IEA-EBC Annex 73
2nd Experts-Meeting

Energy in Buildings and Communities Programme

Annex 73, Subtask B.2

Pilot Case Study Evaluations → German contribution

‚Smart Energy Retrofit of a Multi-family Building Cluster‘

- Pre-planning Results -

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Frankfurt, April 17th, 2018

Neighbourhood location : City of Karlsruhe, Ersinger Straße

Google Maps

Ersinger Str. 1 (3 entrances, 5 floors, 30 apartments)

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Building-Cluster
Ersinger Str. 1-5:

- 5 multi-family buildings
- year of construction: 1963, refurbishment 1995
- total living area 11.243 m²
- 160 apartments

~ 400 residents

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Retrofit 1995

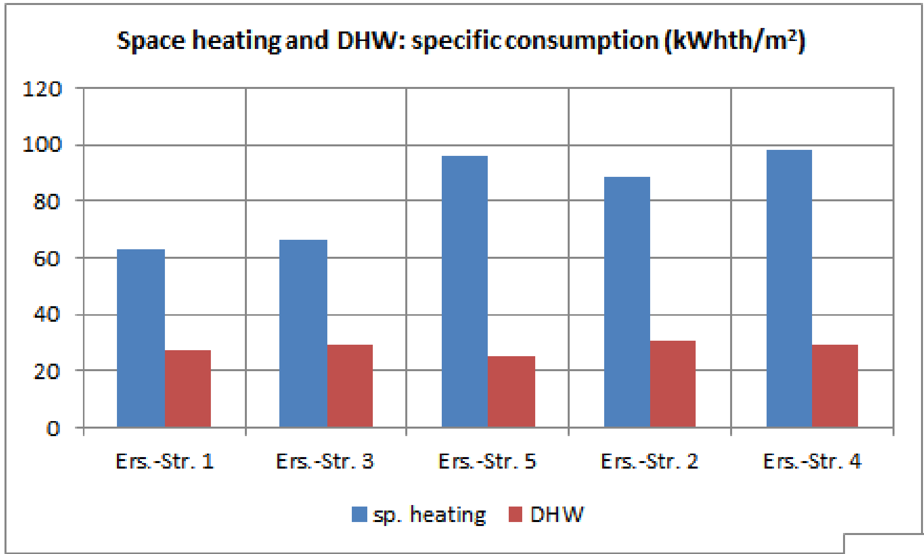
Thermal insulation:

- walls: 6 cm
- basement: 10 cm
- attic floor: 18 cm
- windows replacement
  U_W = 3,1 W/(m².K)

Heating system:

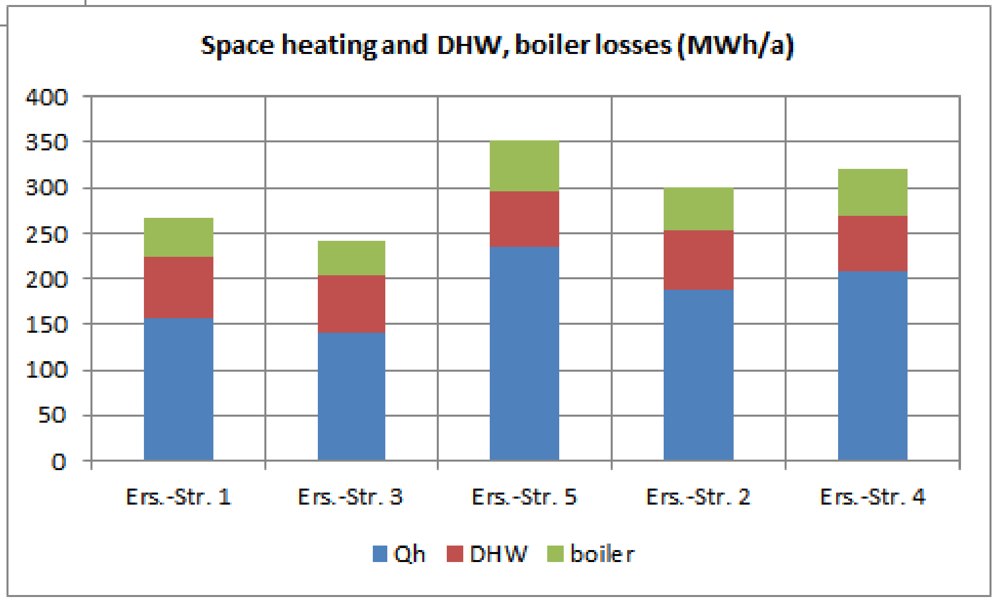
- 5 heating centrals (gas boilers)
  design load: *140 kW_{th}*
- radiators, natural ventilation
- central DHW supply
  (kitchens, bath rooms)

Heating / DHW use after retrofit (1995):
(av. 2015 – 2017)



	living area (m^2)
Ers.-Str. 1	2.471,8
Ers.-Str. 3	2.112,7
Ers.-Str. 5	2.440,1
Ers.-Str. 2	2.112,7
Ers.-Str. 4	2.106,7

(η_{Ks} = 0,84)



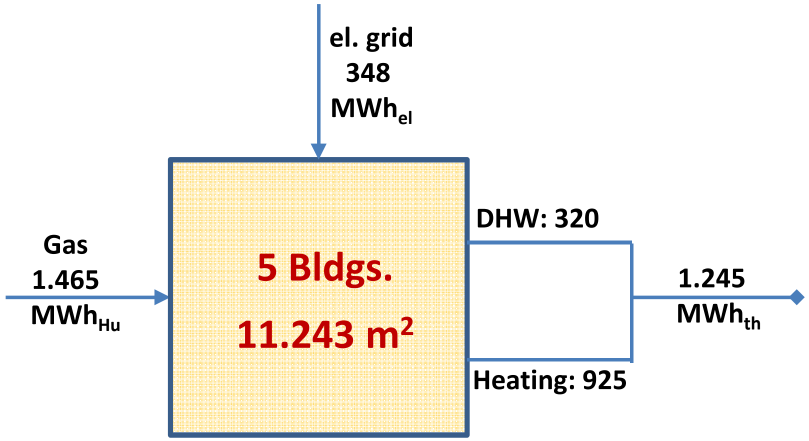
Heating demand before retrofit:

~ 145 kWh_{th}/m^2

calculated demand after retrofit:

~ 65 kWh_{th}/m^2

Energy balance, existing situation:



Key numbers (2017)

- 140 kWh_{PE}/m^2 thermal
- 70 kWh_{PE}/m^2 HH electricity

▹ PE total: *210 kWh_{PE}/m^2 *)*

▹ 48 kg CO_2/m^2

Future energy targets?

EBPD: ***‚new Least Energy Buildings'*** → *< 40 kWh_{th}/m^2* → ~ 80 – 100 $kWhPE/m^2$

(‚PH standard') *-60% rel. to total PE*

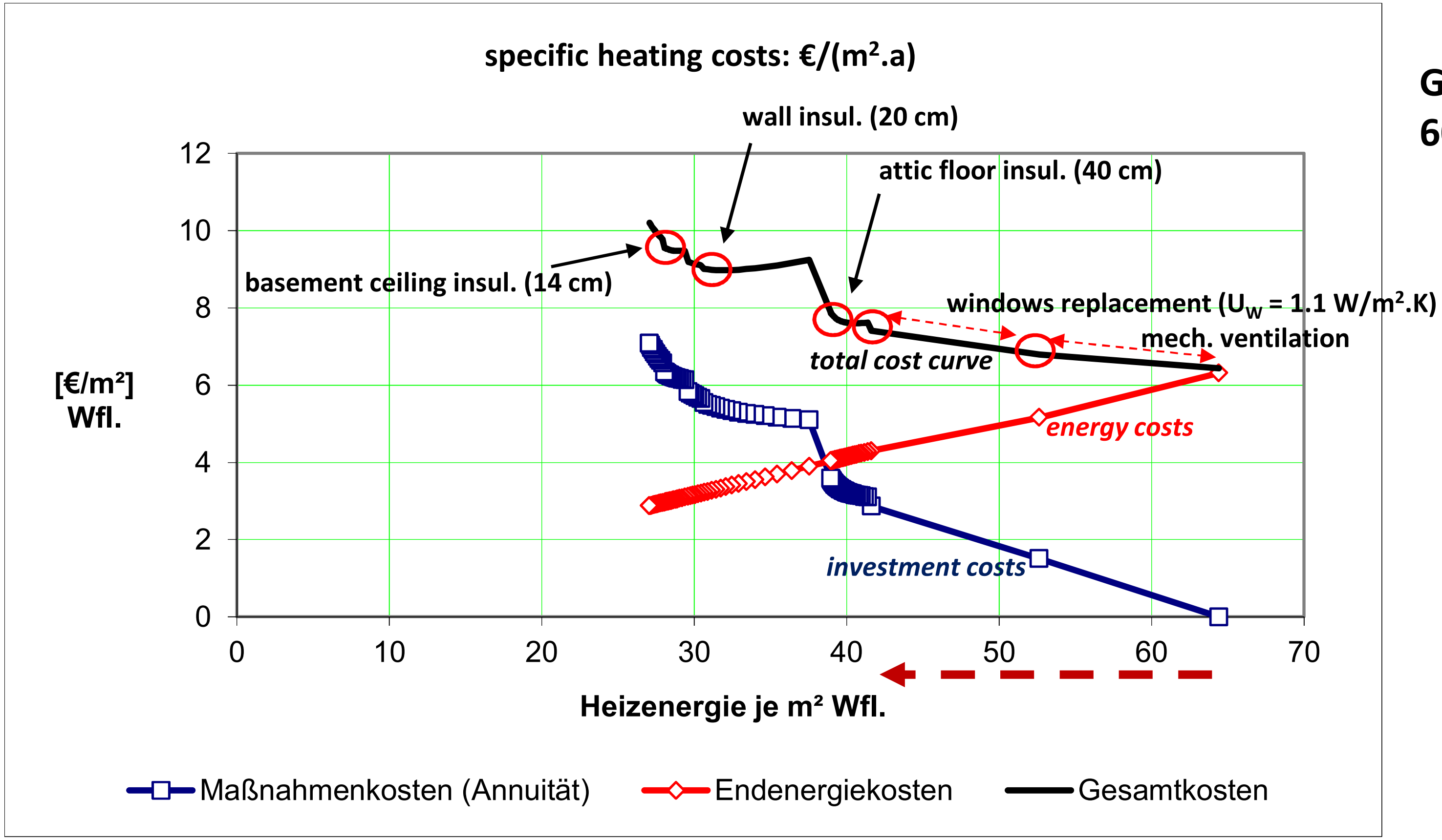
→ **Options:**

(a) Energy conservation

(b) Energy supply system

*) before retrofit: 310 kWh_{PE}/m^2 ⇒ -75%

(a) Energy conservation measures:
‚Least-cost path‘:



Gas price:
60 €/MWhHu

Result:

- **mechanical ventilation / windows replacement ~ cost-efficient**
- **Δq_h: ~ 33 kWhth/m² (~ 14 % of PE_{tot})**
- **cost increase: ~ 7 %**

(b) Energy supply:

- boiler replacement (condensing boiler)	ΔPE ~ -15 kWh_{PE}
- additional insulation of ducts	-5
- solar collectors (2/3 of DHW)	-18
	-38 kWh_{PE} (-16 % of total PE)

→ *Conventional retrofit strategy:*

	PE reduction (%)	*costs (%)*
building retrofit	*~ -14*	*~ +7*
energy supply	*~ -16*	*~ +10*
total	***-30%***	***+17%***

More ambitious targets ??

- Combination of
  - cogeneration plant
  - roof PV arrays
  - electrical heat pumps
  - energy storage
  - ‚LowEx'-measures

→local solution

→scalable to district

System analysis in pre-planning phase:

Problem: ***no system simulation***

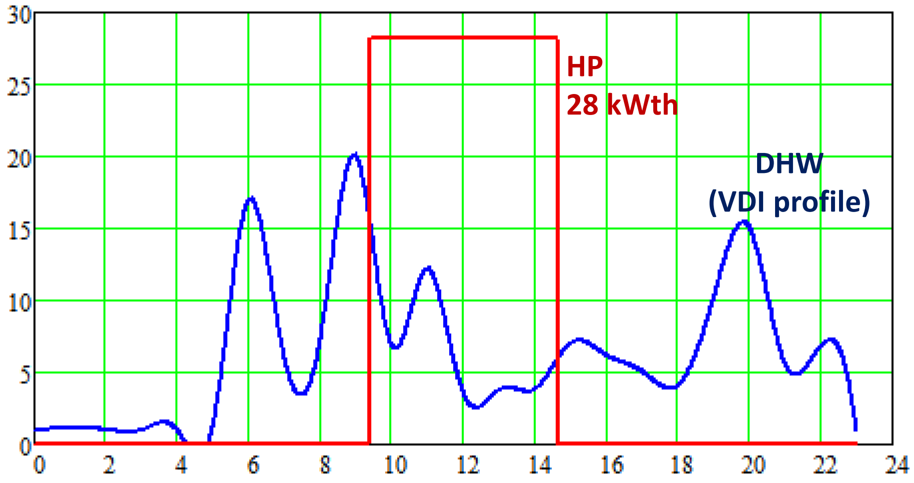
→ **Conventional planning means to**

- **make ‚*educated guess*' for system lay-out**
- **derive cost estimate**

→ **stop/go – decision by investor**

- **full load hours**
- **seasonal efficiencies**
- **load duration curves**
- **standardized load profiles**
- **daily solar radiation curves**

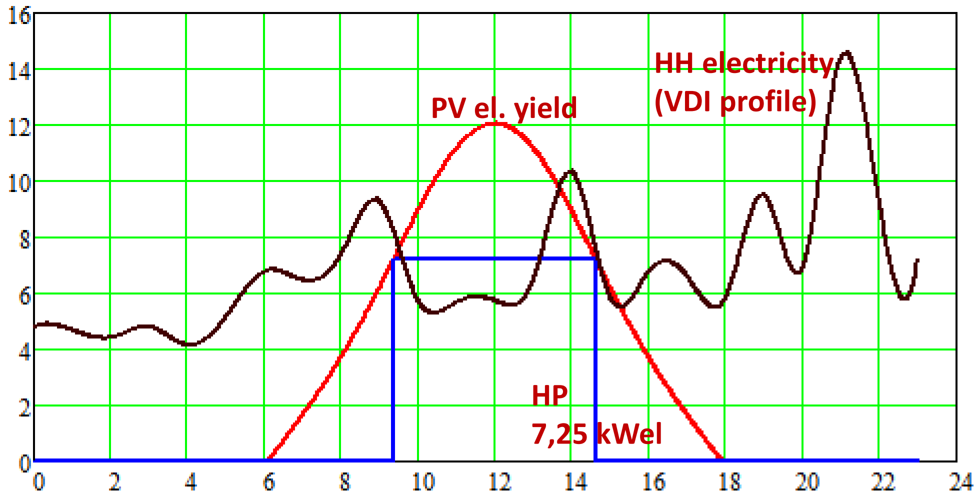
Example: Summer day



HP lay-out and operation:

