DEROM

Deep Energy Retrofit Model

Integrated Energy Analysis Tool for Building Retrofit Strategies

... entry into Subtask E neighbourhood pre-planning tool
Options for building energy retrofit:

- Insulation of envelope: how many cm?
- Windows replacement: which quality?
- Mechanical ventilation
- Distribution losses
- Supply: efficiency? Energy source?
- Energy control
- DHW: solar collectors? Heat pump?
- ......

- Cost efficiency?
- Least-cost combination?
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
DEROM:

,'Least-cost Path‘:

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

**Required:**
- investment costs \( \rightarrow \Delta c_{\text{Inv}} \)
- energy saving effects \( \rightarrow \Delta c_{\text{En}} \)
- energy prices

**Building:**
- geometry
- U-values

,**Gradient‘:** \( \frac{\Delta c_{\text{Inv}}}{\Delta c_{\text{En}}} \rightarrow \text{minimum!} \)
Example 1:
KA-Rintheim
Heilbronner Str. 27-31

before retrofit

after Retrofit
Empirical cost structure of envelope insulation: *Rintheim*

€/m² (incl. VAT)

- walls
- basement ceiling
- attic floor

(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

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

Energy costs before retrofit: 12.4 €/m².a

qₜ before retrofit: 126 kWhth/m²
'Passive Haus' strategy:

- 'PH standard': $q_h = 18 \text{ kWh/m}^2$

![Diagram showing heating costs and demand with labels for different cost categories and strategies.](image)
Result of DEROM runs: (Gas price: 80 €/MWh$_{Hu}$)

Heating demand before retrofit: 126 kWh$_{th}$/m$^2$; 12.4 €/m$^2$

<table>
<thead>
<tr>
<th></th>
<th>cost minimum</th>
<th>energy target</th>
<th>’Passiv-Haus’</th>
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<tbody>
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<td>$q_h$</td>
<td>kWh$_{th}$/m$^2$</td>
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<td>38</td>
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<tr>
<td>walls</td>
<td>cm</td>
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<tr>
<td>basement ceiling</td>
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<td>10</td>
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<td>cm</td>
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<td>ventilation</td>
<td>no</td>
<td>mech.</td>
<td>heat rec.</td>
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<tr>
<td>total costs</td>
<td>€/m$^2$.a</td>
<td>9.8</td>
<td>10.6</td>
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</tbody>
</table>

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

Total costs of thermal energy supply (€/m².a)

\[ q_{h} + q_{DHW} \text{ (kWh}_{th}/m².a) \]
Detailed cost structures of alternatives (€/m².a)

Energy prices:
- Gas: 78 €/MWhHo
- DH: 90 €/MWhth
- pellets: 55 €/MWhHu
- electricity: 220 €/MWhel
DEROM $\rightarrow$ corresponding PE / CO$_2$ characteristics:
... more alternatives:

Detailed cost structures of alternatives (€/m².a)
Corresponding PE / CO$_2$ characteristics:

- $kWh_{PE}/m^2$
- $kg CO_2/m^2$
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
Thank you for your attention!
Existing building: known $T_i$, $T_H$, $U_{m0}$; geometry

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

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

$\Delta U_m \rightarrow \Delta T_H(U_m) \rightarrow$ new HDD($T_H$)

Heating demand $q_h$ as function of $U_m$:

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

$\rightarrow$ built-in algorithm to calculate $q_h(U_m)$
Resulting heating demand $q_h(U_m)$ for the projected building:

![Graph showing the relationship between $U_m$ and $q_h(U_m)$ with empirical values for 3 similar buildings before and after retrofit.]
built-in algorithm to determine base-load share in bivalent energy system
Optimization of base load lay-out: