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Energy in Buildings and Communities Programme

IEA-EBC Annex 73

2nd Experts-Meeting

DEROM

Deep Energy Retrofit Model

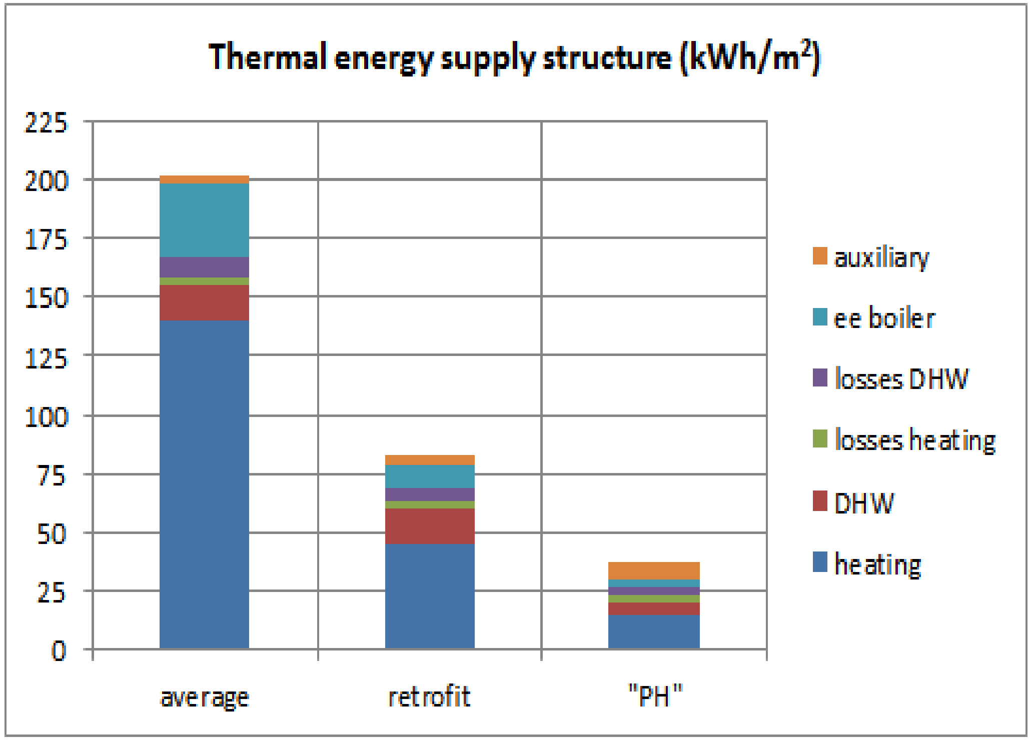
Integrated Energy Analysis Tool for Building Retrofit Strategies

... entry into Subtask E neighbourhood pre-planning tool

R. Jank

Options for building energy retrofit:

- Insulation of envelope: how many cm?
- windows replacement: which quality?
- mechanical ventilation
- distribution losses
- supply: effiziency? energy source?
- energy control
- DHW: solar collectors?
  heat pump?
- ......



- cost efficiency?

- least-cost combination?

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Energy analysis tools check compliance with building code:

→ detailed data input

→ cost efficiency of individual measures: possible, but tedious

Required:

Find most cost-effective technical option in conceptional planning phase:

→ limited effort
→ sufficient reliability

→ **DEROM** (Deep Energy Retrofit Optimization Model)

KA-Rintheim: 36 MF buildings, 6 building types
Least cost strategy? → new decision tool

Photo: Volkswohnung KA

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DEROM:

‚Least-cost Path‘:

Combination of measures
to achieve a certain energy target
with *lowest total costs* (= *energy costs + investment costs*)

Required:

- investment costs → Δc_{Inv}
- energy saving effects
- energy prices

→ Δc_{En}

Building:

- geometry
- U-values

‚Gradient‘: $\dfrac{\Delta c_{Inv}}{\Delta c_{En}}$ → **minimum!**

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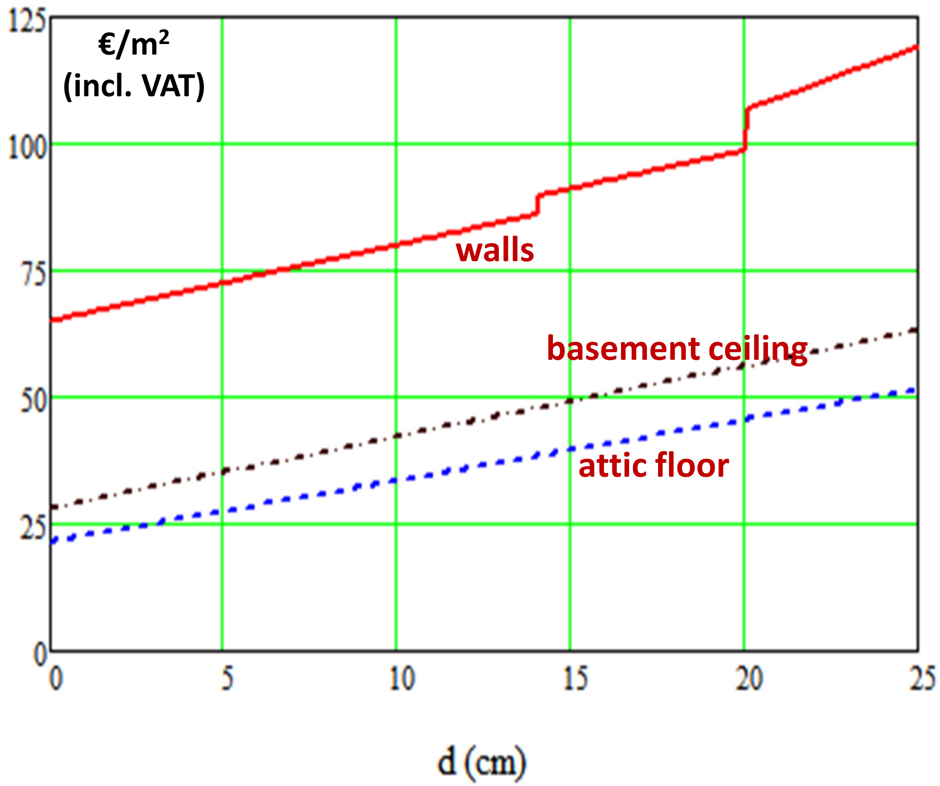
Example 1:
KA-Rintheim
Heilbronner Str. 27-31

before retrofit

after Retrofit

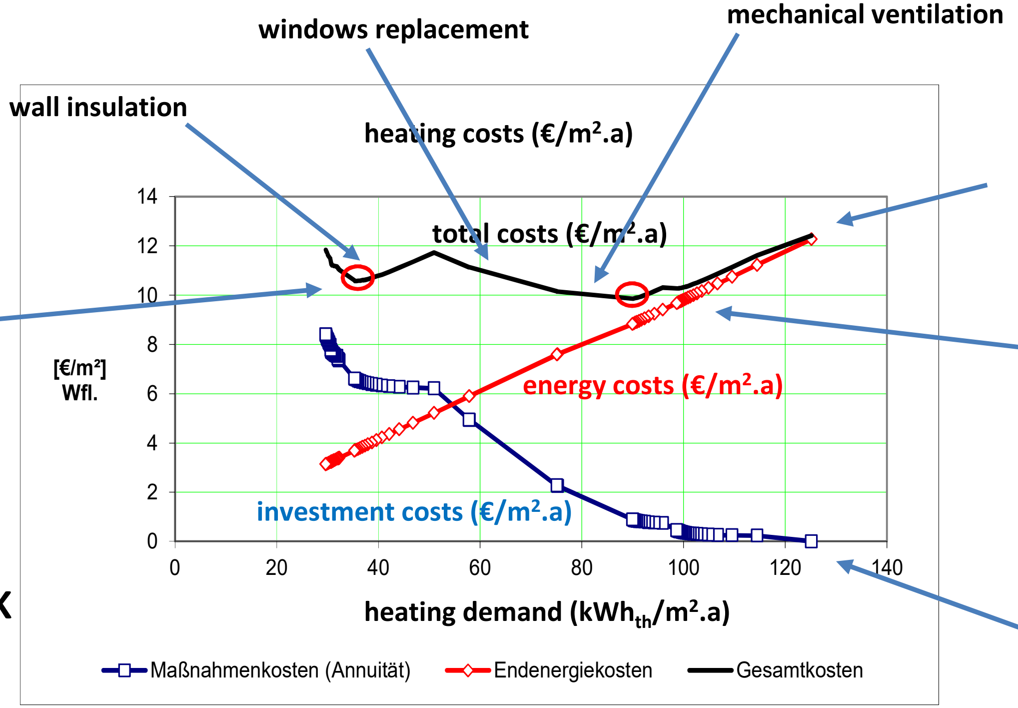
Empirical cost structure of envelope insulation: *Rintheim*



(DEROM default functions)

DEROM run, stage 1:

Energy conservation measures → Heilbronner Str. 27-31



Target:
38 kWhth/m²

basement: 10 cm
attic floor: 23 cm
walls: 9 cm
windows: 1.1 W/m².K
mech. ventilation

energy costs before retrofit:
12.4 €/m².a

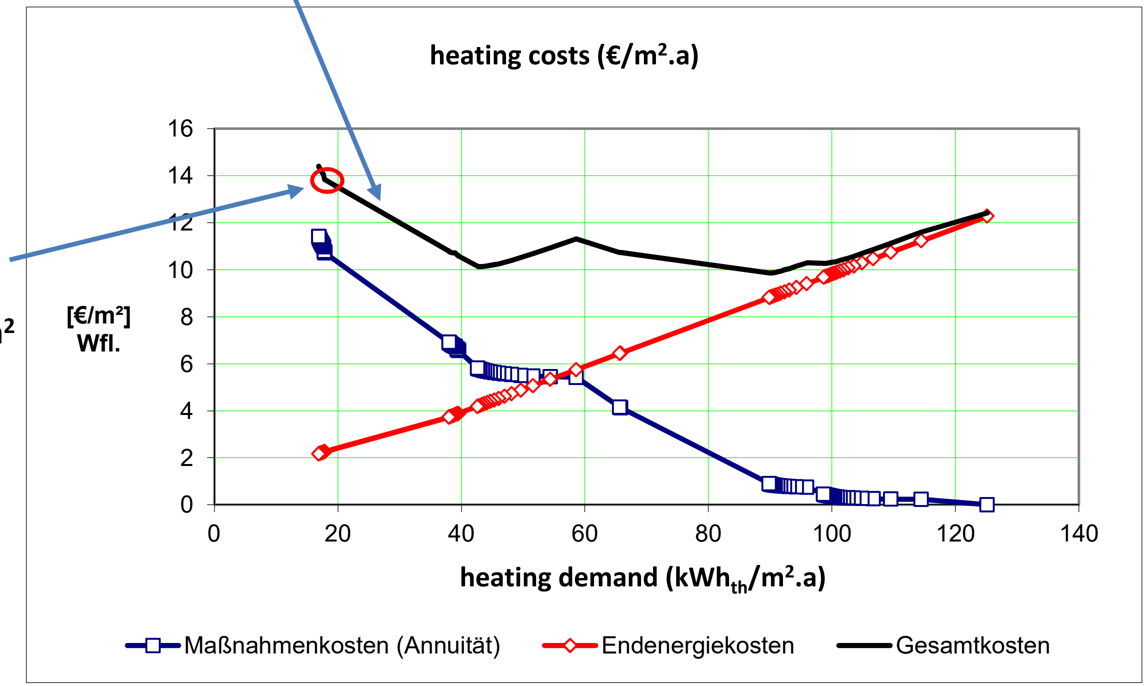
Cost minimum:
90 kWhth/m²
basement: 10 cm
attic floor: 19 cm

q_h before retrofit:
126 kWhth/m²

‚Passive Haus' strategy:

mech. Ventilation + heat recovery

‚PH standard':
q_h = 18 kWhth/m²



Result of DEROM runs:

(Gas price: 80 €/MWh_{Hu})

