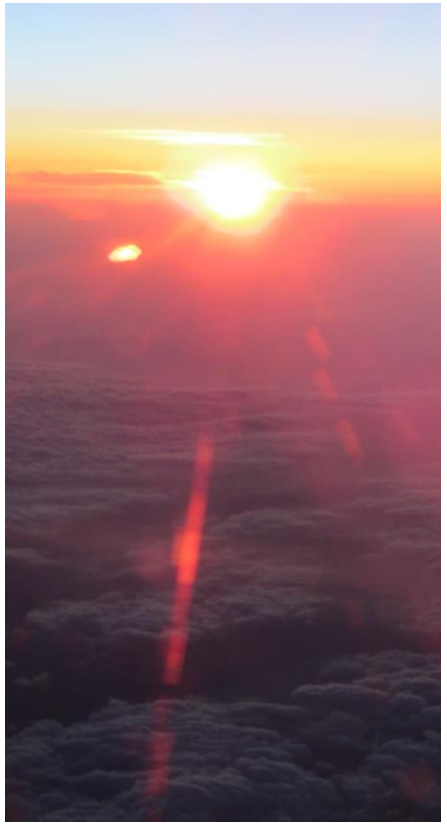
Smart Micro Grids and Cellular Grids



Elements of Renewable Energy System

Introduction for New Brunswick Delegation,
Stuttgart,11.05.2016

Dr. Thomas Walter

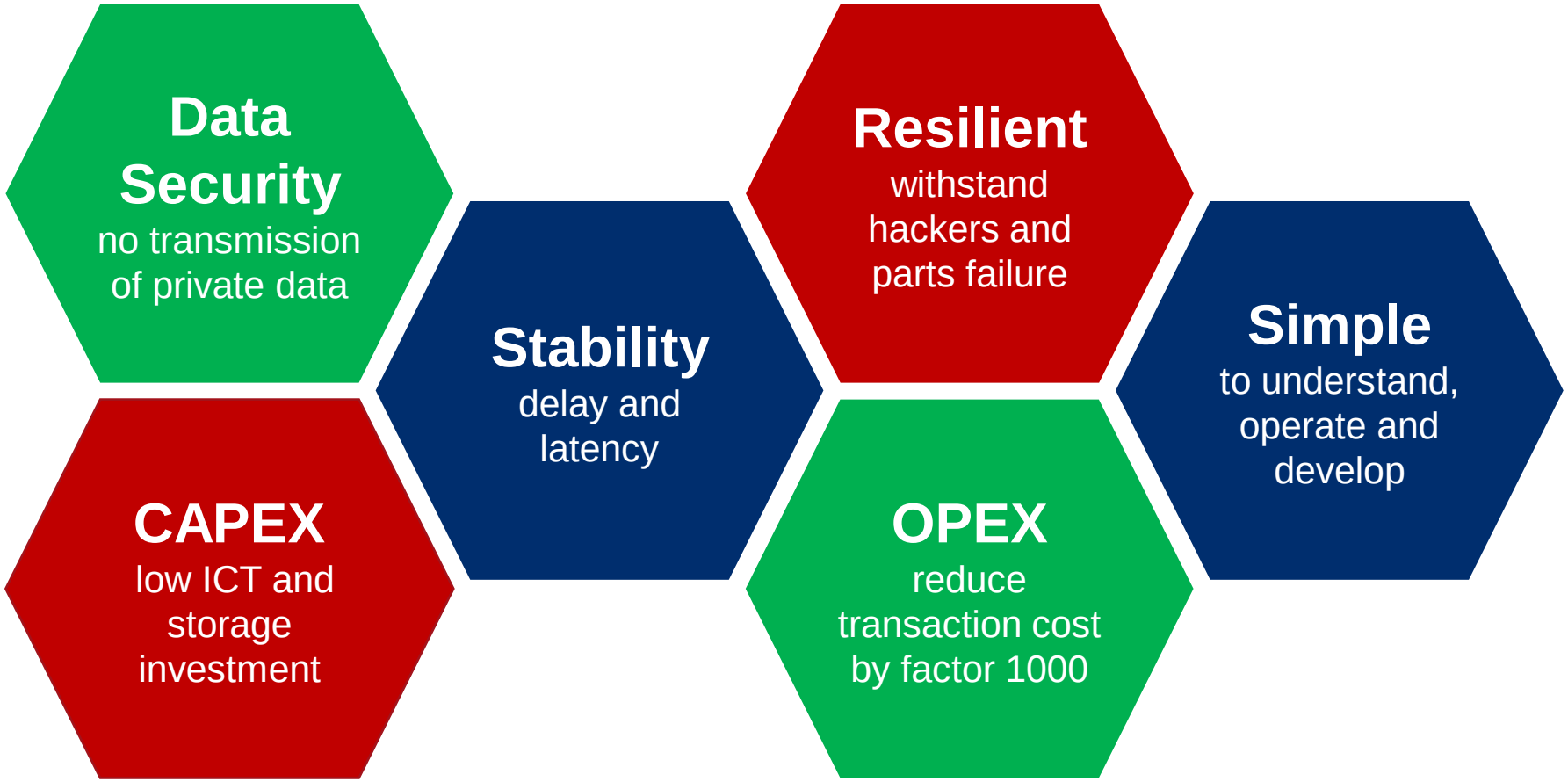
Easy Smart Grid GmbH

„Leapfrogging“ means
The future is not a linear interpolation of the past

- Everybody expects a disruptive transformation of the energy system.
- A „jump“, not a „step“ to the next generation.
- Where this happened recently:
  - Cisco leapfrogged Siemens/Alcatel
    Analogue voice => Digital data
  - Apple leapfrogged Nokia
    Mobile phone => Smartphone

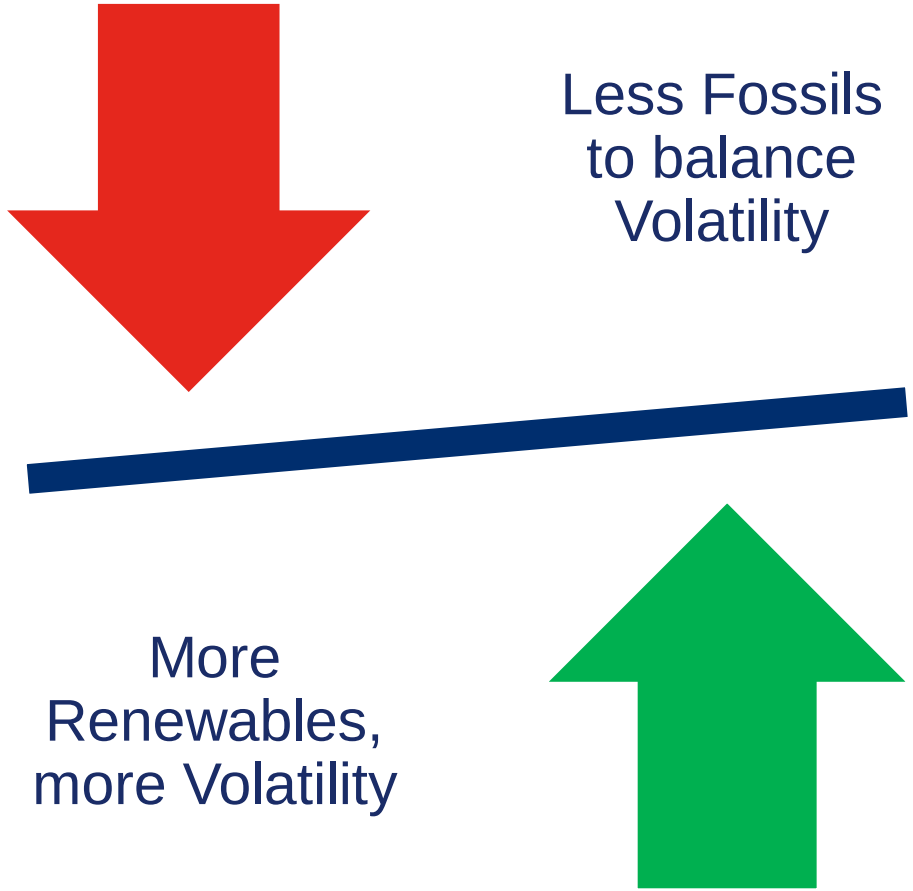
Source: Blog Prof. Wettengl: wettengl.info/Blog/?p=5072, Download 21.08.2015, Bullet points by Thomas Walter

Requirements are clear
Where we need to improve on “SG 1.0”



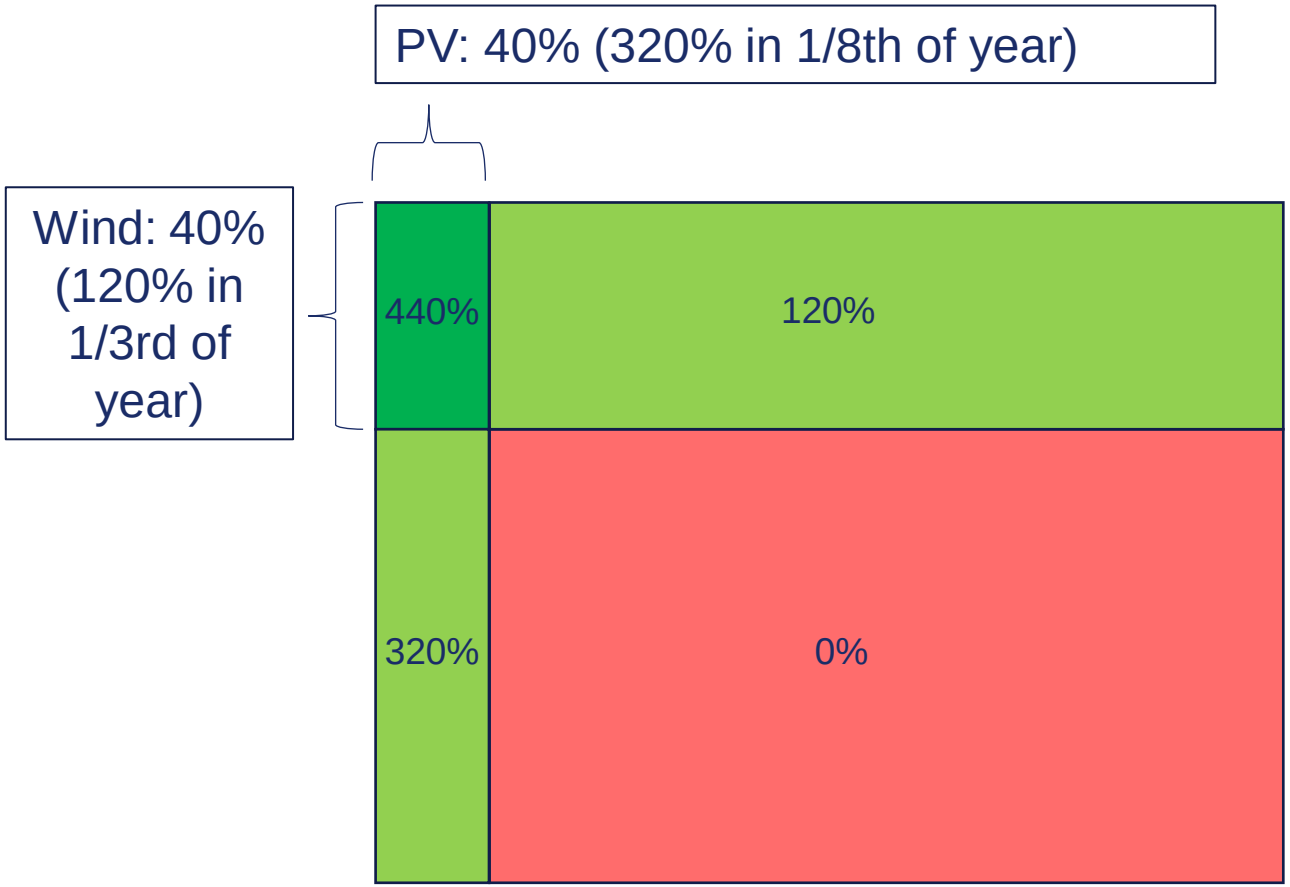
Challenge Flexibility
Why a paradigm change is needed

- Today: Central supply of **Energy** and **Flexibility.**
- Photovoltaics and wind provide **Energy**, but not **Flexibility**.
- System transformation requires **new Flexibility Sources**.
- Paradigm Change results: **Consumption follows Production**



Challenge Flexibility
Expected Situation (K-V-Diagram)

Germany 2050: Wind and PV supply 40% each

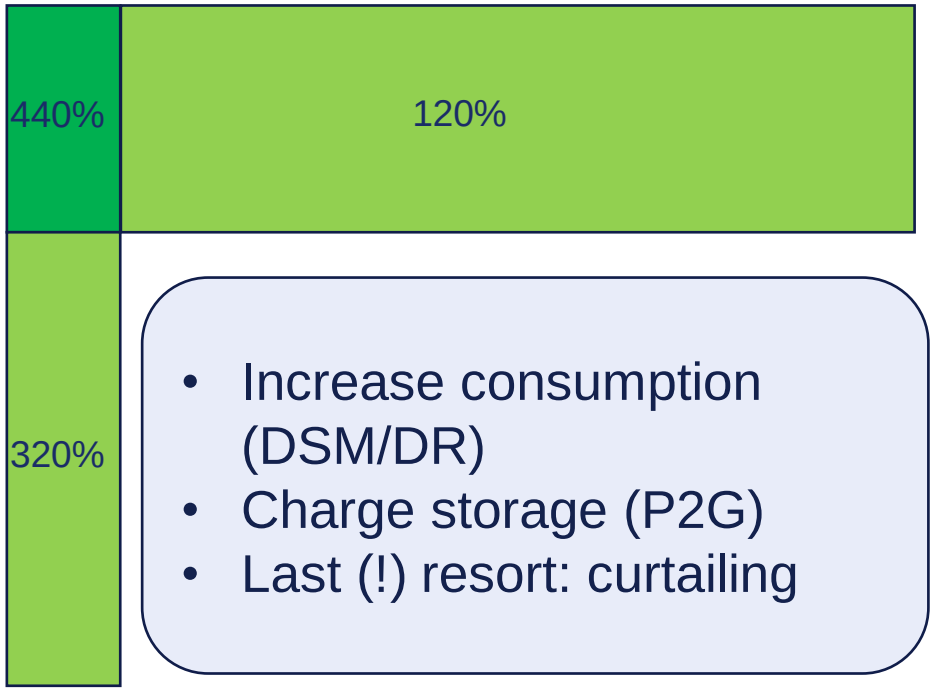


- PV and wind are volatile.
  Annual production (8,740 hrs):

  PV ~1,100 hrs
  Wind ~3,000 hrs
- Challenge #1:
  Motivate Flexibility
  => Market design
- Challenge #2:
  Activate Flexibility
  => ICT Implementation

Challenge Flexibility
System will split into two normal states

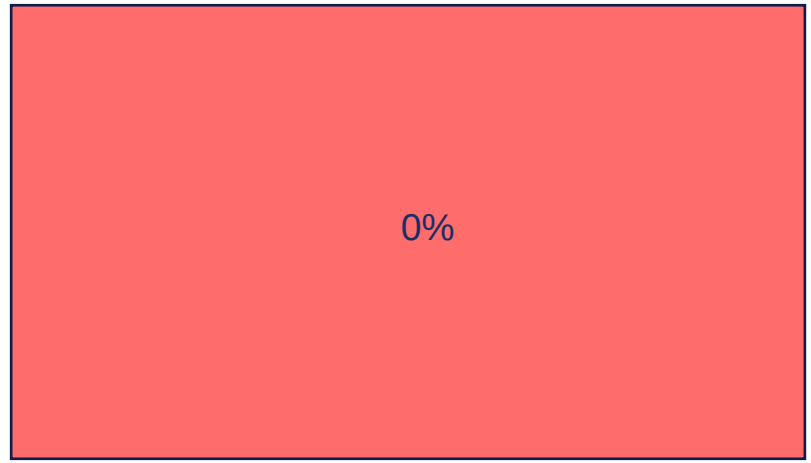
Too much wind or sun -> low price
80% of energy, 42% of time



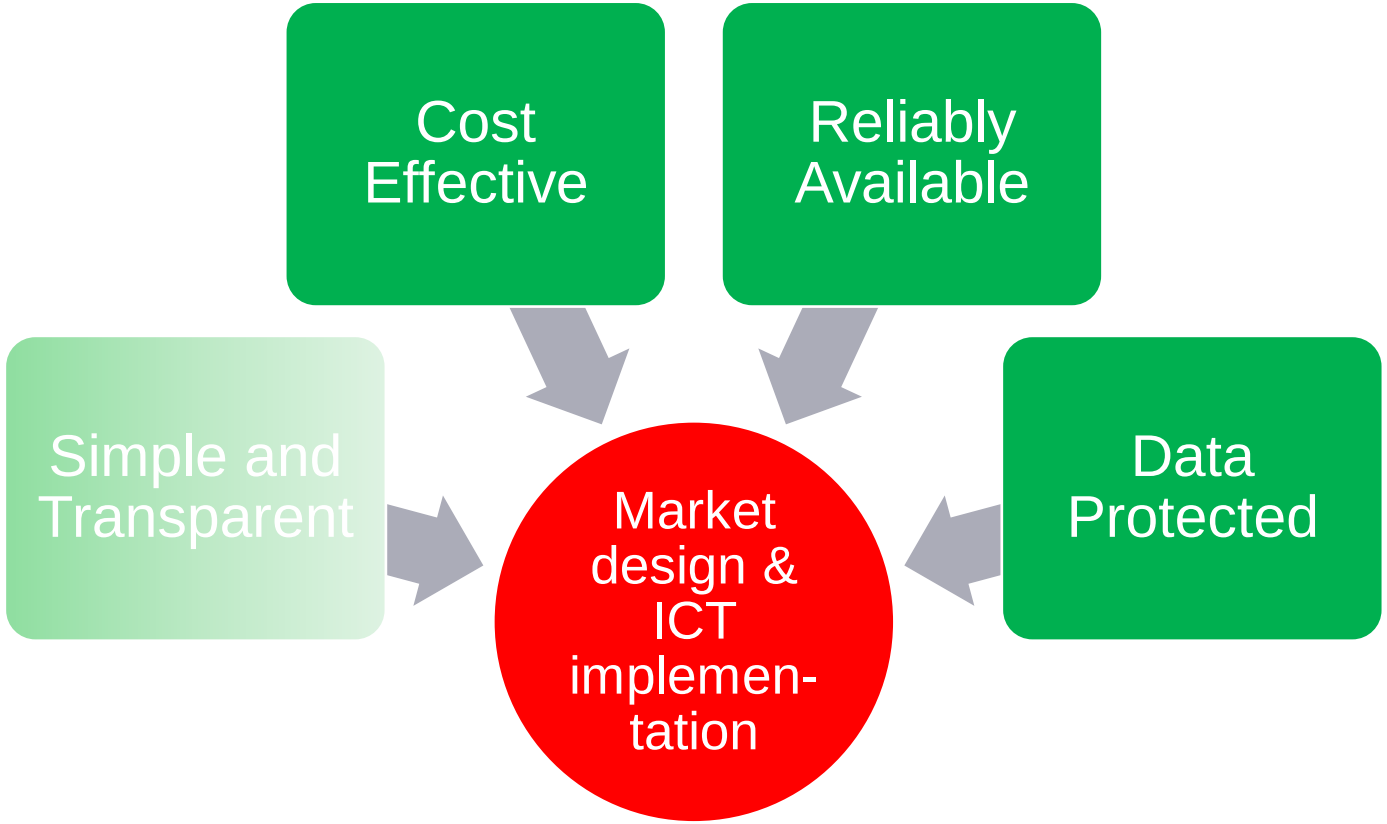
- Increase consumption (DSM/DR)
- Charge storage (P2G)
- Last (!) resort: curtailing

Too little wind or -> high price
20% of energy, 58% of time

- Reduce consumption (DSM)
- Use bio or synfuels
- Discharge storage



Customer Needs
What do customers want?



