Power Balancing in Low Voltage Grids with high PV-Power Input

DERlab PhD-Seminar

Glasgow, April 7th, 2011

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Introduction

- Facts of the project:

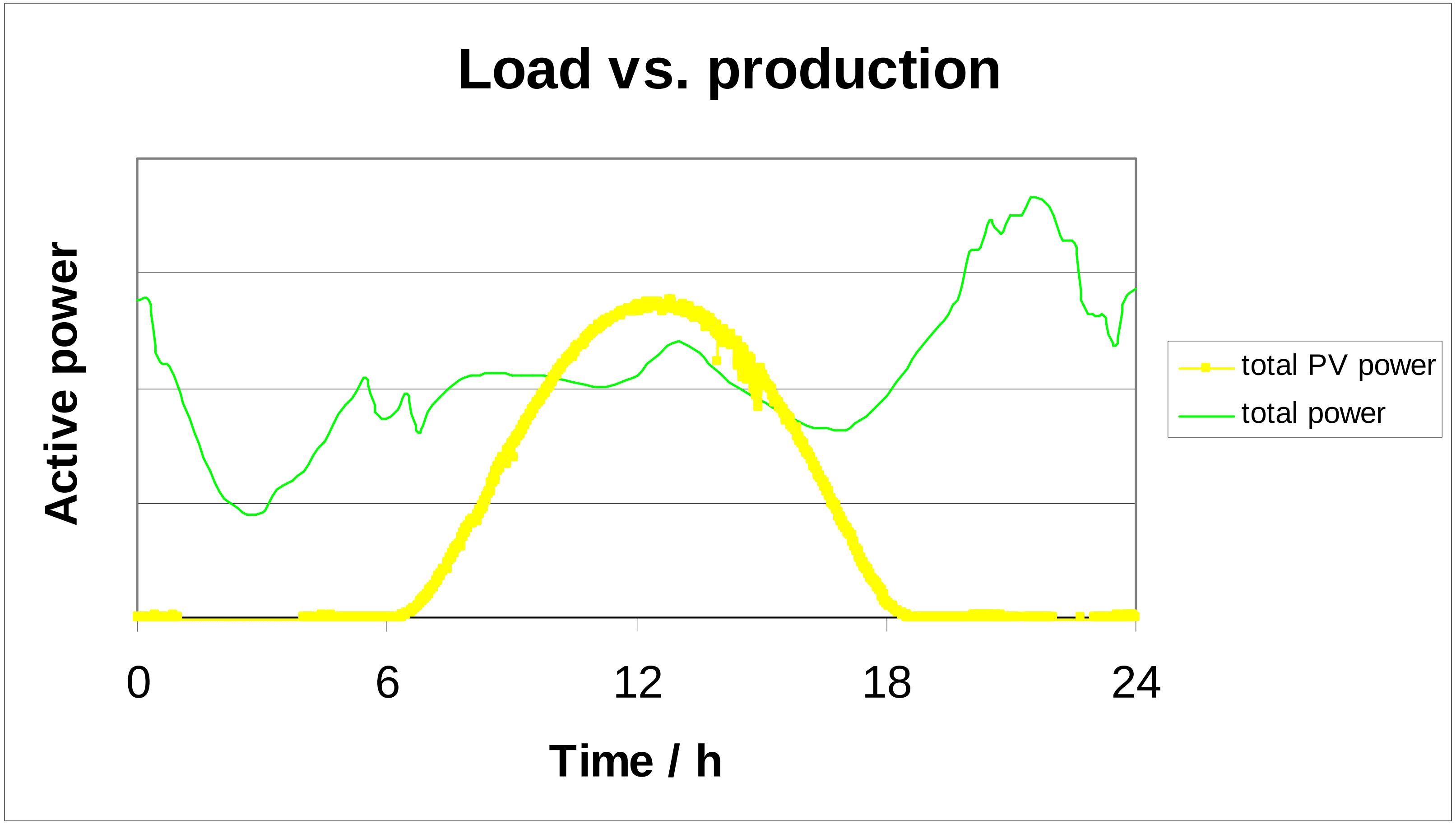
- Title: regional energy supply 2020
- Project consortium:
  - deENet (coordinator)
  - Fraunhofer IBP and IWES
  - SMA
  - Samco Networks
  - E.ON Mitte (Funding)
- Place: Felsberg (a small town south of Kassel)

- Aim: to use as much renewable and regional energy as possible

Introduction

- Why power balancing with high PV penetration?
- PV power can exceed load during peak times (around noon)
- Energy should be used where and when it is produced in order to avoid voltage increase and network losses

Local power surplus



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Presentation of the grid

Transformer

cable distribution cabinet

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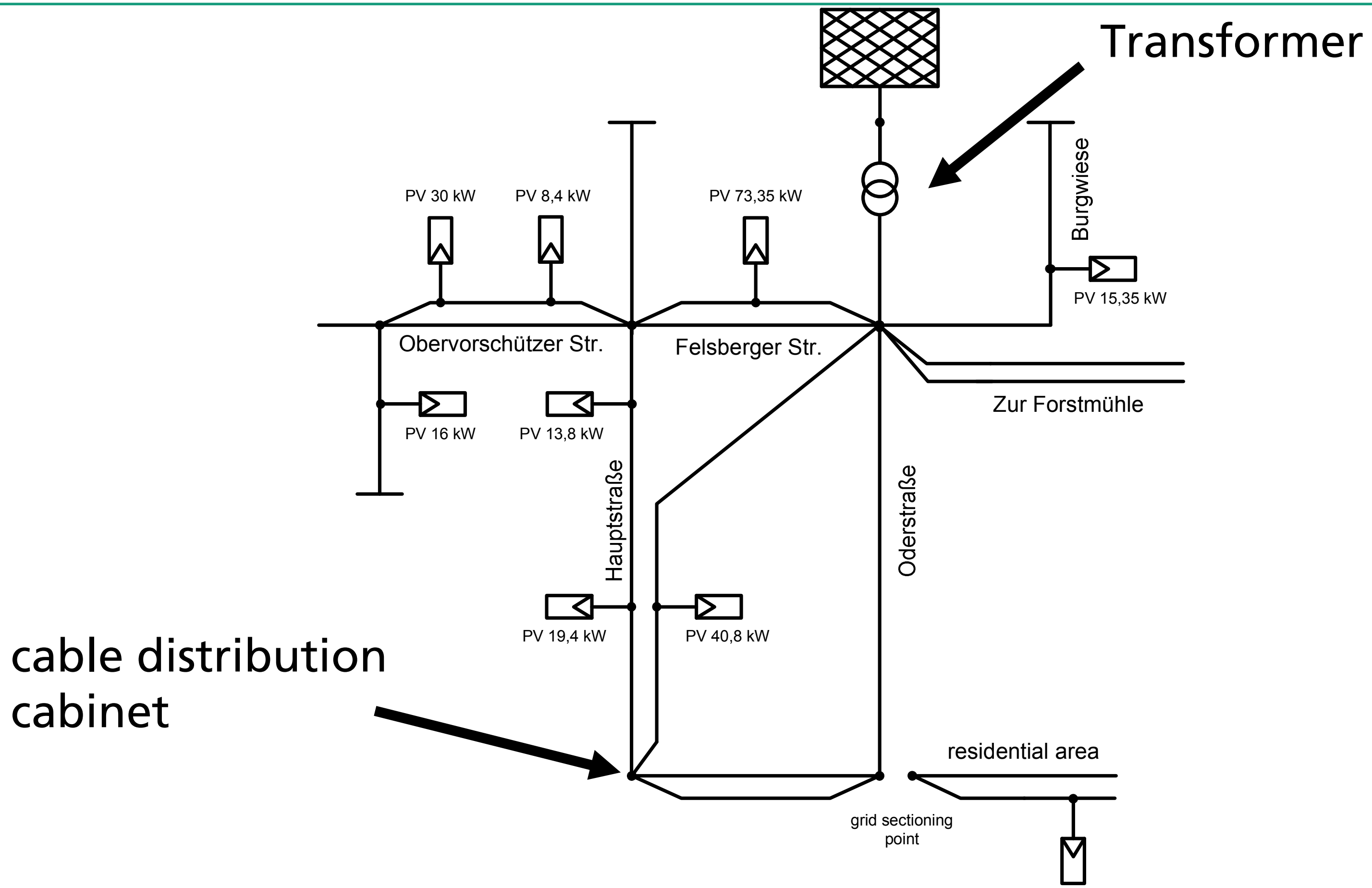
Single line diagram of the network cell



