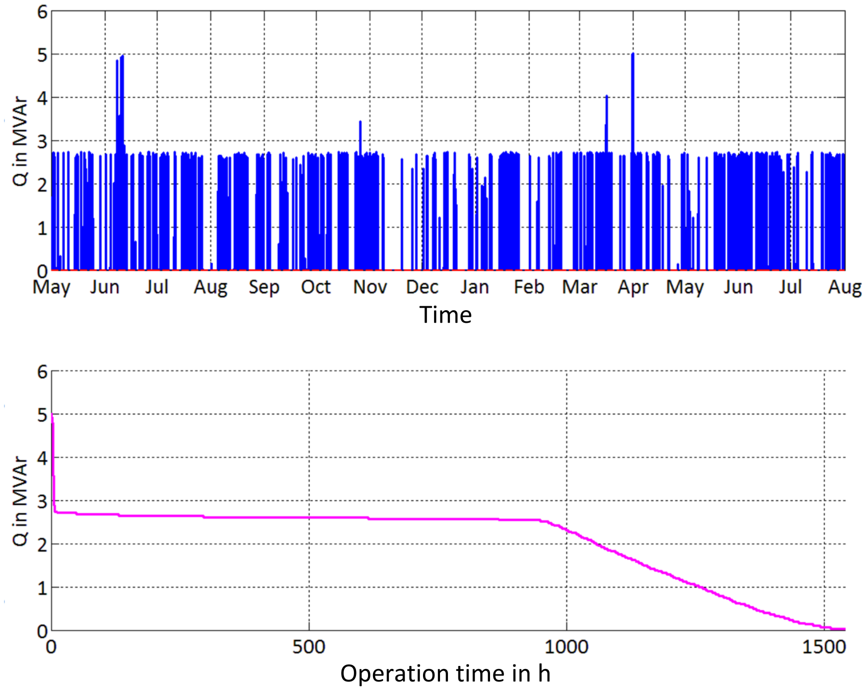
UseCase: Reactive power control for Wind & PV parks

- Economic benefits: no reactive demand at times without infeed
- Supported application or substitution of power transformers



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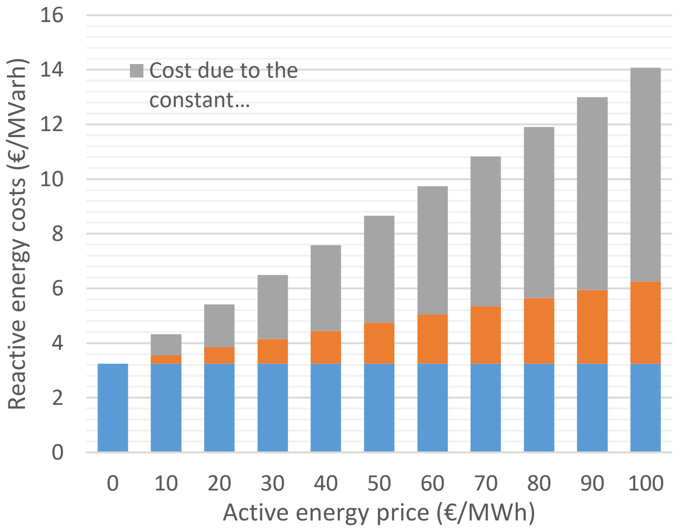
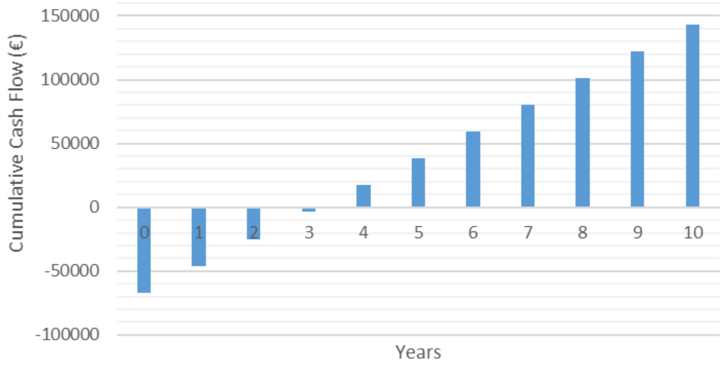
UseCase: Reactive power control for Wind & PV parks

→ Economic analysis for application of “Smart transformer“





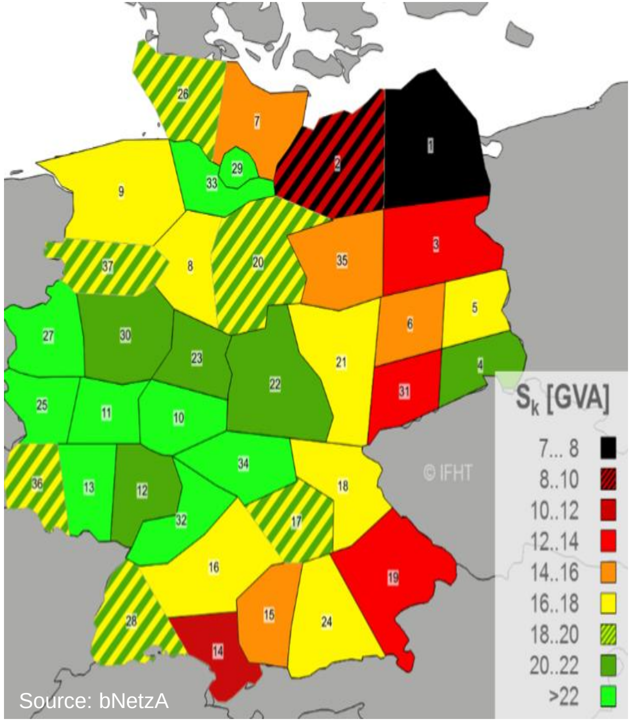
$$C = \frac{I}{h} \cdot \frac{r}{[1-(1+r)^{-y}]} + \frac{p_{el} \cdot L_{op}}{B} + \frac{p_{el} \cdot L_{fix}}{B}$$

Symbol	
I	Investment costs
h	Full load hours
r	Discount factor
L_{op}	Operative losses
L_{fix}	Fix losses
B	Reactive energy
pel	Electricity price
y	Life time

UseCase: Short circuit power contribution

- Fictional quantity as indicator
  - Voltage stability @errors
  - Rotor angle / inertia
- Selectivity of protection requires high currents way above nominal values

Short circuit contribution of power electronics is limited to nominal value of components.



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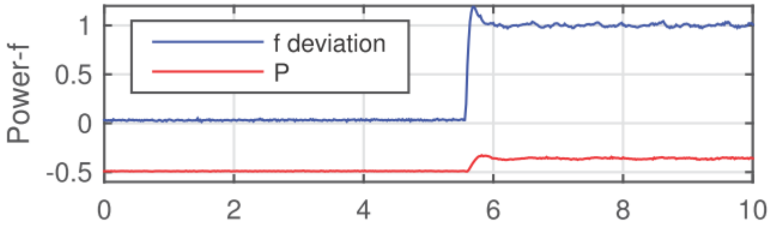
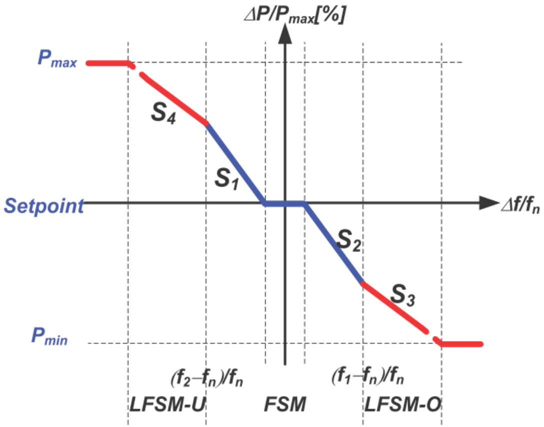
UseCase: Momentary reserve

- Technology: Synthetic inertia emulation
- **Successfully implemented and tested** on a hybrid hard- & software model in 2013 (SeaPowerGridSecure)





