Grid Resilience

Andreas Hauer

Solar World Congress 2025
Fortaleza, Brazil

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Resilience by Distributed Structures

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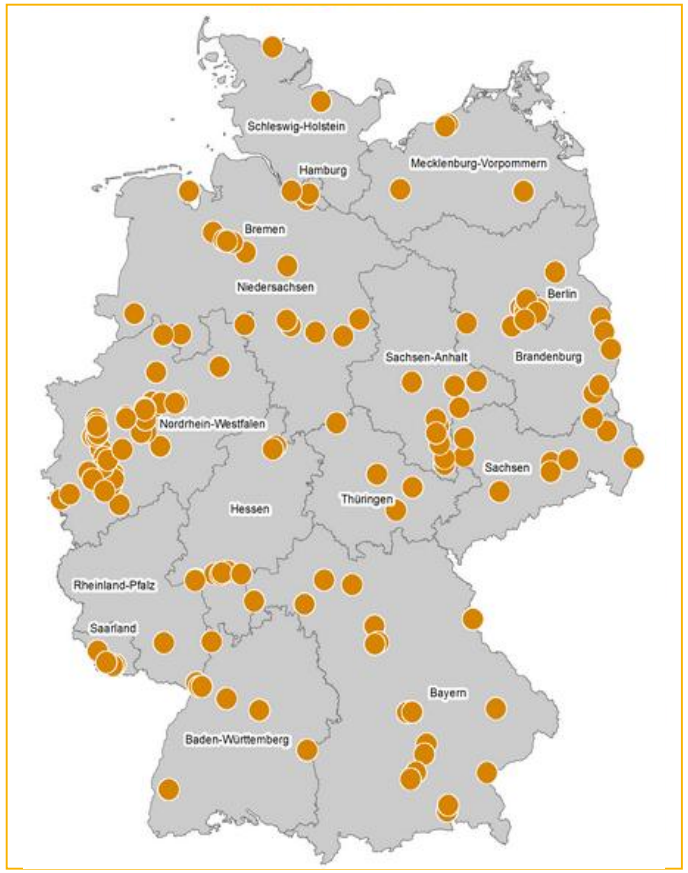
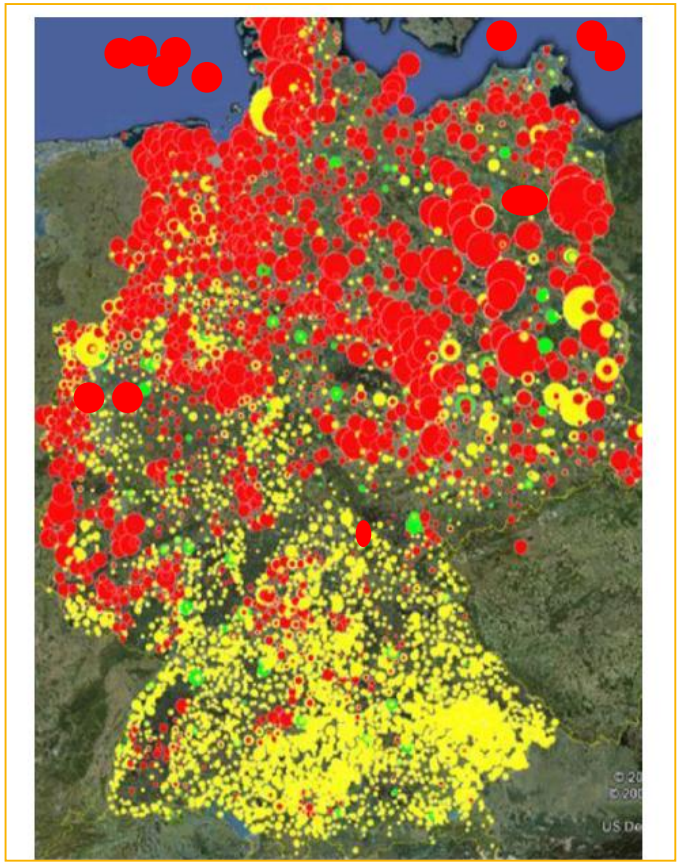


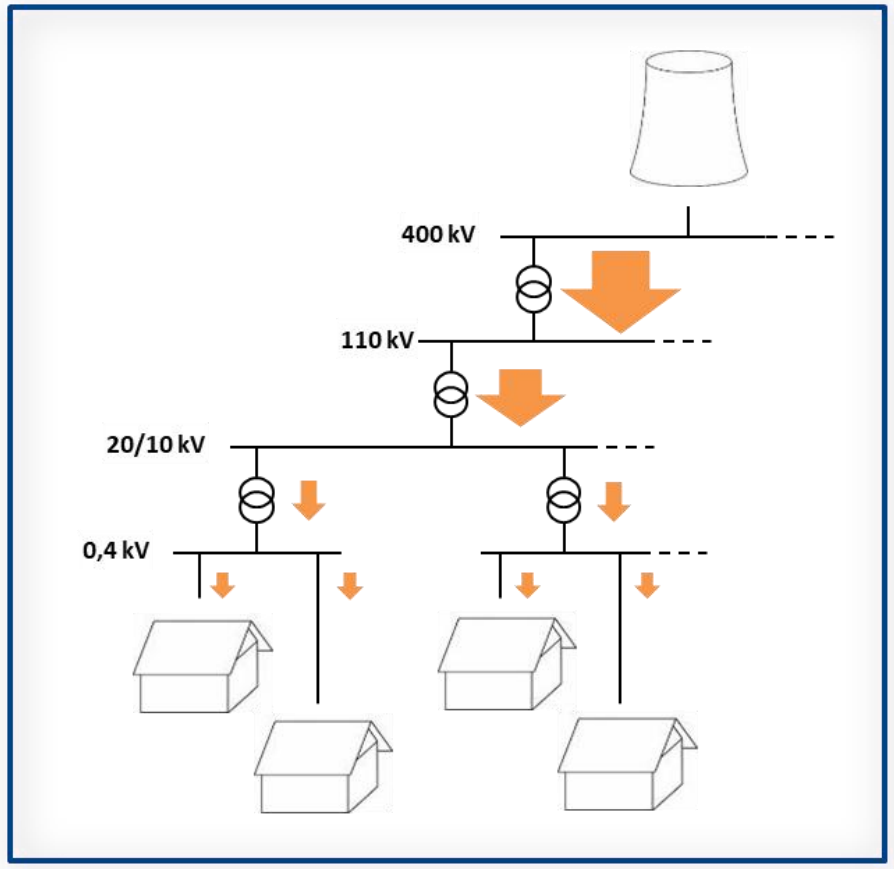
Conventional Power Plants

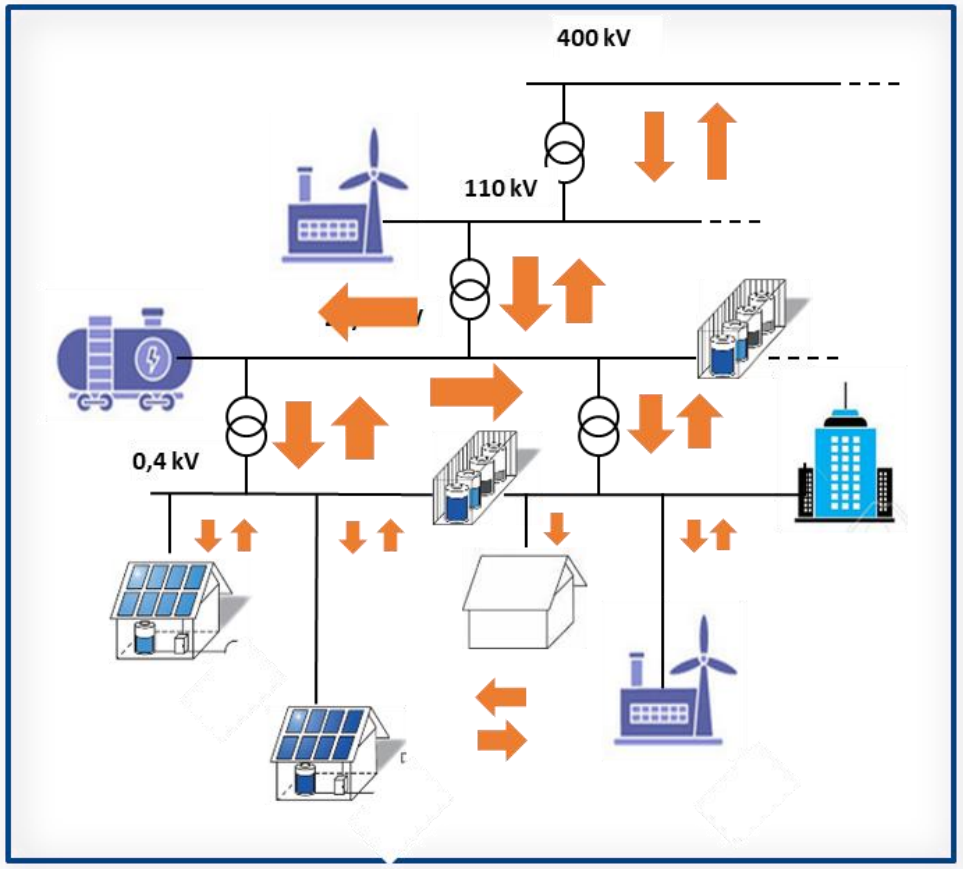


Renewable Energy Production

Resilience by Distributed Structures

New Structures, new tasks and new challenges





Resilience by Flexibility

TCP Coordination Group on Energy System Flexibility

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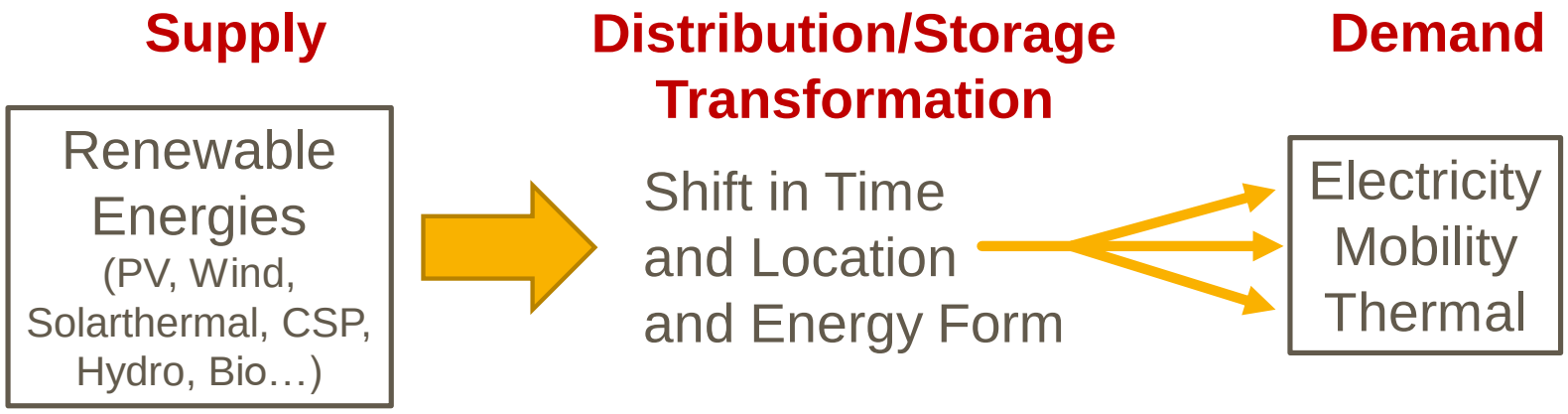
Definition Proposal of Flexibility

Flexibility of an energy system is the ability to adjust
supply, transmission, distribution & storage, and demand,
across all relevant time and geographical scales considering all energy vectors, in response to changing conditions or policy objectives.

TCP = Technology Collaboration Programme

Integrated Energy System Flexibility



„Supply matches demand“
… if it is not the case, we need to

- Adapt „supply“
- **Shift in location (e.g. grid)**
- **Shift in time (e.g. storage)**
- Shift in energy form (P2H, P2F,…)
- Manage „demand“

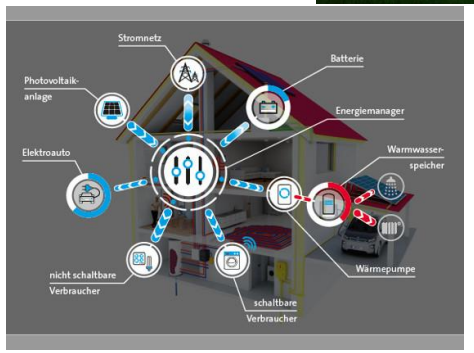
} Distribution/Storage/Transformation

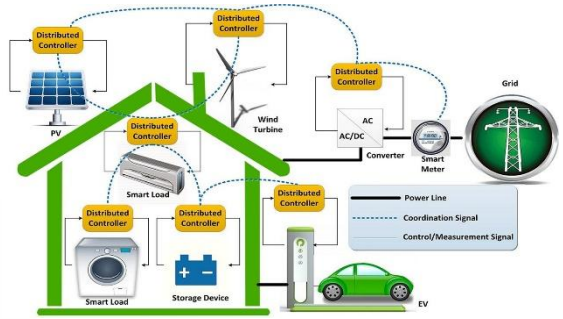
A Small Examples…

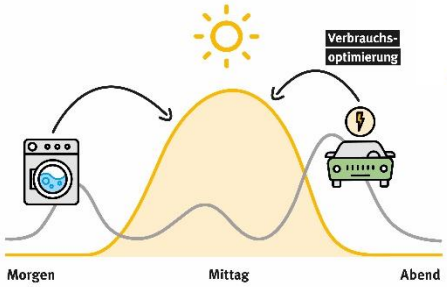
Energy System = Home
„Behind the Meter“

PV ⟷ Electricity Demand

1st flexibility	Battery
2nd flexibility	Energy Managment
3rd flexibility	Heat Pump + Thermal Energy Storage
4th flexibility	Wallbox + EV (bidirectional)
5th flexibility	Connection to other homes…