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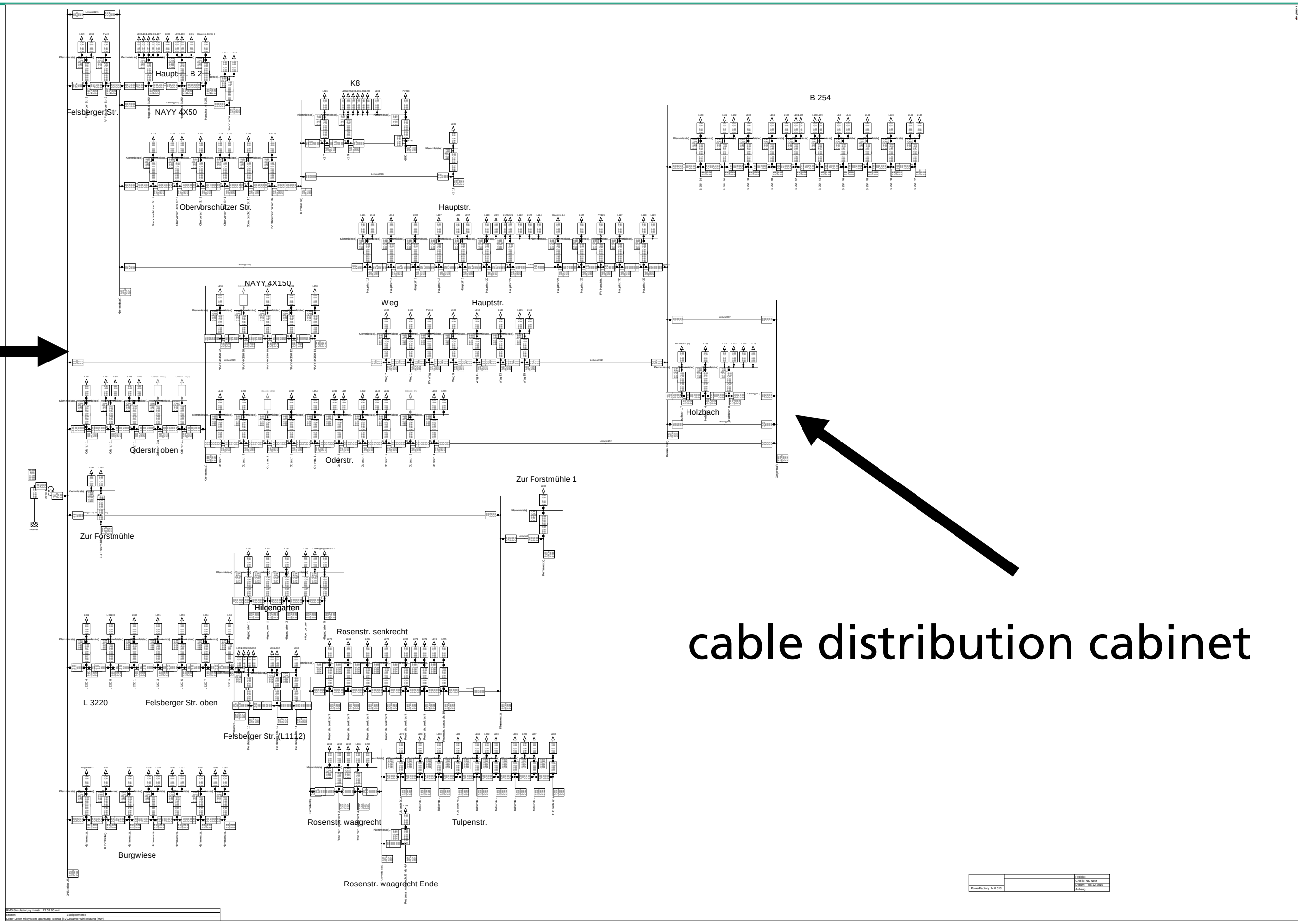
Mapping of the network cell in PowerFactory