Customer Needs
Market: Intransparent for Customers

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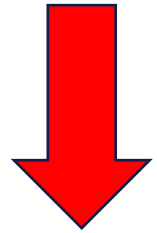
Five Time Variable Cost/Price Elements

- Day Ahead Trade
- Intra Day (Spot) Trade
- Tertiary Control Power
- Secondary Control Power
- Primary Control Power

Integrated Real Time Market



=> Four Entry Barriers to Flexibility Market

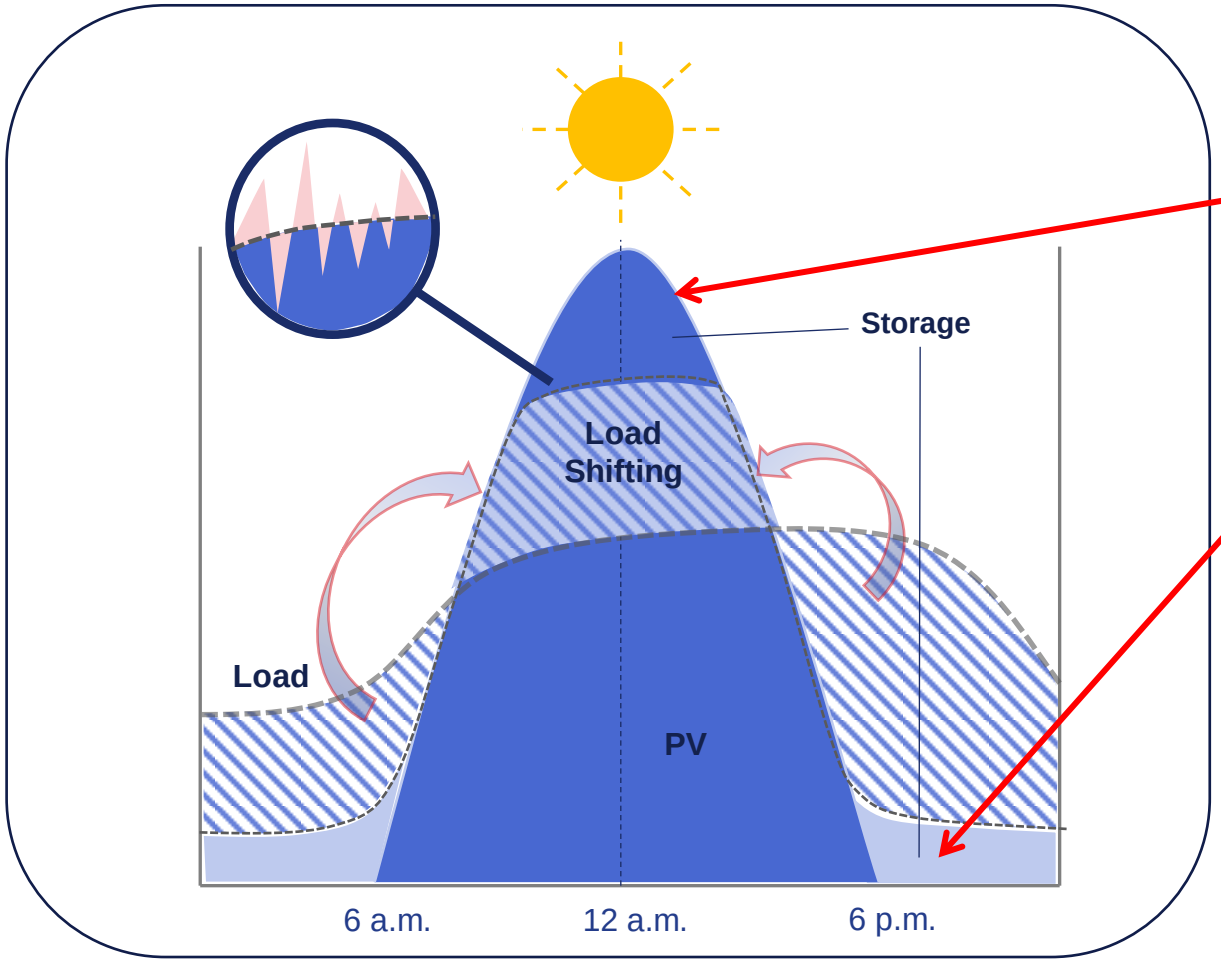
- Product Fragmentation & Fit
- Minimum Required Quantity
- Availability over Period
- Pre-Qualification

All Entry Barriers Removed

Changing Markets
Fast Transformation in isolated Grids

- Potential diesel replacement:
  > 50 GW, equivalent to
  > 100,000,000,000 $/a
- PV saves **0.2 $/kWh when** replacing diesel.
- **High DSM potential reduces storage investment:**
  Heating/cooling, pumps, desalination, electro mobility.
- Picture shows PV potential. Similar opportunities for wind

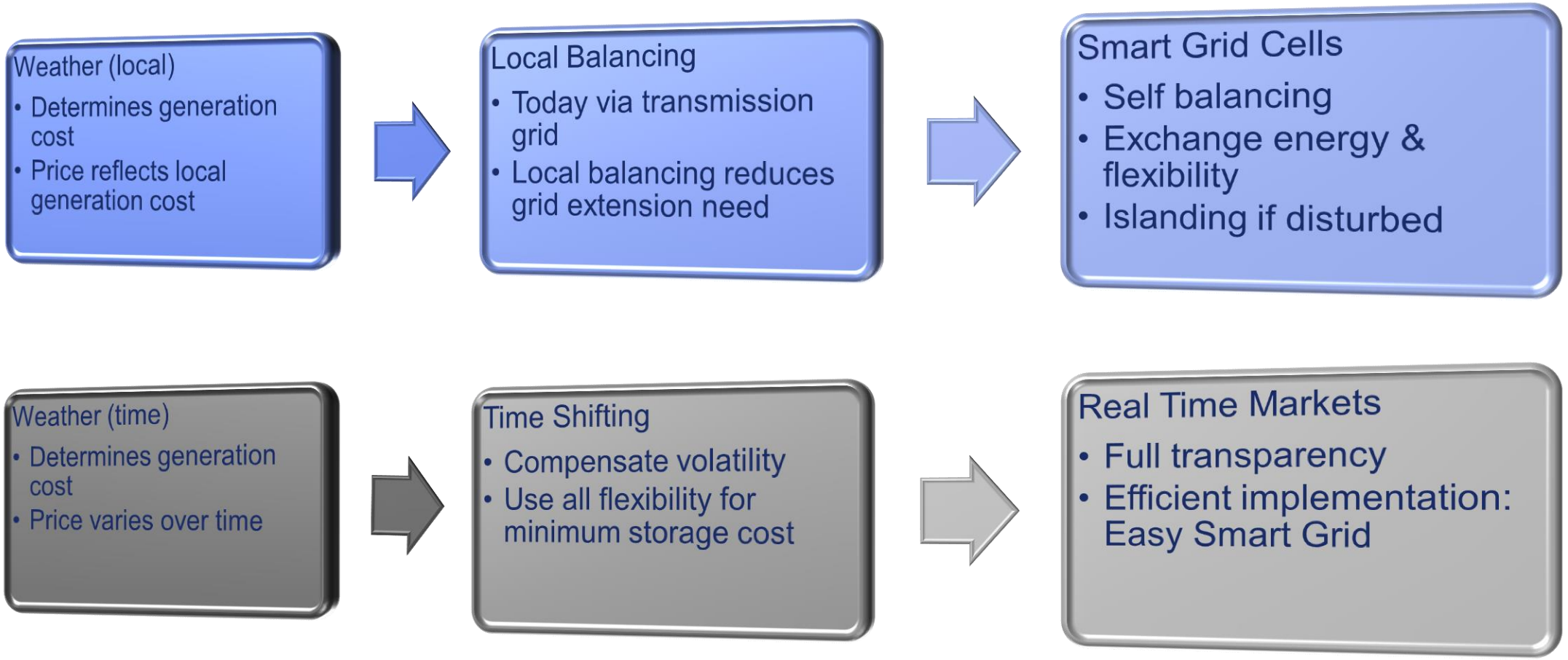
Demand Side Management
The cheapest Battery: Customer Flexibility



Benefits:

- **Use more Renewables:**
  Absorb peaks,
  don't curtail them
- **Pay less:**
  For fossil energy
  and storage
- **Easy Smart Grid:**
  Coordinate DSM, flexible
  generation and storage

Smart Cells and Cellular Grids
Optimum price: variable in Time and Place



Smart Cells and Cellular Grids

- Germany 2050: 80% of generation weather dependent
- Cell size determined by weather correlation (~60 km Ø)
- 126 grid cells, 635,000 inhabitants each (below: Baden-Württemberg

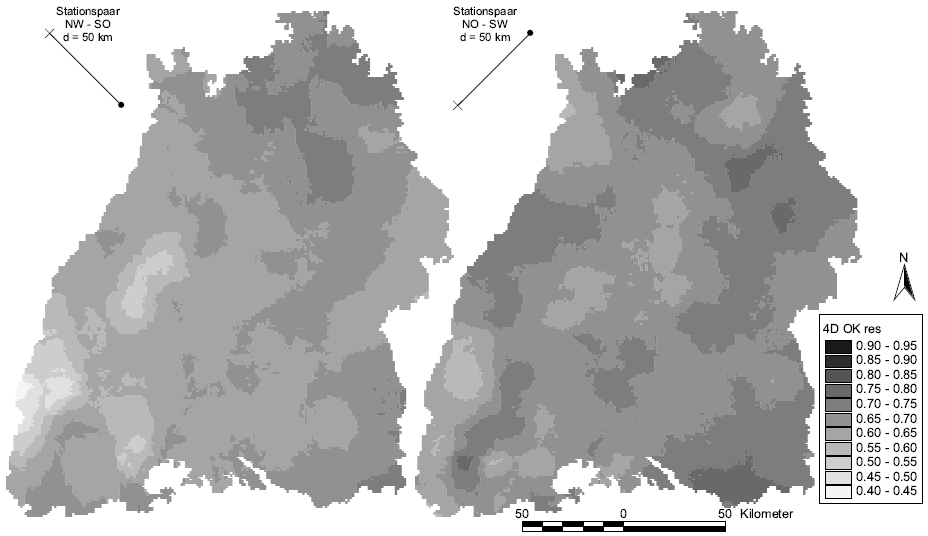


Abbildung 3.7.: Regionalisierte Korrelation zwischen Station und 50 km entfernter Station mit vierdimensionalem Ordinary Kriging der Residuen unter Verwendung eines dreiparametrigen exponentiellen und sphärischen Variogramm (Modell 7 in Tabelle 3.1.

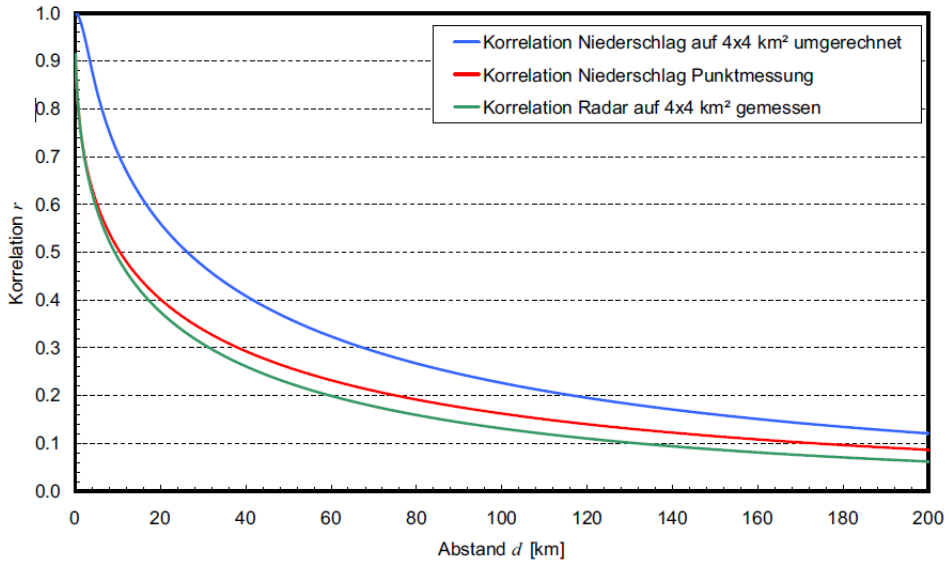
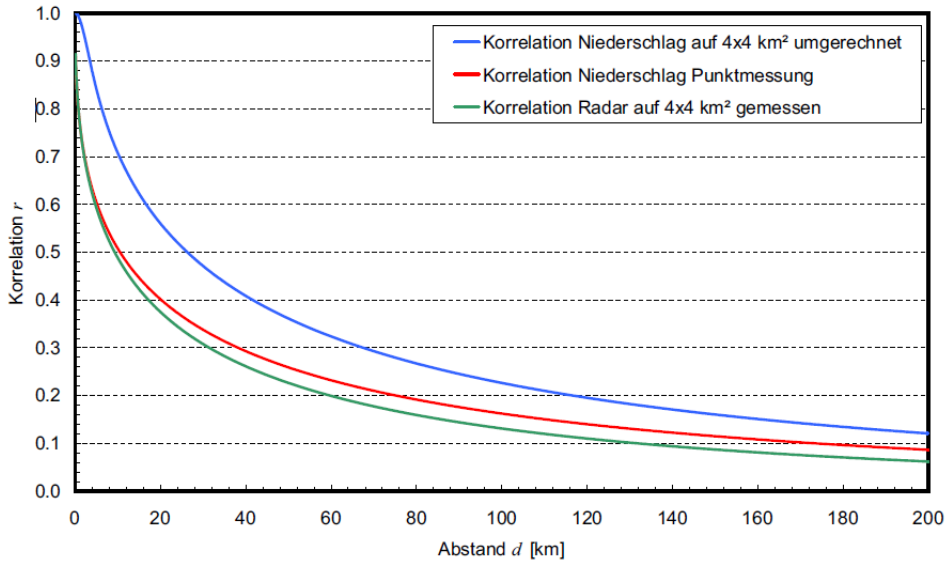


Abbildung 3.12.: Korrelation der Niederschlagspunktmessungen, der Radarmessungen und der auf die Fläche der Radarraster umgerechneten Niederschlagsmessungen.

Source of graphics: Dissertation Jürgen Brommundt, 2008 Institut für Wasserbau Uni Stuttgart, Download 20.08.2015, http://elib.uni-stuttgart.de/opus/volltexte/2008/3470/pdf/Brommundt_170_online.pdf

Smart Cells and Cellular Grids
Likely Smart Micro Grid pioneers

- Gran Canaria (800,000 inhabitants, 55 km Ø)
- Renewables reduce fossil subsidy needs (Spanish Islands: 13 bill €/year)



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Smart Cells and Cellular Grid
New Roles for Players?

Cell/Micro Grid	Neighbours	Transmission Grid

• 0-2.5 GW generation (Avg. power need *4)
• Exchange for energy and flexibility
• System and balancing services
Island-/Black Start modes
• Grid and Market integrated (c/f NY „REV“)
	• Energy exchange (Δ Price)
	• Flexibility exchange (Δ Price)
	• Access to Neighbour n+2
	• Special zones:
	Areas where energy production or consumption dominates
		• „Motorway“ HVDC for Large Area Integration
		• Weaker role in balancing
		• Coupling special zones:
		  • Offshore, „Desertec“
		  • Large Consumers „NRW“ (energy intensive area in Germany)

Smart Cells and Cellular Grids
Balancing by “transactive principle”

Generation < load	*Increase* price until rebalanced
Load < generation	*Reduce* price until rebalanced

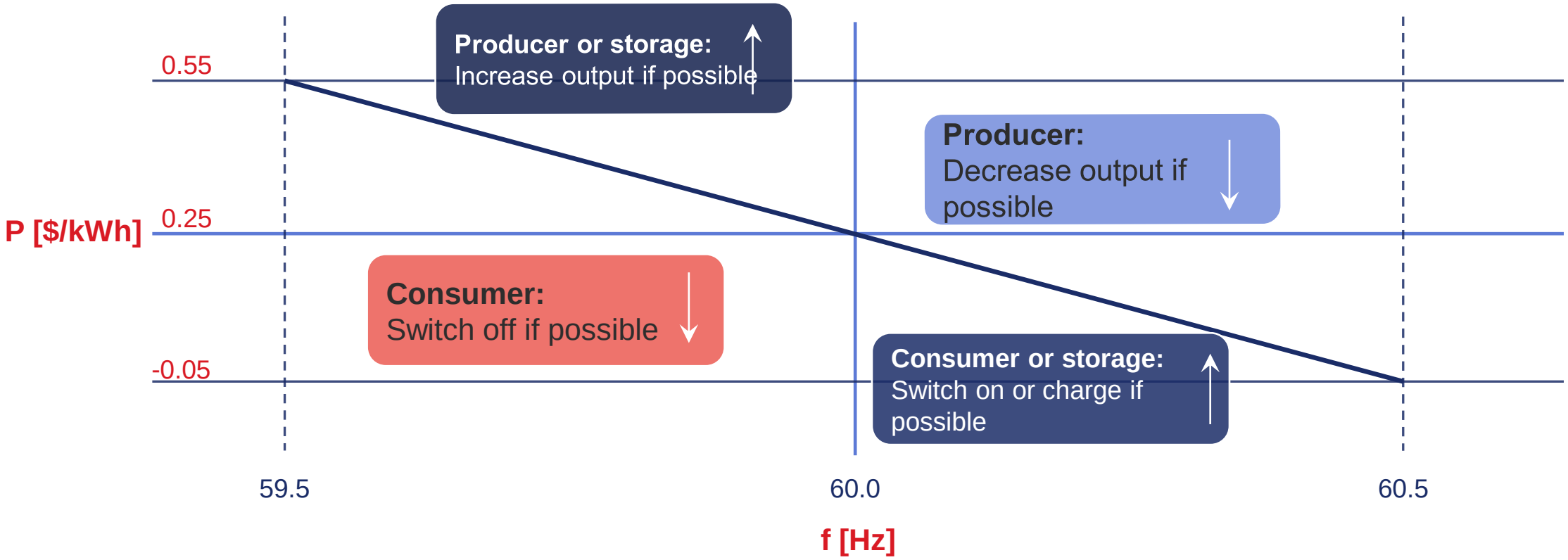
Flexible generators	Shift generation to *high price* times
Flexible consumers	Shift consumption to *low price* times
Storage devices	Charge at *low*, discharge at *high* price

Example „ECOGRID“ – A Real Time Market on Bornholm Island/DK

- ICT investment over 10 M€ (collect, process and communicate data)
- CHP (Combined Heat and Power plants) react to price update (5 Min.)