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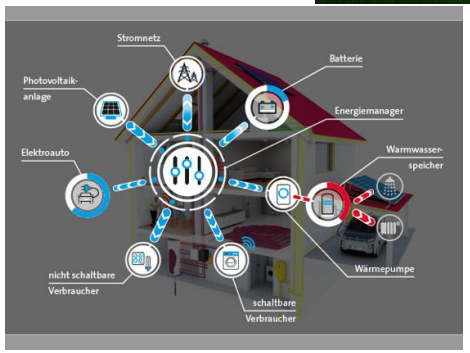

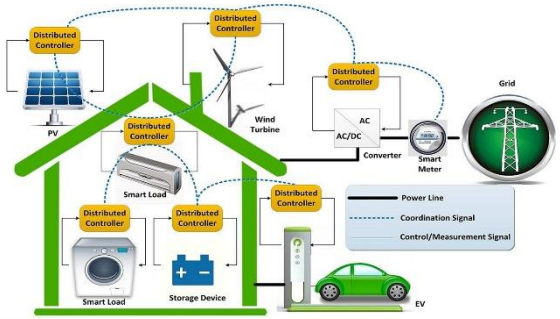

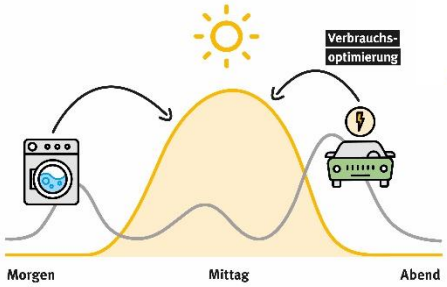

Larger Flexibility Examples

Large Li-Ion Battery

- Capacity: 238 MWh
- Location: front-of-the-meter
- Power: 103,5 MW
- Rate of change: Full power output in <1 second
- Duration: hours

Specific Cost: 150-200 €/kWh Capacity

Larger Flexibility Examples

Seasonal Hot Water Storage

- Capacity: 5.4 GWh
- Location: Local (district heating system)
- Power: 23 MWth (charge)
- Rate of change: Full heating power output in about 0.5 to 1 hour
- Duration: Seasonal

Specific Cost: 0,50-1,50 €/kWh Capacity

Flexible Sector Coupling (FSC) Concept Development - Introduction

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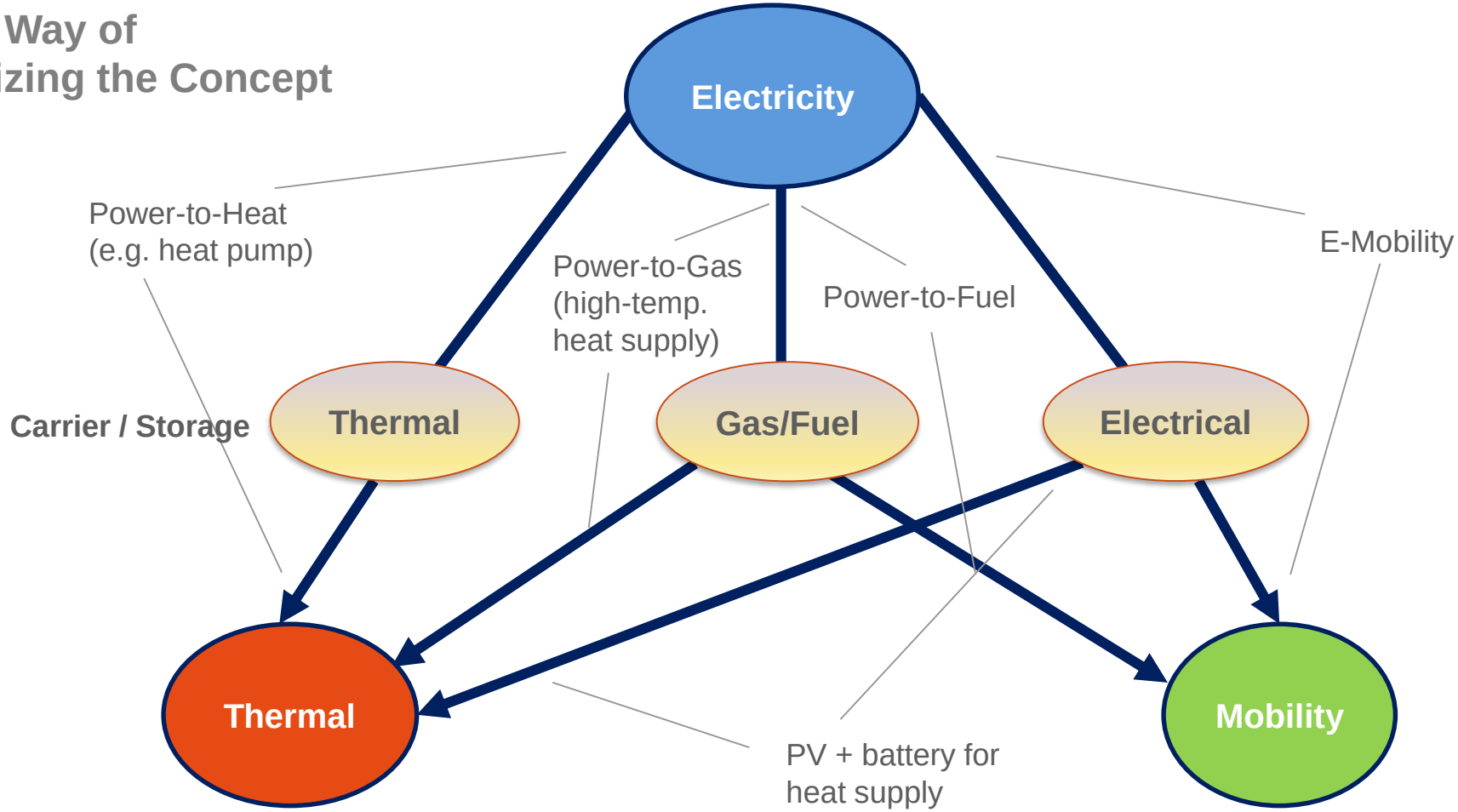
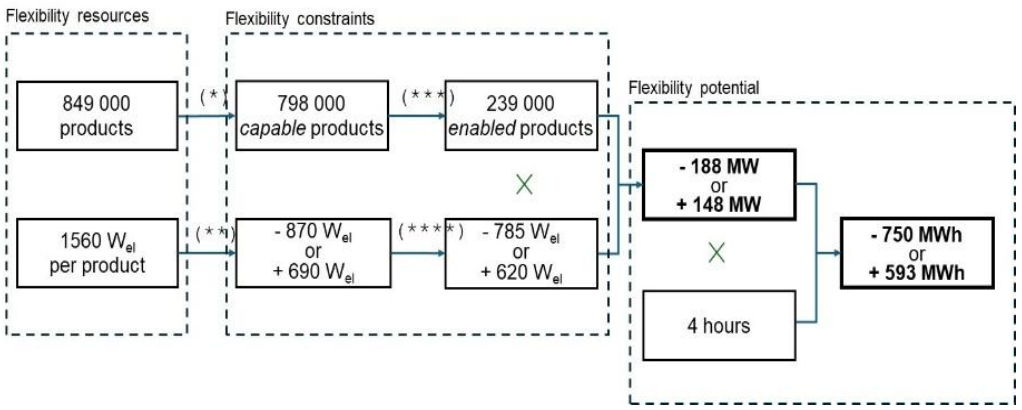
Latest Way of Visualizing the Concept



Larger Flexibility Examples

Potential for Heat Pumps in Austria in 2030 at 0 °C



Dispatchable load for the electricity system by switching heat pumps on and off

- Capacity: - 750 MWh / + 593 MWh
- Location: Buildings
- Power: - 188 MW / + 148 MW
- Duration: Hours

Specific Cost can be very low!

Conclusions

Conclusions

- A distributed, decentralized grid and energy system is more resilient
- A resilient grid with higher shares of renewables needs flexibilities
- Flexibility can be provided in different approaches, but most of them are based on energy storage („shift in time“)
- Flexible Sector Coupling can contribute to cost effective flexibility options

Thank you for your attention!

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Bayerische Klima-Allianz

BVES

Bundesverband Geothermie

FVEE ForschungsVerbund Erneuerbare Energien
Renewable Energy Research Association

ZUSE-GEMEINSCHAFT

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