Transformer

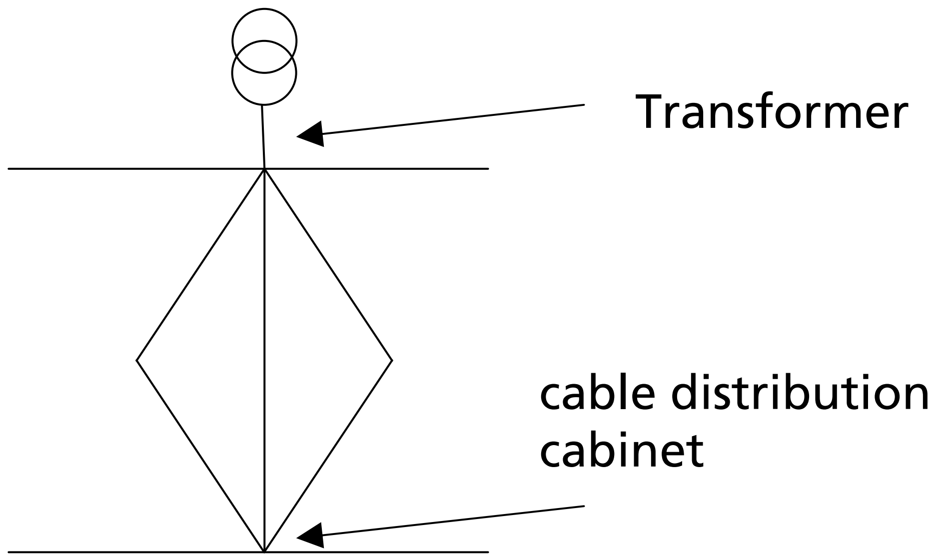


cable distribution cabinet

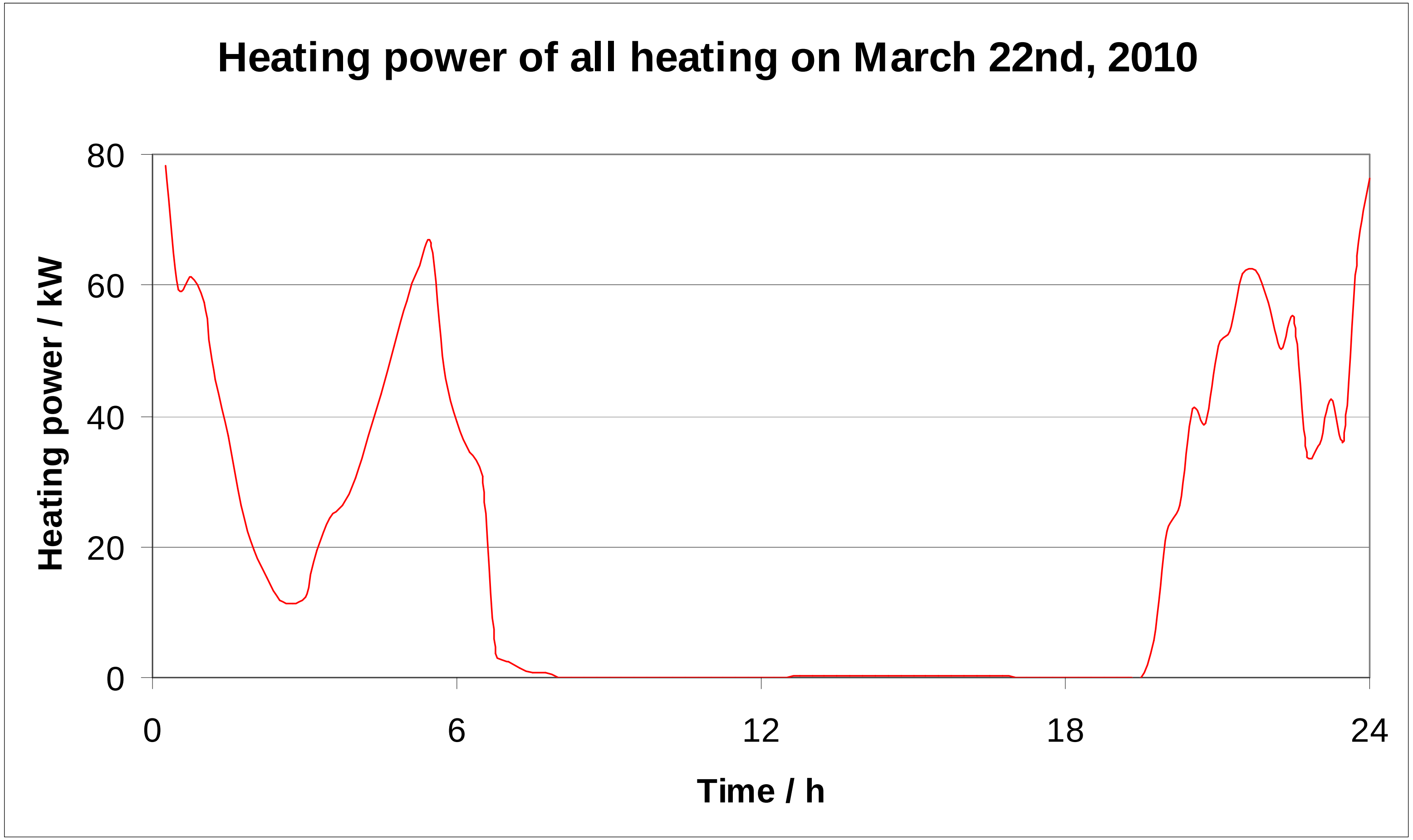
Facts about the network cell

- 3-phase grid, 400 V
- Used type of cable along the street: NAYY 4x150SE 0.6/1kV
- Used type of cable from the street to the houses: NAYY 4x50SE 0.6/1kV
- Installed PV power: 209 kW (8 PV power plants)
- 147 loads (household, agriculture, average consumption: ca. 4600 kWh/a)
- 14 heatings (off-peak heating)
- reference day: March 22nd, 2010, Average temperature: 10°C

- tripod:



Standard load profile off-peak heating at 10°C



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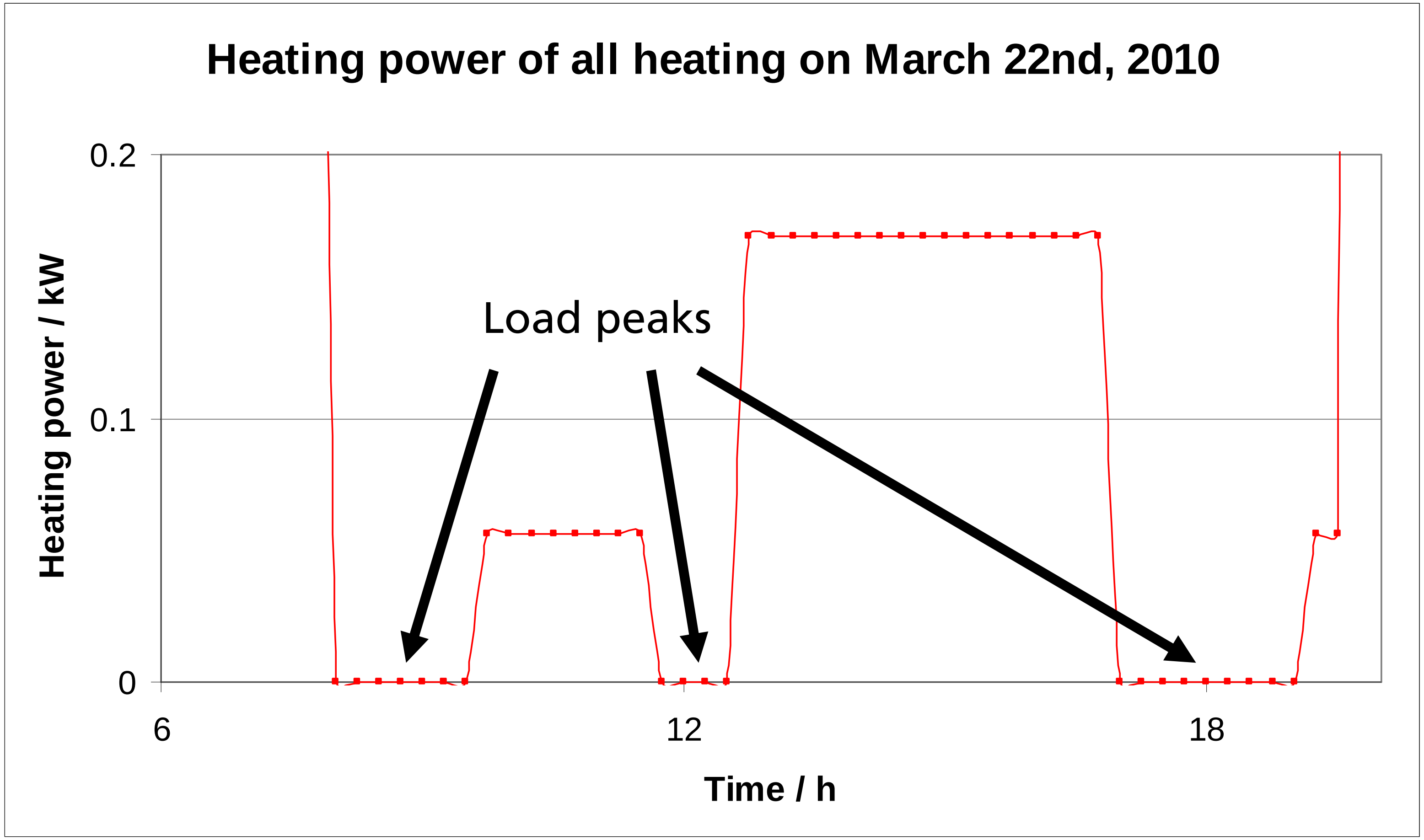
Standard load profile detail