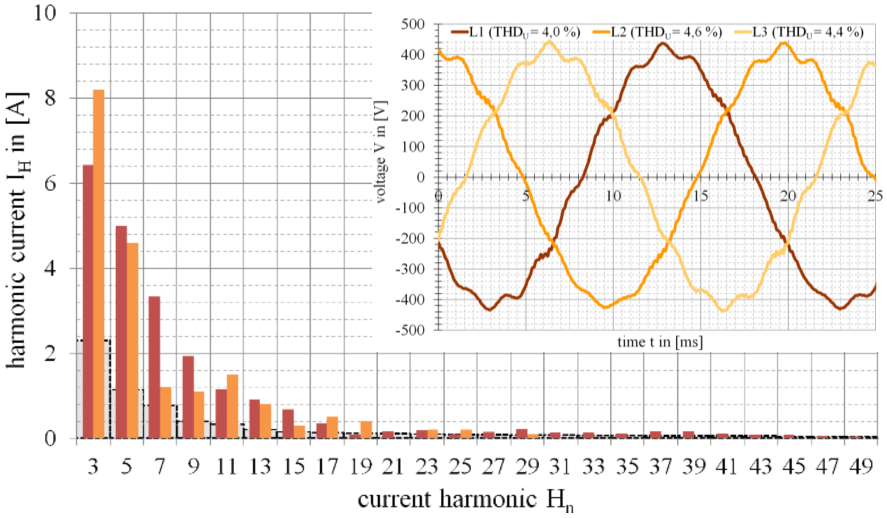
Frequency sensitive mode

UseCase: Decoupled voltage quality

- Independent voltage characteristics between two decoupled networks
- Dynamic voltage regulation
- Active filtering

Chance for power quality requirements per network area (AC/DC)

EV charging B6U (non controlled)

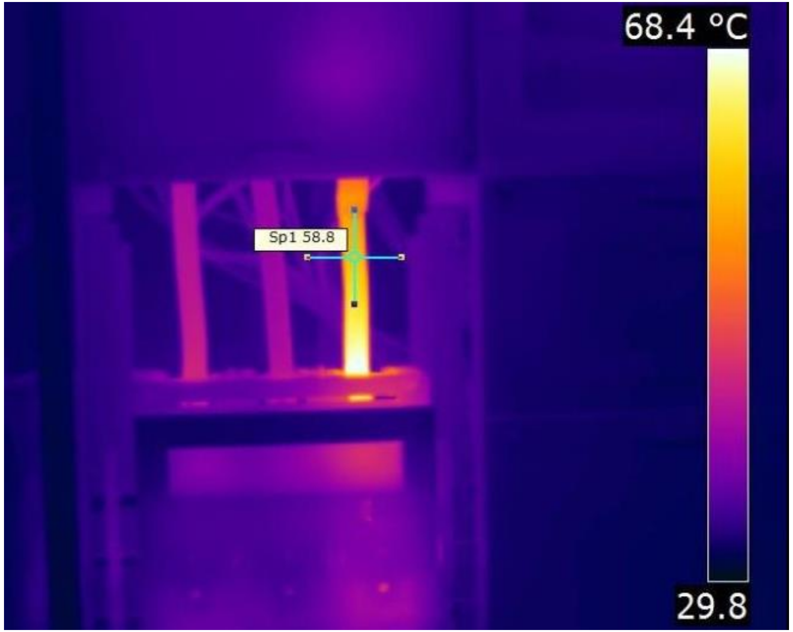


PV plant with storage infeed

UseCase: Phase balancing

- Loss of symmetry through unbalanced loads
- Different aging effect on components
- Overheating of transformers (saturation of overloaded phases)
- Reduction of transmission capacity

Ongoing project: E-Mobility Grid Service 4



Summary & Conclusion

- **Most of the requirements** for systems service provision can be fullfilled by PE
- RES-capacity in MV-Grid fits frequency control reserve needs
- MMC structure opens up additional possibilities for **"SystemServices+"**
- Utilization of internal measurement data for grid purposes
- Coordination vs. centralization

System service	Capability of power electronics
Classic system services	Yes, but dependent on generation unit
Phase balancing	Yes
Voltage quality	Yes
Active voltage control / support	Yes
Provision of short circuit power	Nominal values only
Momentary reserve	Restricted

Thank you.

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