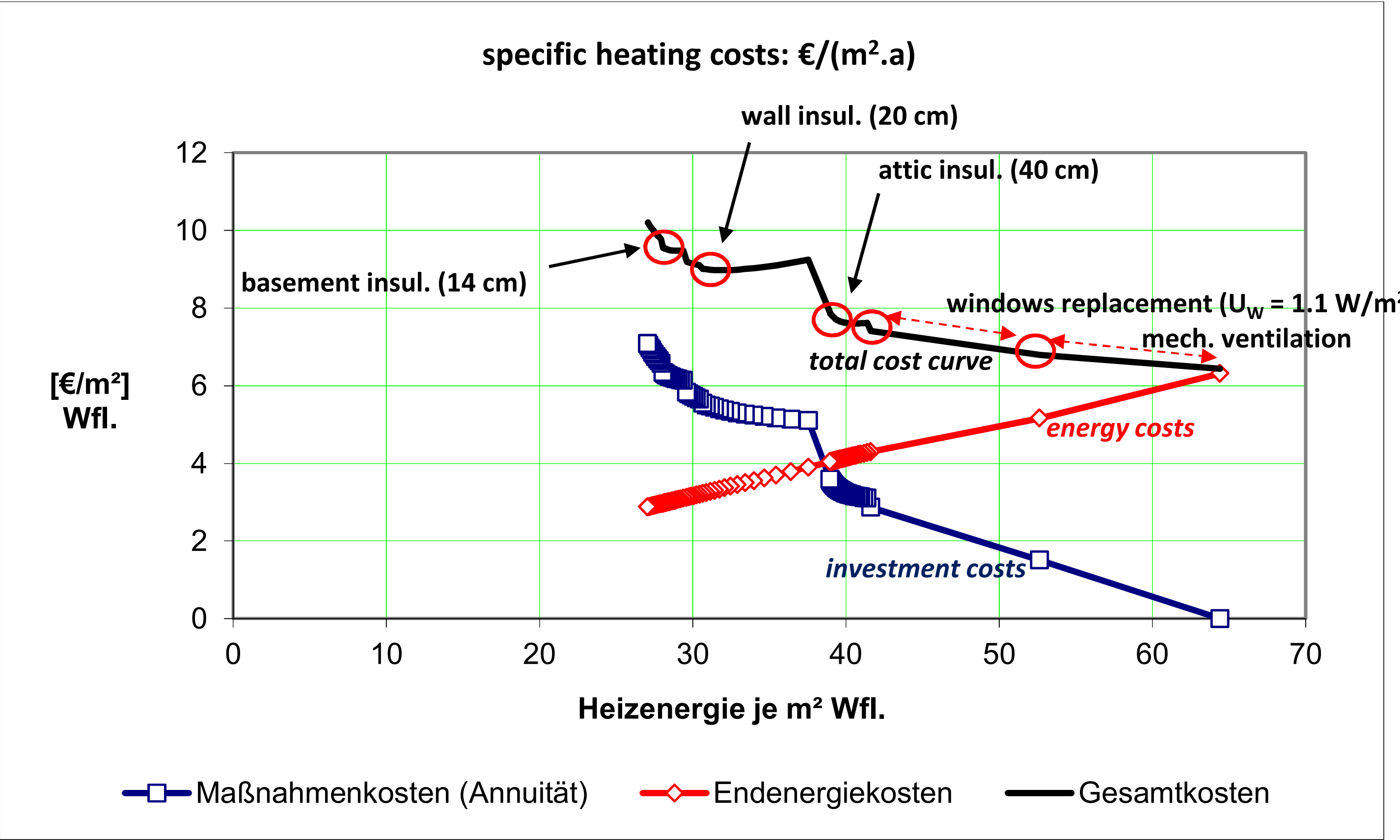
Heating demand before retrofit:
126 kWhth/m²; 12.4 €/m²

		cost minimum	energy target	‚Passiv-Haus'
q_h	kWh_{th}/m^2	90	38	18
walls	cm	0	9	20
basement ceiling	cm	10	10	10
attic floor	cm	19	23	36
windows	$W/m^2.K$	no	1.1	0.8
ventilation		no	mech.	heat rec.
total costs	€/m^2.a	9.8	10.6	13.8

Total cost increase:
30 % compared to ‚target'

Example 2: Ersinger Str. 2 *(1995 pre-retrofitted)*

DEROM *Least-cost path*



Conclusions:

- mechanical ventilation + windows replacement ‚cost-efficient'
- q_h: ~ 42 kWhth/m²
- increase of heating costs: ~ 7 %

DEROM run, stage 2:
Integration of energy supply options → *thermal energy: heating, DHW*

⇒ Inclusion of

- DHW demand
- distribution losses
- auxiliary electricity

⇒ **Choice of supply system required:**

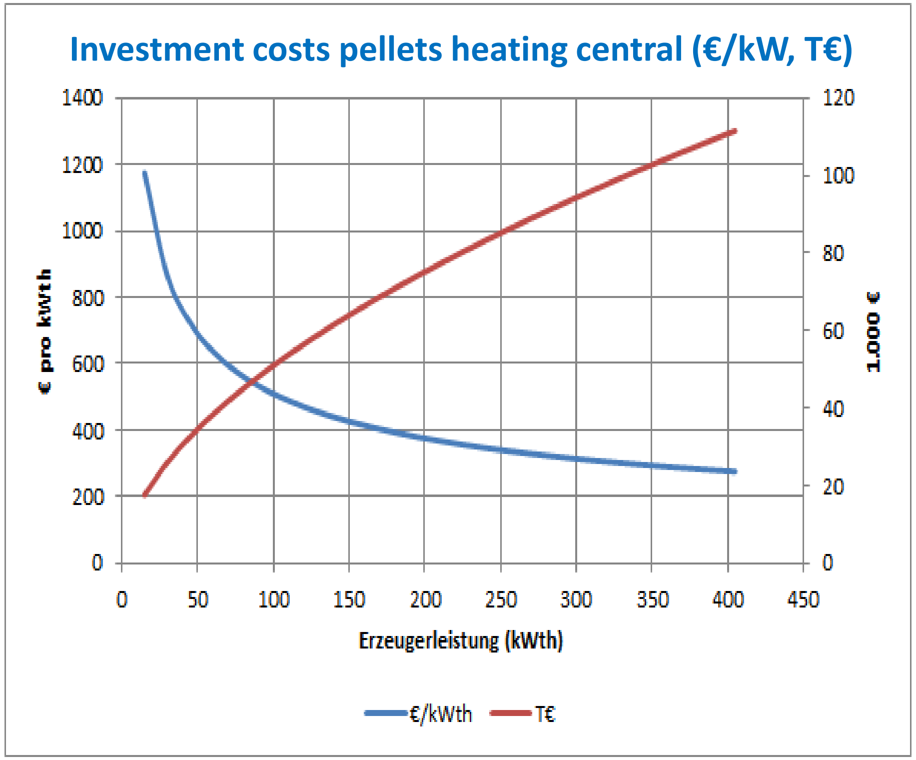
→ Selection from

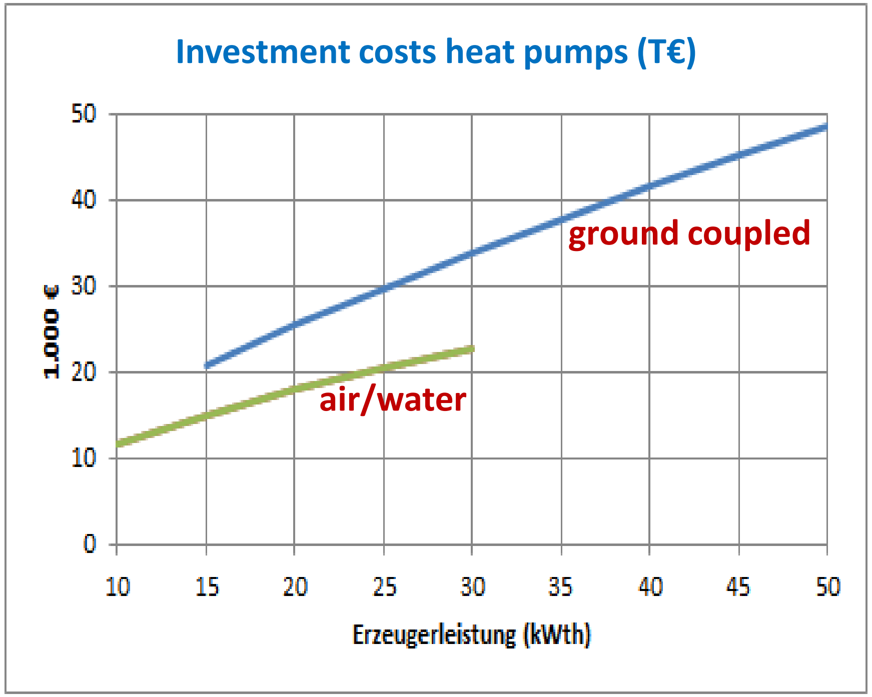
- existing gas / oil central boiler (the ‚*base case*')
- new gas / oil boiler
- DH supply
- pellet boiler (mono-/bivalent)
- heat pump (ground/air, mono-/bivalent)