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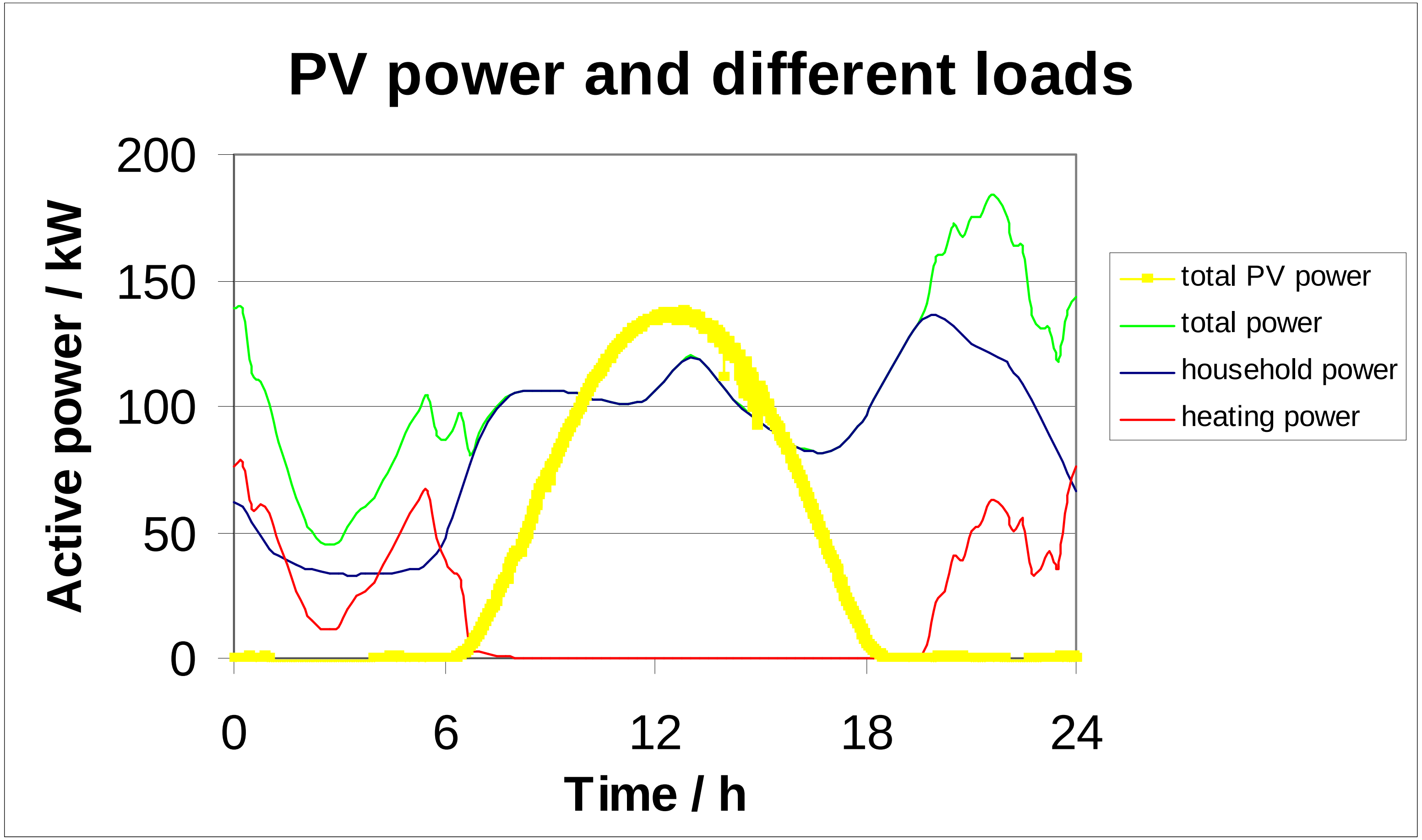
Load and generation profile March 22nd, 2010



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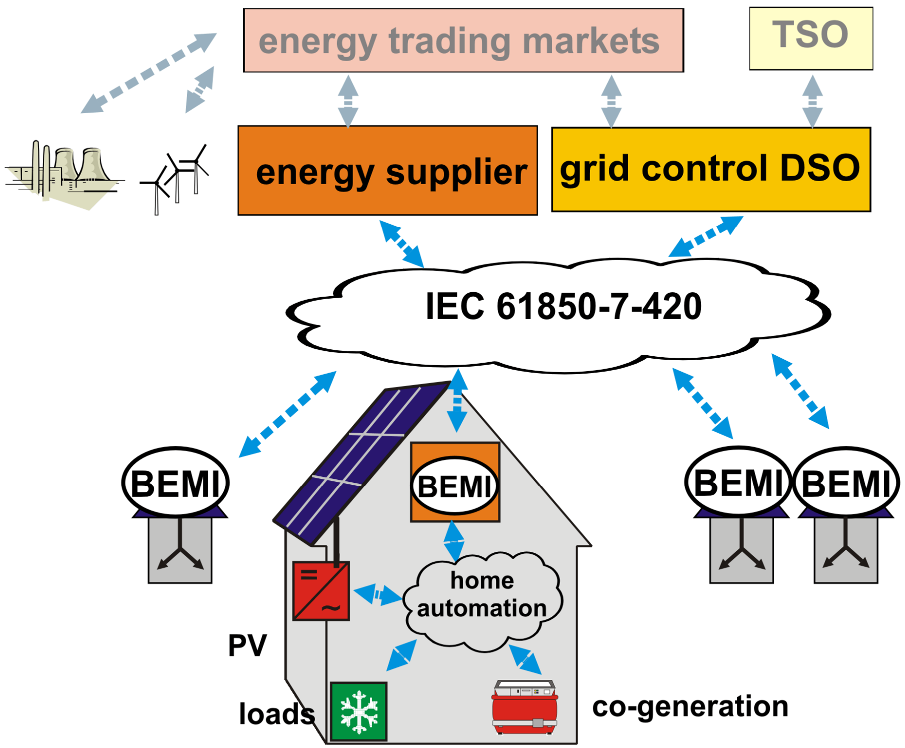
Vision of the pilot installation

- Today: load valley filling
    - heaters are charged at night to facilitate the operation of central base load power plants

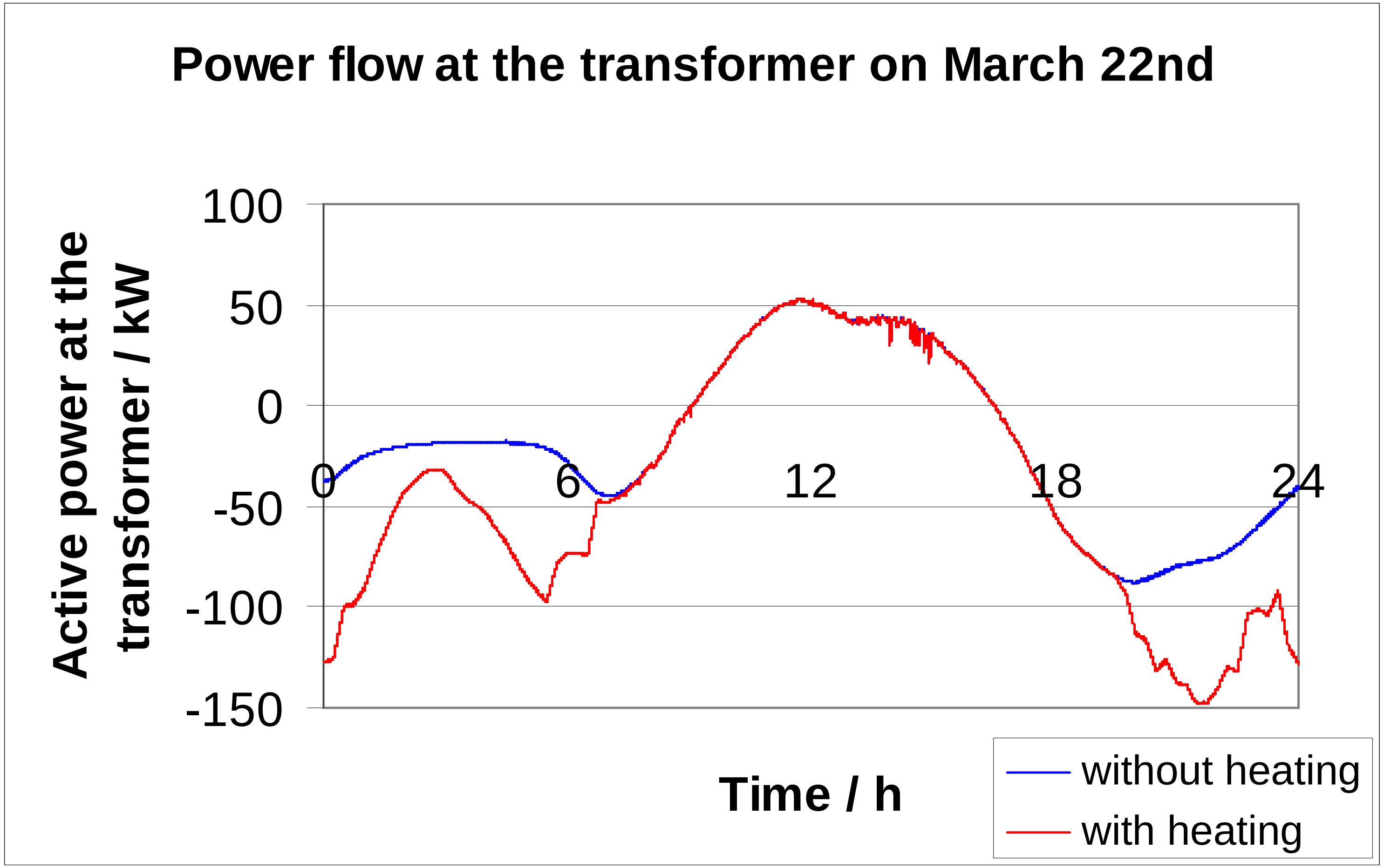
- Tomorrow: local load and generation matching
    - Energy should be used when and where it is produced
        - heaters and freezers could be charged when local surplus power is available
        - demand side management → BEMI / OGEMA

Bidirectional Energy Management Interface (BEMI)



- Variable tariff
- Automated device measurement and switching
- User interface
- Energy management system
- Open communication standards
- Open software platform www.ogemalliance.org