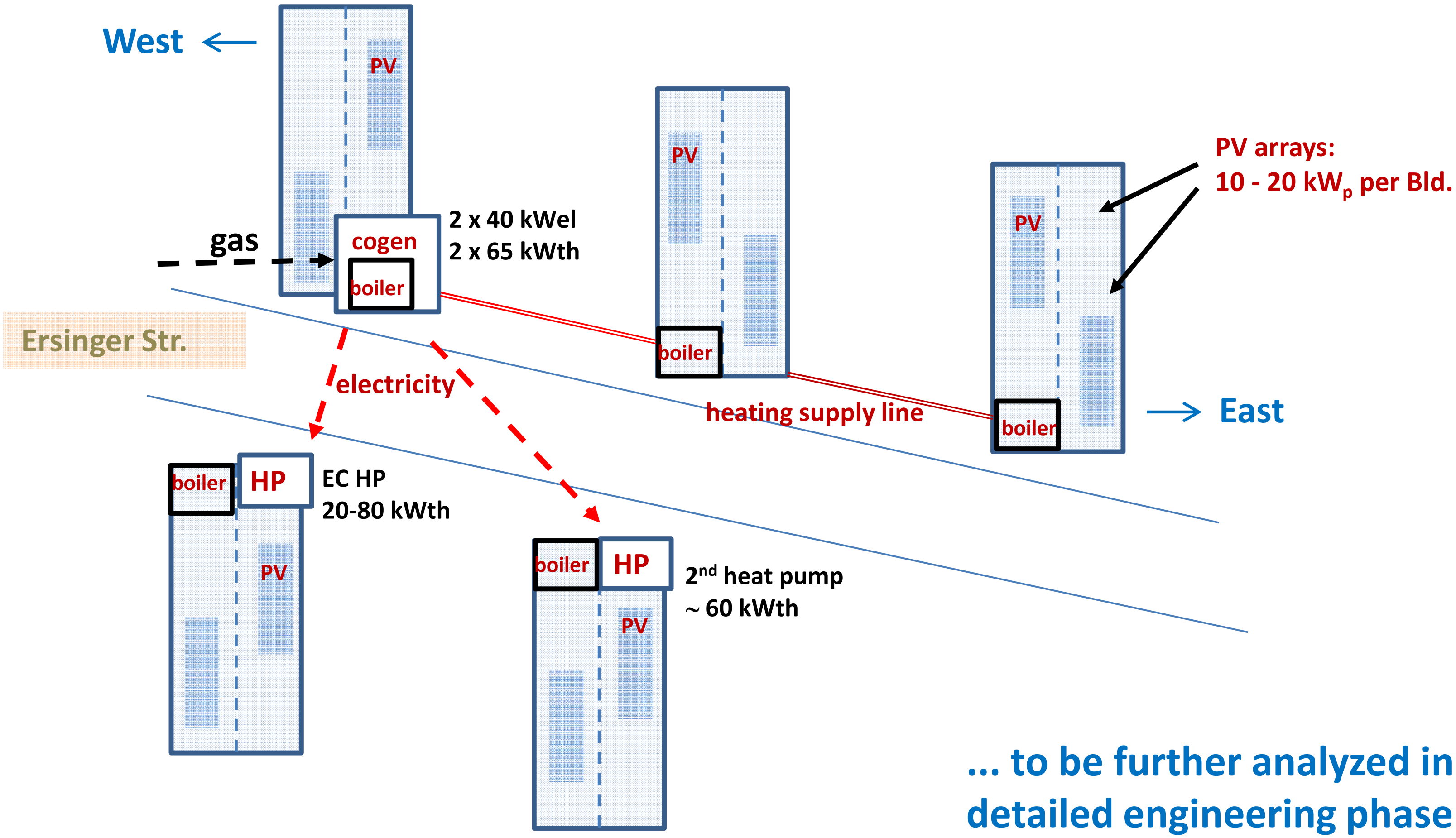
148 kWh_{th}/d

- **HP: 7,25 kW_{el}, 28 kWth**
- **PV: 12 kW_{p}**
- **th. store: 1.500 Liter**



Resulting energy concept:

- Cogen plant: $2 \times 65\ kW_{th}$, $2 \times 40\ kW_{el}$
- 2 heat pumps: 20 – 80 kWth
- PV-Arrays: ~ 65 kW_p
- thermal storage ~ 1.500 Liter per bldg.
- el. storage *(if economic)*



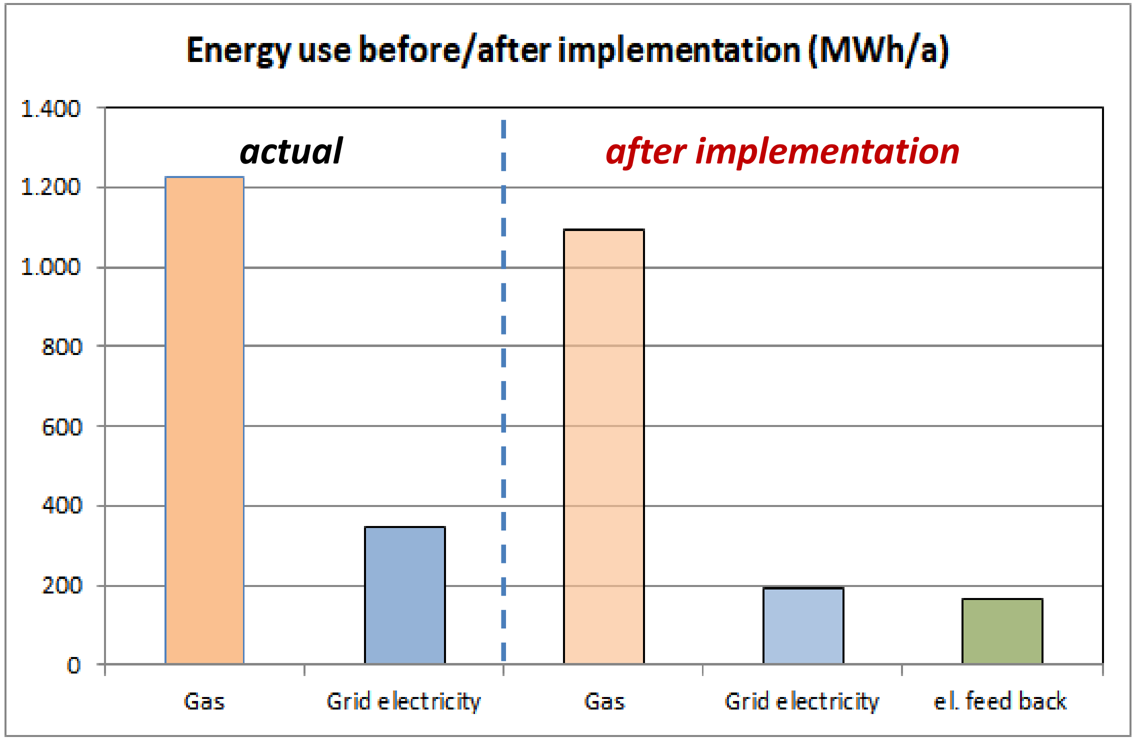
... to be further analyzed in detailed engineering phase!

→ Energy balance (estimate)

Energy ‚import‘: gas; grid electricity

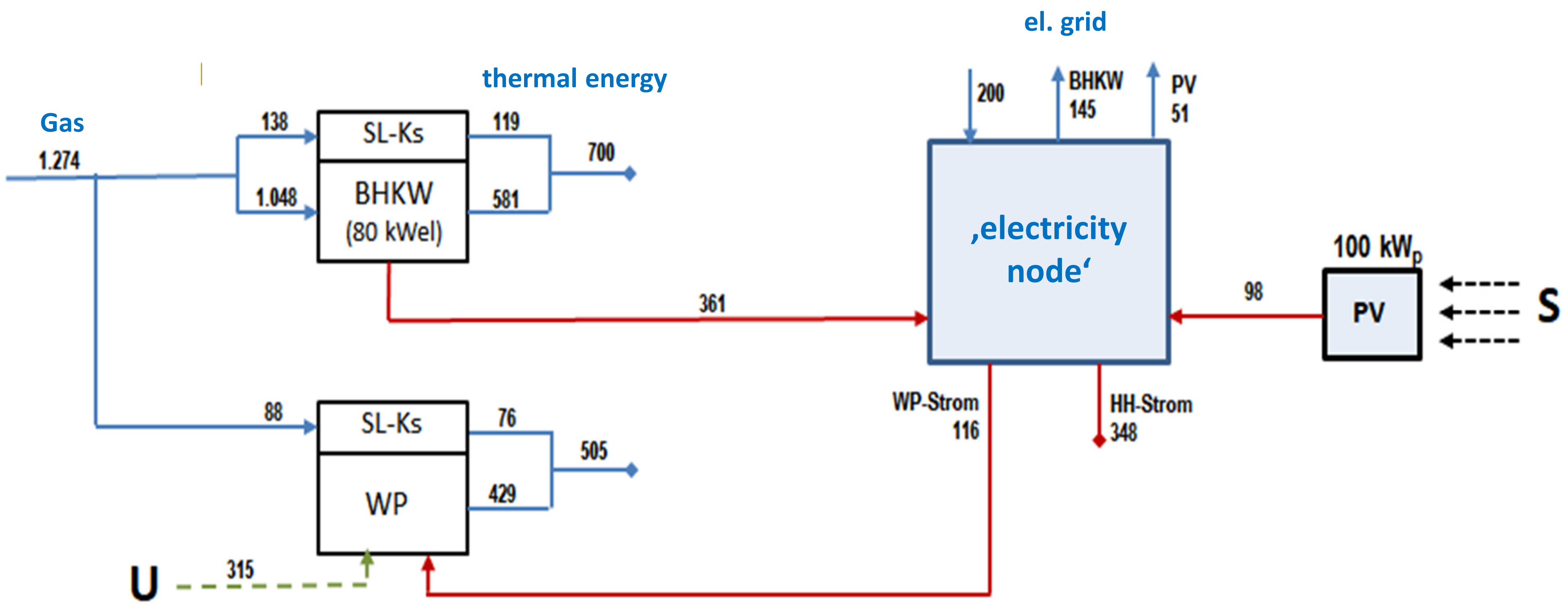
Local energy sources: PV (~ 6%); ambient energy (~ 25%

(no electricity storage!)



- **gas use: reduced**
- **grid electricity use:**
  - **halved**
  - **compensated by ‚export‘**

Energy flows:



Result:

- total PE consumption: 220 → 125 kWh$_{PE}$/m^2 (-43 %)
- building retrofit added: 86 kWh$_{PE}$/m^2 (-61 % total)
- resulting total costs: 5 – 10 % higher (at actual energy prices)

Phase 2:

- develop system model (Fraunhofer ISE)
- analyze energy system and modifications
- verify investment costs
- find system optimum (incl. el. accum.)

Next steps:

2) contact manufacturers
3) detailed engineering + call for proposals
4) control and monitoring concept
5) implementation
   (planned start of operation: 2019)
6) monitoring and optimization phase (> 1 year)

Research issues:

1) **System Simulation-Model for**

Fraunhofer ISE

- concept definition
- lay-out of components
- fault detection / optimization (operation phase)

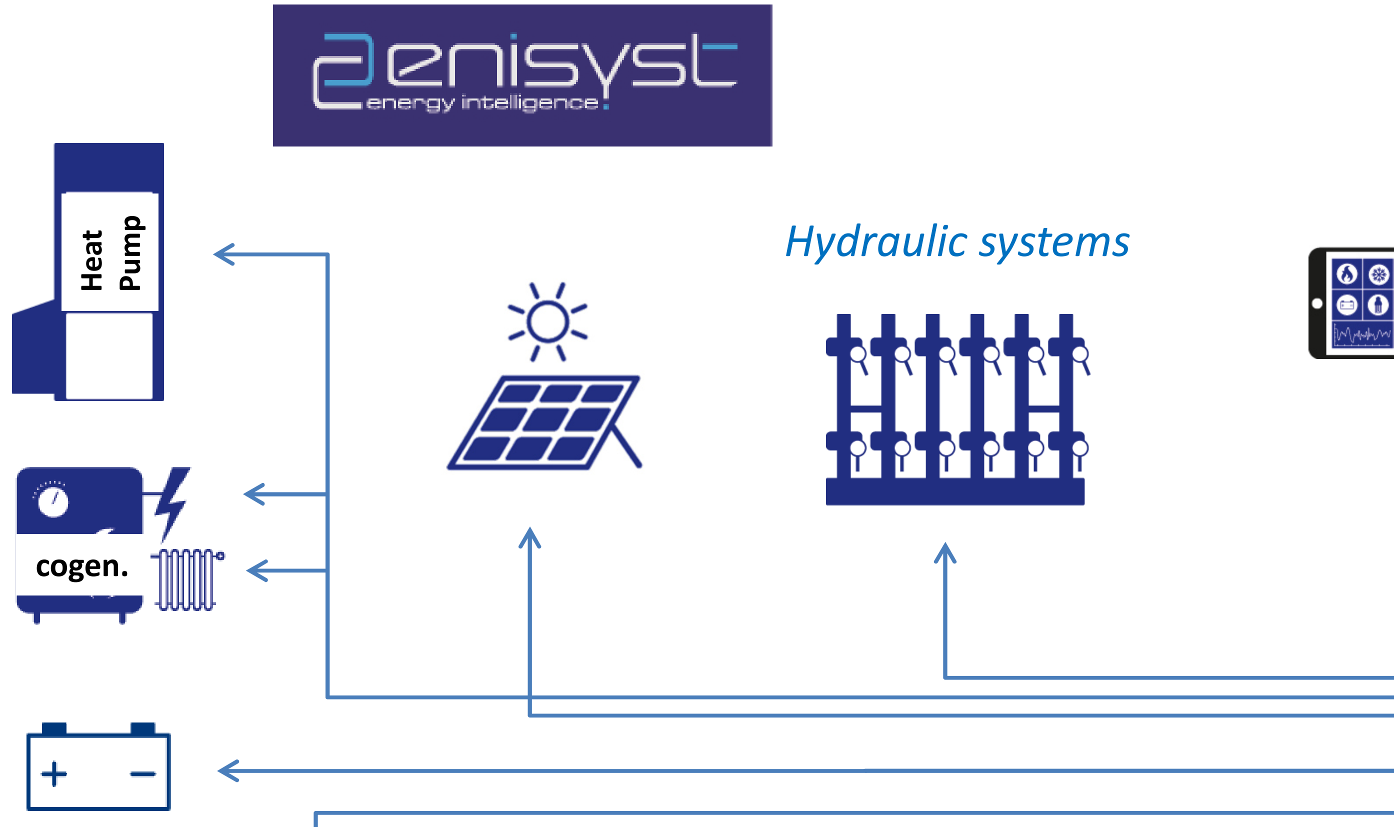
2) **LowEx-Adjustments**

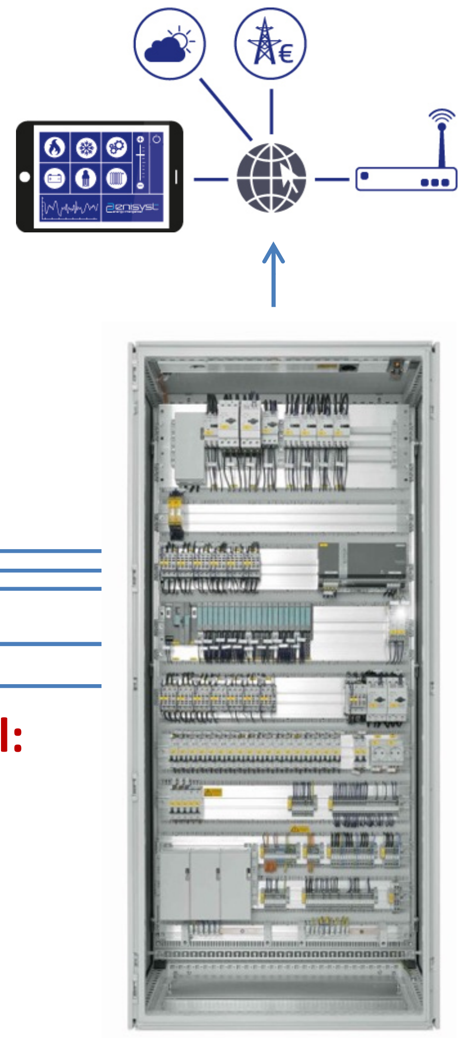
Housing company

- precise hydronic adjustment of piping
- radiator lay-out check
- adjustment of circulation pumps
- demand management

3) **General system control device**

Co-operation with manufacturer





Optimization through efficient system control:

- demand control
- optimised operation of cogeneration, peak load boilers, heat pumps, PV
- smart load and storage management (incl. weather forecast)

→ Scalable for neighbourhood system ...

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Project R&D goals:

- *‚integrated system modelling‘* approach
- development and application of versatile system control/monitoring device
- verification of (economic) energy conservation potential in practice
- Final document: Generic engineering guidelines for complex energy systems

→ *application to further energy projects in Karlsruhe by local utility*