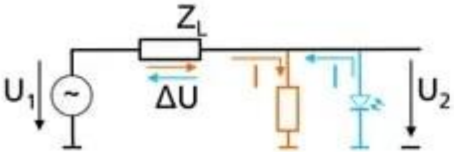
GRID INTEGRATED SOLAR SYSTEM

AGENDA

- The Challenge
- Solutions for grid integration
- Grid planning with renewables
- Conclusion

What is the challenge for grid integration?

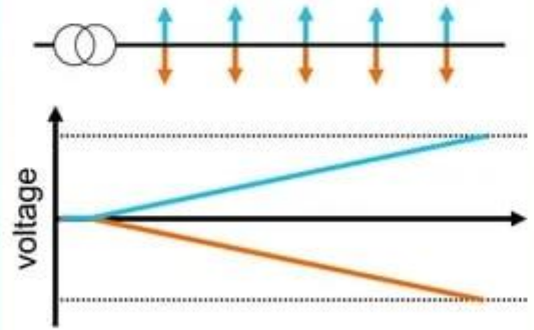
And its classical solution



$U_2 = U_1 - Z_L I \rightarrow$ voltage decrease

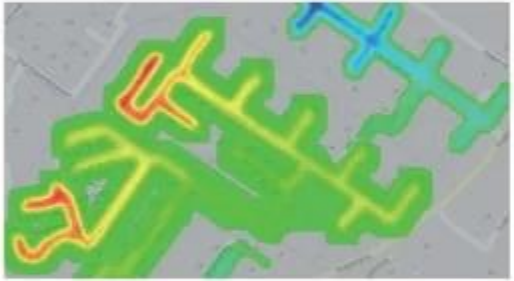
$U_2 = U_1 + Z_L I \rightarrow$ voltage increase

voltage band violations



- decreasing of line impedance Z_L

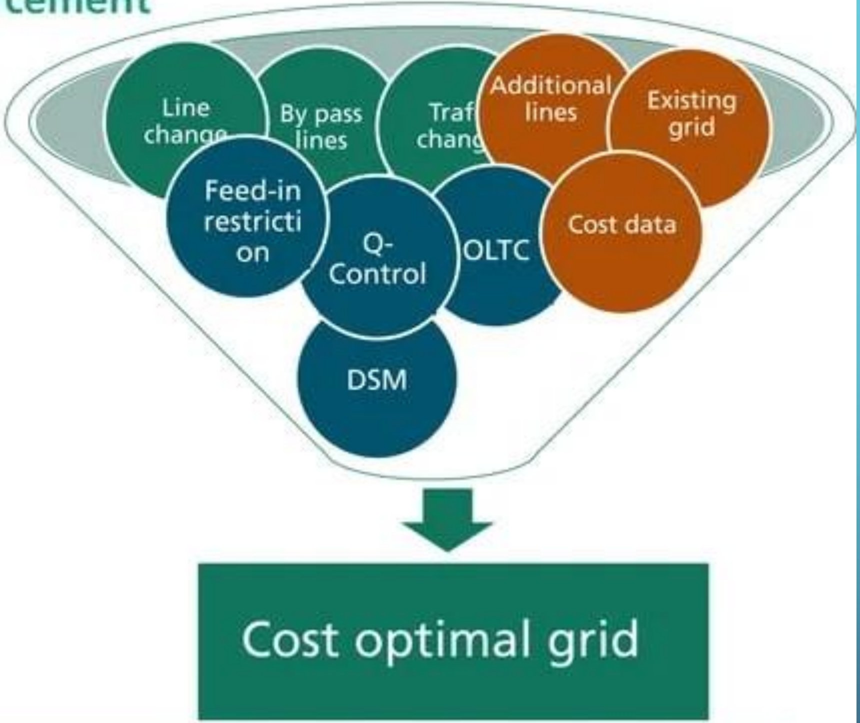
thermal limitations



- Current lead to heating of cable
- Increase cross section of cable

Fraunhofer ISE

Optimal grid expansion
Avoid grid reinforcement

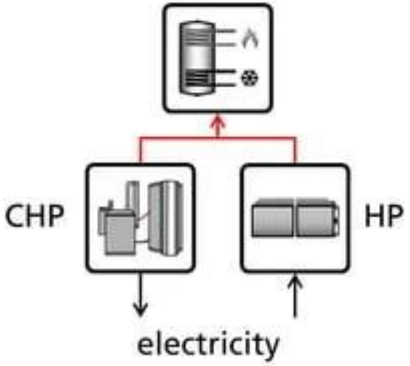


Fraunhofer ISE

Operation of Local Systems

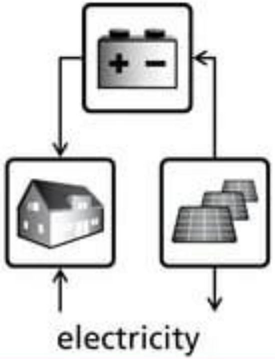
Electric thermal systems

- Thermal storages offer the possibility to decouple thermal and electric processes



PV-Battery Systems

- Local self consumption of electricity from PV
- Grid oriented operation

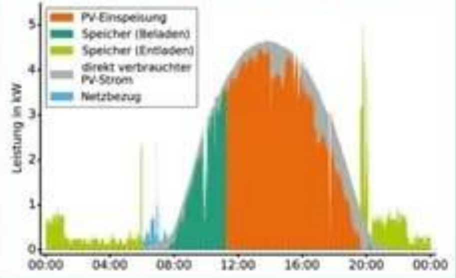


▶ What are services for the Smart Grid?

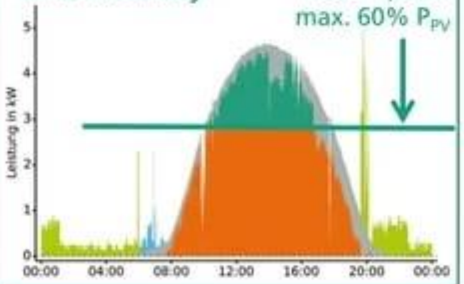
Fraunhofer ISE

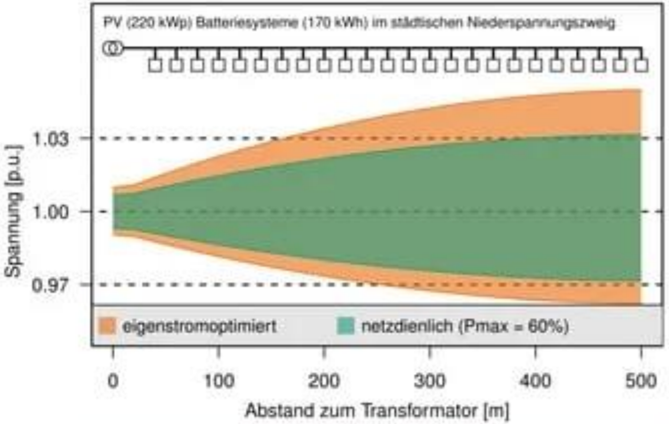
Grid-friendly operation of PV battery systems

Self consumption optimized



Grid friendly



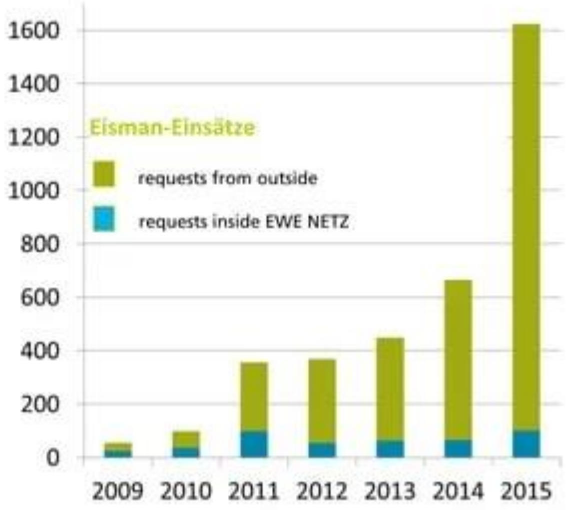


- Self consumption optimization does not avoid grid peaks
- Grid friendly operation: up to 66% surplus PV can be installed.

Fraunhofer ISE

External Feed-in Reduction requests
Electricity grids are increasingly stressed

- Increasing feed-in of fluctuating renewables affects grids operation
- Feed-in management becomes more important
- Decentralized feed-in of renewables influences dimensioning of electricity grids.

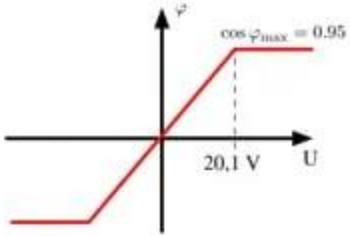


source: EWE NETZ GmbH

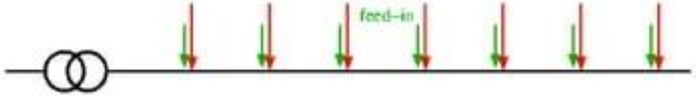
➡ This energy can be used better instead of shutting off.

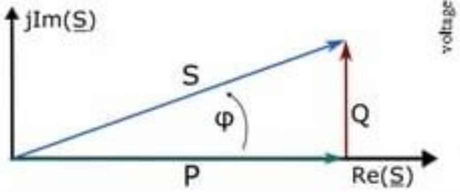
Fraunhofer ISE

Integration: reactive power control



- Voltage will be stabilized by changing the phase between voltage and current.
- Increasing of inverter nominal power
- Increasing of losses
- Reactive power control is defined in grid connection guidelines.



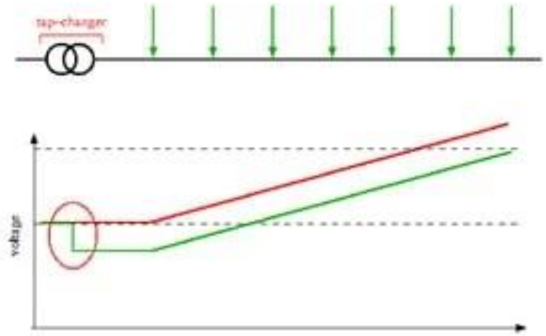


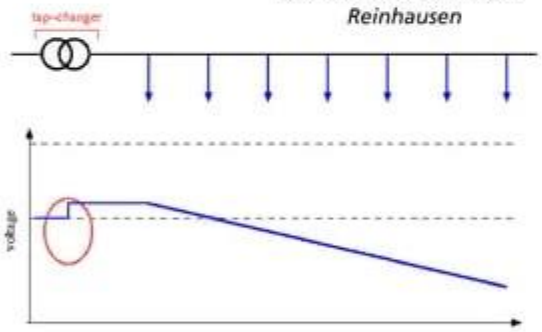
Fraunhofer ISE

Integration: voltage control with tap changer

- Usage of variable tap-changer at transformer
- Dynamic adaptation of voltage a point of connection
- Usage of the full voltage range
- No reduction of PV necessary.