Power flow at the substation



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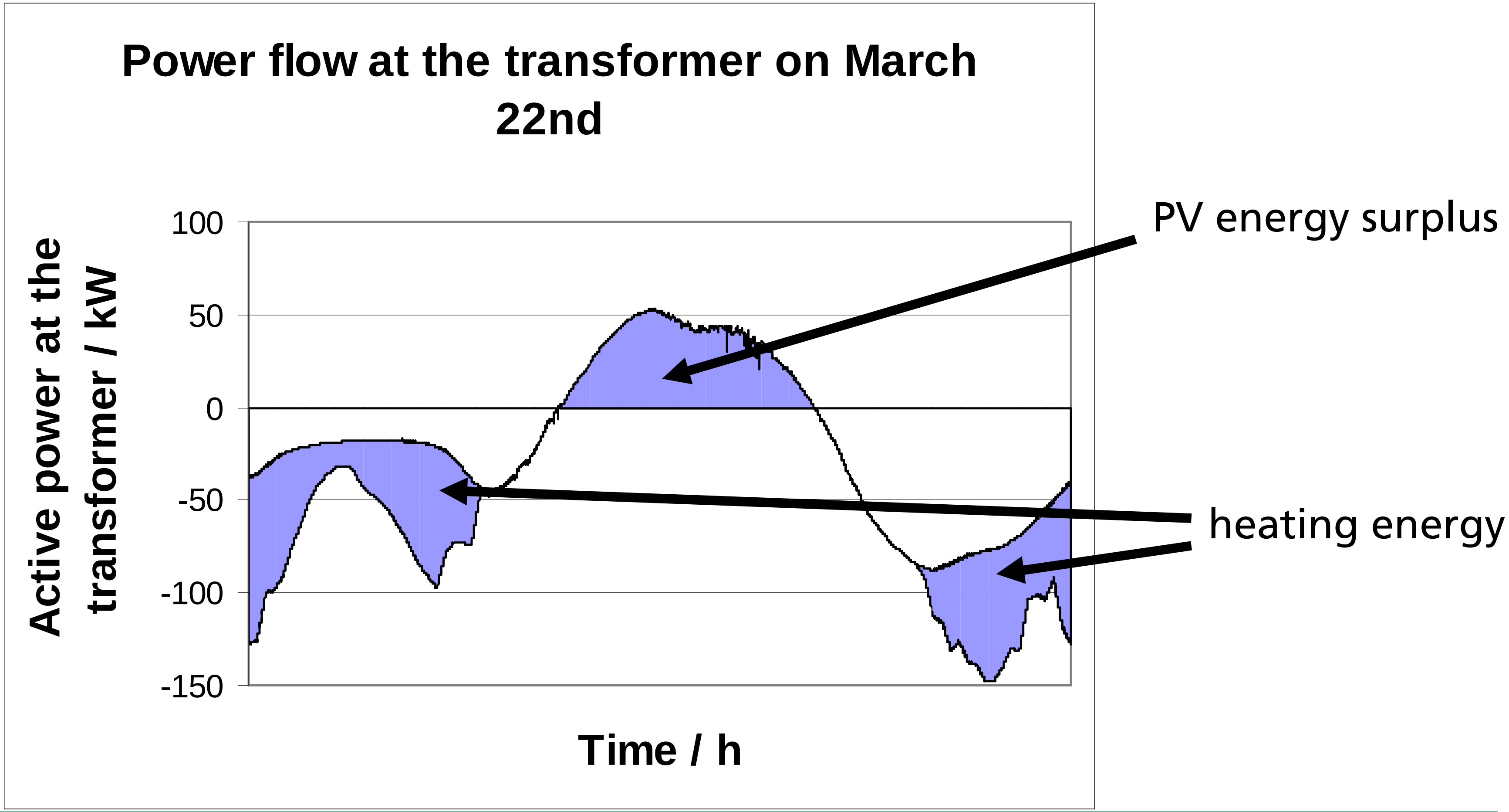
PV energy surplus and heating energy



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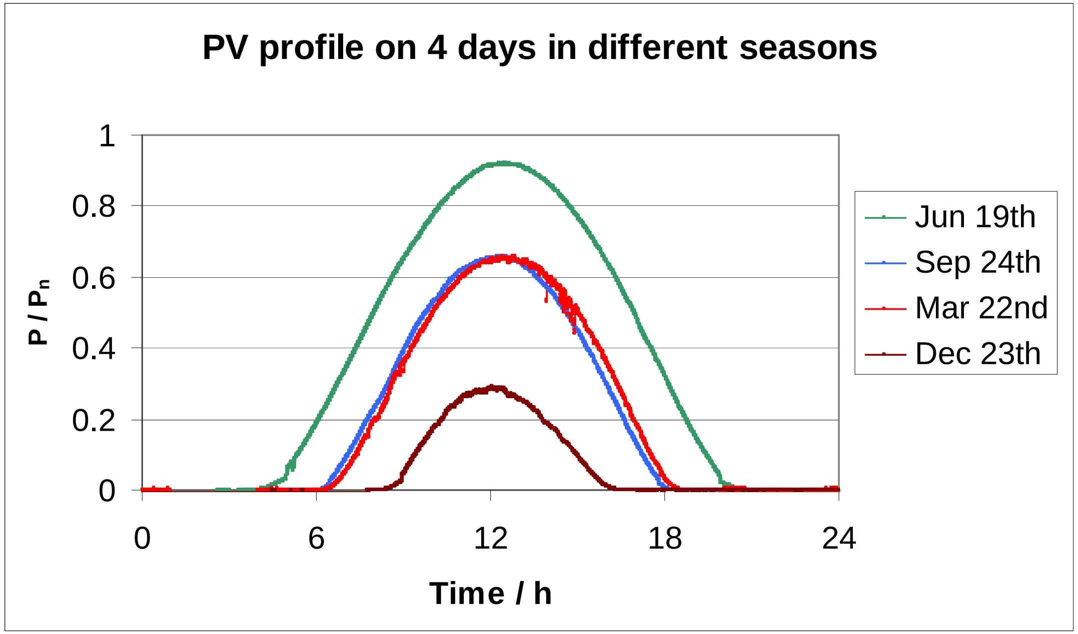
Use of PV energy surplus in spring (March 22nd)

- Energy surplus in the network cell: 253 kWh (around noon)
- Energy need for heating: 525 kWh

→ PV surplus can be stored completely (thermal storage) in the network cell
→ heating cannot fully be supplied by PV
→ public grid must fill the gap

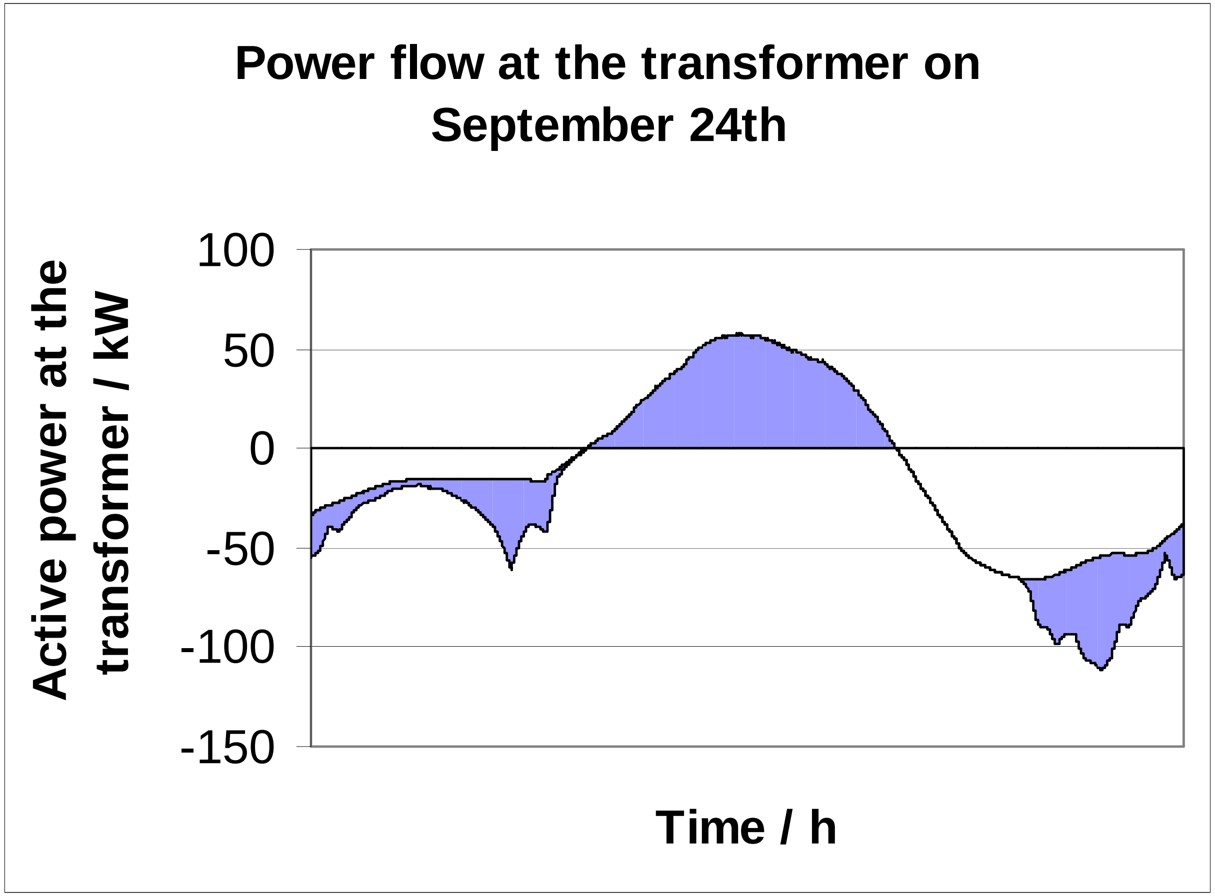
→ avoidance of grid losses approximately 6%
PV surplus: 2 x 1% transform (MV/ LV), 1% transport to neighboring network cell;
heating: 1% transform (MV/ LV), 2% transport from central power plant
→ possible contribution to micro-grid or accounting-grid balancing

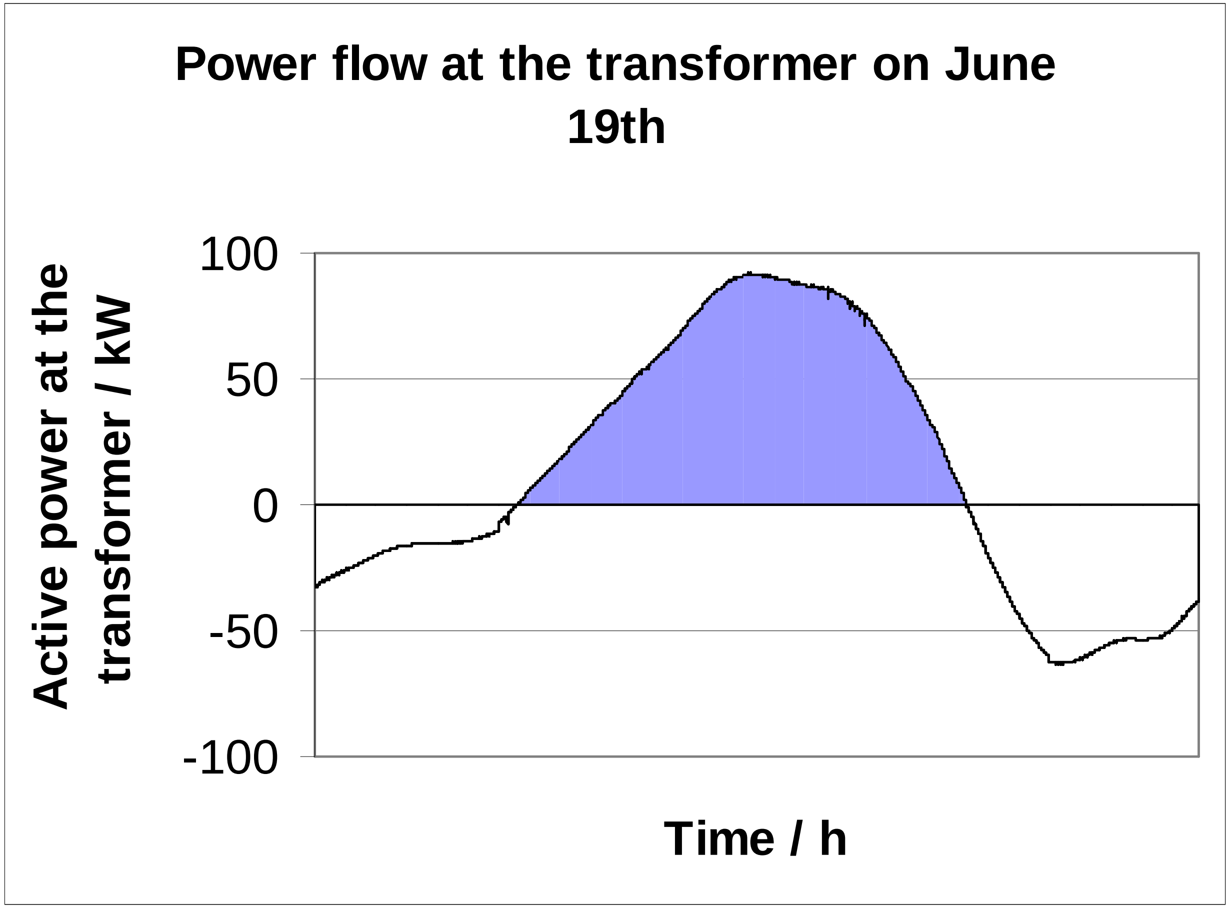
Different seasons

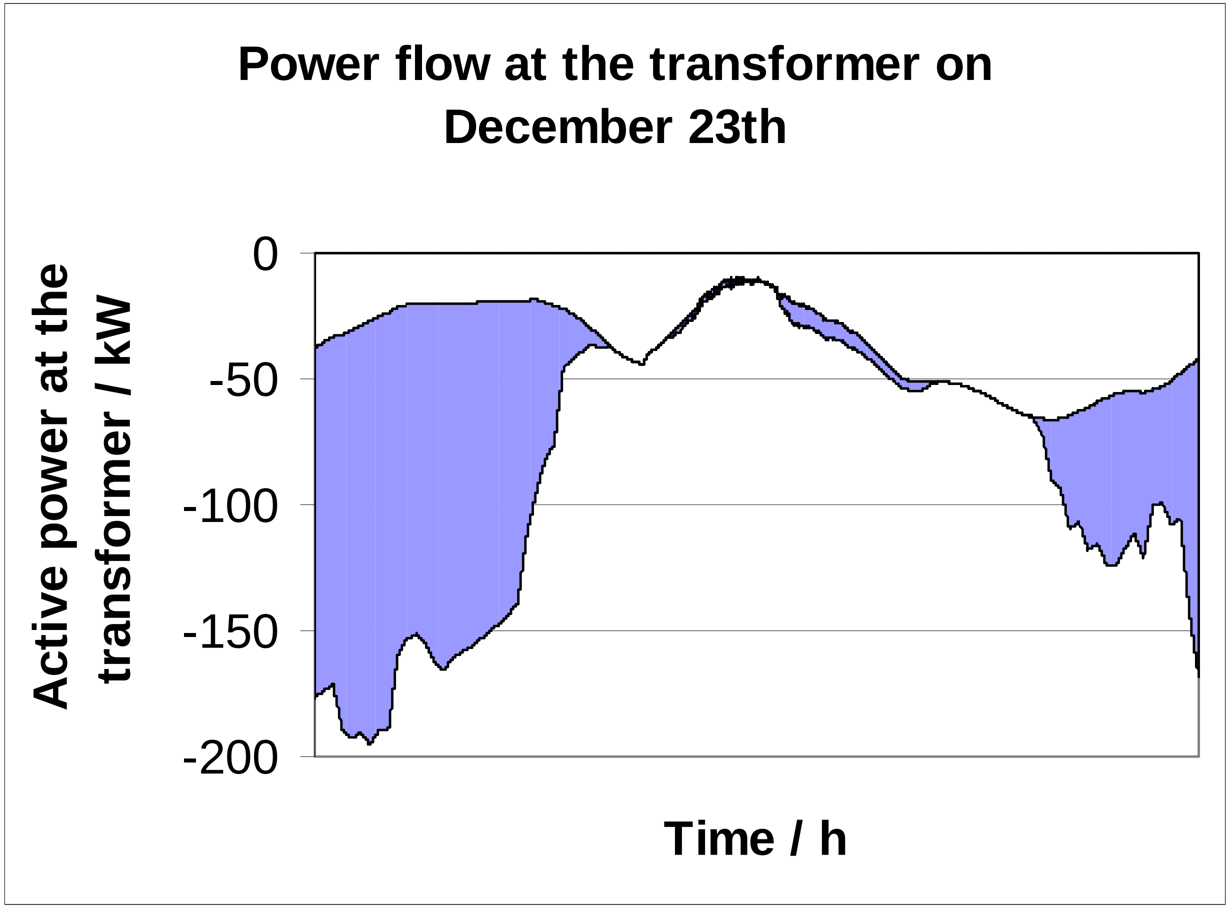


Mean temperature:

- March 22nd: 10°C
- June 19th: 25°C
- Sept. 24th: 13°C
- Dec. 23rd: 4°C


Power flow at the transformer on
September 24th
Active power at the transformer / kW
100
50
0
-50
-100
-150
Time / h


Power flow at the transformer on June 19th
Active power at the transformer / kW
100
50
0
-50
-100
Time / h



Power flow at the transformer on December 23th
0
-50
-100
-150
-200
Active power at the transformer / kW
Time / h

Energy balance

Day	PV surplus / kWh	heating energy / kWh
March 22nd	253	524
June 19th	694	
September 24th	303	233
December 23th		1154

- The pilot installation will start with off-peak heating and freezers.
- More devices can be considered:
  - room air conditioners, washing machines and tumble dryers, refrigerators, circulation pumps, and in future also heat pumps and batteries of electro vehicles.

Thank you for your attention!

Test house of the IWES smart grid laboratory

We acknowledge the support of E.ON Mitte. Only the authors are responsible for the publication.

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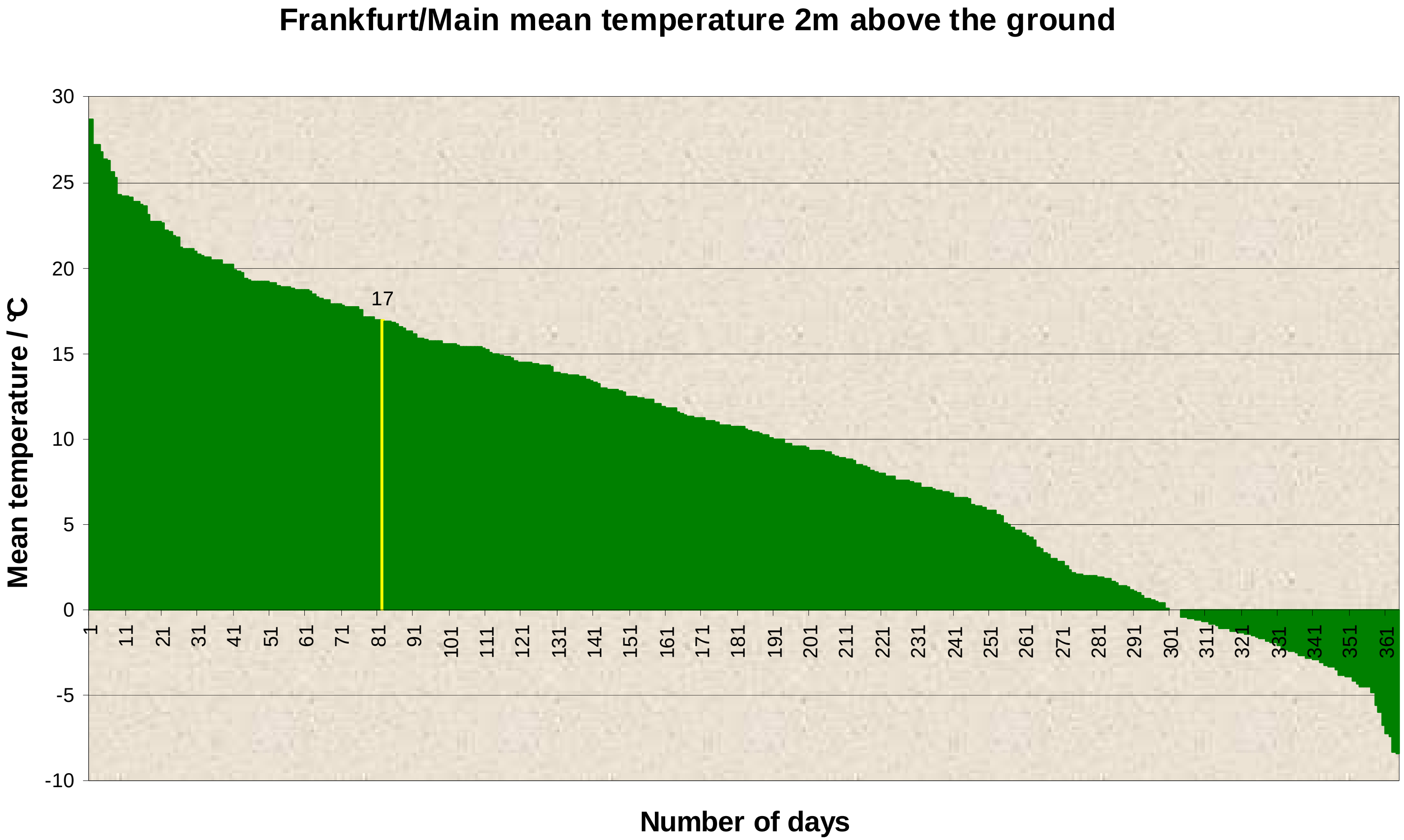
Average temperature in Germany



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