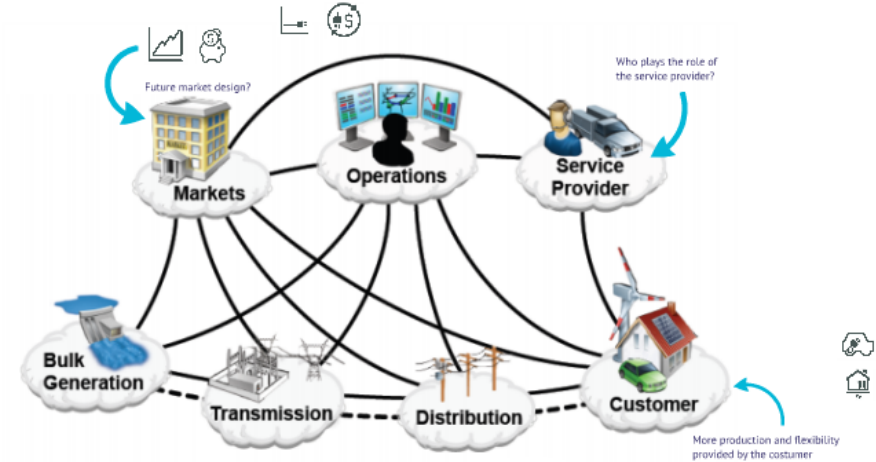
# Grid integration of renewables:
## Dispatching and exploitation of virtual power plants

misurio
EnergyOn Group




(c) NIST Smart Grid Framework

____ Secure Communication Flows
_____ Electrical Flows






misurio

# Grid integration of renewables:
## Dispatching and exploitation of virtual power plants

Dr. Karl Werlen | Workshop @University of Geneva | 11th December 2014

# Optimal Exploitation of Flexible Energy Systems


EnergyOn AG, Visp

energy on

**Energy Services**
**operation of VPP**
industry, SME, consumers

Misurio AG, Visp

misurio

**Misurio Optimizer**
**development of VPP**
studies, analyses,
software for planning and operation
MPC-controllers

# Misurio Optimizer | Applications


**Studies**
Feasibility studies
Sensitivity analyses
2D-Sensitivity diagrams

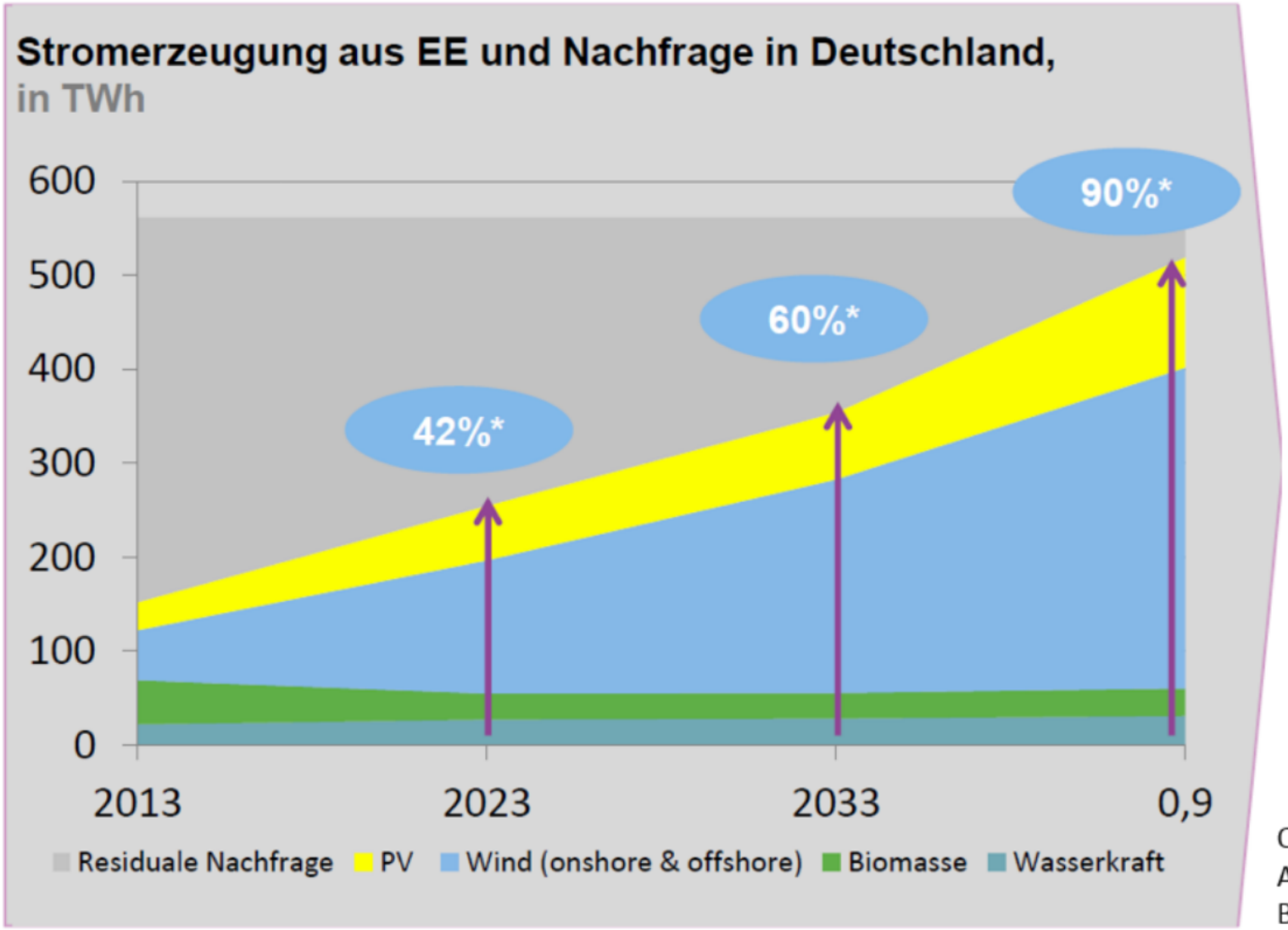
**Simulator**
Software-Tool
Project evaluation
Business model validation

**Scheduling**
Software-Tool
Optimal scheduling
Optimal bidding strategy
Ancillary services and spot markets

**Optimal control**
MPC = model predictive control
«near-time»
Optimisation with online interface to SCADA

**Virtual Power Plants**
Pooling of flexible energy systems
Design of virtual power plants

# The Challenge of the Energy Transition



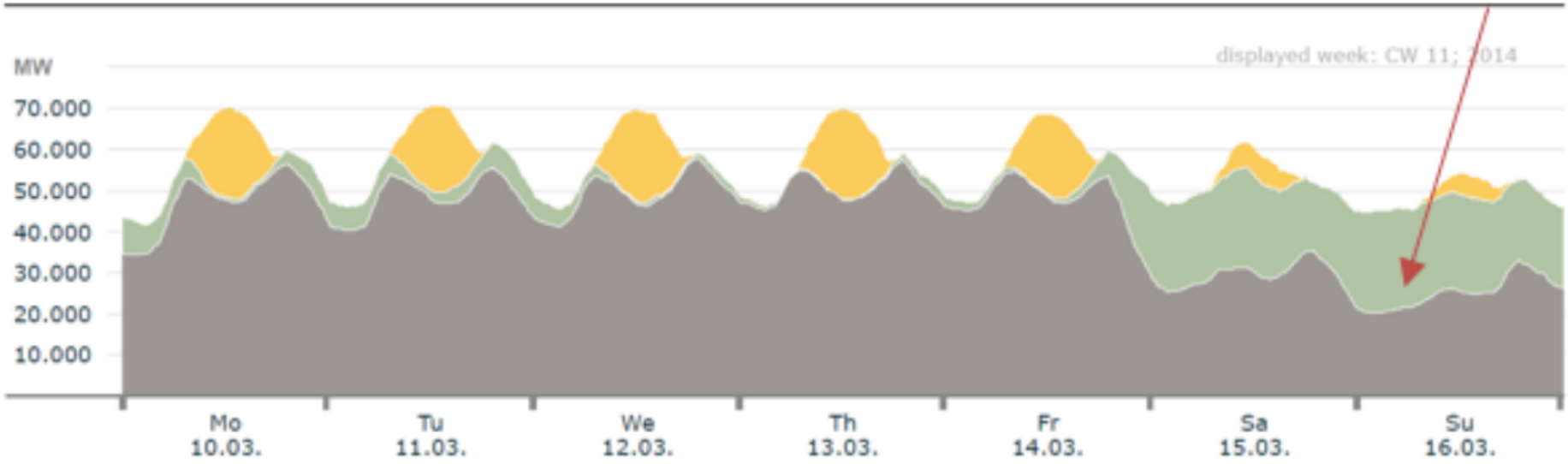

Quelle:
Agora Energiewende
Berlin 15.09.2014

* Für das restliche Europa wurde verzögerter Ausbau der Erneuerbaren Energien angenommen:
23% bei 42% in D, 40% bei 60% in D, 60% bei 90% in D

# Electricity Production in Germany: Calendar Week 11

**negative electricity prices**
*(min = -60.26 EUR/MWh)*

**Actual production**




| | max. power | date max. power | weekly energy |
|---|---|---|---|
| Solar | 22.1 GW | 12.03., 12:15 (+1:00) | 0.8 TWh |
| Wind | 24.8 GW | 16.03., 02:30 (+1:00) | 1.44 TWh |
| Conventional > 100 MW | 57.9 GW | 12.03., 19:00 (+1:00) | 7.2 TWh |

Graph: Bruno Burger, Fraunhofer ISE; Data: EEX Transparency Platform



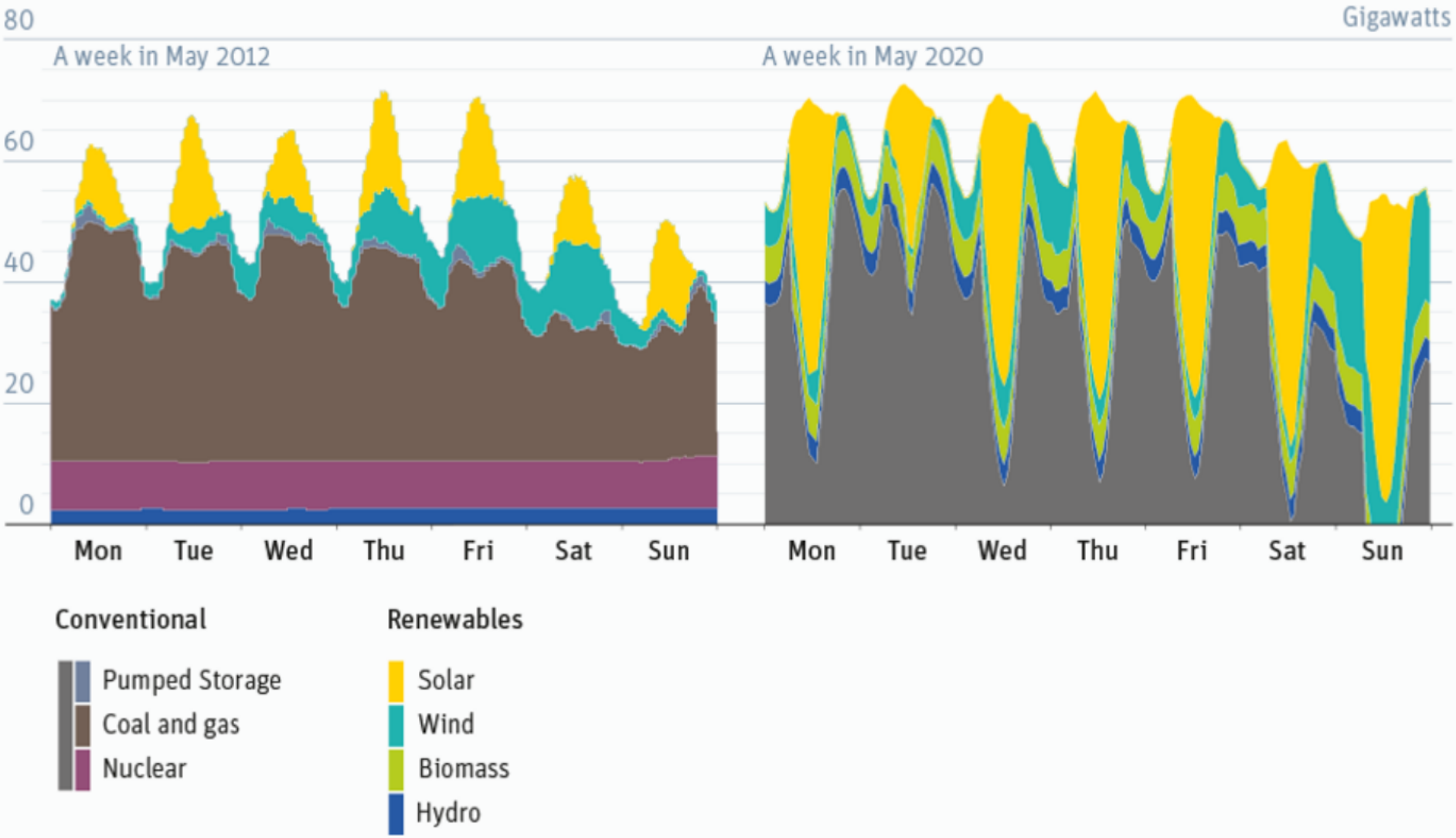


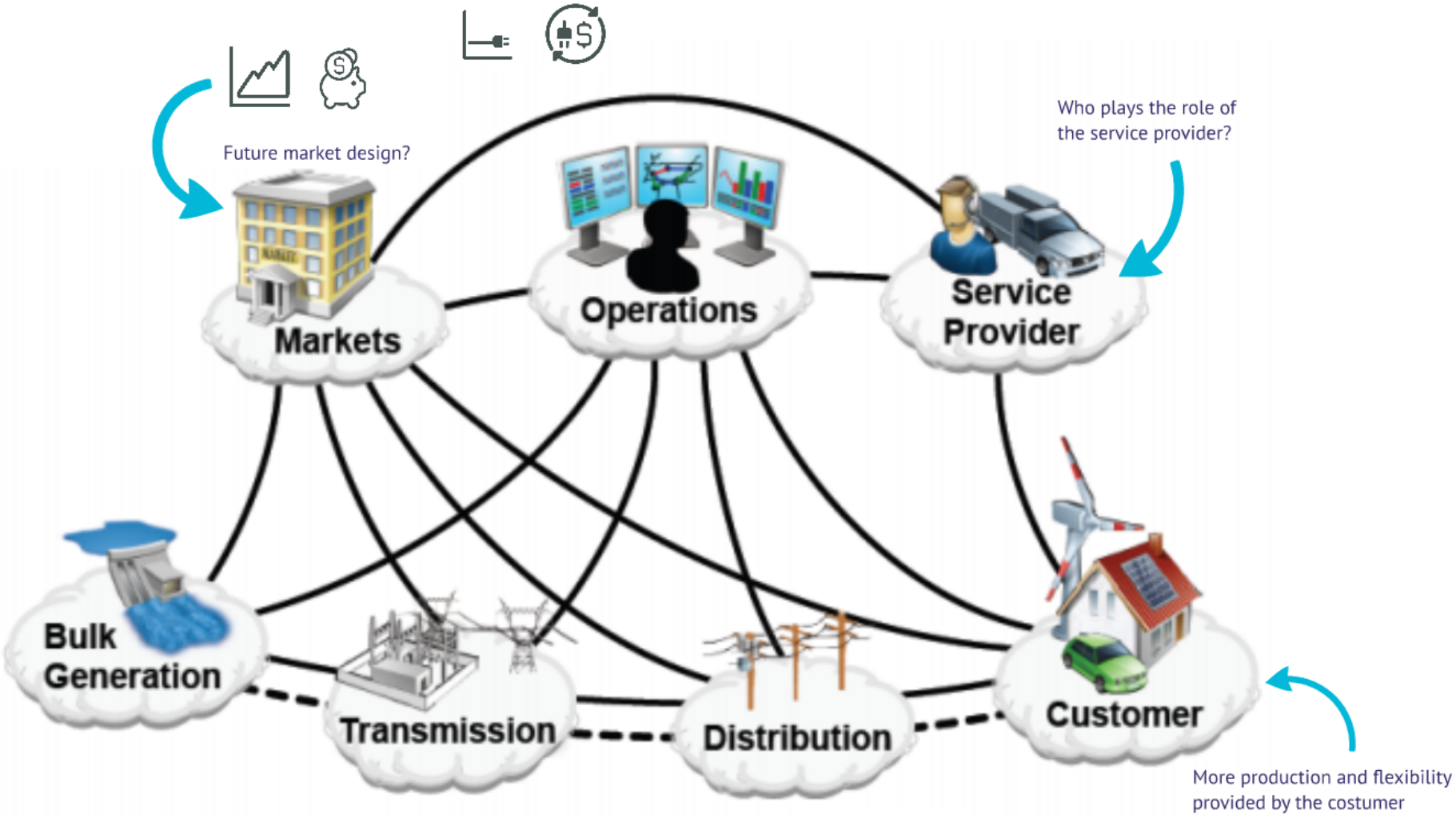
Fraunhofer ISE

# Renewables need flexible backup, not baseload

Estimated power demand over a week in 2012 and 2020, Germany

*Source: Volker Quaschning, HTW Berlin*



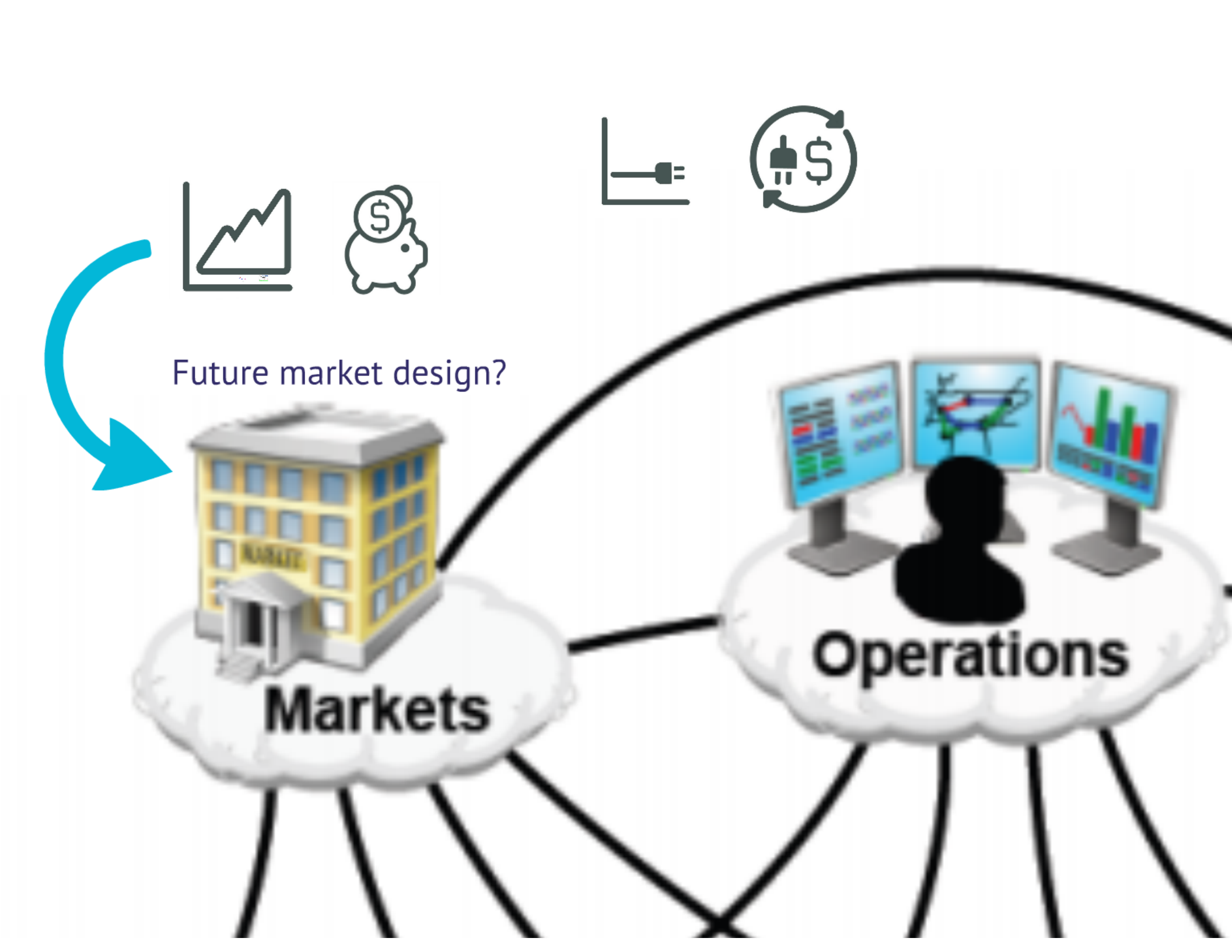



(c) NIST Smart Grid Framework

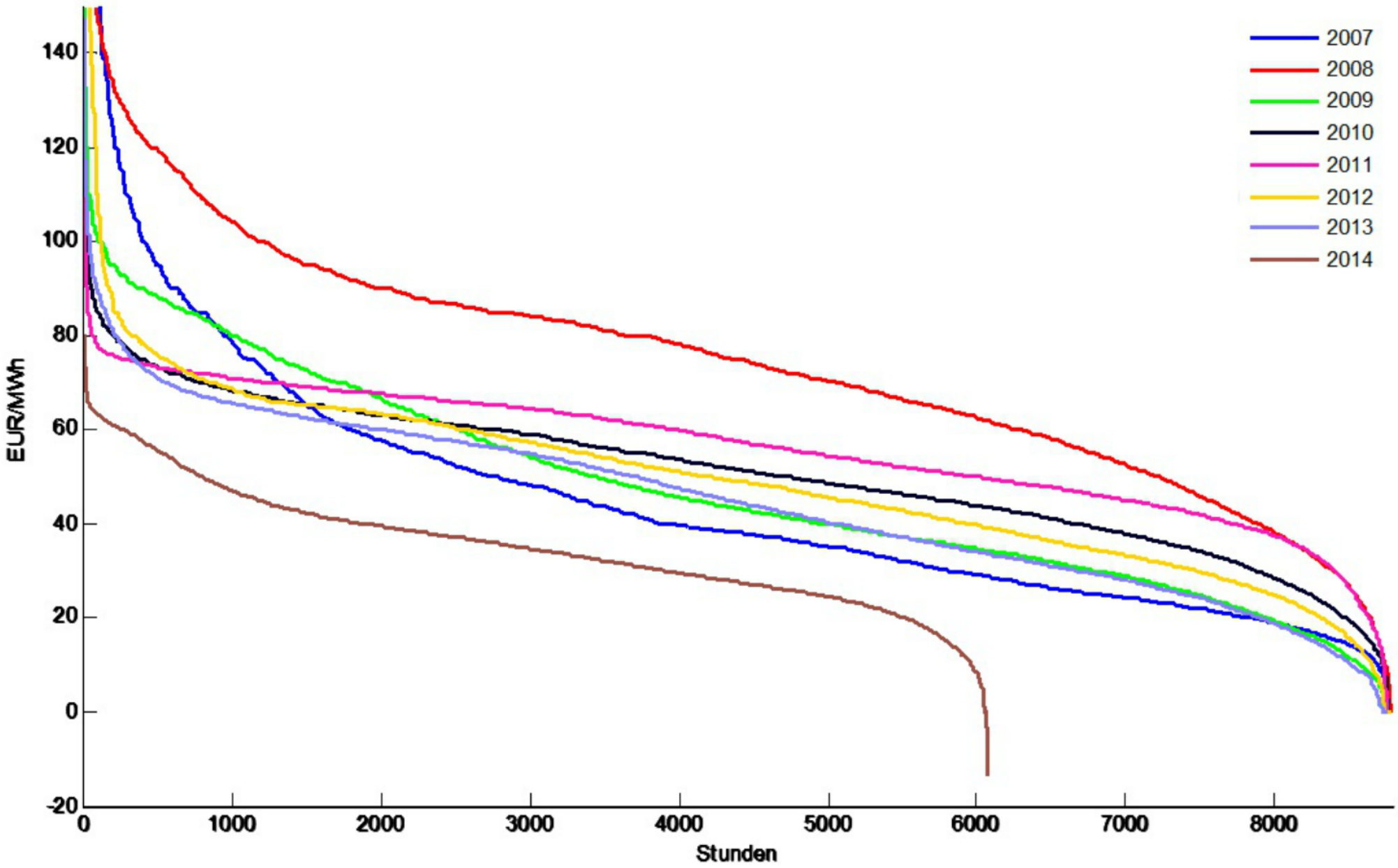
_ _ _ _ Secure Communication Flows
_____ Electrical Flows


More production and flexibility provided by the costumer

Who plays the role of the service provider?


Future market design?
Markets
Operations

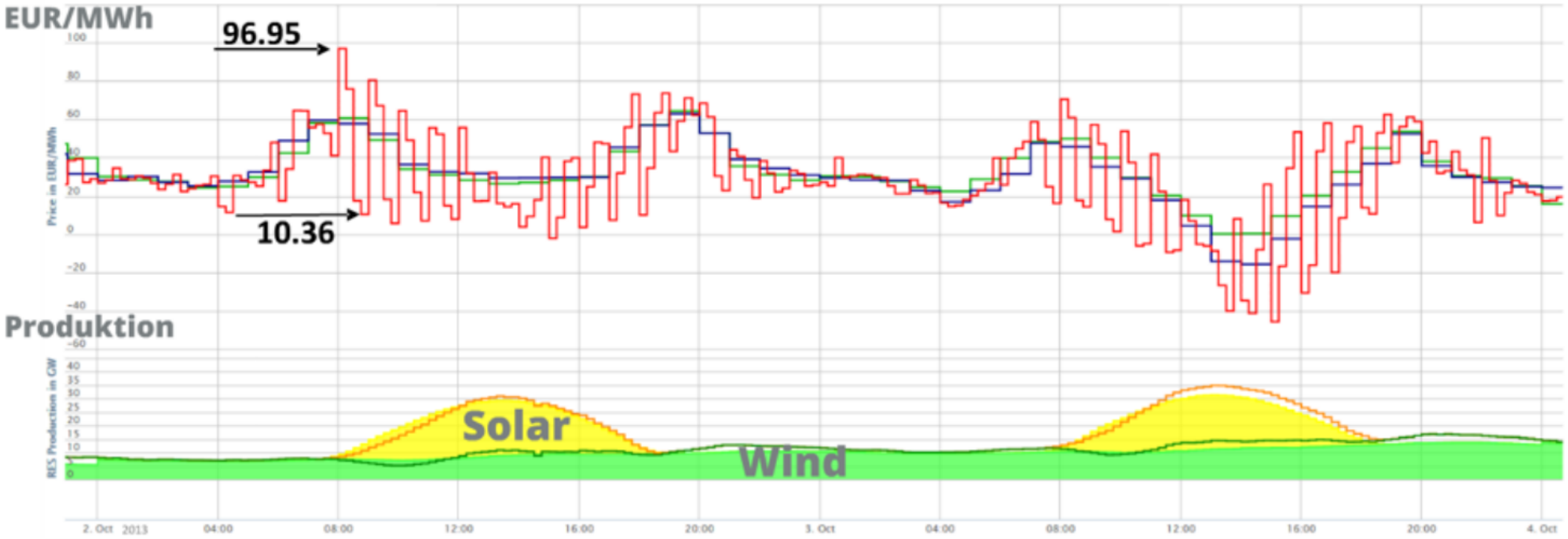
# Swissix Electricity Prices 2007 – 2014

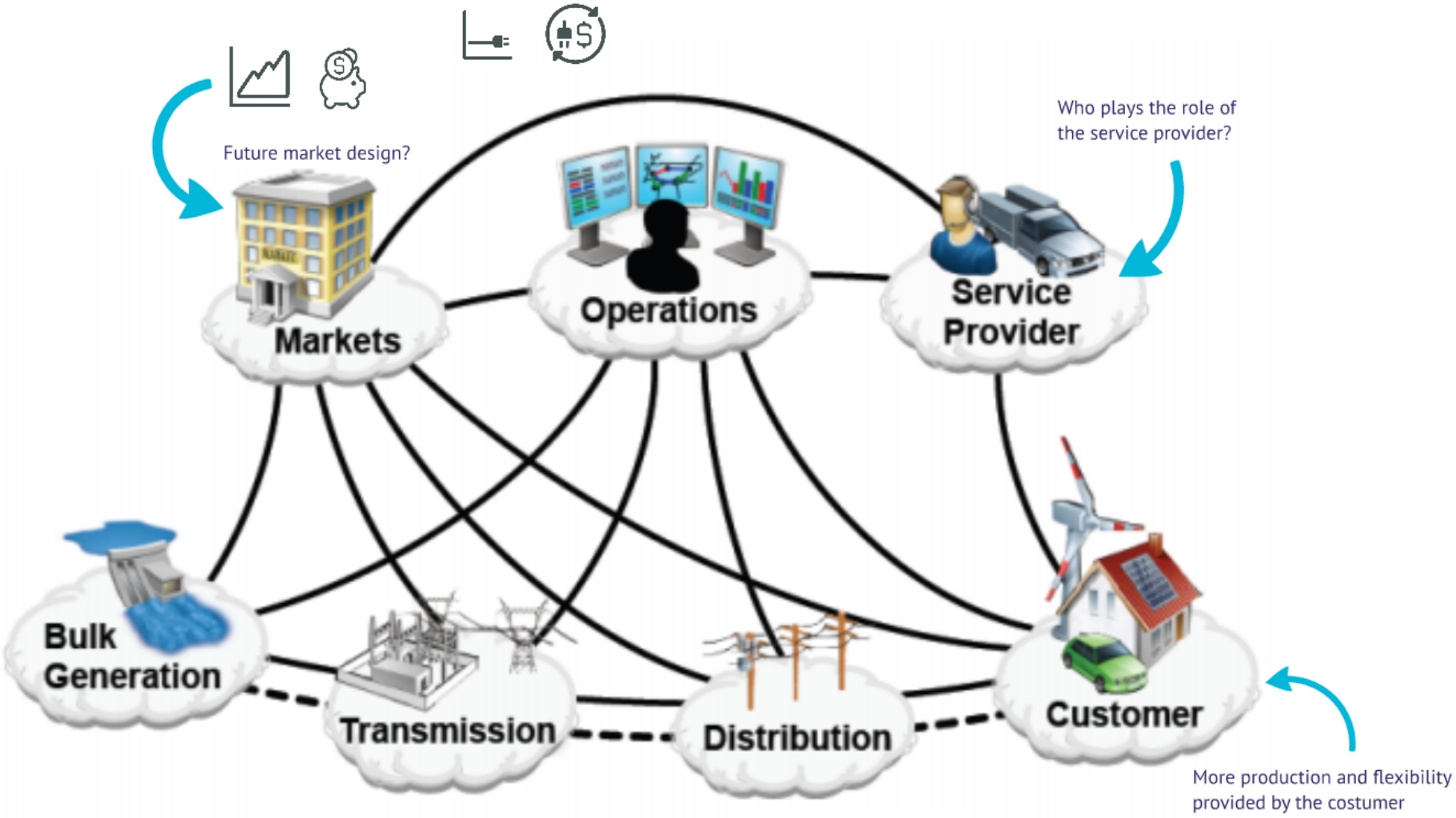


EPEX SPOT
EUROPEAN POWER EXCHANGE

# Power Exchange

## 1/4 Stunden Marktpreise Deutschland
## 2./3. Oktober 2013
## Intraday und Day-ahead






(c) NIST Smart Grid Framework

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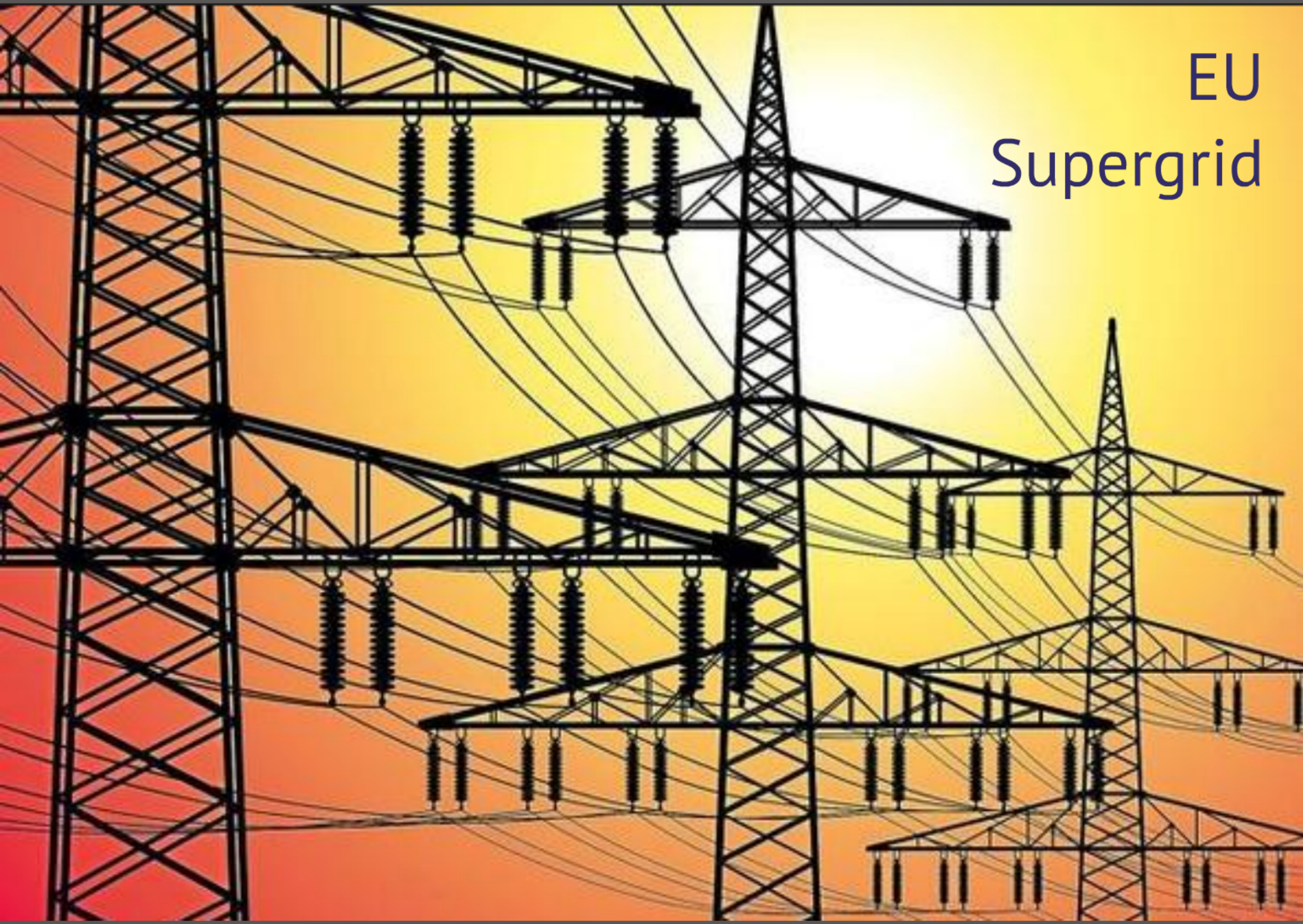
# Desertec


EU
Supergrid

# The Energy Transition

**PAST = top-down**

flexibility provided by vertical integrated utilities

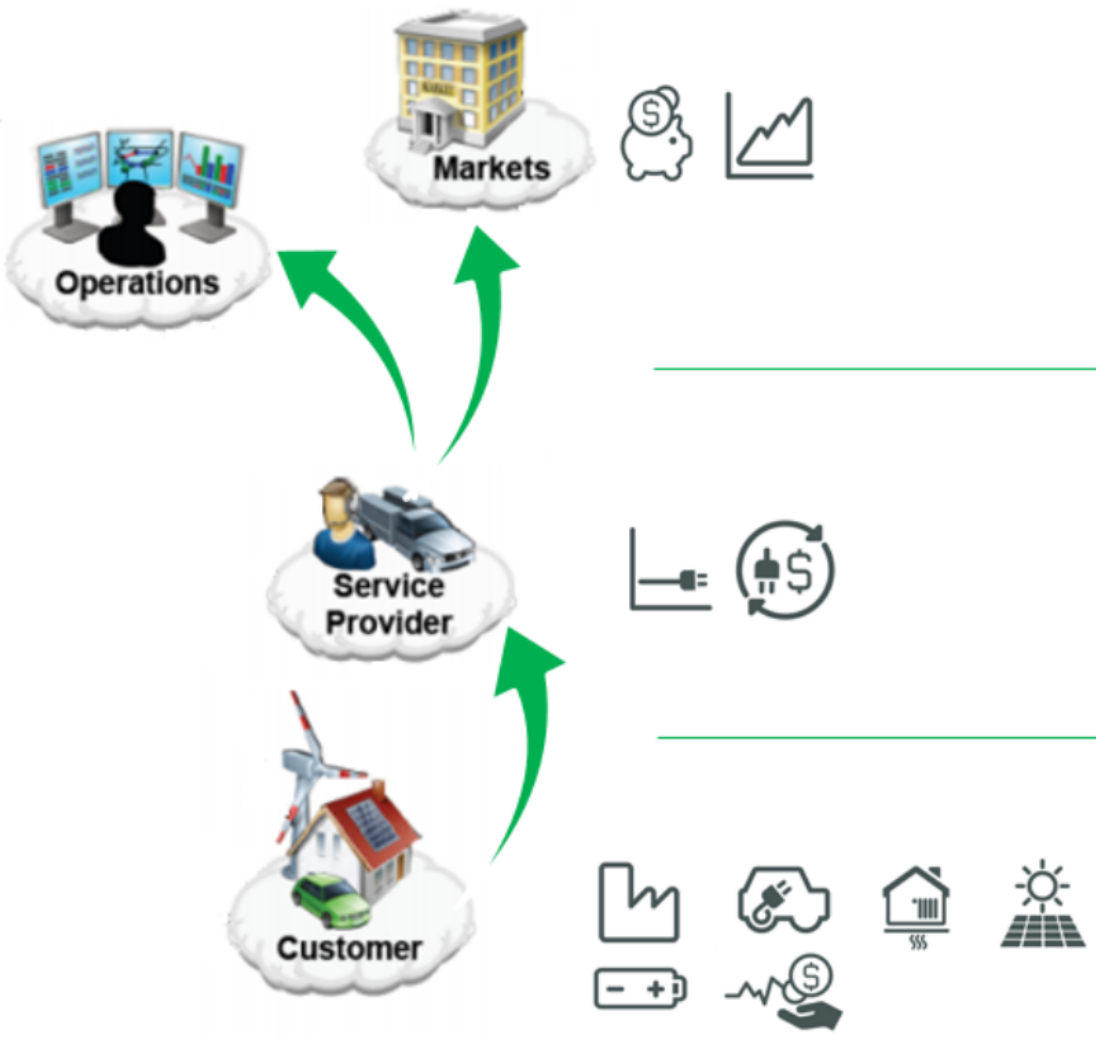
(supply, transmission, distribution, service provider)


**FUTURE = bottom-up**

flexibility provided by customer / prosumer

service provider plays a key role as an aggregator of flexibility and access provider to markets

# Priorities for the Exploitation of Flexibility

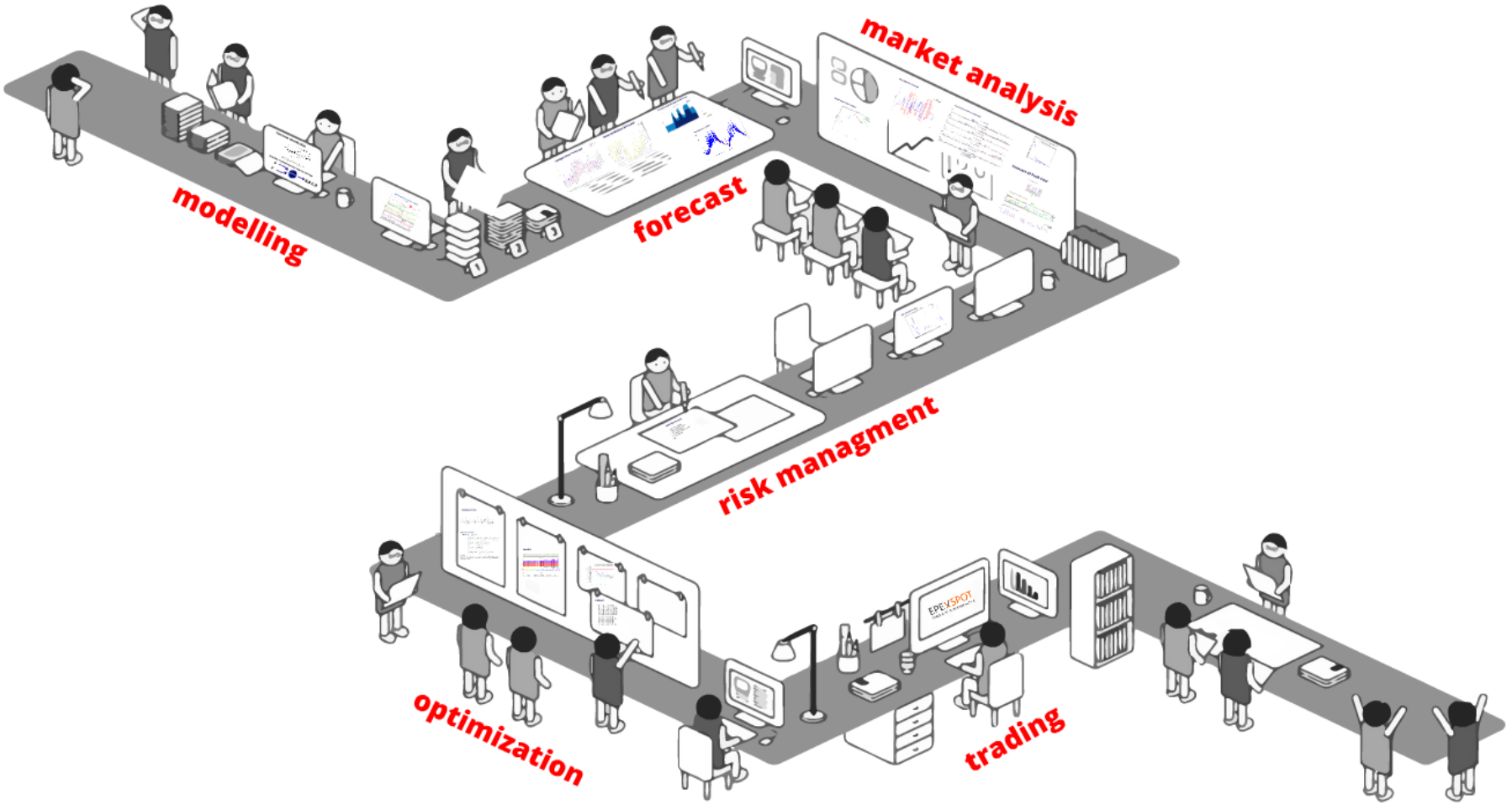


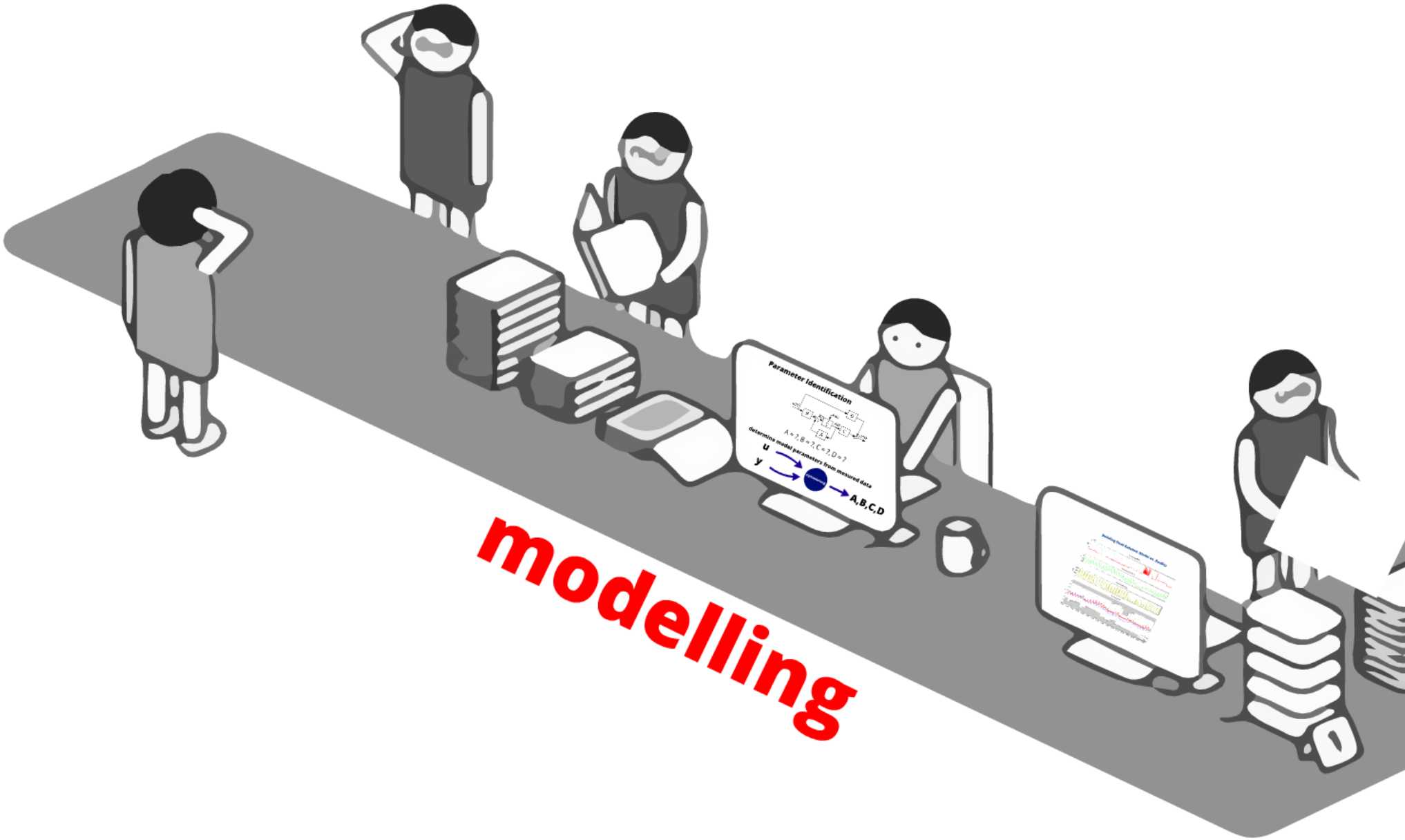

**Priority 3 = commercialization**

**Priority 2 = (technical) security**

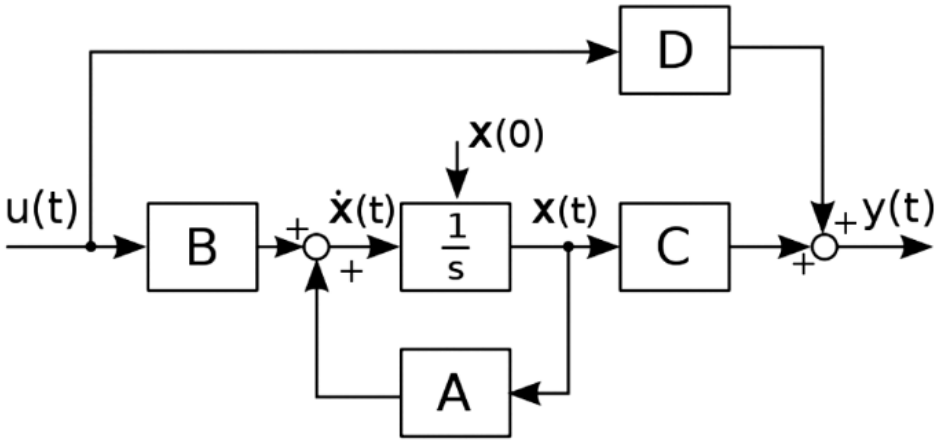
**Priority 1 = comfort**

# Multi Optimization Method




Parameter Identification
A=?,B=?,C=?,D=?
determine model parameters from measured data
u
y
A,B,C,D
modelling

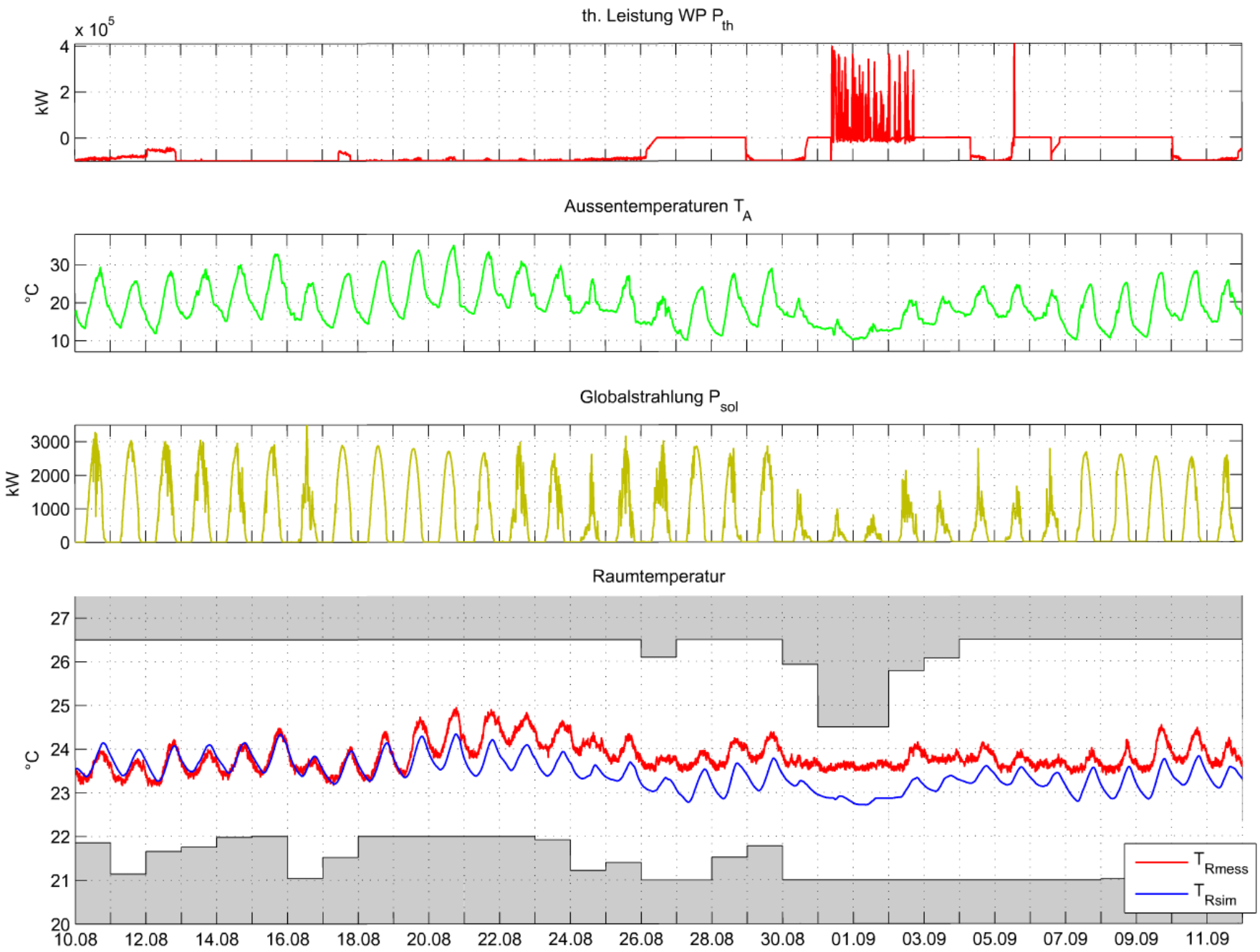
# Parameter Identification

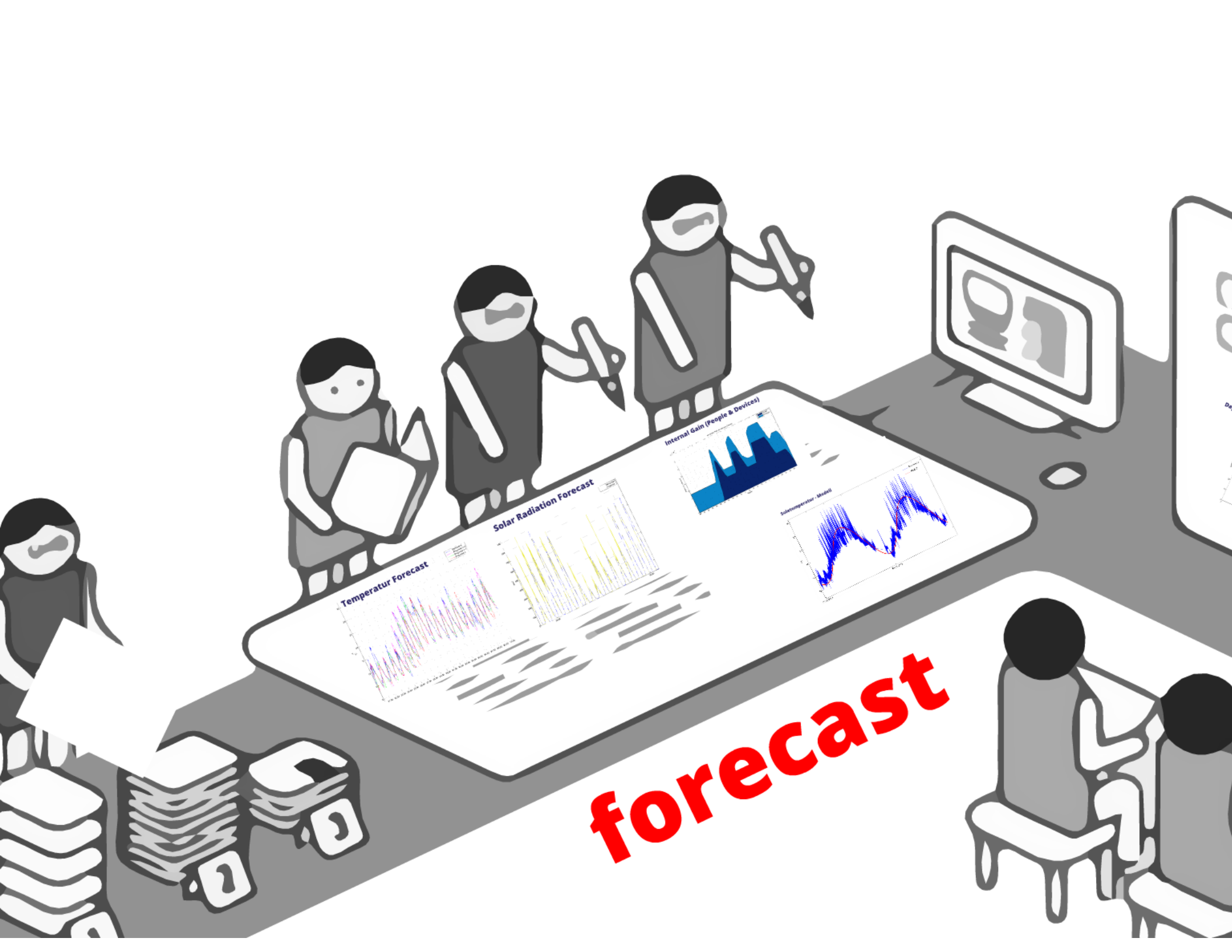



$$A = ?, B = ?, C = ?, D = ?$$

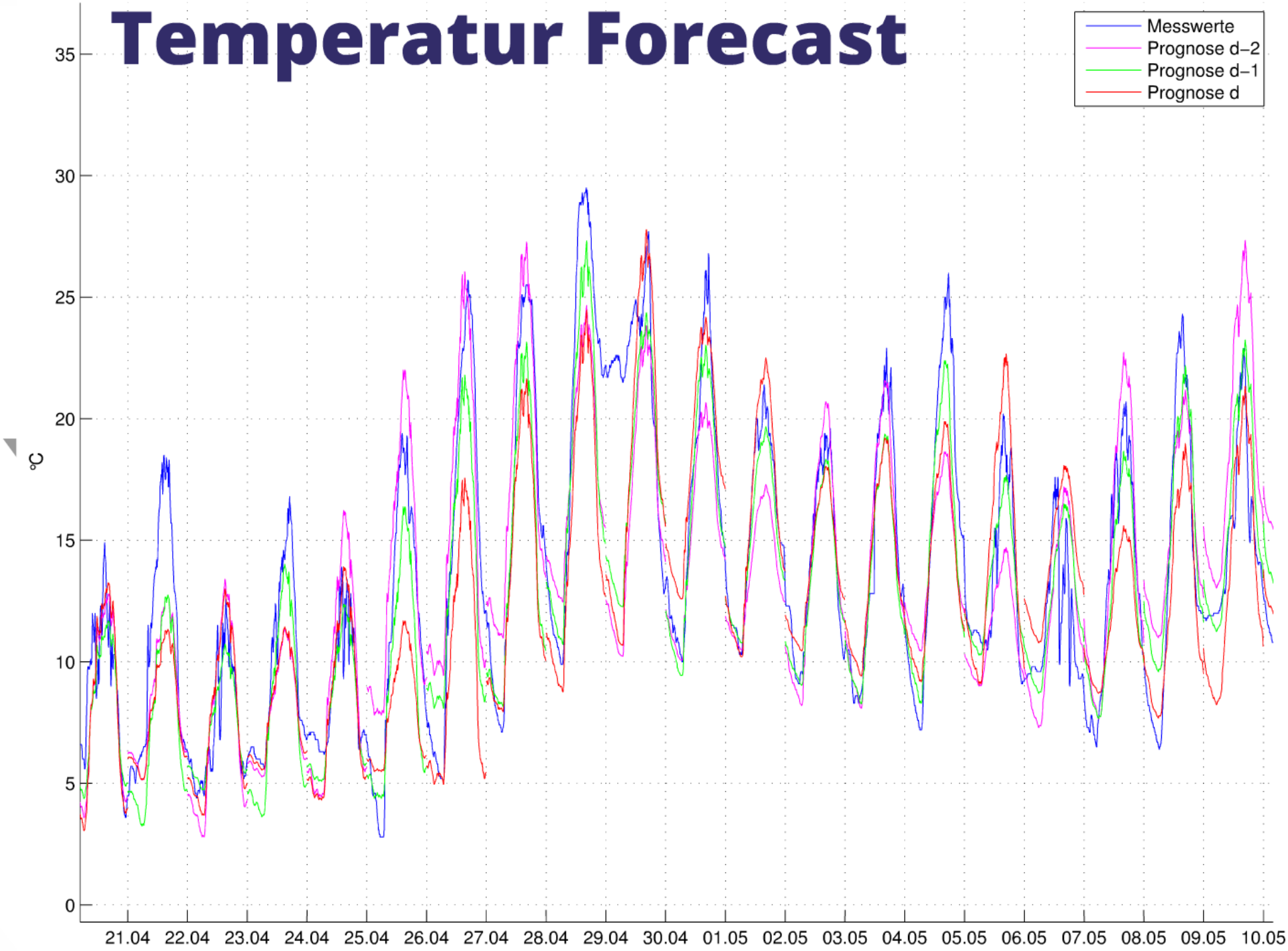
**determine model parameters from mesured data**

# Building Heat Balance: Model vs. Reality

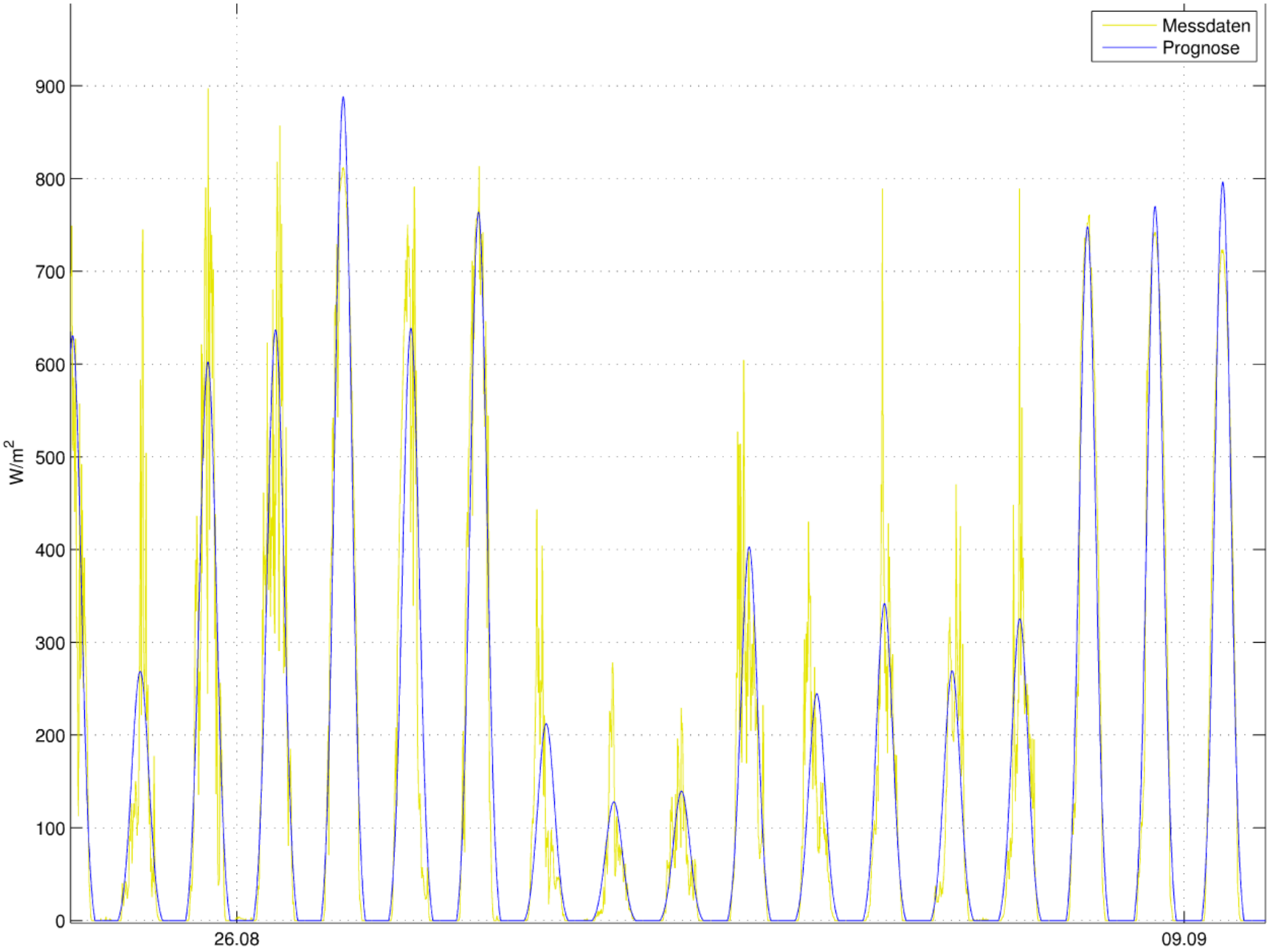



Temperatur Forecast
Solar Radiation Forecast
Internal Gain (People & Devices)
forecast

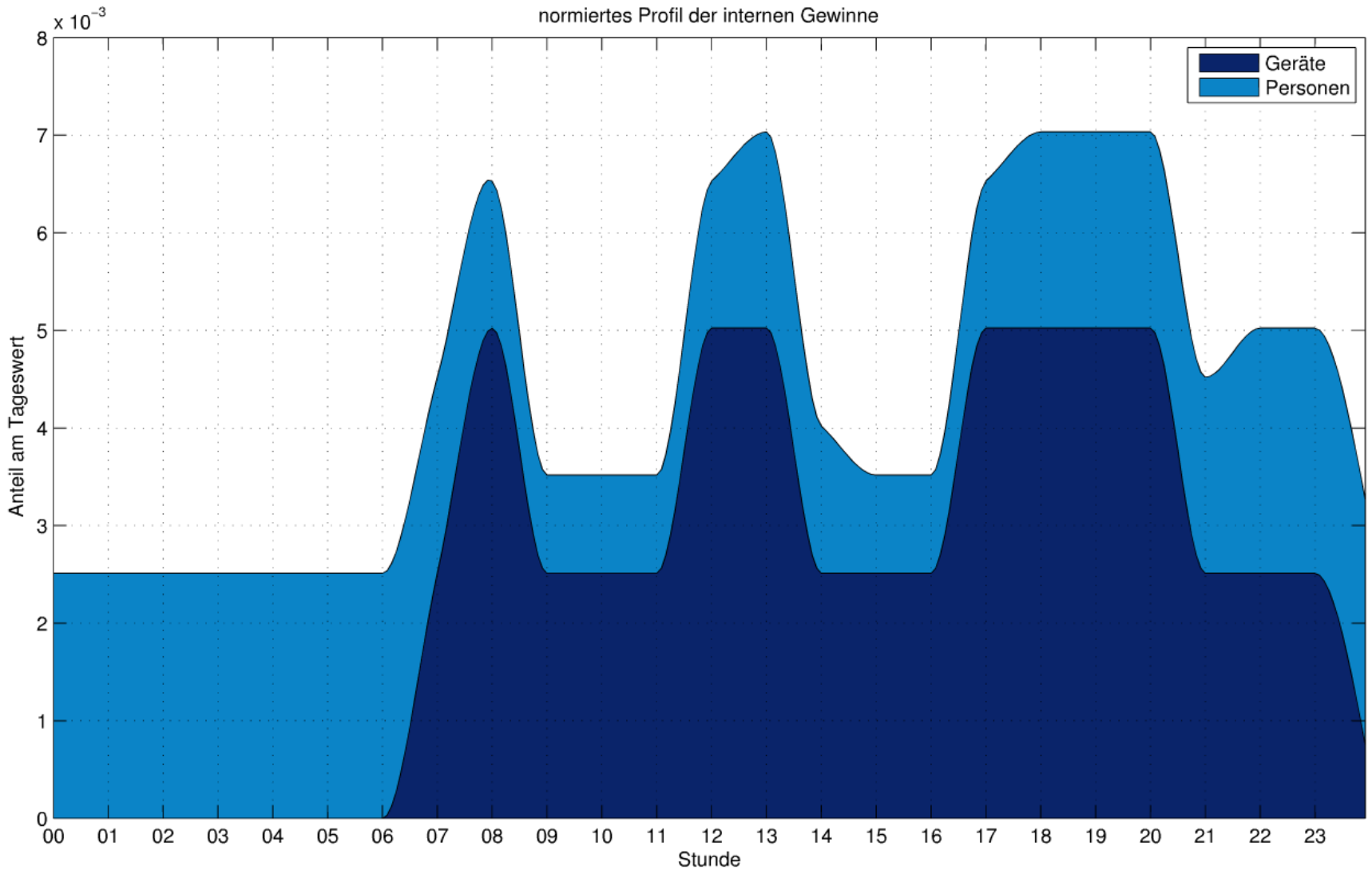
# Temperatur Forecast

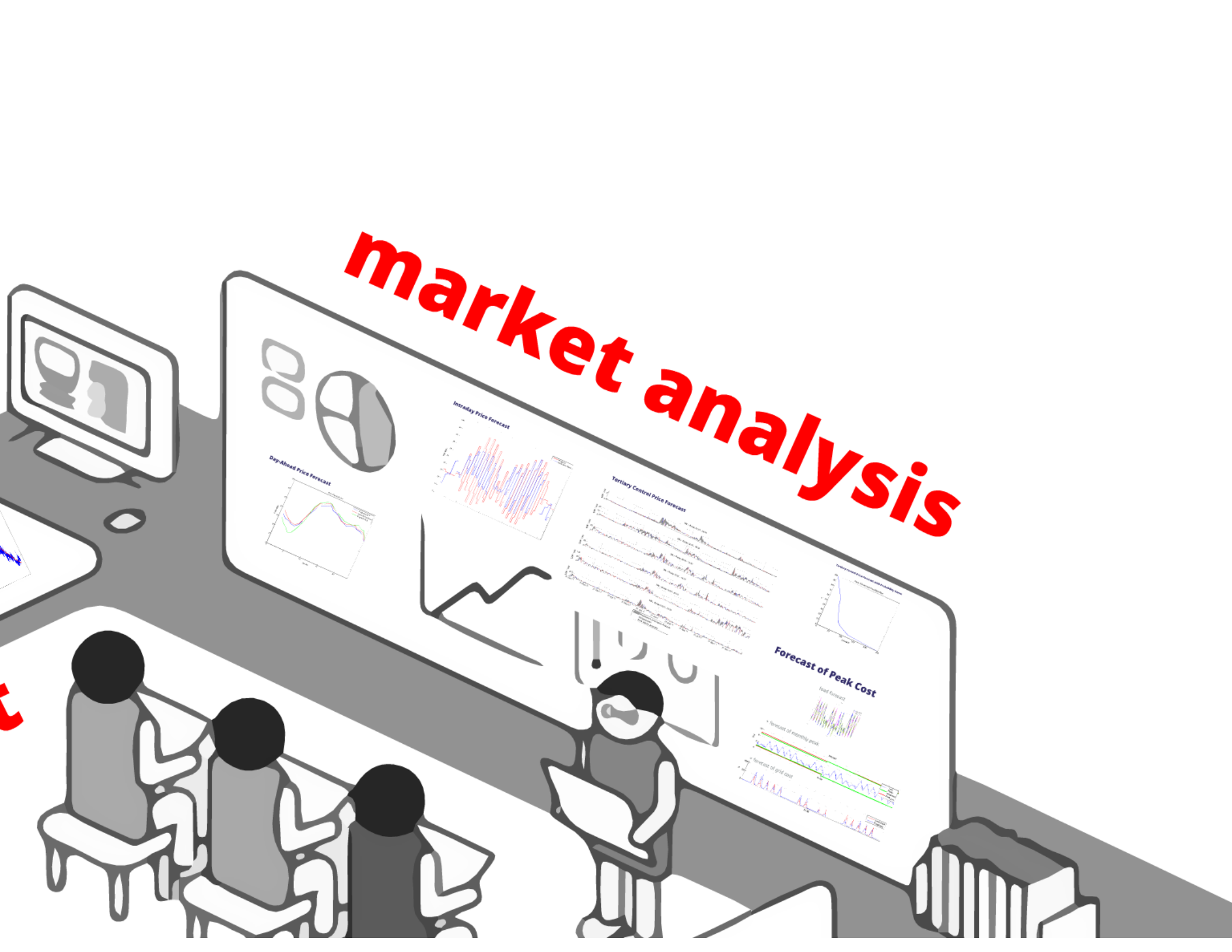


# Solar Radiation Forecast

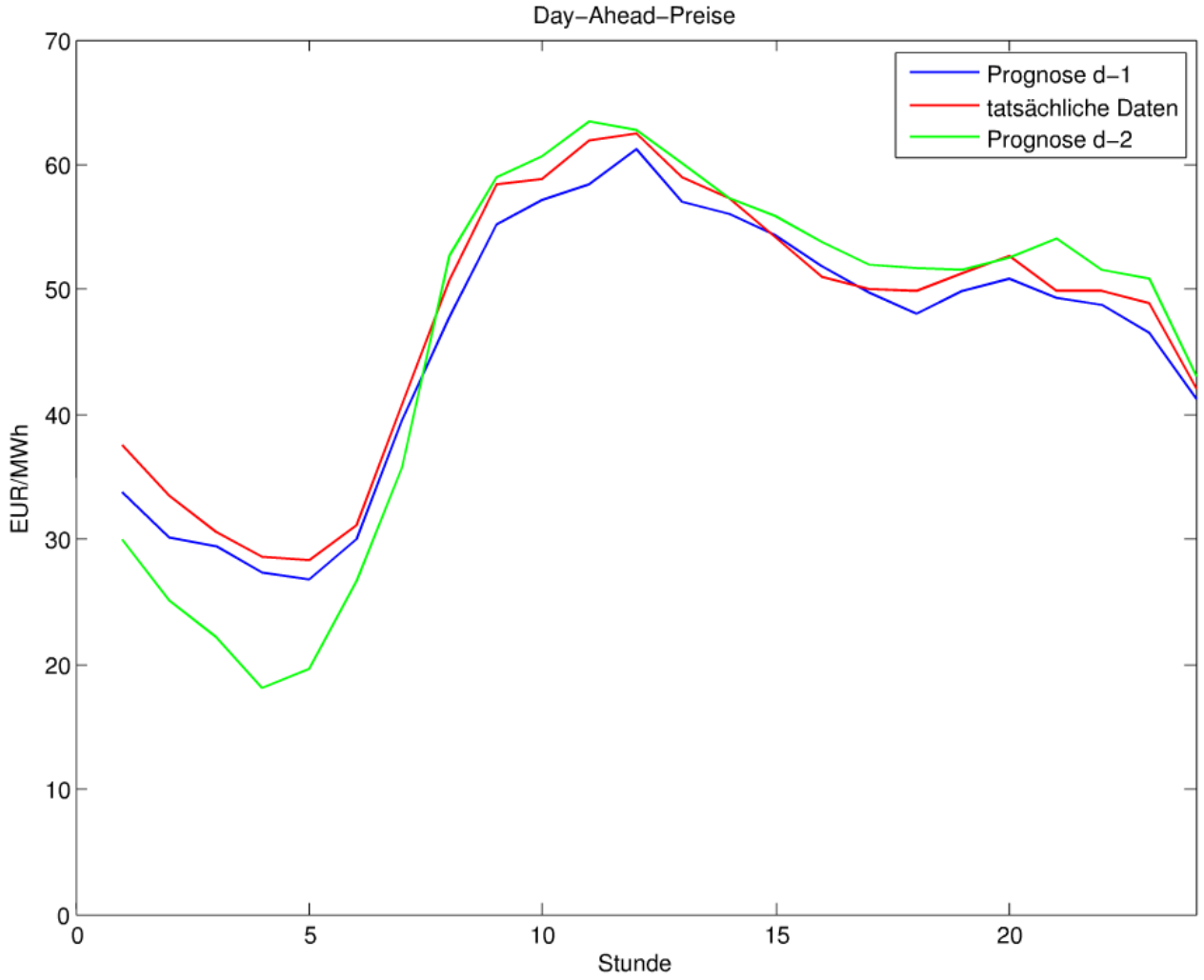


# Internal Gain (People & Devices)

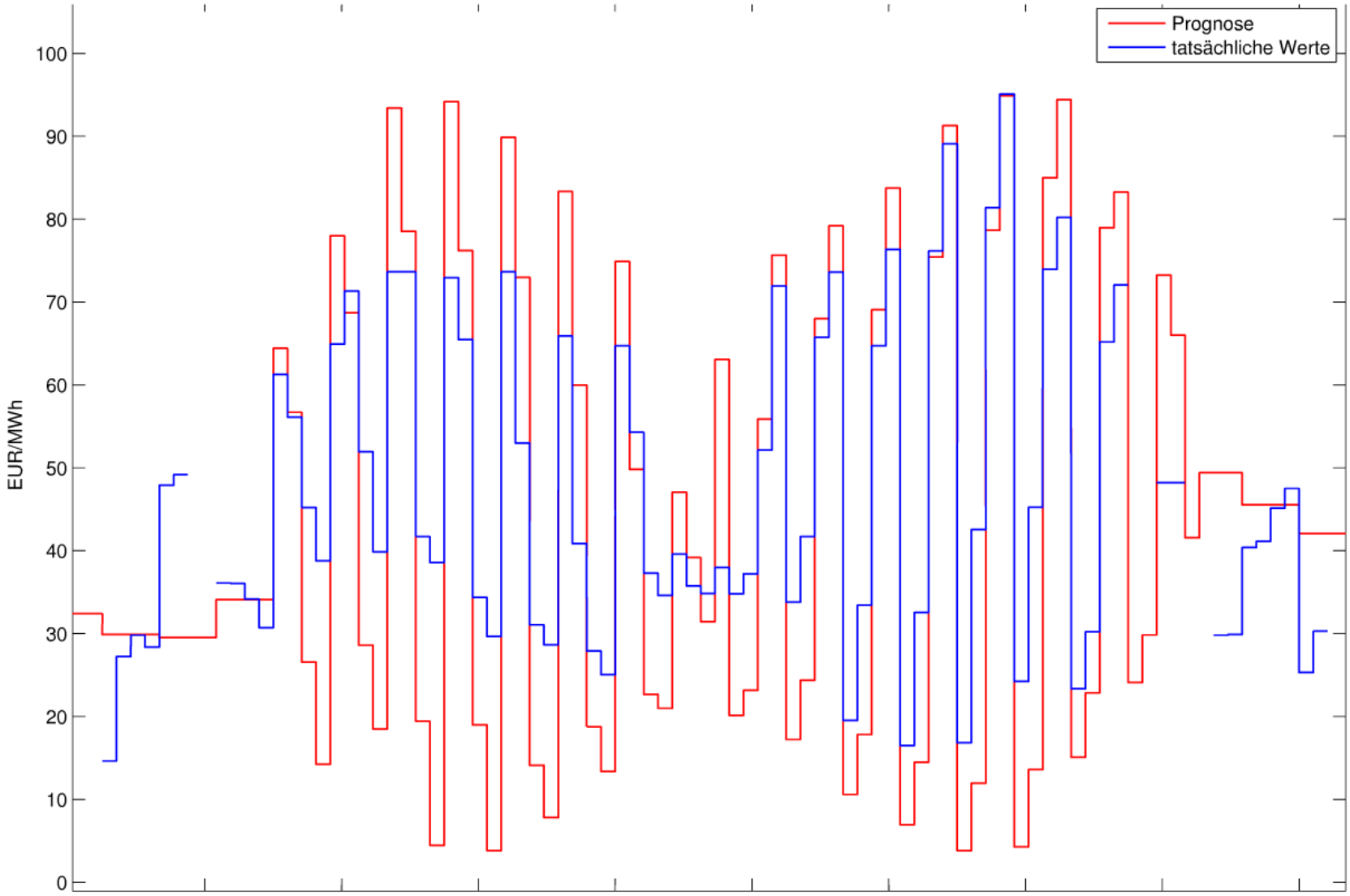



market analysis
Intraday Price Forecast
Day-Ahead Price Forecast
Tertiary Control Price Forecast
Forecast of Peak Cost

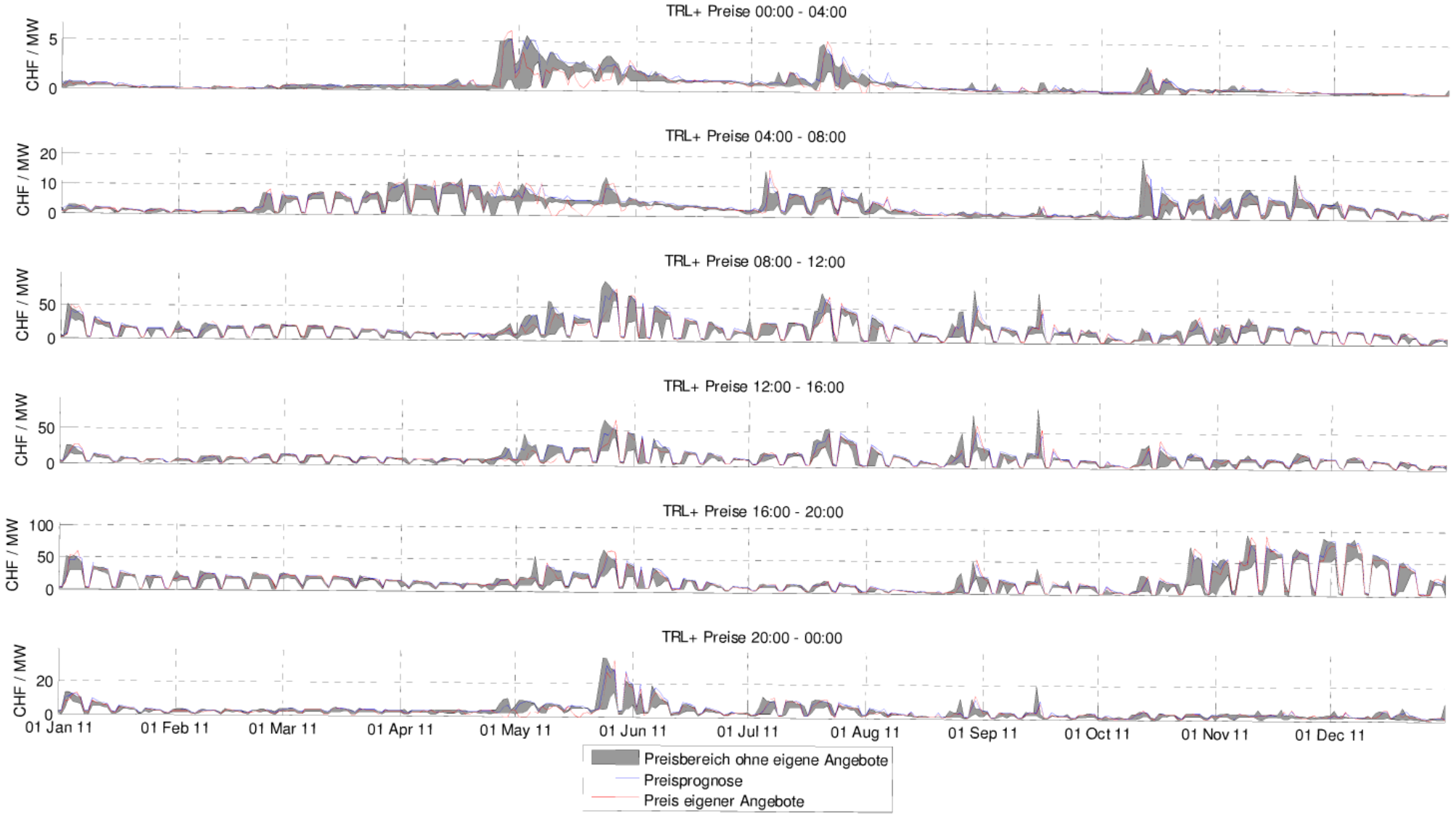
# Day-Ahead Price Forecast



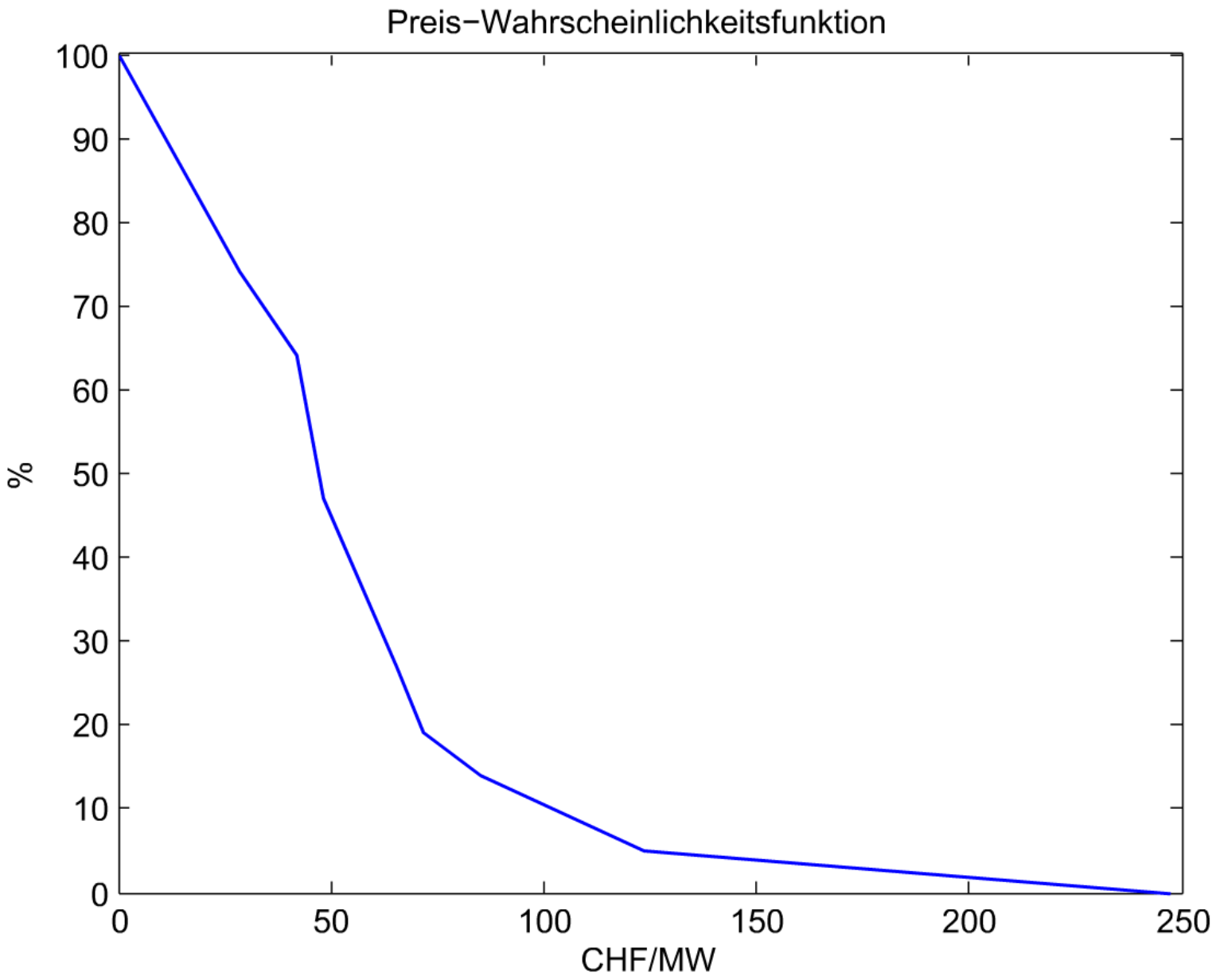
# Intraday Price Forecast



# Tertiary Control Price Forecast

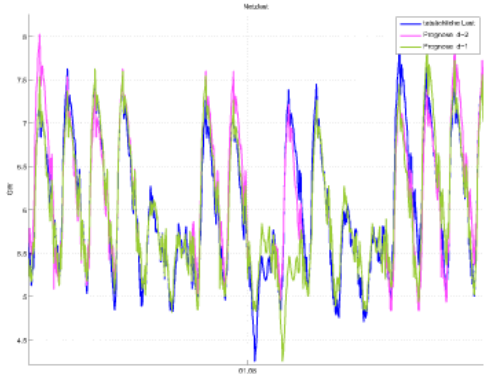


# Tertiary Control Price Forecast with Probability Curve

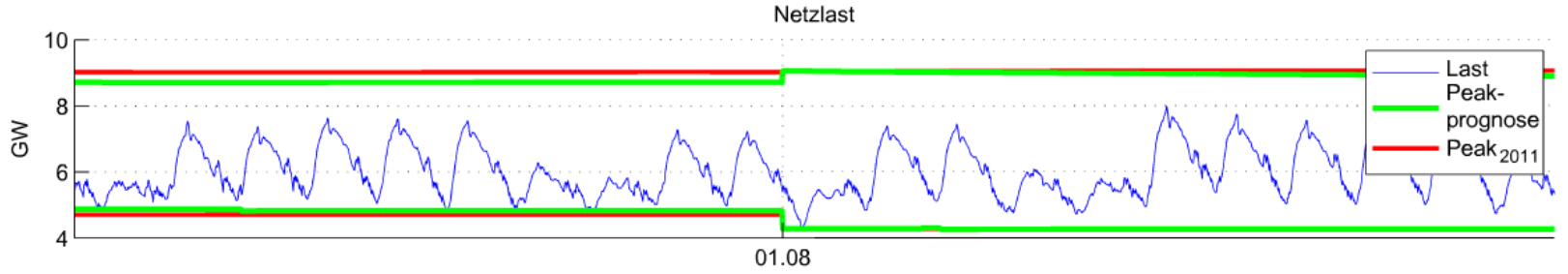


# Forecast of Peak Cost

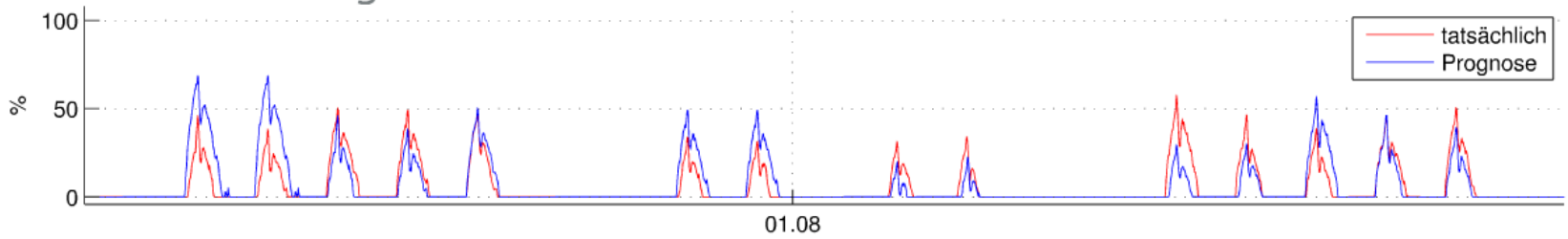
load forecast



+ forecast of monthly peak

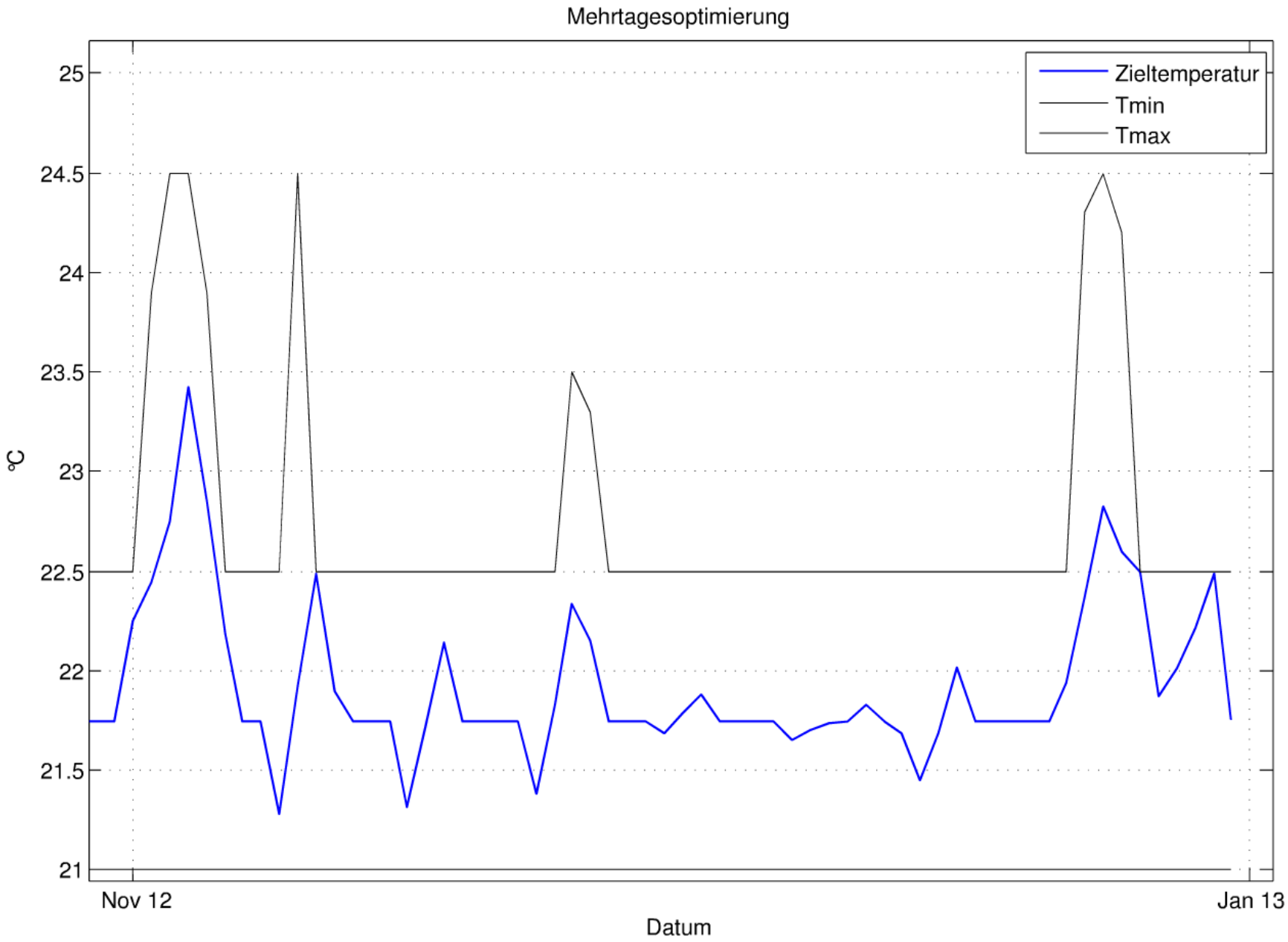



= forecast of grid cost



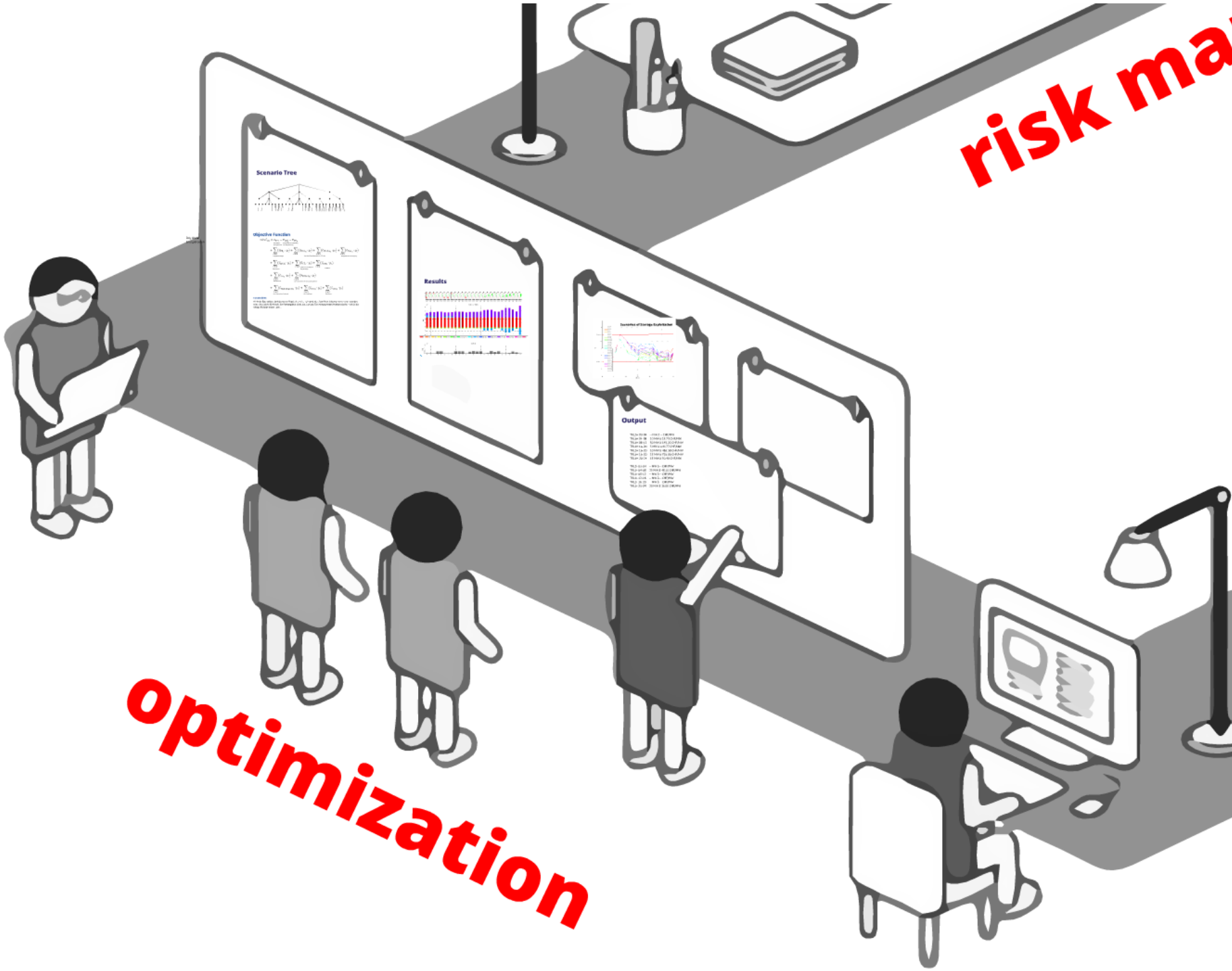

Risk Parameters
Mid-term Optimization
risk managment

# Mid-term Optimization

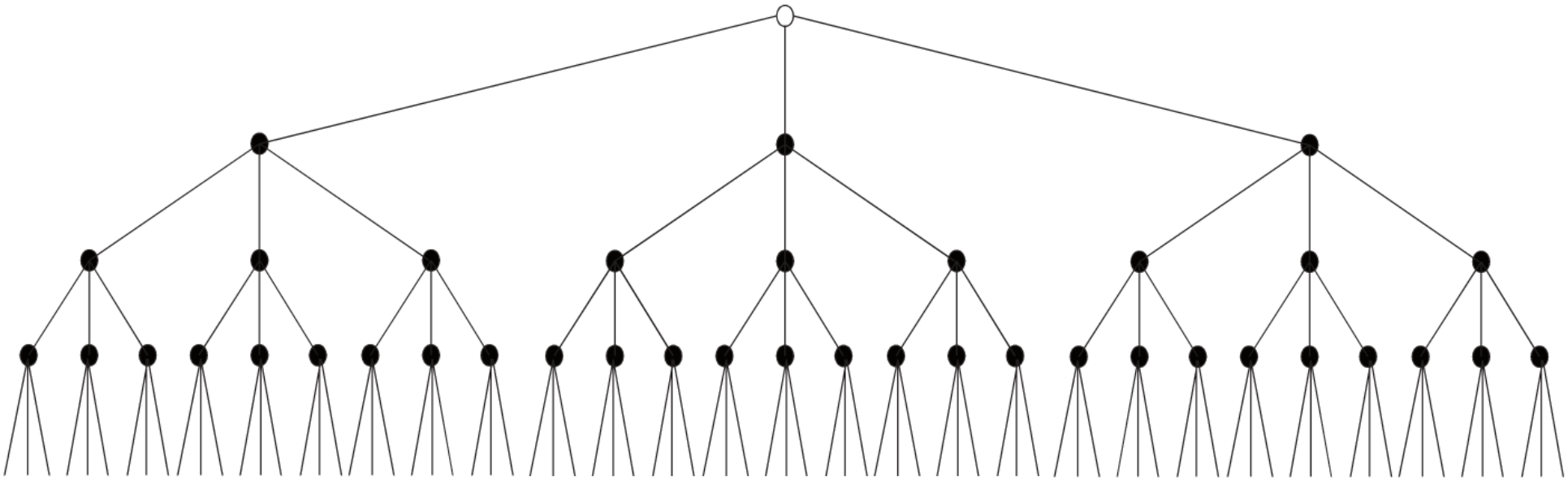


# Risk Parameters

- short-/long-Positions
- intraday trading volume
- power balancing costs
- soft constraints (penalty cost)
- hard constraints
- *etc.*


risk ma
Scenario Tree
Objective Function
Results
Output
optimization

# Scenario Tree



# Objective Function

$$min\, C_{\mathrm{tot}} = C_{\mathrm{D-1}} - P_{\mathrm{CP}_b^+} - P_{\mathrm{CP}_b^-}$$

Day ahead Energiekosten — Erträge durch Vorhaltung von Regelleistung

$$+ \sum_{s \in \mathcal{S}} \left(C_{\mathrm{PB}_s} \cdot p_s\right) + \sum_{s \in \mathcal{S}} \left(C_{\mathrm{ID1h}_s} \cdot p_s\right) + \sum_{s \in \mathcal{S}} \left(C_{\mathrm{ID15m}_s} \cdot p_s\right) + \sum_{s \in \mathcal{S}} \left(C_{\mathrm{D+1}_s} \cdot p_s\right)$$

Ausgleichsenergie — Intraday Energiehandel 1 h / 15 min — Energiekosten am Folgetag

$$+ \sum_{s \in \mathcal{S}} \left(C_{\mathrm{grid}_s} \cdot p_s\right) + \sum_{s \in \mathcal{S}} \left(G_{\mathrm{CE}_s} \cdot p_s\right) + \sum_{s \in \mathcal{S}} \left(C_{\mathrm{pen}_s} \cdot p_s\right)$$

Netzkosten — gelieferte / bezogene Regelenergie — Pönalen

$$+ \sum_{s \in \mathcal{S}} \left(C_{\mathrm{sw}_s} \cdot p_s\right) + \sum_{s \in \mathcal{S}} \left(C_{\mathrm{WHsoft}_s} \cdot p_s\right)$$

Schaltkosten — Soft Constraints Warmwasserspeicher

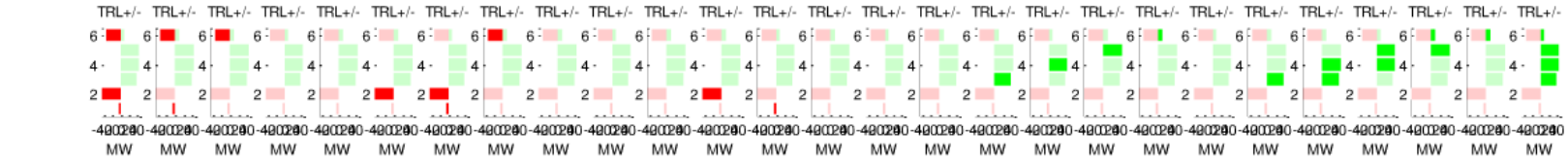
$$+ \sum_{s \in \mathcal{S}} \left(C_{\mathrm{Buildingsoft}_s} \cdot p_s\right) + \sum_{s \in \mathcal{S}} \left(C_{\mathrm{fees}_s} \cdot p_s\right) + \sum_{s \in \mathcal{S}} \left(C_{\mathrm{cert}_s} \cdot p_s\right)$$

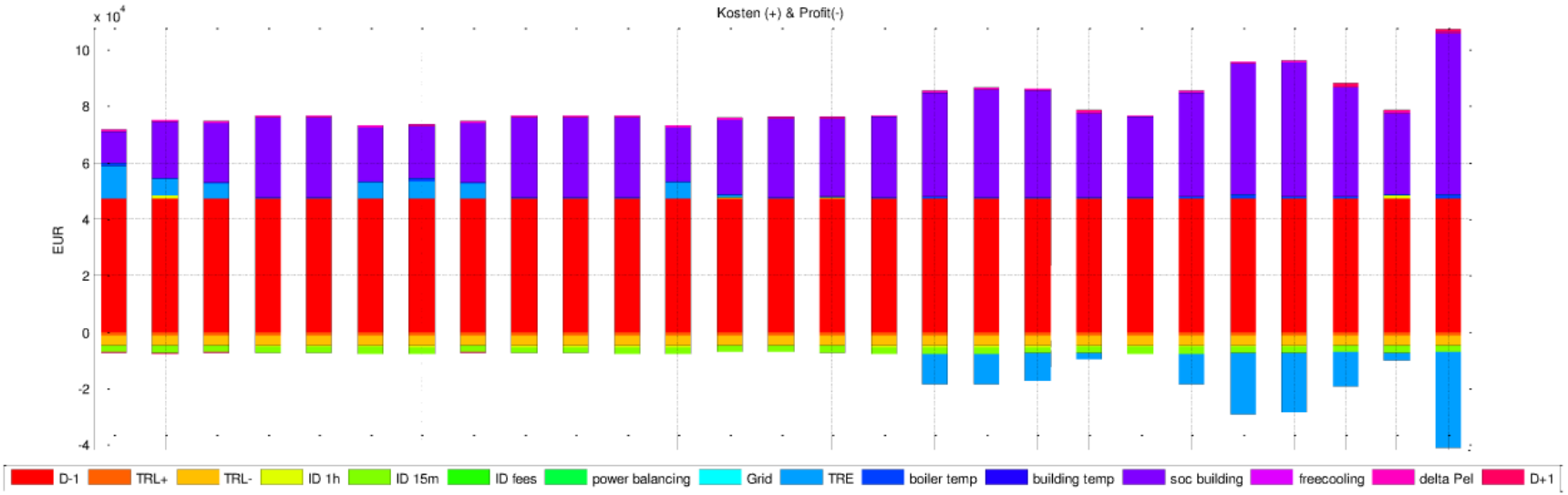
Soft Constraints Gebäude — div. Gebühren — Zertifikate

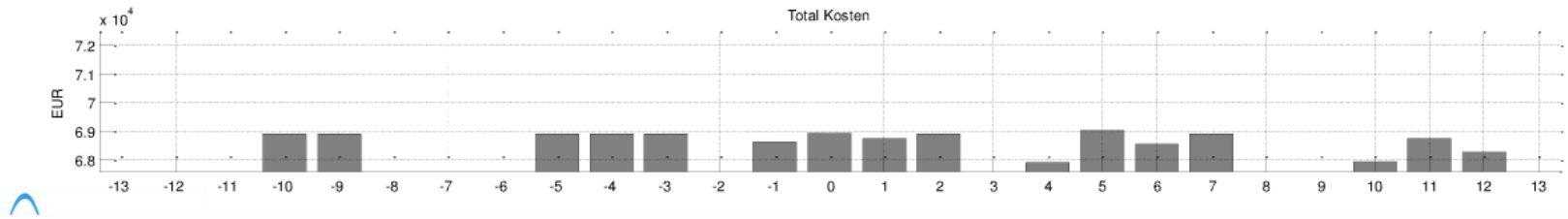
## Constraints:

Minimale Blockgrösse, Vorhaltung von Regelleistung ist zwingend, Abruf von Regelleistung muss erbracht werden, keine Voraussicht für Abrufe, Komfortvorgaben einhalten, absolute Temperaturgrenzen, Mathematische Modelle der Anlage, Risikoparameter, usw...

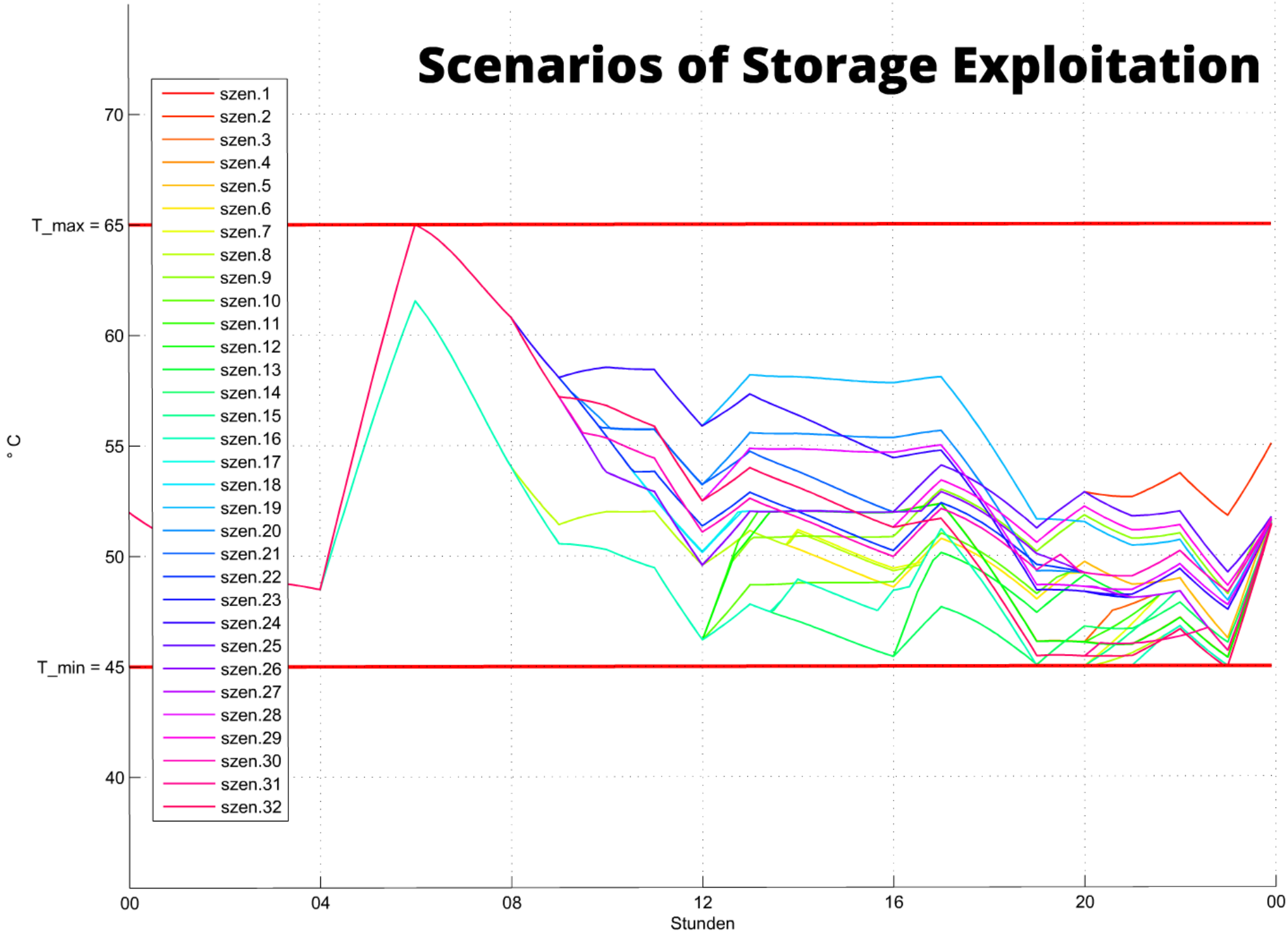
# Results


TRL+/-
MW


Kosten (+) & Profit(-)
x 10^4
EUR
D-1
TRL+
TRL-
ID 1h
ID 15m
ID fees
power balancing
Grid
TRE
boiler temp
building temp
soc building
freecooling
delta Pel
D+1


Total Kosten
x 10^4
EUR

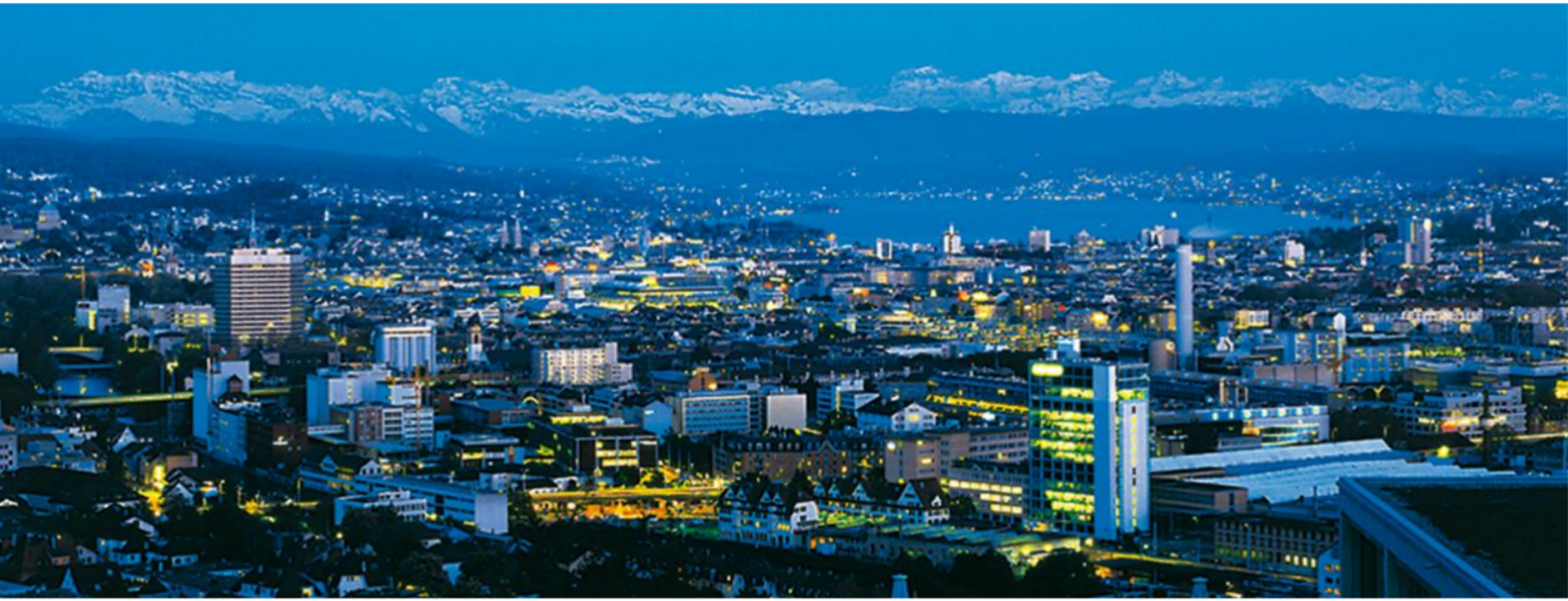
# Scenarios of Storage Exploitation




EPEXSPOT
EUROPEAN POWER EXCHANGE
trading

WarmUp2

ewz
Die Energie



# SEMIAH

AARHUS UNIVERSITY

Fraunhofer IWES

DEVOTEAM

DEVELCO PRODUCTS

SEIC-TELEDIS GROUPE

csem

UNIVERSITETET I AGDER

misurio

net+

EnAlpin

agder energi nett

Hes·so
Haute Ecole Spécialisée de Suisse occidentale

Funded by the European Union

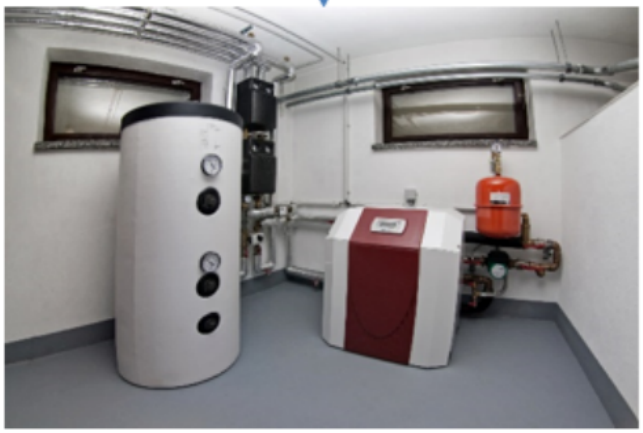
This project has received funding from the European Union's Seventh Framework Programme for research, technological development and demonstration under grant agreement no 619560.

energy on platform

misurio

Anbindung an VPP

Smart Energy Gateway



Wärmepumpen
Gebäude (thermischer Speicher)

Photovoltaik

Batteriespeicher

# Improved Framework Enables New Business Models And Innovations

- complete market opening in 2018
- technically neutral incentives
- enable demand response products
- adapt grid peak tariffs
- sunshine regulation
- smart metering → smart control
- Swiss standard for the protection of data privacy
- unbundling = non discriminating access to the grids and relevant data

# CONCLUSIONS

- increase energy efficiency (local und global)
- additional benefits and cost savings
- comfort zone has first priority
- VPP business model is beeing implemented