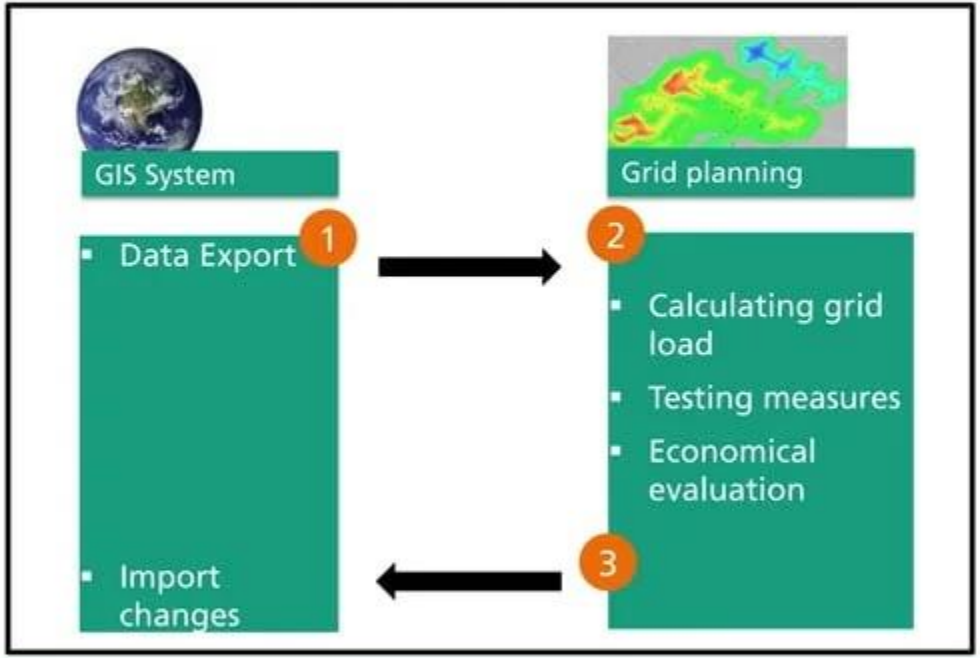
source: Maschinenfabrik Reinhausen





Fraunhofer ISE

The planning process of a local DSO



Fraunhofer ISE

NEMO Use Case – Reference Ringkøbing

2

Step 1: Problem

Expected Development

- **Decentralized production**

Photovoltaic:	180 kWp
Combined heat:	0 kW

- **Heat**

Needed heat:	50 MWh
Heatpump	50 %
Storage per HP	3 h

- **Electrical Storages**

EV:	0
PV-batteries:	0 kWh

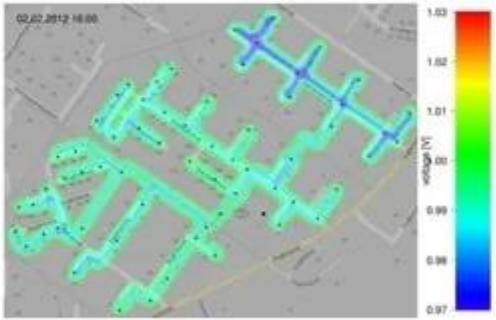
Fraunhofer ISE

NEMO Use Case – Reference Ringkøbing

Step 2: Identifikation

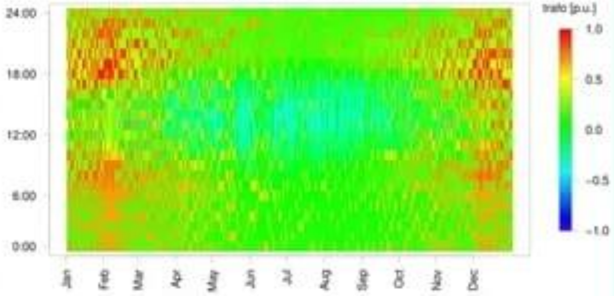
2

Voltage



- Heatpumps dominate
- Low voltages

Transformer load



- Winter: high trafo load by HP
- Summer: Inversed power flow because of PV

Fraunhofer ISE

NEMO Use Case – Reference Ringkøbing

Step 3: Definition of possible solutions

2

Solution possibilities

- **Grid reinforcement**
  - ☑ conventional
  - ☐ OLTC
  - ☐ Q-Control
- **Intelligent Control**
  - ☑ Demand Side Management
  - ☐ Local energy management
  - ☐ grid friendly PV

Fraunhofer ISE

NEMO Use Case– Reference Ringkøbing

Step 4: Solution with convention reinforcement

2

Cost*: 93.000 €

Conventional reinforcement

- Replace cables : 1,1 km NAYY 4x240
- Change transformer: 400 kVA

* 1km NAYY240 57.000€ (inkl. Verlegung)
Transformator 400 kVA: 9.000 €

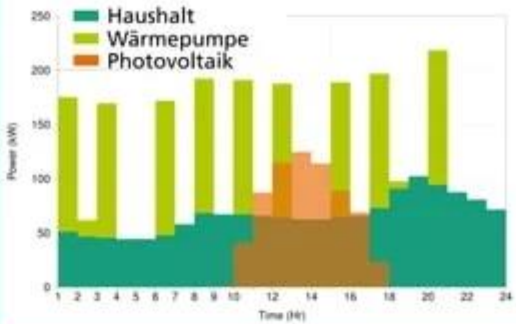
Fraunhofer ISE

NEMO Use Case– Reference Ringkøbing

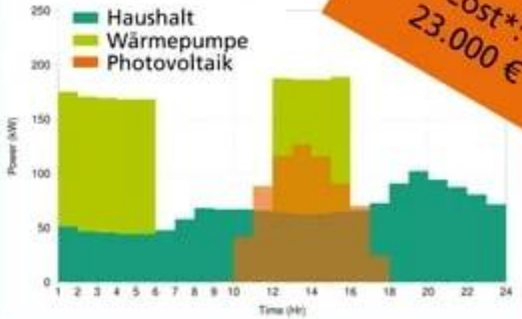
2

Step 5: Solution with Demand Side Management

Status Quo



Demand Side Mana



Cost*:
23.000 €

Demand Side Management

- Reducing peak load : 220 kW → 170 kW
- Replace cables: 0,3 km NAYY 4x240
- Change transformer: not necessary

* 1km NAYY240 57.000€ (inkl. Verlegung)
Transformator 400 kVA: 9.000 €

Fraunhofer ISE

Conclusion

- Decentralized generation can lead to
  - Violations of voltage bands
  - Violation of thermal restriction
- Beside conventional reinforcement
  - Energy Management
  - Low voltage on load tap changers
  - Reactive power control

➡ **Gird planning has become a multi criteria optimization problem.**

Fraunhofer ISE