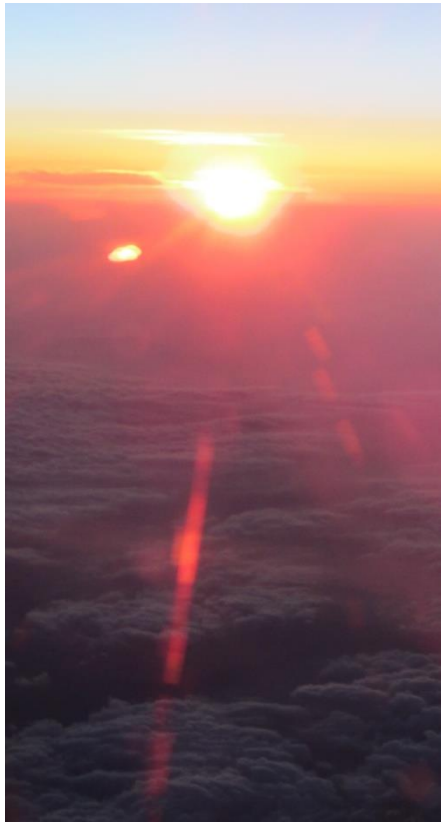
# Smart Micro Grids and the Easy Smart Grid Approach



## RE integration-
## simple, robust, secure and affordable

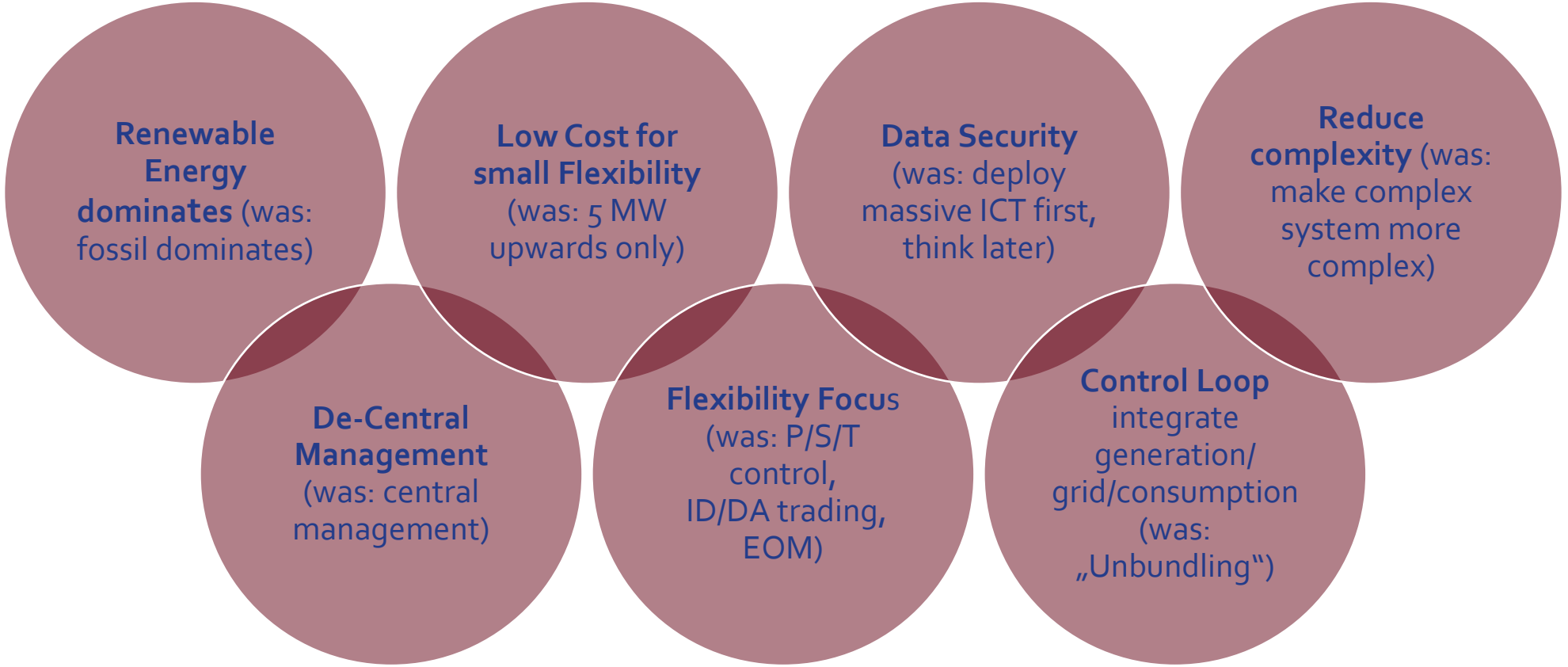
Workshop and Symposium „Future Energy Systems“
Göttingen, Dec. 11th, 2014

Dr. Thomas Walter

# Agenda

1. Status and Challenge of „Smart Grid“
2. Applications ready for „Smart Grid“
3. Smart Grid to manage Infrastructure and Balance
4. Easy Smart Grid – an Approach to meet Requirements
5. Research issues for Smart Grid

# 1. Status and Challenge
# 7 Requirements of future Electric Energy Systems reflect Paradigm Change



# 1. Status and Challenge

## Status as seen by European Electricity Grid Initiative (EEGI)

### MAPPING AND GAP ANALYSIS

| | T1 | T2 | T14 | T3 | T4 | T5 | T6 | T7 | T8 | T9 | T10 | T11 | T12 | T15 | T16 | T17 | TD 1 | TD 2 | TD 3 | TD 4 | TD 5 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Hardware | -1 | -1 | 3 | 1 | 1 | 1 | 1 | -1 | -1 | -1 | -1 | -1 | -1 | 3 | -1 | 2 | -1 | 2 | 1 | -1 | -1 |
| Software tools | 2 | 2 | 3 | 2 | 2 | 2 | 3 | 2 | 2 | 3 | 3 | 2 | 2 | 2 | 3 | -1 | 2 | 2 | 2 | 3 | -1 |
| Integration into the system | 3 | 3 | -1 | 2 | 2 | 2 | 3 | 2 | 2 | 3 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 3 | 2 | 3 | 3 |
| Market Design | -1 | 2 | -1 | -1 | -1 | -1 | -1 | -1 | -1 | -1 | 3 | 3 | 3 | -1 | -1 | -1 | -1 | 3 | 3 | -1 | -1 |
| Cost-benefit analysis | -1 | 2 | 3 | 2 | 2 | 2 | -1 | -1 | -1 | 2 | 3 | 2 | 2 | 2 | 2 | 2 | -1 | 3 | 3 | -1 | 3 |
| Regulation of grid services | -1 | -1 | 3 | 2 | -1 | 2 | -1 | 1 | -1 | 3 | 3 | 2 | 3 | -1 | -1 | 3 | 2 | 3 | 3 | 3 | 3 |
| Stakeholders involvement | -1 | 3 | 3 | -1 | -1 | 1 | -1 | -1 | 2 | 2 | 3 | 2 | 2 | -1 | -1 | -1 | 2 | 2 | 3 | 2 | 3 |
| System reliability | -1 | 3 | 3 | 2 | 3 | 3 | 3 | 3 | -1 | 3 | 3 | 2 | 2 | 2 | 3 | 2 | 2 | 3 | 2 | 3 | -1 |

| | |
|---|---|
| Not relevant | |
| Ready to deploy at large scale | |
| Need more demonstration or pilot project to validate the maturity | |
| Need moderate development | |
| Require more research (work with research institutes) | |

Source:

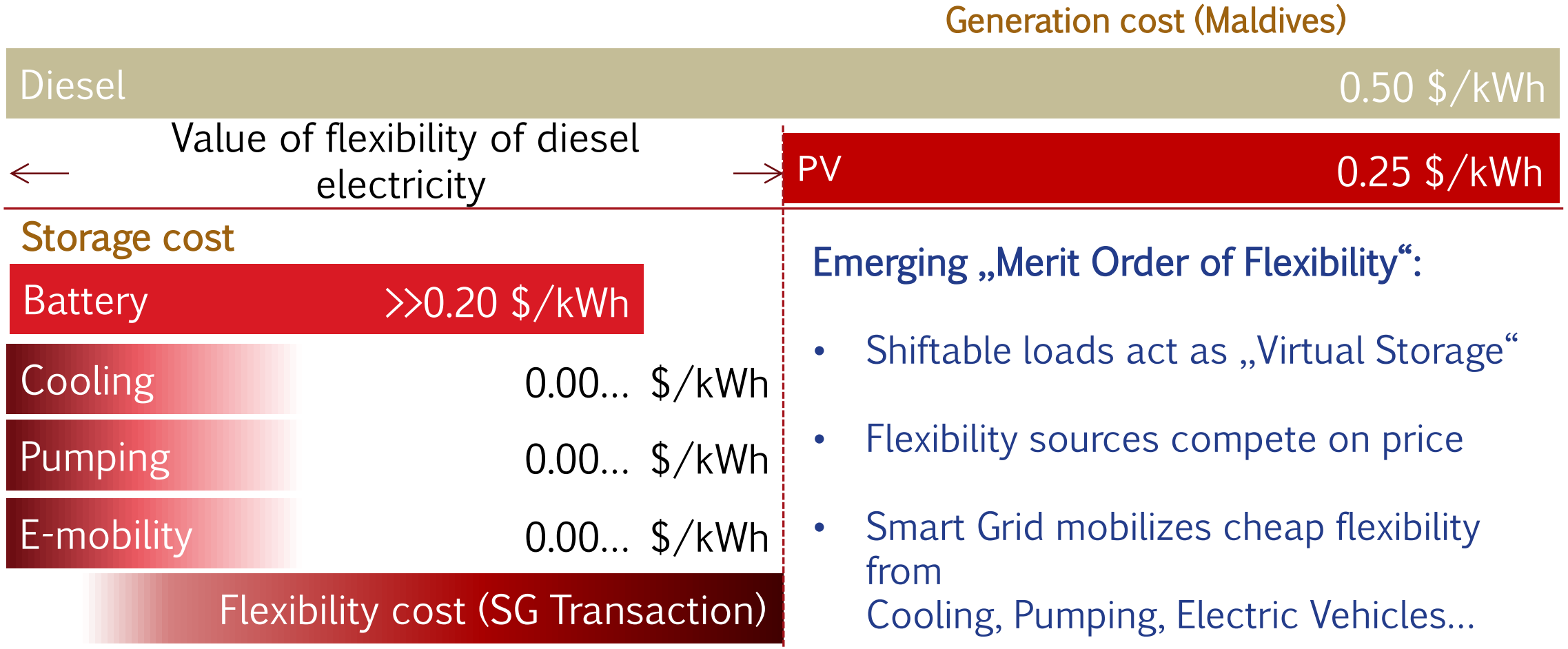
Michele de Nigris, GRID+ COORDINATION ACTION IN SUPPORT TO THE EEGI: RECENT UPDATES

# 2. Applications ready for Smart Grid
# PV- a cheap substitute for Diesel Electricity

**Huge Application Area:**

- Diesel powered grids
  >50 GW, 100.000 Mil.$ p.a.
- RE cheaper than Diesel already:
  ~0.3 $/kWh fuel cost
- Storage is bottleneck, but:
- Ample load shift potential in
  cooling, pumping, e-mobility..

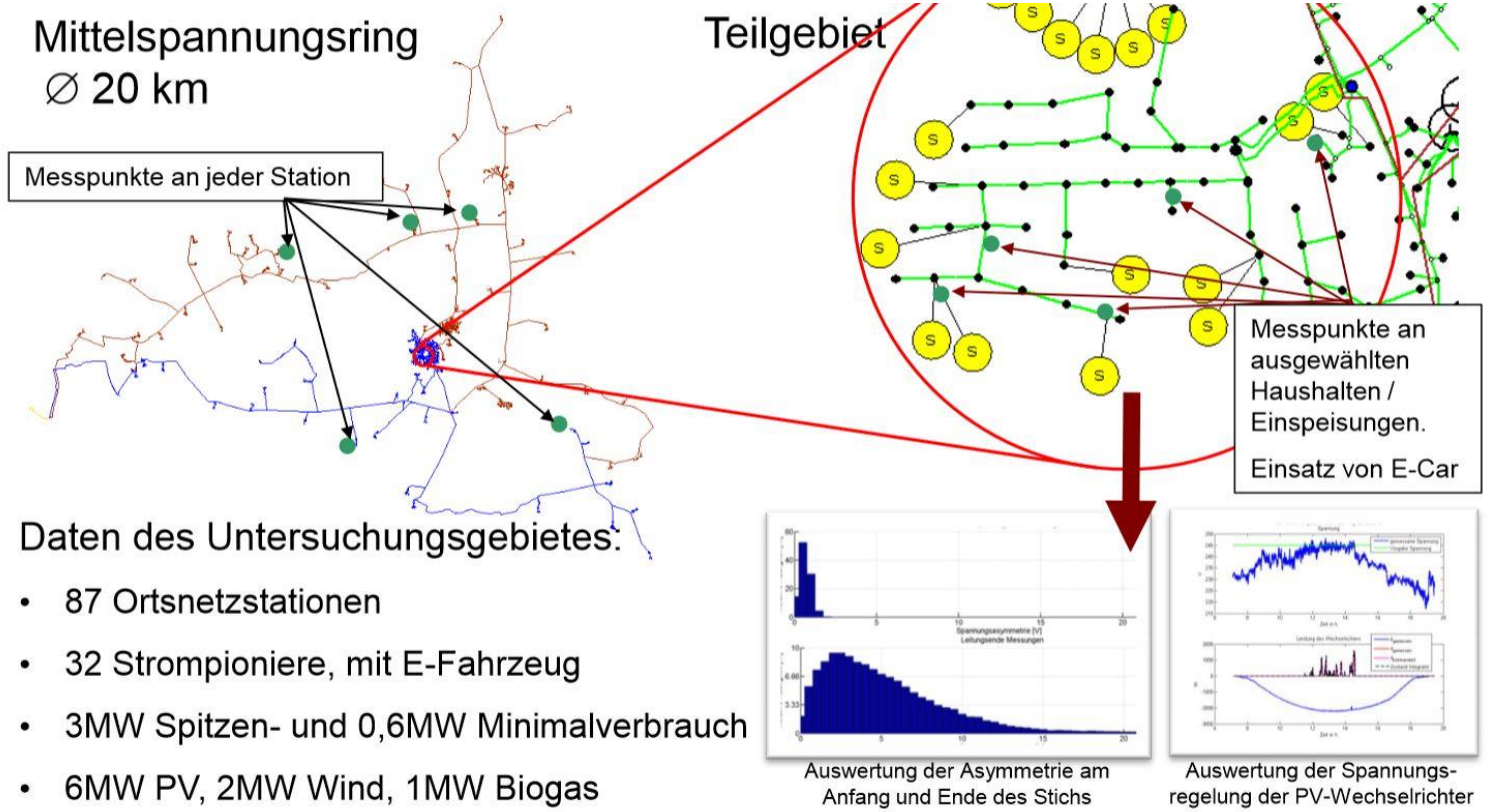
# 2. Applications ready for Smart Grid
# Storage and ICT are largest cost elements




**Emerging „Merit Order of Flexibility“:**

- Shiftable loads act as „Virtual Storage“
- Flexibility sources compete on price
- Smart Grid mobilizes cheap flexibility from
  Cooling, Pumping, Electric Vehicles…

# 3. Smart Grid to manage Infrastructure and Balance



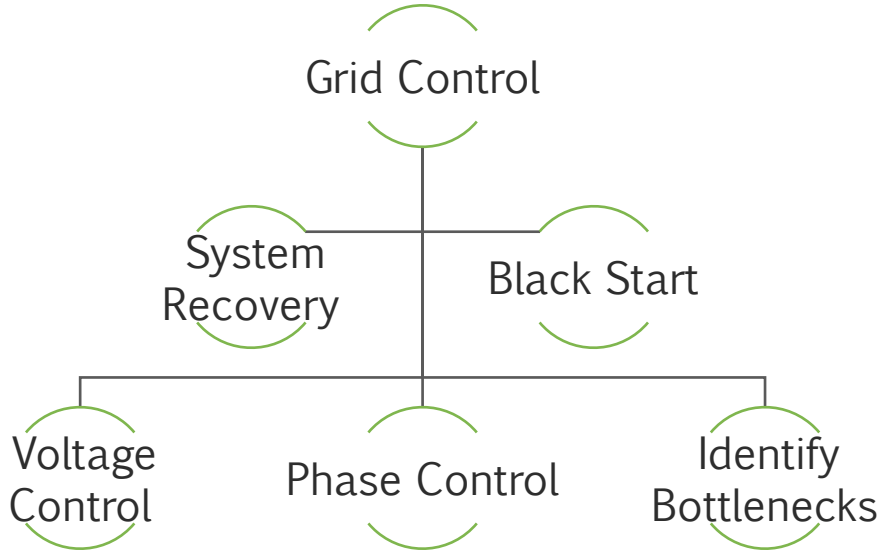

Smart Grid in Germany driven by EEG (focus on infrastructure):

- **Unplanned** grid extension
- Solutions aim to **fixing problems** (overvoltage, congestion)
- Work on RONT, reactive power, energy management (=reduce DER input)-
  Shifting PV mid-day production to evening consumption **not yet in focus**

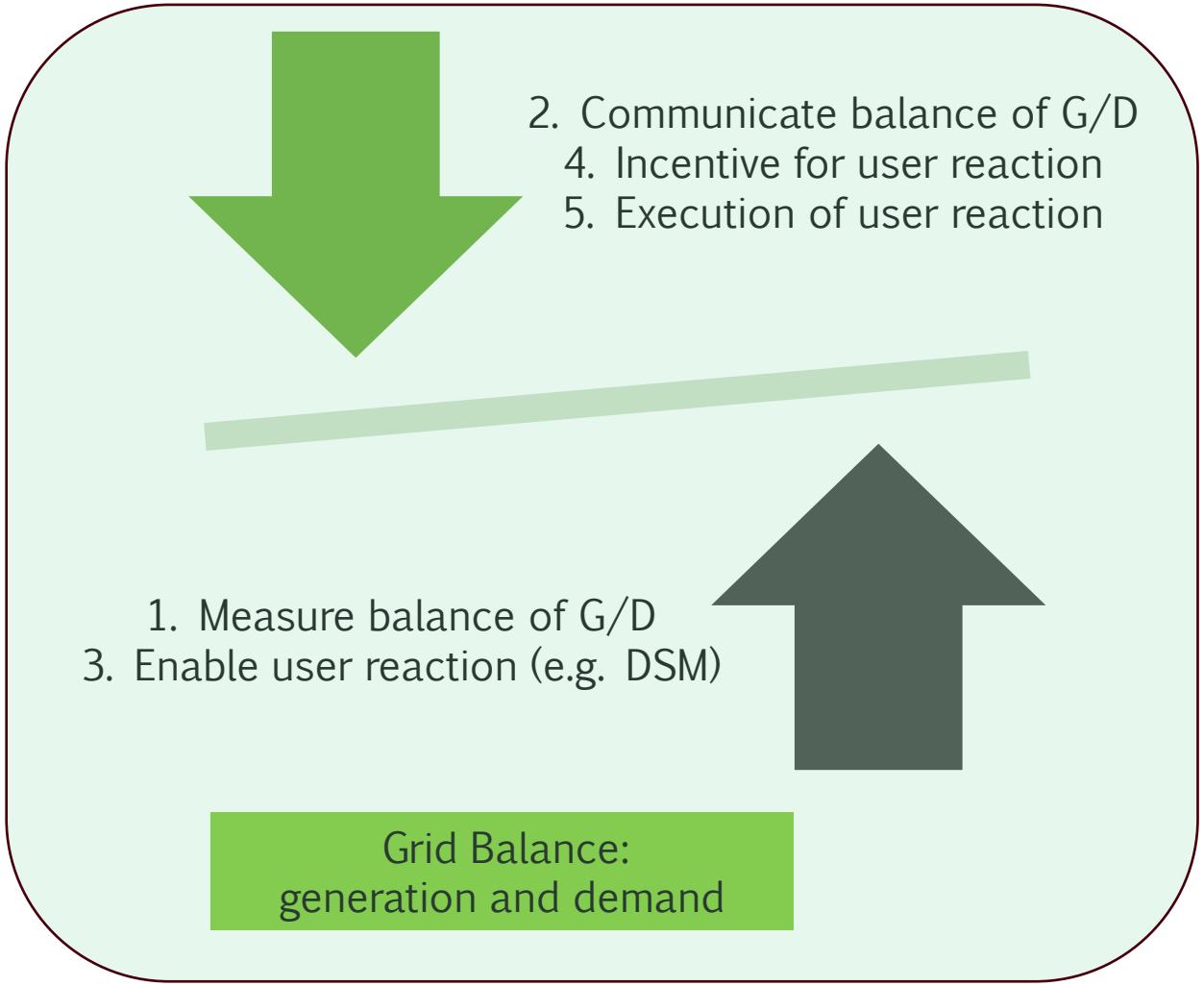
Source: Grid info on Wildpoldsried taken from IRENE web site Dec. 4th, 2014

# 3. Smart Grid to manage Infrastructure AND Balance

## Focus shift to new bottleneck: grid balance




Grid Infrastructure:
lines and topology

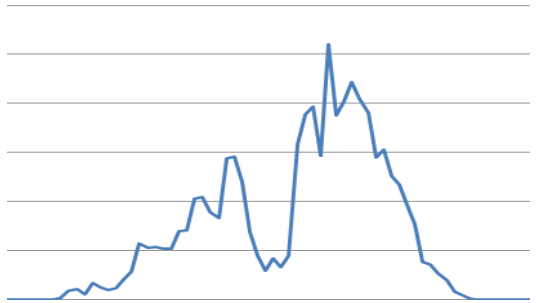


# 3. Smart Grid manages Infrastructure and Balance
## Balancing instruments in use today

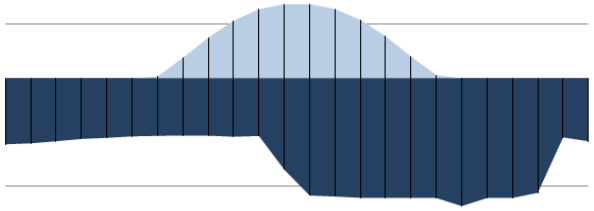
### ~20 % RE Share - Grid balancing and stability become critical

**Challenge**

Volatility of Renewables



Balancing Demand and Supply

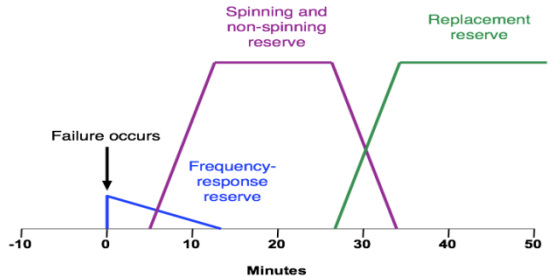


**Flexibility type 1: Primary, Secondary, Tertiary control**

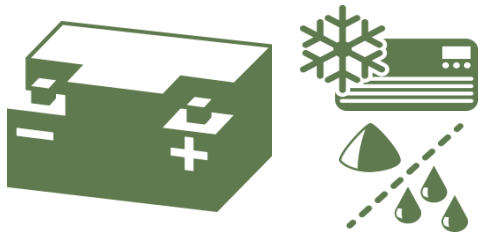
**Flexibility type 2: Intra Day, Day Ahead trading**

**Solution**

Spinning Reserve (short term <minute)




Storage & DSM[1] (long term >hour)



- [1] DSM = Demand Side Management

# 3. Smart Grid Infrastructure and Balance „Flexibility products“ must become more flexible

## Flexibility products come from two (mostly) separate worlds

- **Control by frequency:**

| Owners | Engineering people |
|---|---|
| Time range | Milliseconds to hours |
| Detection | Automatic (rotating mass) |
| Transmission | Automatic (grid frequency) |
| Product | (Semi) automatic Primary, Secondary, Tertiary control |

- **Control by price:**

| Owners | Commercial people |
|---|---|
| Time range | (Quarter )hour to days |
| Detection | Prediction, bidding, exchanges |
| Transmission | ICT (computers and communication) |
| Product | ID (Intra Day), DA (Day Ahead) blocks of (quarter) hours scheduled |

# 4. Easy Smart Grid to meet Requirements KISS: “Keep It Simple, Stupid”

## A Real Time Price for Electricity in Micro/Mini Grids:

- If generation < load: Increase price until balance is reached
- If load < generation: Reduce price until balance is reached

Result:

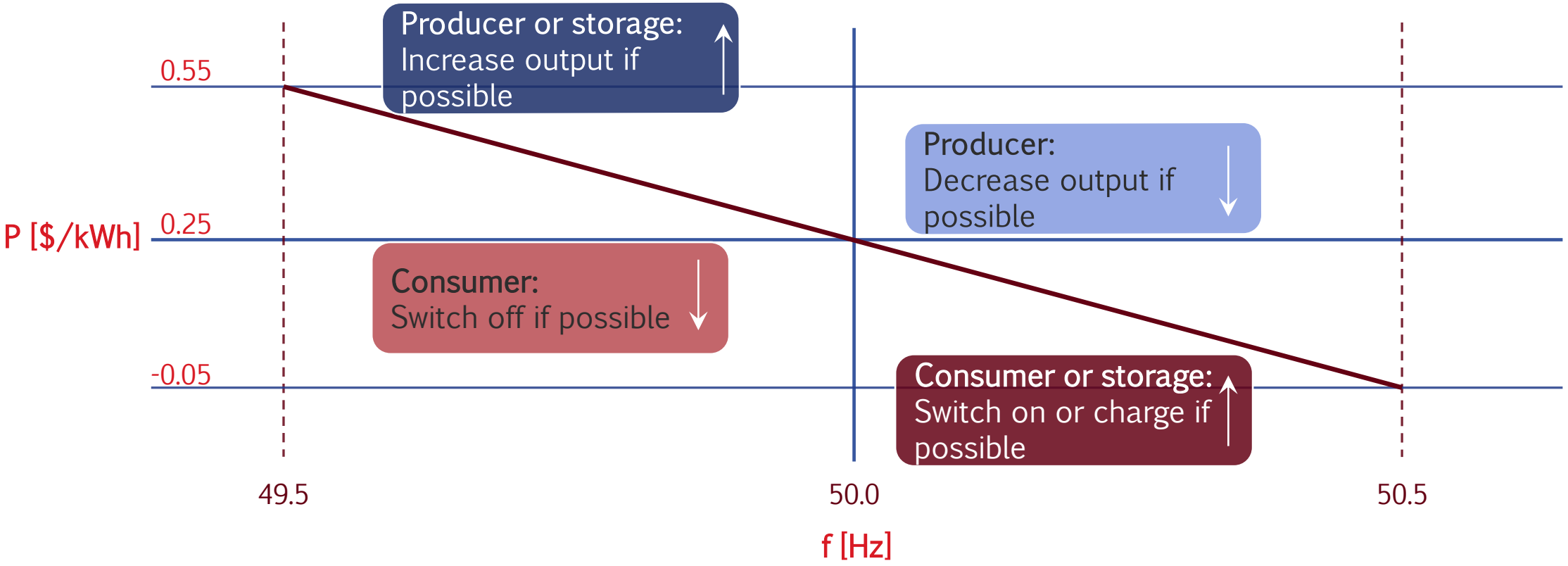
- Flexible generators: Shift generation to high price times
- Flexible consumers: Shift consumption to low price times
- Storage devices: Charge at low, discharge at high price (arbitrage)

## How to implement?

- „Big Data“ ( ICT calculates balance and communicates price)
- „Easy Smart Grid“ (ICT largely provided by grid physics)

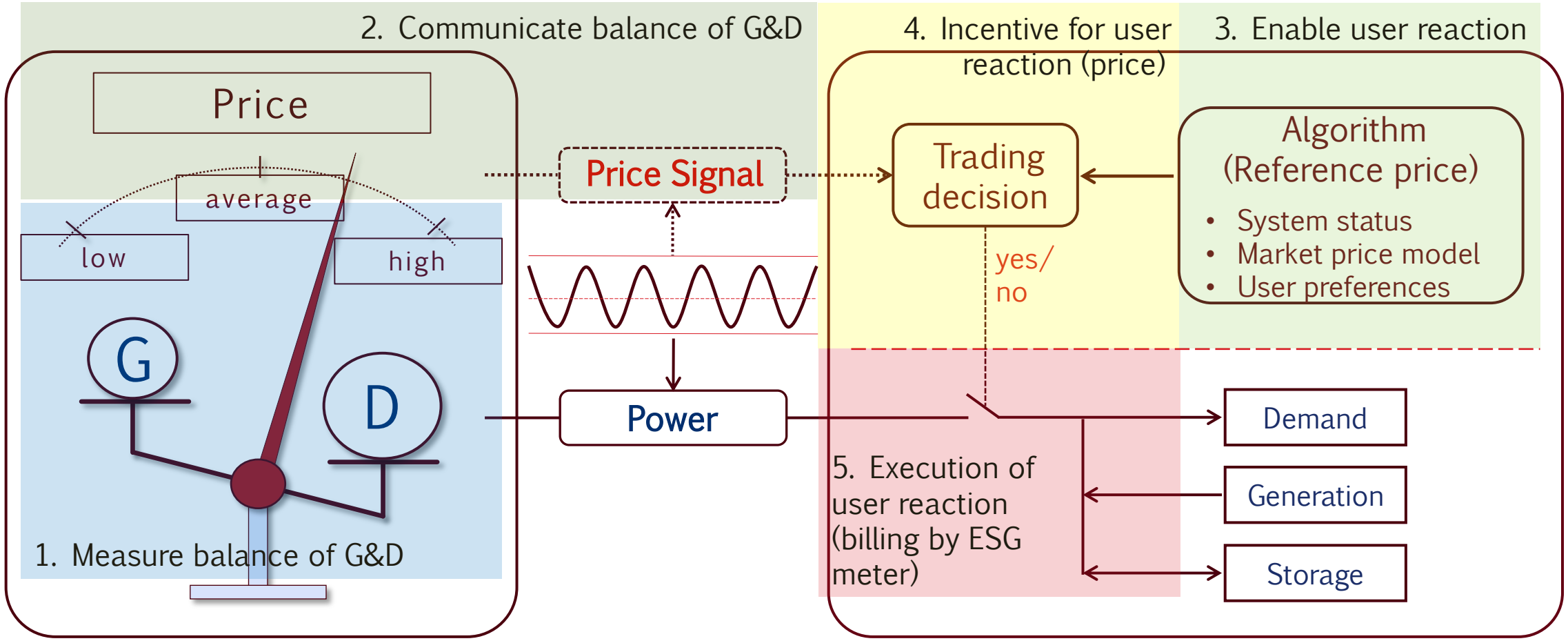
# 4. „Easy“ Smart Grid to meet requirements KISS: “Keep It Simple, Stupid”

Map price (economic world) on frequency space (technology world)

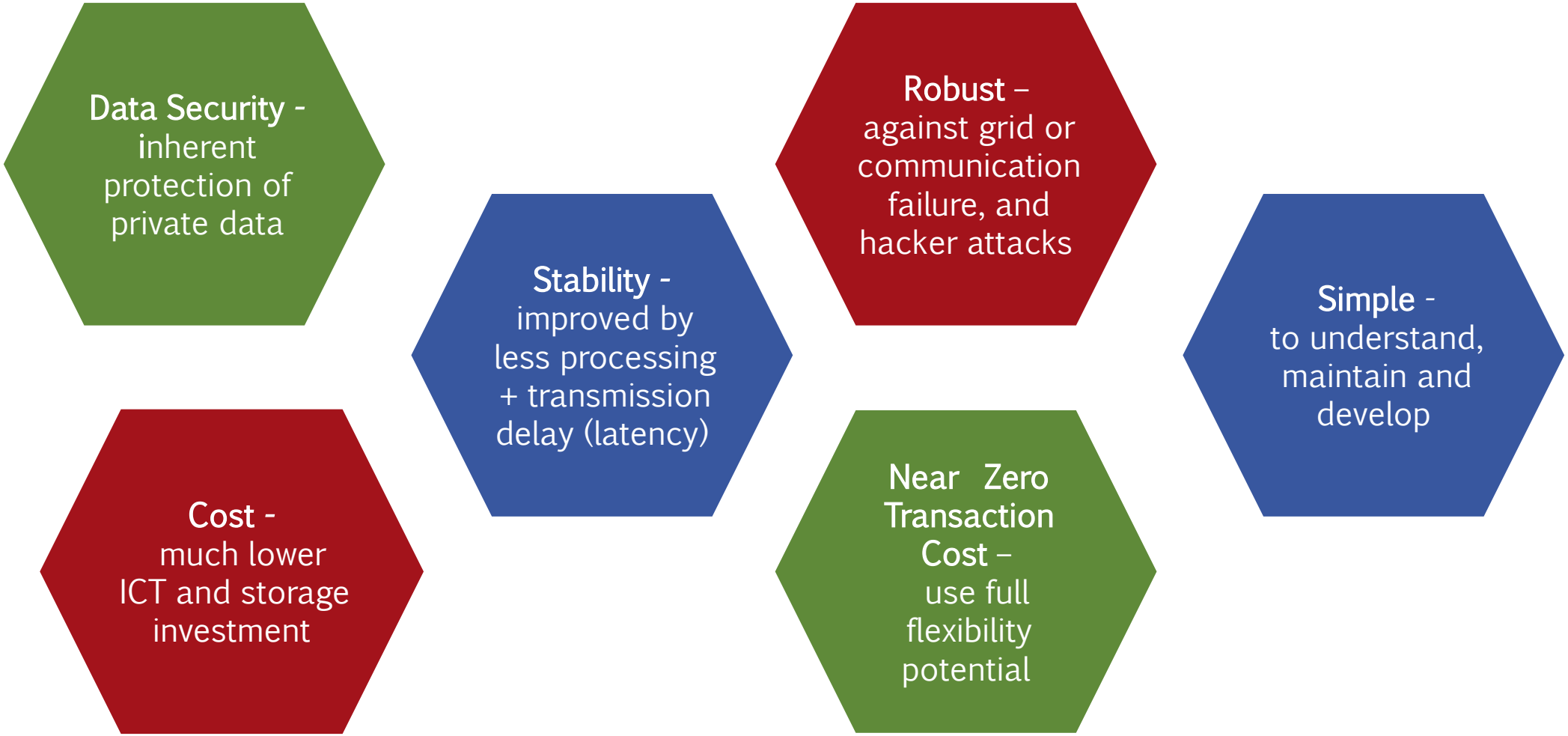


# 4. Easy Smart Grid key functionality

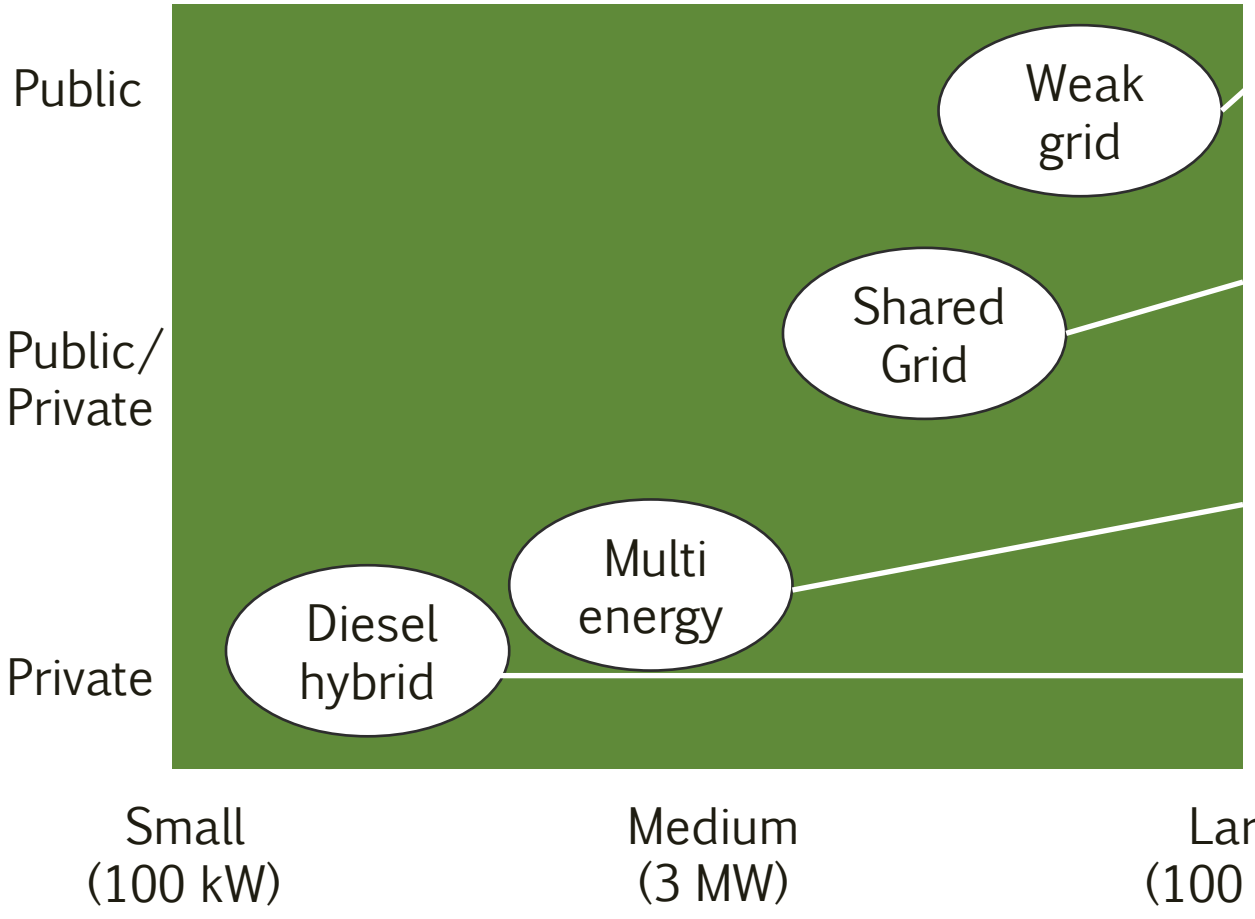
Balance generation and demand with near zero investment -> low transaction cost



# 4. Easy Smart Grid meets Requirements: It is simple, secure, robust and affordable



# 4. Short Term Applications
# Easy Smart Grid adds value today



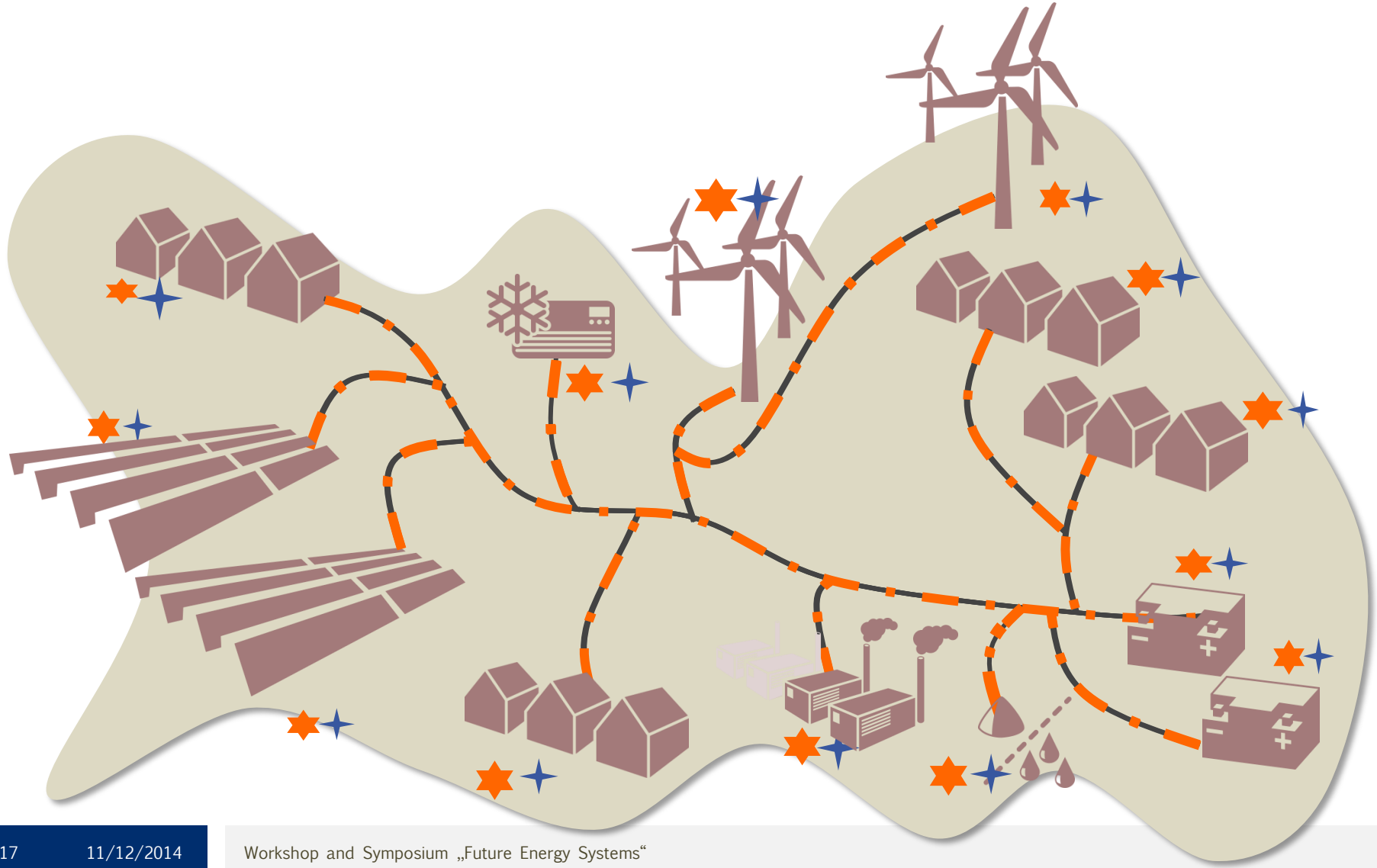

**Grid Operators**
- Protect assets and customer satisfaction
- Improve stability in weak grids
- Better use of limited capacity

**Infrastructure Players** (governments, facility managers) - fair electricity pricing in
- Green-/brownfield developments
- Clusters and anchor models, PPP

**RE developers and industry**
- Multi source integration (PV+Wind+Hydro +Biomass)
- Orchestrate complementarity, fair pricing

**PV developers and industry**
- More PV in diesel+PV hybrids

# 4. Easy Smart Grid with step by step approach

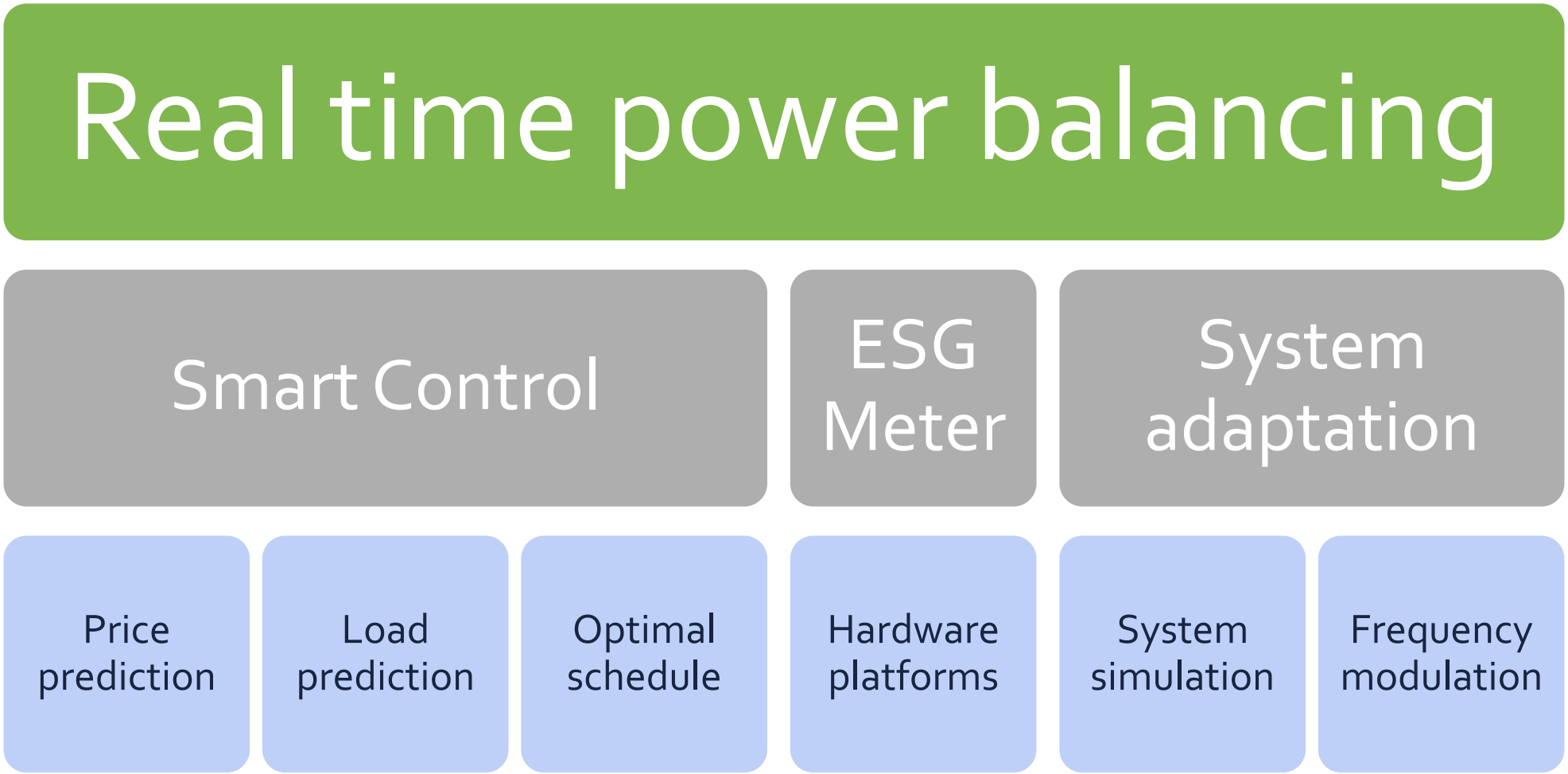


- Step 1: Harvest low hanging fruit
- Step 2: Higher RE integration and storage
- Step 3: Full ESG implementation

SmaCo box

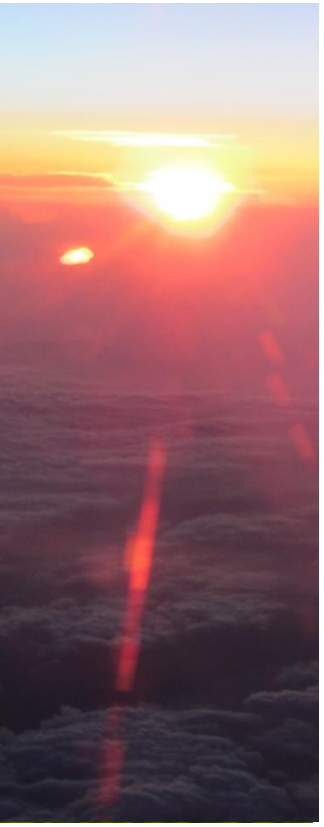
ESG meters

# 5. Research issues for Easy Smart Grid Products and Solutions to be developed



# 5. Easy Smart Grid to re-use know-how
# Areas where technology could be available

| Area | Inputs |
|---|---|
| Price prediction | Algorithms to predict price from history<br>Integration of external forecasts and scheduled activities |
| Load prediction | Predict storage reach for minimum loss of comfort (sensors, algorithms) |
| Optimal schedule | Scheduling based on price and load predictions |
| Hardware platforms | Use of available smart meters and industrial controllers |
| System simulation | Modelling and simulation of component/system behaviour: Technical/Commercial, Static/Dynamic, Models and Tools |
| Frequency modulation | Migration from central <start> to de-central systems <long term><br>For centrally managed systems (diesel hybrids): calculate and encode variable price<br>For fully de-central systems: „Translator“ of imbalance to frequency change (real or virtual spinning reserve, existing algorithms in BESS (Battery Electric Storage Systems) |



# Thank you for your interest!

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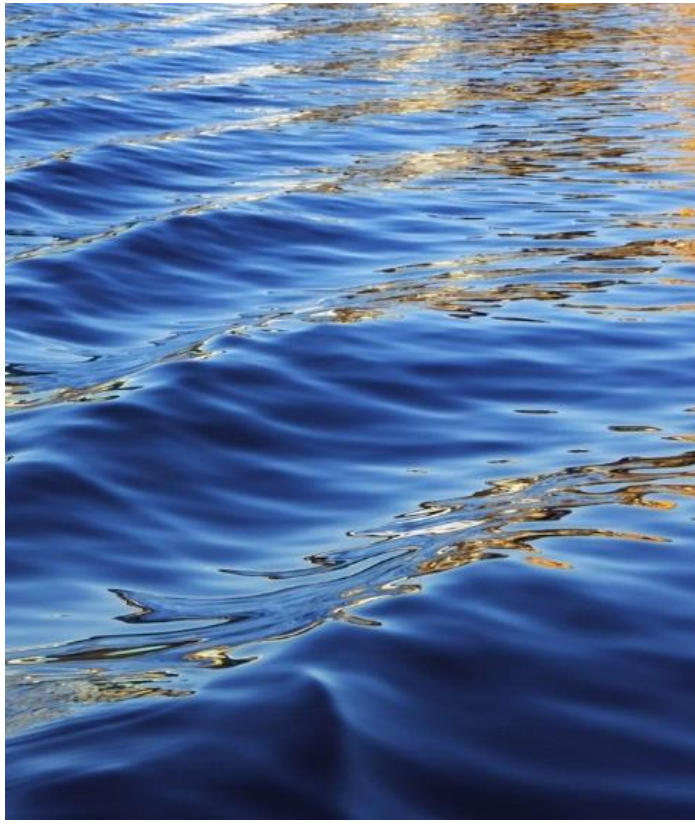
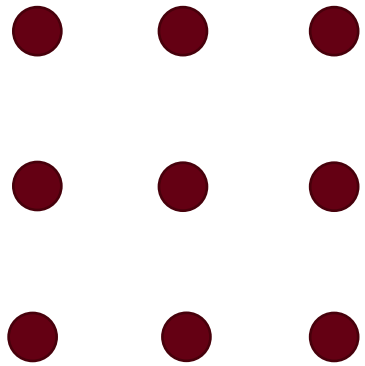
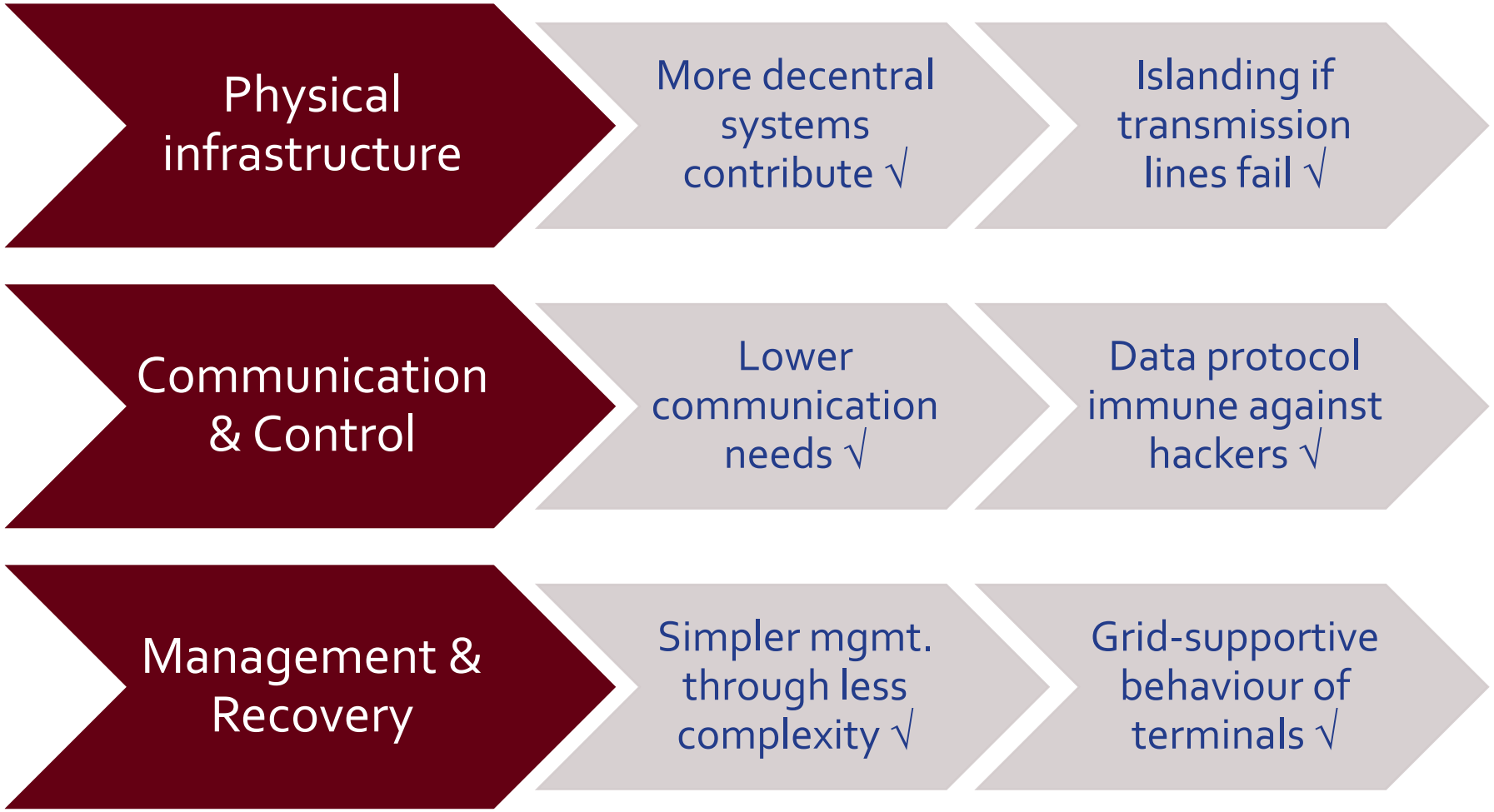


# 1. Status and Challenge
# Paradigm Change (Load follows Generation)



►Challenge: Connect nine points with four straight lines without removing pen from paper

# 4. ESG makes Grid and Smart Grid robust



- What do we need for Innovation? (fear and greed)
- - A problem to solve (how many projects in Germany address Energy balance and new approaches) – who suffers?
- - A benefit if problem is solved (who benefits from the change?) There is no short term benefit in Germany, and no long term thinking in actors
- Am environment open for experiments (things may not work well first time – in Germany everybody is proud of and believes to need security of supply (15 min grid failure per year)