Easy Smart Grid allows Efficient “Transactive” Control

1. Fix needed price range, 2. Fix frequency range. 3. Combine



Easy Smart Grid
Create added value, Don‘t burn money

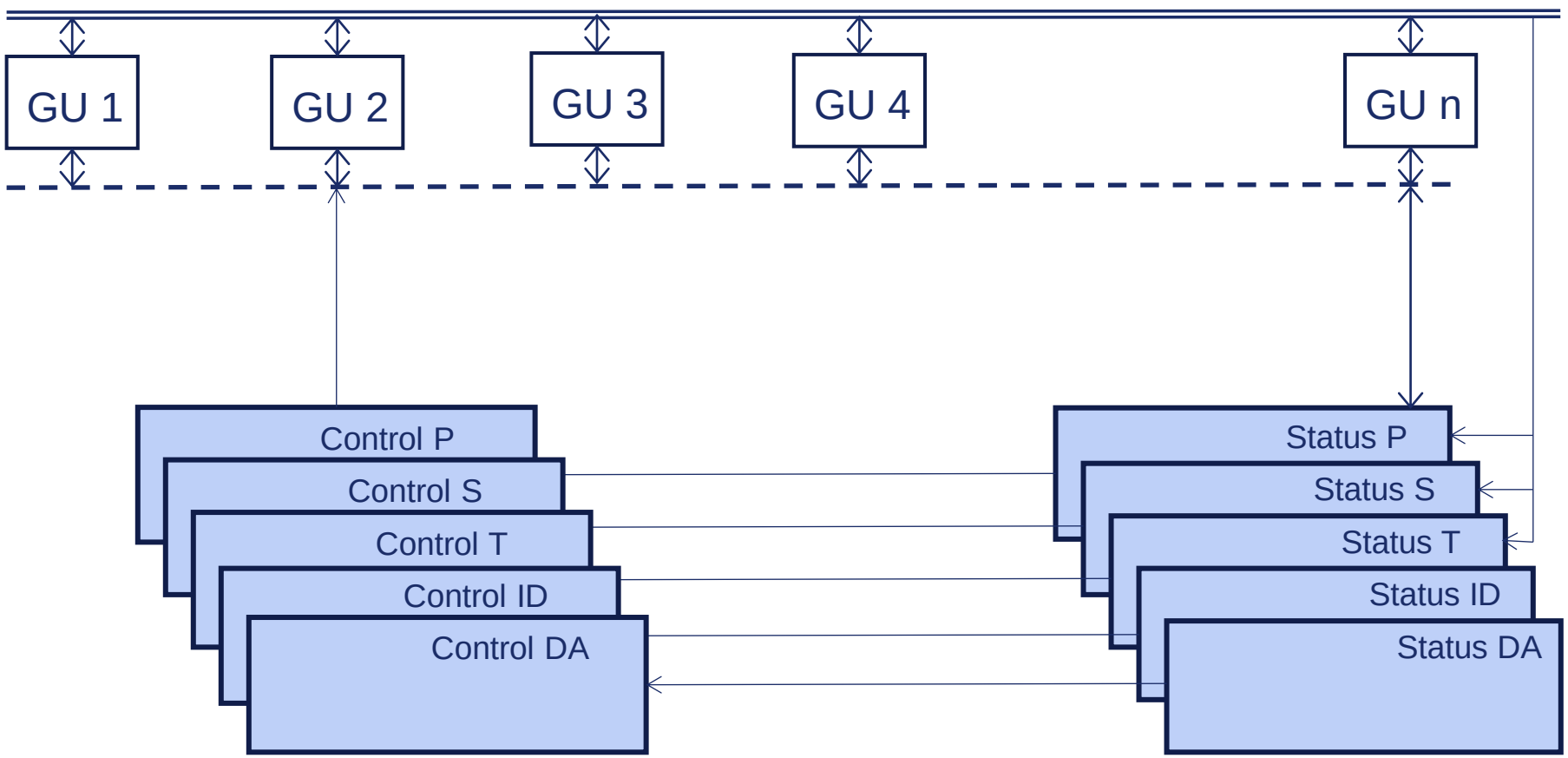
Not needed

- Measure net generation/consumption (AMI)
- Communicate net balance from all grid users (AMI)
- Compute overall balance and price
- Communication and processing latency
- Communication of price to all grid users (AMI)zz

Still needed

- Electricity meter (but no RT communication need)
- Rotating mass (physical and virtual)
- Storage (much less, use customer flexibility instead)
- System supervision (limit to „system critical“ users)

Smart Cells and Cellular Grids
Today: Five parallel Control Loops



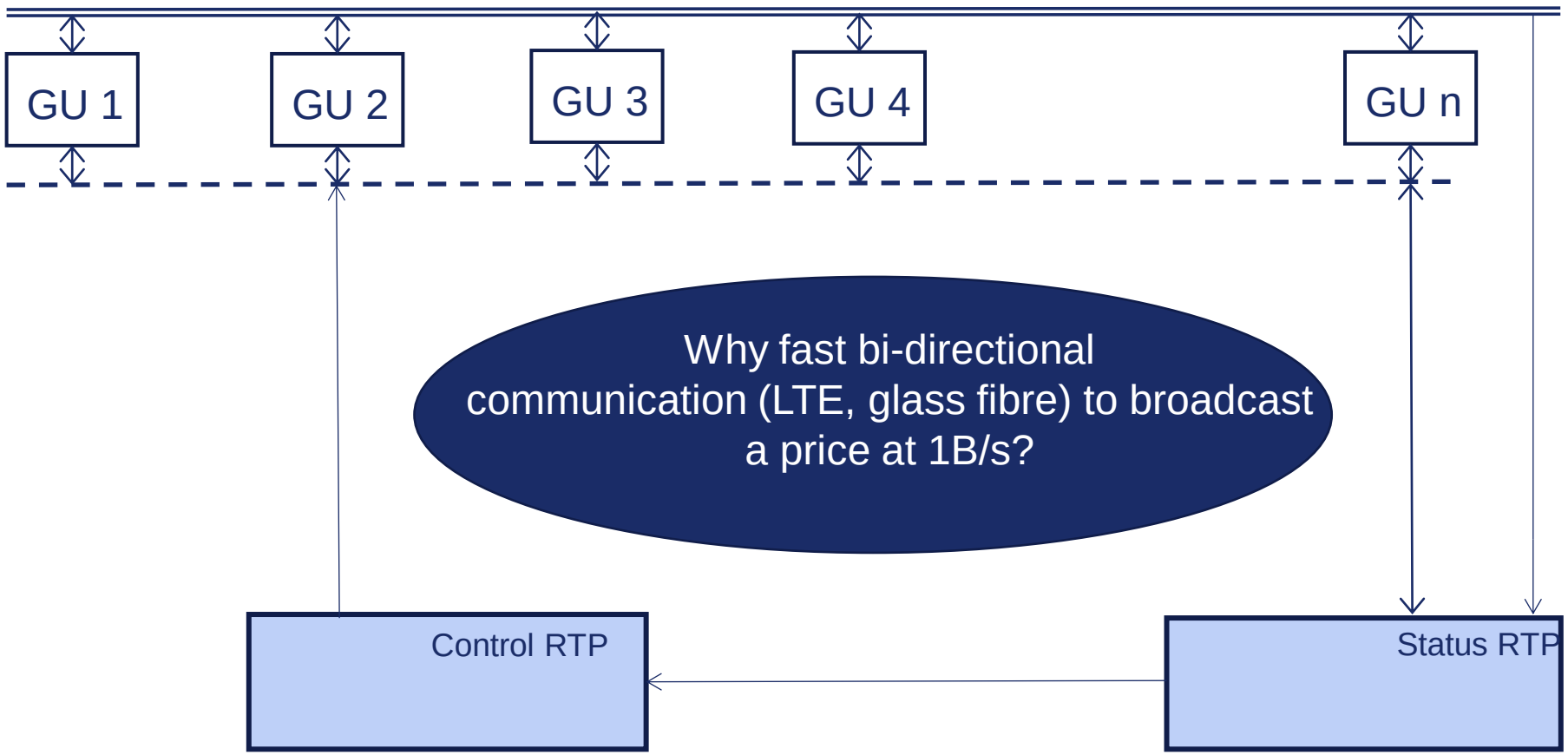
Electric Grid

Grid User

Communication

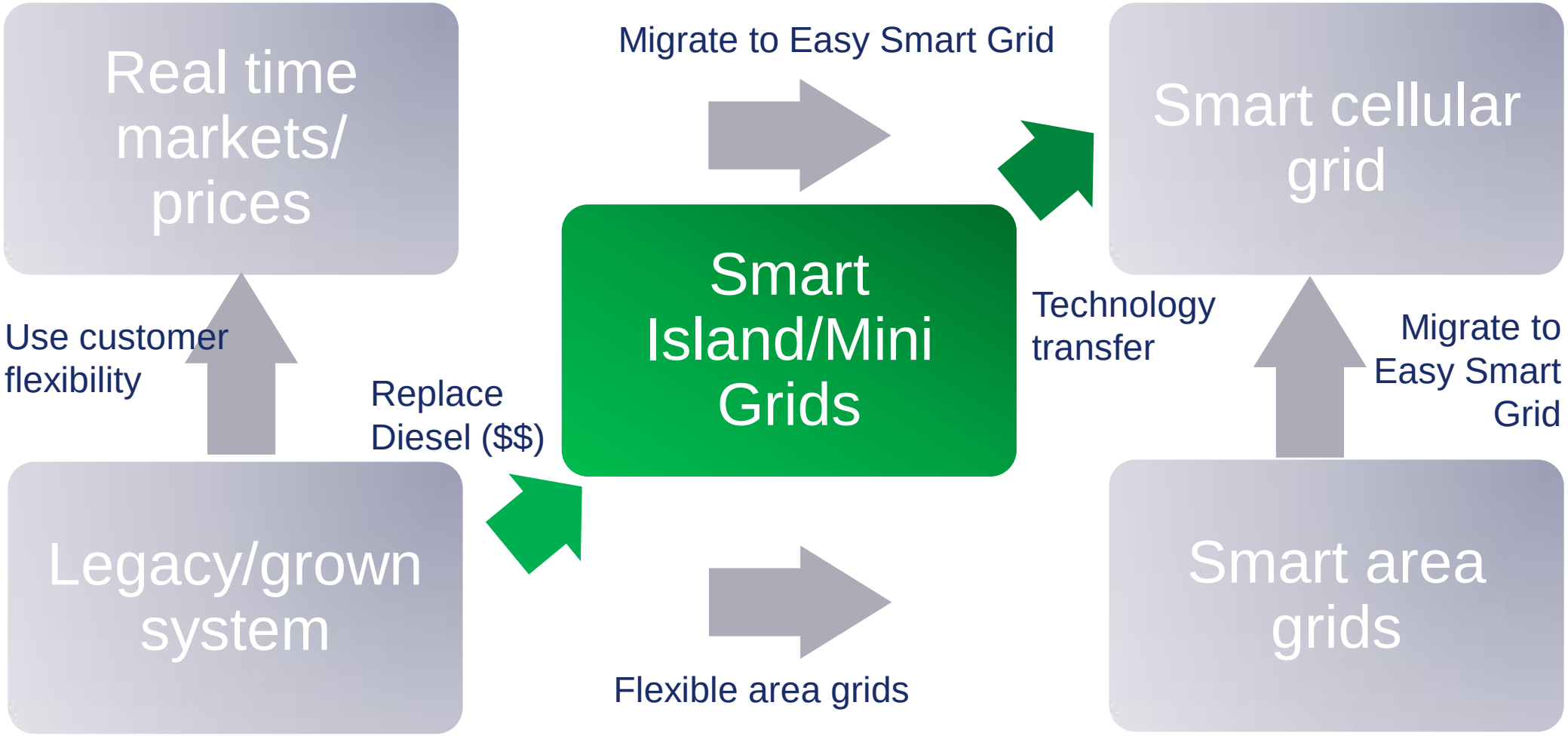
P, S, T:
Frequency for technical control
ID, DA:
Price for control via electricity exchange

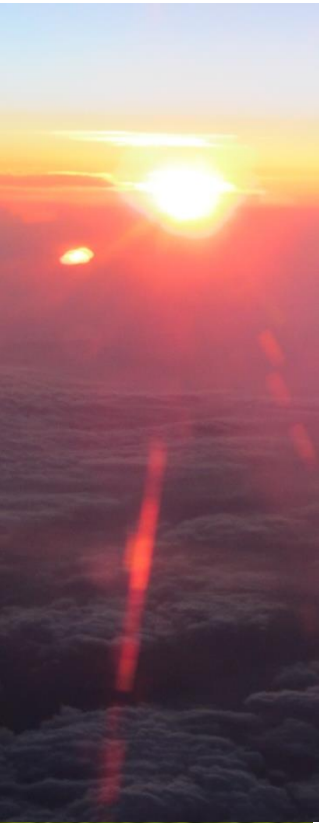
Smart Cells and Cellular Grids
Real Time Market: Only one control loop?



P, S, T, ID, DA:
Integrated into Real Time Market
Important:
Real Time Prices (RTP) today not „in real time“. Control Power may still be needed?

Smart Cells and Cellular Grids
Opportunities of Transformation





Thank you for your interest and questions!

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