- additional DHW supply options:
  - ▻ solar collectors
  - ▻ air/water heat pump, PV

Required: cost functions for supply systems

DEROM: default functions (+ default values for *seasonal performances*)

Examples:

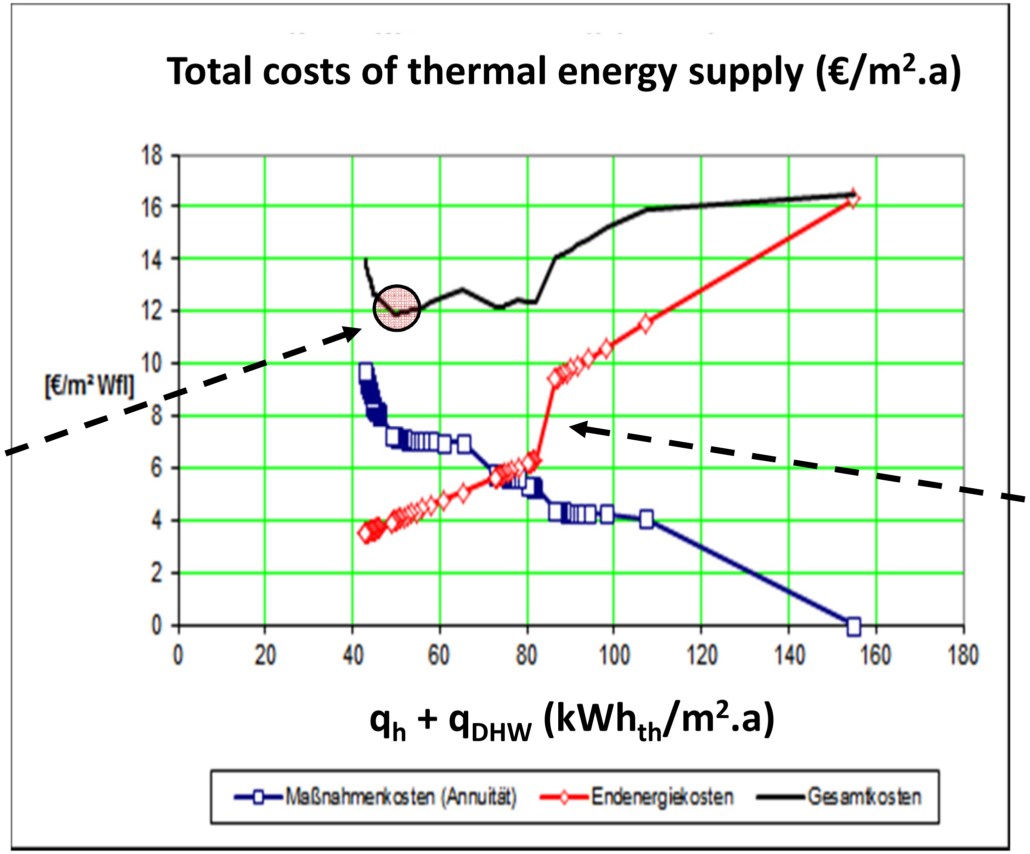




Example for DEROM stage 2 run:

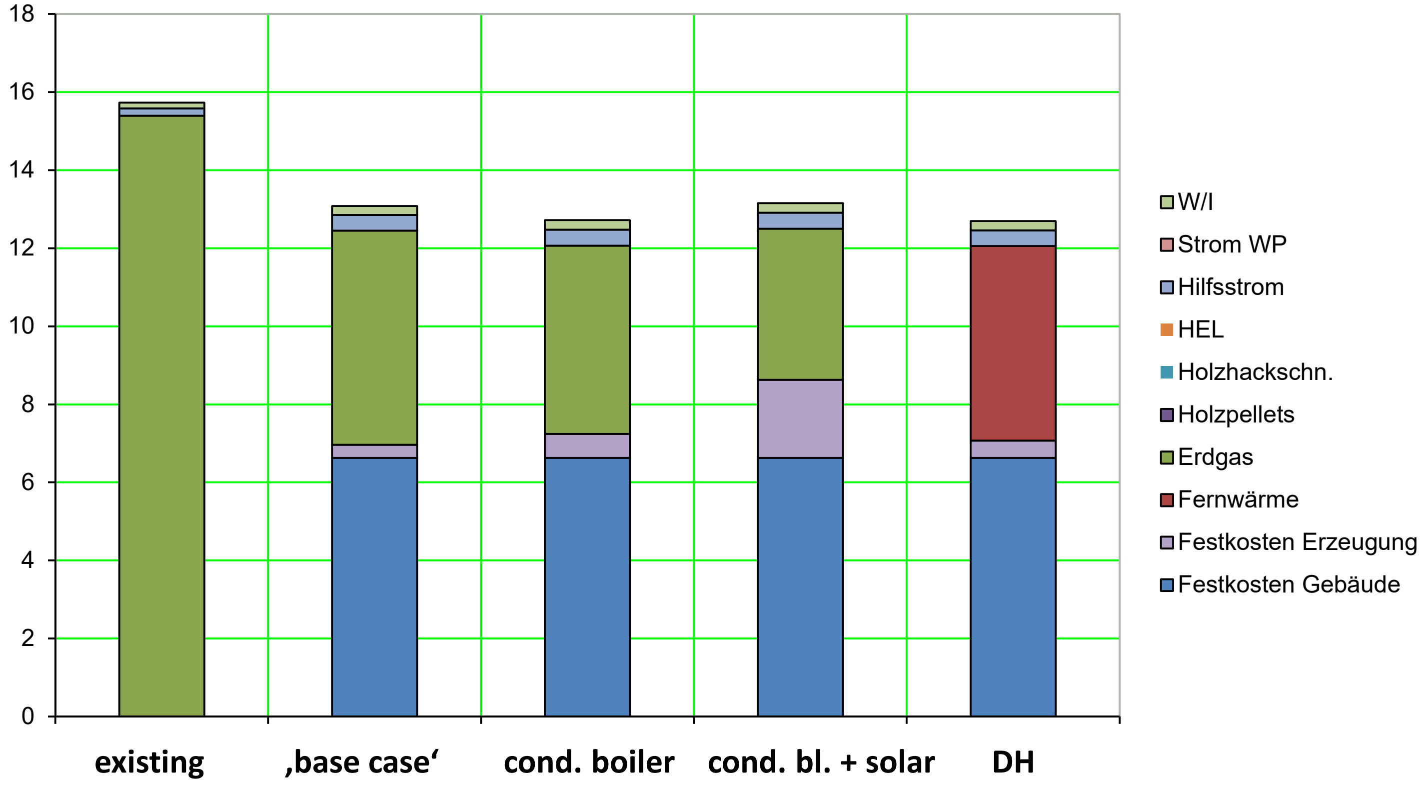
Pellet boiler replaces existing gas boiler

Thermal energy supply:
Costs of
- heating
- DHW
- distribution losses
- auxiliary energy



Pellet boiler replaces existing oil boiler

Detailed cost structures of alternatives (€/m².a)



Energy prices:

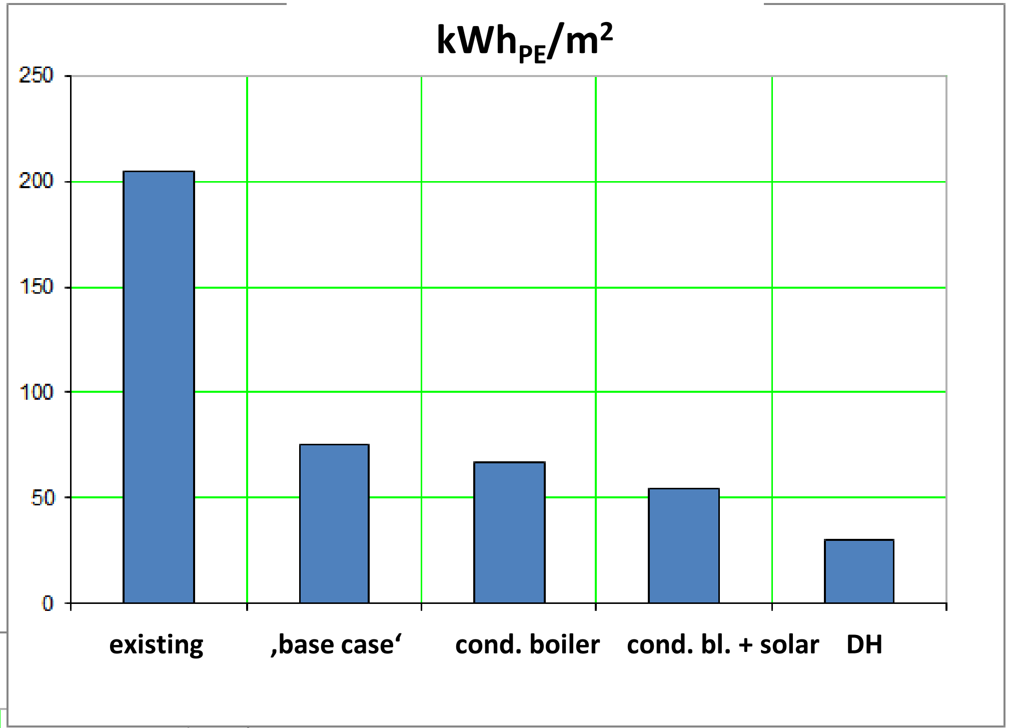
Gas 78 €/MWhHo

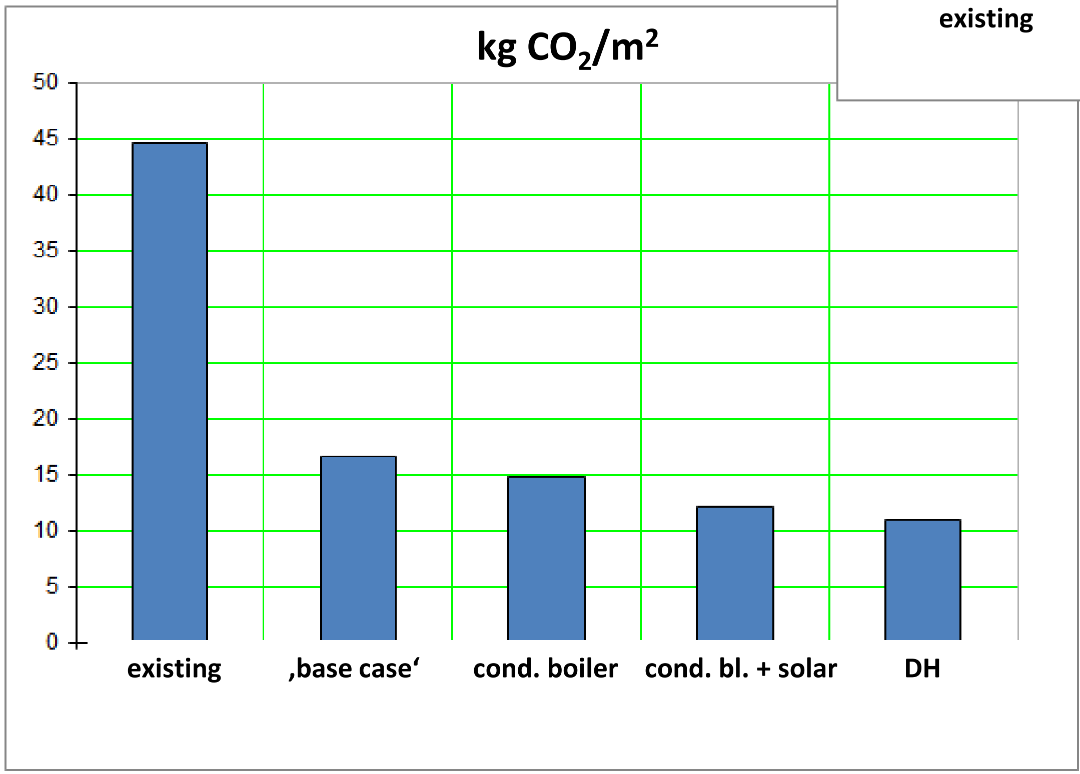
DH 90 €/MWhth

pellets 55 €/MWhHu

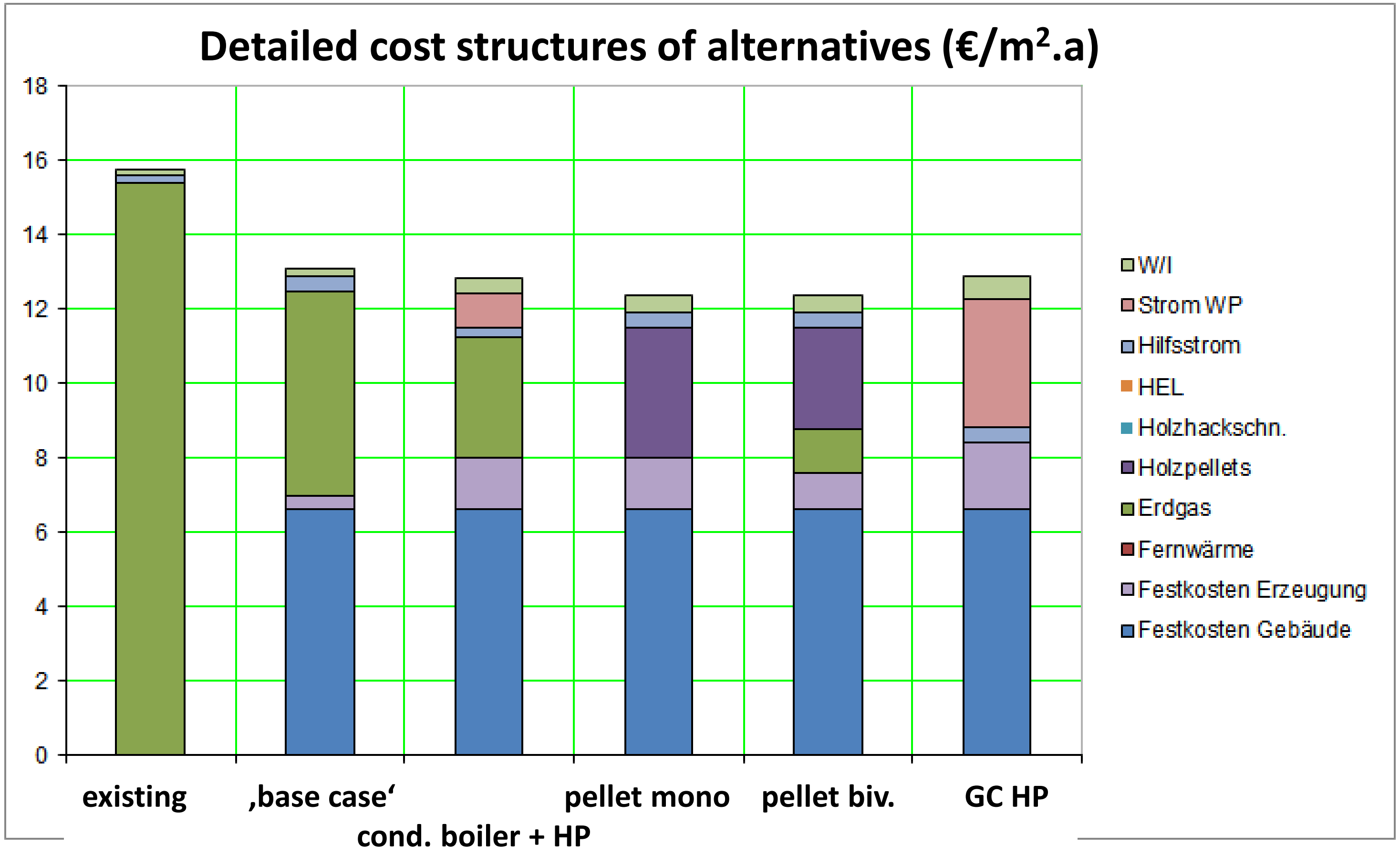
electricity 220 €/MWhel

DEROM → corresponding PE / CO_2 characteristics:

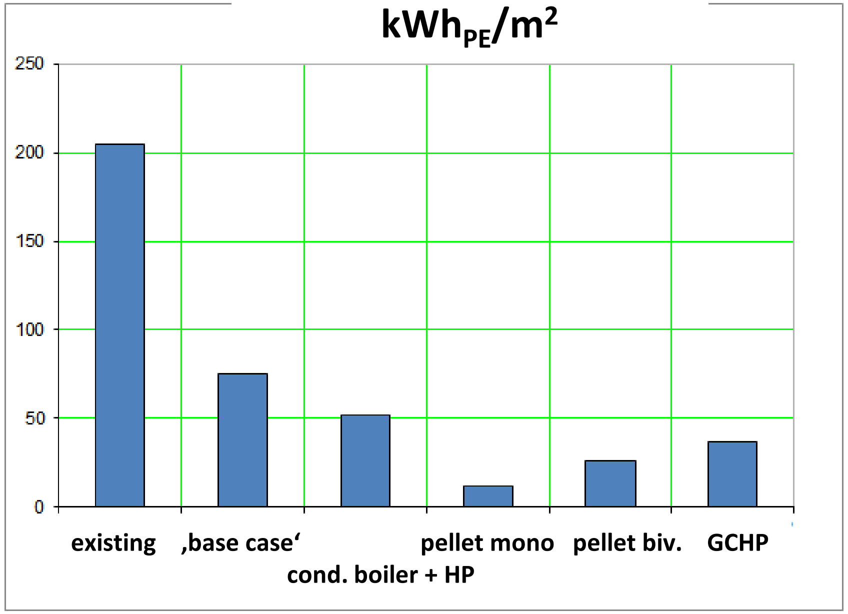


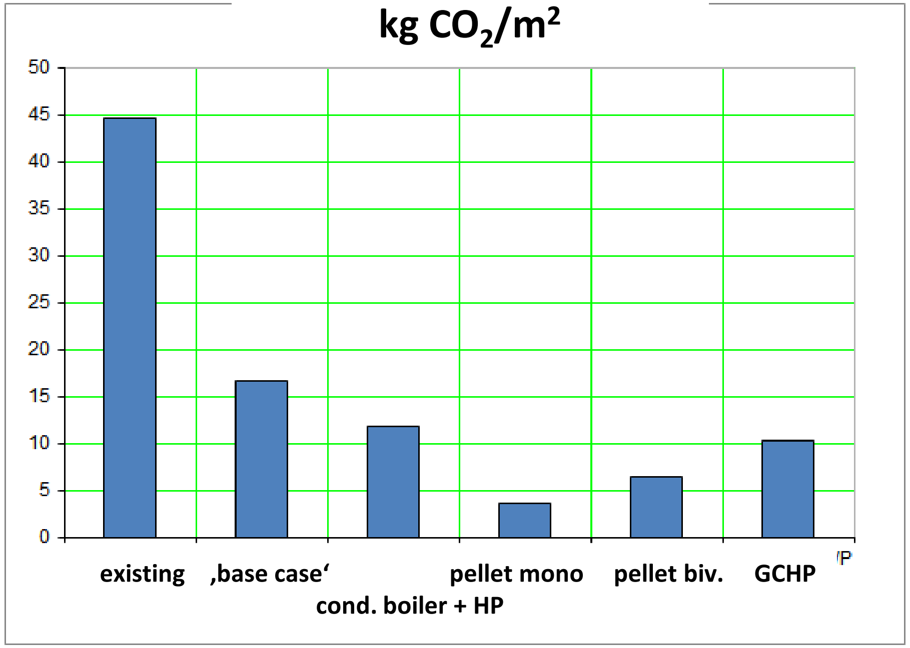


... more alternatives:



Corresponding PE / CO_2 characteristics:





DEROM key features:

- calculation method: based on conventional bldg. analysis tools
- simple input of building geometry
- built-in algorithms:
  U-values, $q_h(U_m)$, distribution losses, baseload share
- user support by default values:
  film coefficients, ventilation rate, seasonal performances,
  auxiliary energy, internal/solar gains, cost functions
- flexibility: easy input of user-defined specifications
- transparent graphical result representation
- no simulation nor design tool!
- decision making tool for *pre-planning phase*
- assessment of options based on comparison of
  - total costs
  - PE use
  - CO_2 emission

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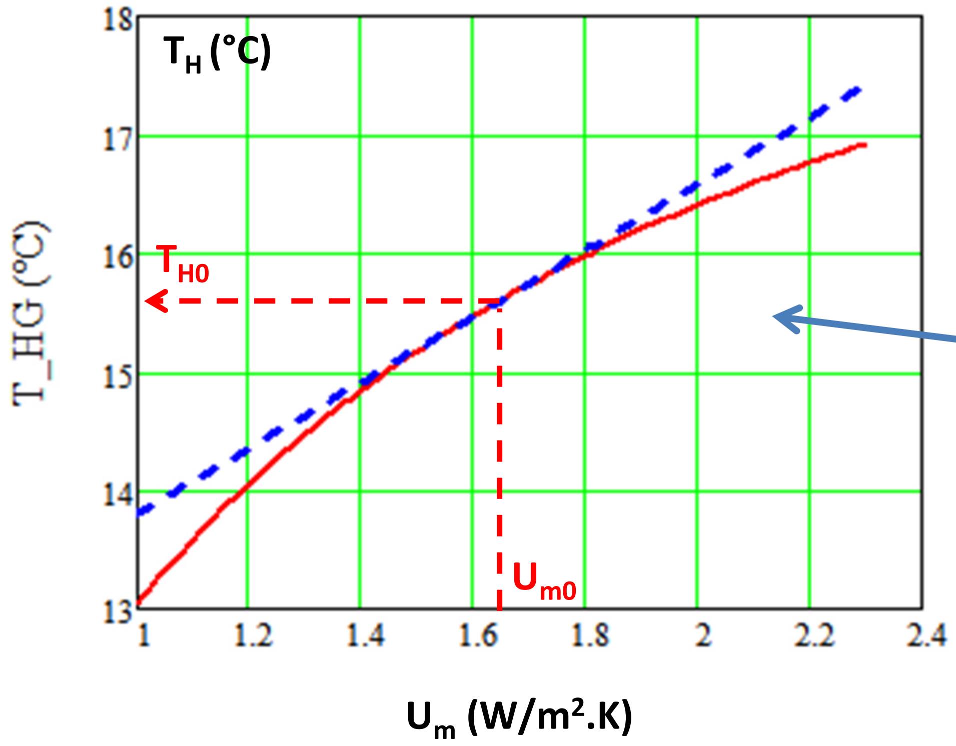
Thank you
for your attention!

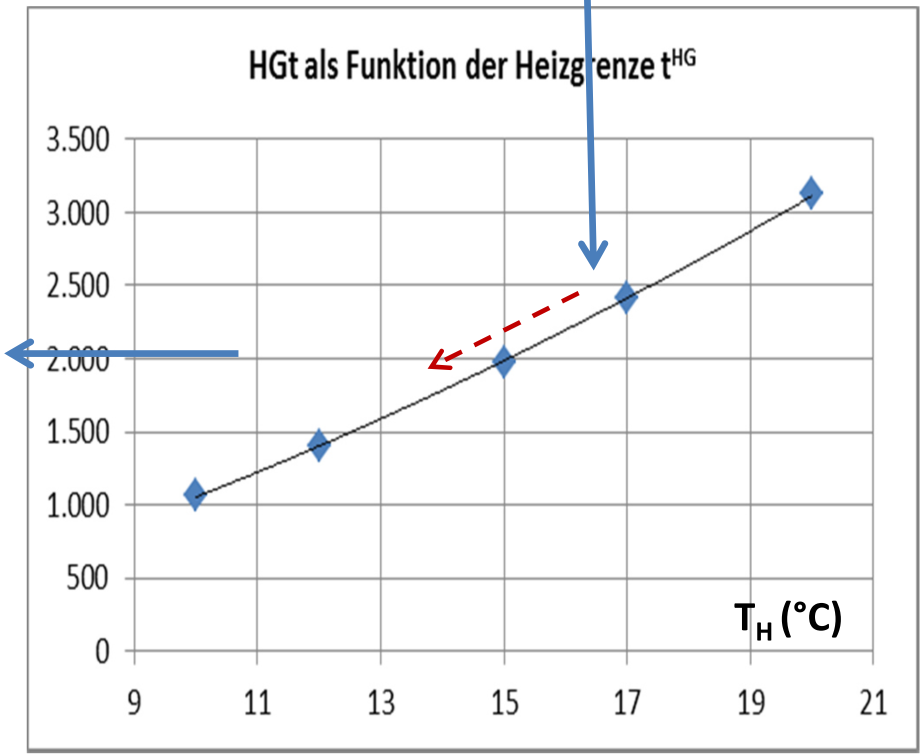


Existing building:
known T_i, T_H, U_{m0}; geometry

$$q_i + q_S = \frac{U_{m0} \cdot A_E + c_A \cdot n_V \cdot V_V}{A_{Liv}} \cdot (T_i - T_{H0})$$

$$T_H(U_m) = T_i - \frac{(q_i + q_S) \cdot A_{Liv}}{U_m \cdot A_E + c_A \cdot n_V \cdot V_V}$$

ΔU_m: → $\Delta T_H(U_m)$ → new HDD(T_H)

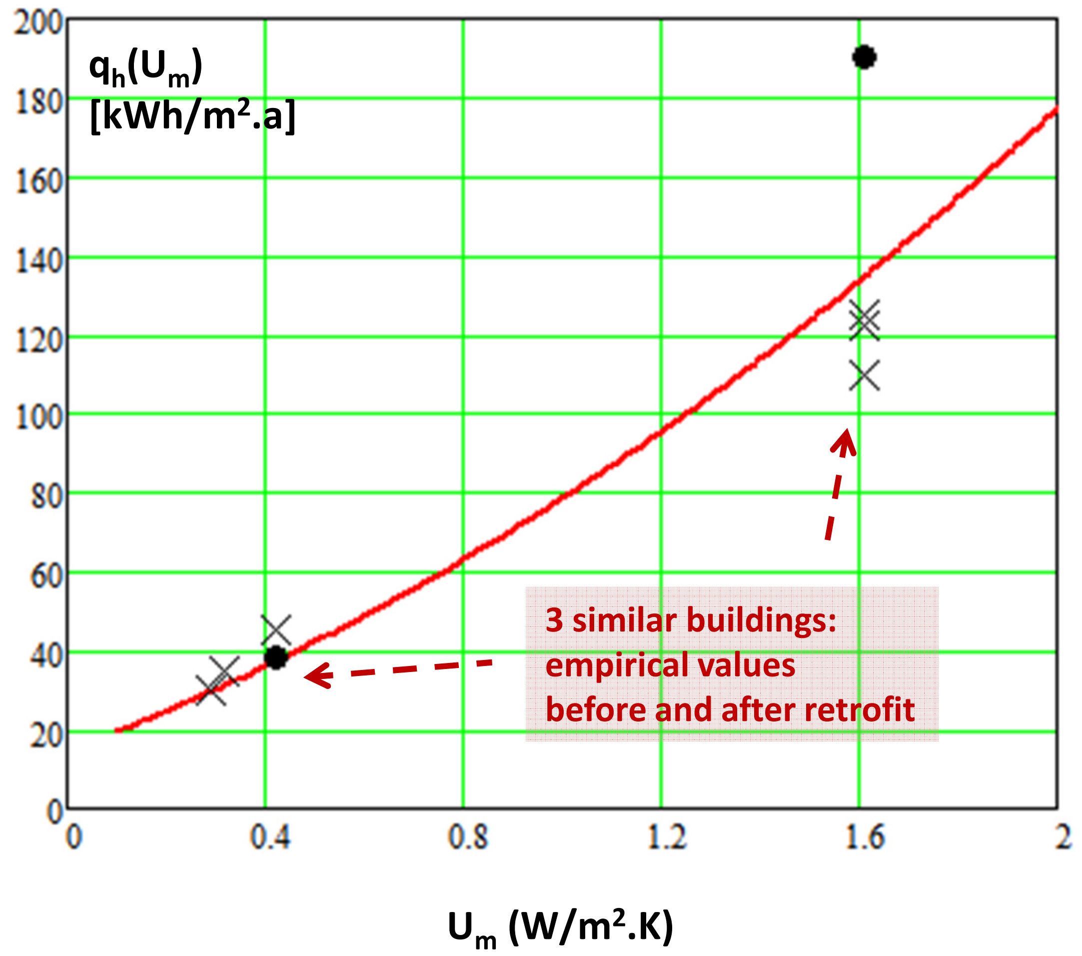


Heating demand q_h as function of U_m:

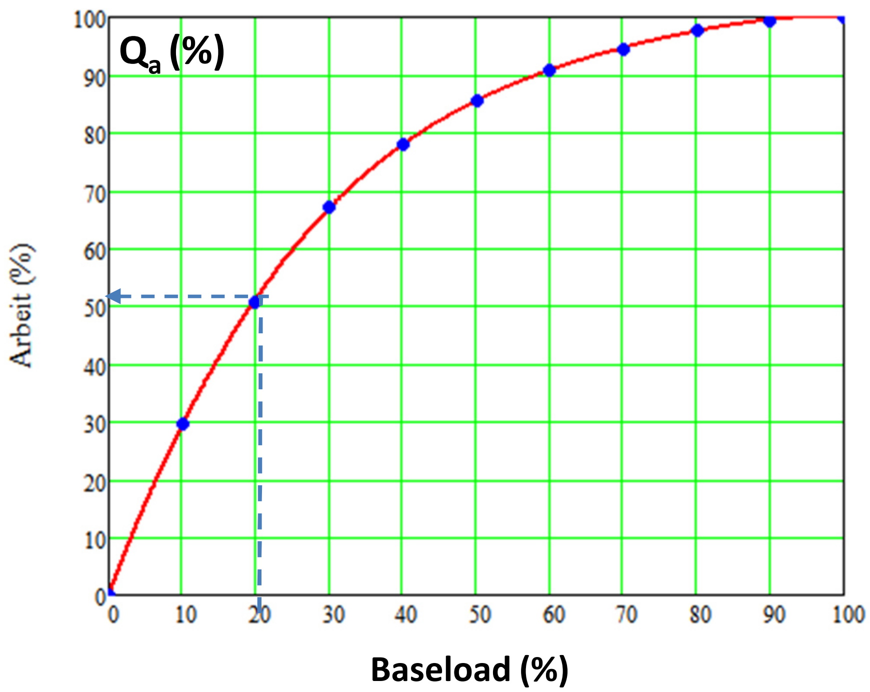
$$q_h(U_m) = \frac{24}{1000} \cdot \frac{U_m \cdot A_E + c_A \cdot n_V \cdot V_V}{A_{Liv}} \cdot HDD(U_m)$$

→ built-in algorithm to calculate $q_h(U_m)$

Resulting heating demand $q_h(U_m)$ for the projected building:



→ **built-in algorithm to determine base-load share in bivalent energy system**



Optimization of base load lay-out: