# LEHR

# Low Energy Housing Retrofit

FEDERAAL WETENSCHAPSBELEID

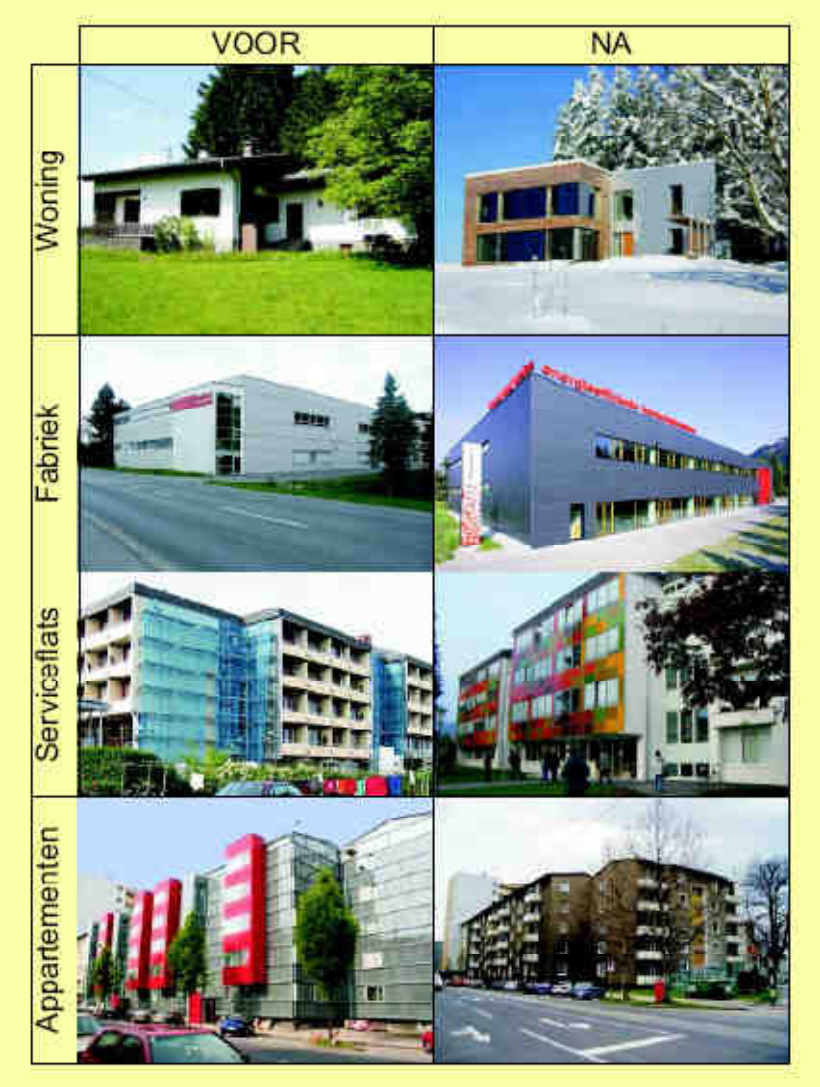
POLITIQUE SCIENTIFIQUE FEDERALE

Dit onderzoek werd uitgevoerd in het kader van het LEHR project, welke drie onderzoekteams bijeenbrengt:
Passiefhuis-Platform vzw - Plate-forme Maison Passive asbl, Architecture et Climat - UCL, WTCB.
Dit onderzoek werd uitgevoerd voor rekening van het Federaal Wetenschapsbeleid, ter uitvoering van het "Programma ter bevordering van de kennisoverdracht op strategisch belangrijke gebieden".

# LEHR – Low Energy Housing Retrofit

## CONTEXT

- 35 % van de Europese energieconsumptie = tgv gebouwde omgeving: vooral residentiële sector
- Renoveren bestaande woningen = enorm besparingspotentieel qua energie
- Voorbeelden tonen aan dat verbruik tot vijf keer kan worden verlaagd, met sterk verbeterde leefomstandigheden



# LEHR – Low Energy Housing Retrofit

## DOEL Project

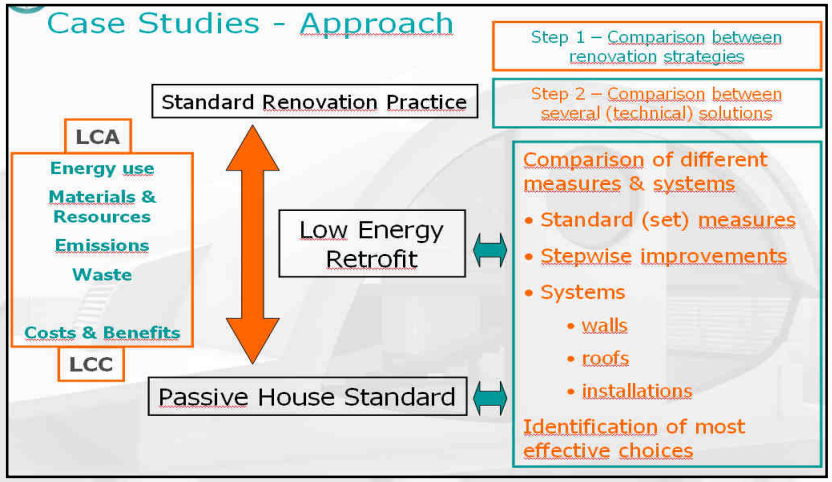
- Identificatie van succesvolle doorgedreven energetische renovaties
- Systematisch verzamelen van informatie omtrent het ontwerp, de constructie en de prestaties van deze renovaties
- Publiceren van de projecten : bouwheren en ontwerpers
- www.lehr.be

# LEHR – Low Energy Housing Retrofit

## ❖ DELIVERABLES

- ❖ Fundamentele onderzoekswerk => gerichte communicatie naar specifieke doelgroepen
- ❖ Via gedrukte publicaties, via de sites van de partners en via een workshop.
- ❖ Drie kernpublicaties van het project:
  - Een publicatie toont eigenaars het ABC van de zeer energiezuinige, duurzame renovatie (UCL)
  - Een technische voorlichtingsnota toont voor de bouwsector aan hoe deze succesvolle zeer lage energierenovaties kunnen worden bereikt (WTCB)
  - Een publicatie deelt met planners de inzichten, verworven bij de studie van essentiële voorbeeldprojecten (PHP)

# Objectives LCC/LCA




- Get a clear insight in the cost structure of renovation projects
- Identify economic efficient measures & viable concepts
- Study the influence (and variation) of parameters (VAT, primes, cost data, …)
- Common methodology for economic evaluation
- Study environmental impact of renovation measures

# LEHR – Low Energy Housing Retrofit

Stap 1 – Vergelijken Renovatie-strategieën

Stap 2 – Vergelijken van verschillende technische oplossingen

Standaardrenovatie

**LCA**

**Energieverbruik**

**Materialen**

**Emissies**

**Afval**

**Kosten en baten**

**LCC**

Laag-Energie Renovatie

Vergelijken van technische oplossingen:

- Standaardmaatregelen
- Stapsgewijze verbetering
  - Muren – Vloeren – Daken
  - Systemen
- Identificatie optimale niveau

Passiefhuisstandaard

Nieuwbouw

# Approach

- Literature review
  - Guidance on cost calculation
  - Existing study work on cost efficiency and environmental impact of energy saving renovation measures & existing case studies
- Practical work by studying case studies
  - Detailed study of cost structure and environmental impact
  - Comparison of alternatives
- General conclusions & recommendations

# Literature Review - Guidance on cost calculation

- Existing standardisation documents
  - ISO 15686-5 – Buildings and construction assets – Service-life planning – part 5: Life Cycle Costing (2008)
  - NBN EN 15459 – Energy Efficiency in Buildings – Standard economic evaluation procedure for energy systems in buildings (2008)
  - EU – Life cycle costing (LCC) as a contribution to sustainable construction: a common methodology – DLMC for EU DG Enterprises & Construction (2007)
  - Energy Concept Evaluation based on Life Cycle Costs (IEA Annex 48, 2007)

# Literature review – Existing study work

- Reviewed
  - Cost-effective climate protection in the EU Building Stock (Ecofys for Eurima, 2005)
  - Wirtschaftlichkeid von Wärmedämm-MaBnahmen im Gebäudebestand (PHI for GDI, 2005)
  - Optimisation of Extremely Low Energy Residential Buildings (G. Verbeeck, 2007) + additional studies (with 3E)
  - Optimisation of Insulation measures on existing buildings (S.I. Gustafson, 2000)
  - The Economic Efficiency of Passive-Houses (E. Jordan, 2007)
  - Economic analysis of passive houses and low energy houses compared to standard houses (A. Audenaert et.al., 2008)
  - Total cost analysis for passive houses (A. Versele et.al., 2008)
  - L'application de principes de la maison passive en region de Bruxelles-Capitale (CERAA for IRSIB & IBGE, 2008)
  - Analyse economique d'une maison passive existante (F. Renard et al, 2008)
  - …

# Literature review – Existing study work

- Scope
  - Evaluating cost efficiency of investing in energy saving measures
  - Comparing different concepts (ambition levels) in terms of cost/benefit
- Methodology
  - Calculation of a 'life cycle cost'
    - €/m² for individual measures (in total or yearly)
    - Total cost over certain time for concepts

# Literature review – Existing study work

- Evaluation criterion
  - Net Present Value & Total Present Value
  - Annual Cost/Saving
  - Static or Dynamic Payback Time (yearly savings due to investment)
  - Rate of return
  - Investment cost per saved kWh (independent of energy prices)
  - Impact on family budget (cash flow) due to loan – comparing to saving on the bank
  - CO2 mitigation costs, discomfort costs, …

# Literature review – Existing study work

- Methodology
  - Cost Breakdown Structure
    - Investment cost: €/m², with inclusion/exclusion of 'energy relevant part', 'rest value'
    - Energy cost: based on building evaluation or on ΔU & HDH and a certain cost for energy
    - Maintenance & replacement costs: sometimes included, mostly excluded (due to similar in different scenarios)
    - Financial incentives: can play an important role

# Literature review – Existing study work

- Methodology
  - Cost Breakdown Structure
    - Investment cost: €/m², with

| | BTV | NEH40 | PH | PH+K |
|---|---|---|---|---|
| **Production cost** | 260.400 | 279.600 | 296.400 | 302.400 |
| **Governmental subsidies** | - | 37.800 | 56.220 | 57.720 |
| **Remaining financial requirements** | 260.400 | 241.800 | 240.180 | 244.680 |
| | | | | |
| **Production costs p.a.** | 18.122 | 17.584 | 17.839 | 18.152 |
| **Energy costs p.a.** | 934 | 611 | 199 | 159 |
| **System costs p.a.** | 598 | 623 | 788 | 903 |
| | | | | |
| **Total annual expenses** | 19.654 | 18.818 | 18.826 | 19.214 |

y relevant part',

ng evaluation or

ost for energy

costs: sometimes

ue to similar in

    - Financial incentives: can play an important role

# Literature review – Existing study work

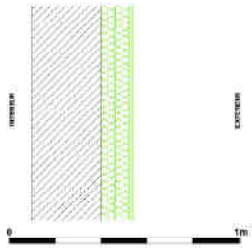
- Data used
  - Analysis period:
    - 20 – 25 – 30 - 40 years : '1 generation'
  - Interest rate:
    - 3.5 – 6 %
  - Energy prices:
    - European average prices
    - Real consumption data
    - Average national data
  - Energy cost evolution:
    - From +1.5%/year to +15%/year (scenarios)
    - Based on studies, based on historic data, …
  - Cost data:
    - Based on real offers of contractors
    - Reference works
    - Expert values
    - National standards

# Literature review – Existing study work

## ❖ External Wall Insulation

- E-Retrofit Kit: External insulation + Plaster: 79-134 €/m² wall
- PHI: External insulation + Plaster: 73 €/m²
- CERAA – BXL

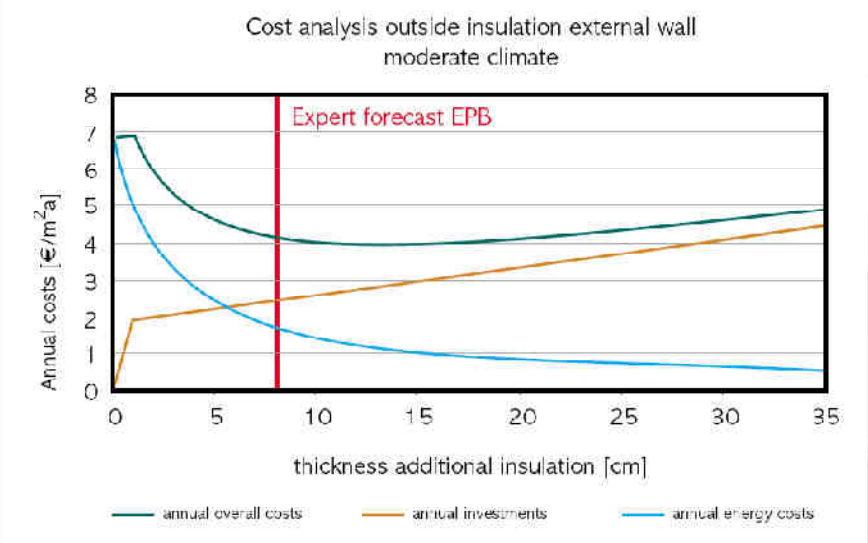
Niveau Basse Energie – mur extérieur - U = 0,3 W / m² . K – Isolation par l'extérieur



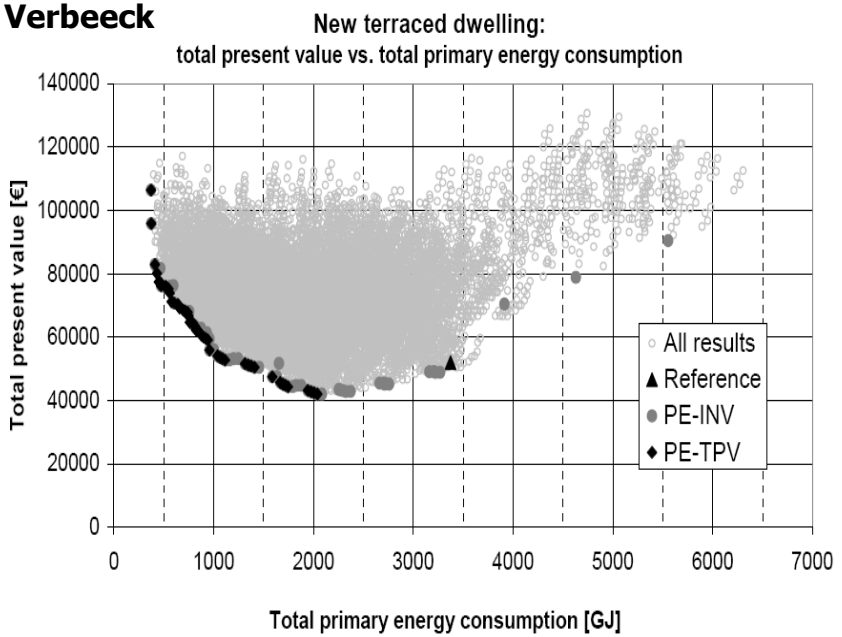
| Composition : | | Composition : | | Composition : | |
|---|---|---|---|---|---|
| - 13cm de panneaux de laine de roche (λ=0,041W/m.K) ; | | - 12cm de polystyrène expansé (λ=0,040W/m.K) ; | | - 12cm de fibre de bois (λ=0,038W/m.K) ; | |
| - Crépis. | | - Crépis. | | - Crépis. | |
| Energie grise estimée : | 97 kWh / m² | Energie grise estimée : | 168 kWh / m² | Energie grise estimée : | 24 kWh / m² |
| Coût fourniture HTVA[26] | 63,00€ / m² | Coût fourniture HTVA[27] | 40,00€ / m² | Coût fourniture HTVA | 58,39€ / m² |
| - 13cm de panneaux de laine de roche | / | - 12cm de polystyrène expansé | / | - 12cm de fibre de bois[28] | 49,80€ / m² |
| - Crépis.et armature | / | - Crépis. et armature | / | - Crépis. et armature | 8,59€ / m² |

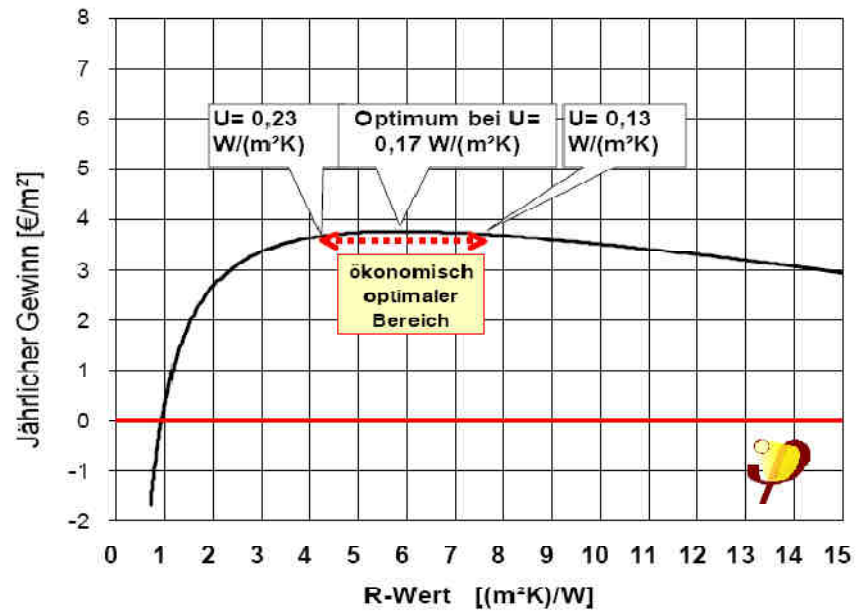
- EcoFys: ± 92 €/m² (42 €/m² energy relevant)
- Bouwinfo: 90-125 €/m² (12-14 cm EPS)

# Literature review – Existing study work




**G. Verbeeck**




*The economic optimum*

- *K25-30 (Umean = 0.3-0.4 W/m²K for compactness of 1.5-2).*
- *high efficiency or condensing boiler on gas or fuel, natural ventilation system*

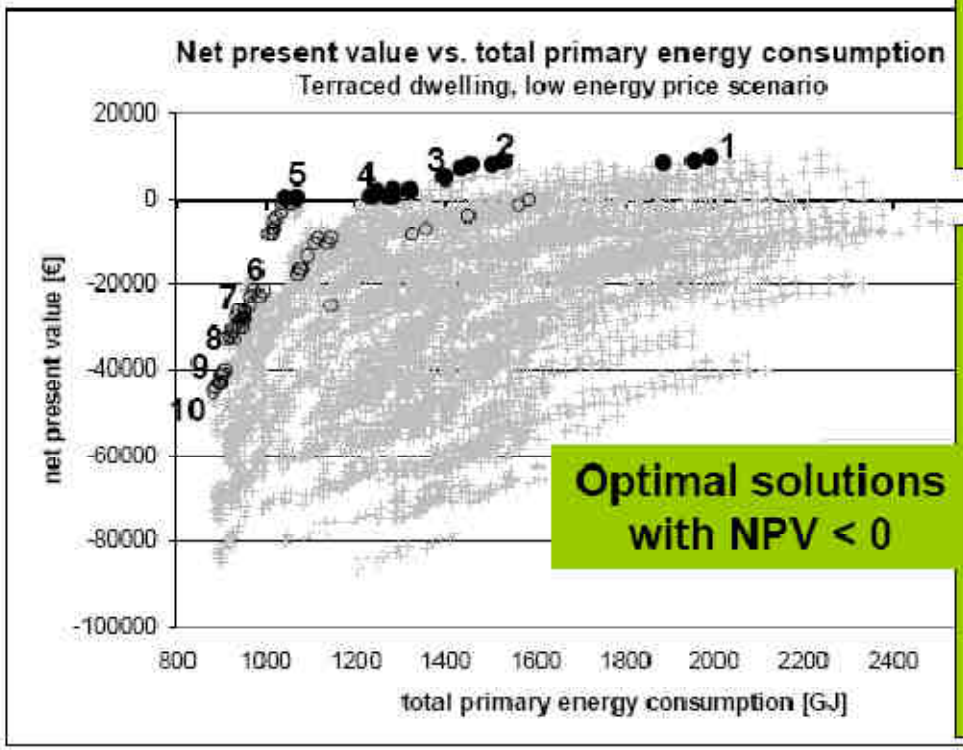
*Further than optimum:*

- *mechanical ventilation system with a good performing heat recovery unit or an air-to-water heat pump*
- *better insulation level (K15-20), a heat pump and with mechanical ventilation with heat recovery*

# ELEP2 - Optimisation of Extremely Low Energy Residential Buildings – Phd Griet Verbeeck

## Reference situation for terraced dwelling:

- total primary energy consumption over 30 years ≈ **3700 GJ**
- annual energy cost ≈ **1600€**
- K107 / E146




**Optimal solutions with NPV > 0**

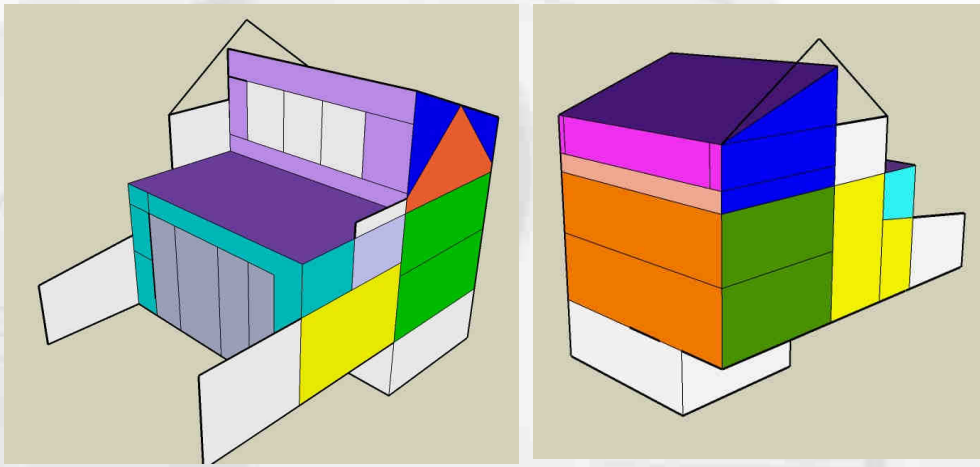
1. U = 0.36W/m²K (K30) + HE-boiler + natural ventilation
2. U = 0.34W/m²K (K25) + good airtightness
3. K25 + condensing boiler
4. K25 + air/water heat pump
5. K25 + HE-boiler + mechanical ventilation with heat recovery

**Optimal solutions with NPV < 0**

6. U = 0.28W/m²K (K21) + HE-boiler + ventilation with heat recovery
7. U = 0.20W/m²K (K15) + idem
8. K15 + condensing boiler
9. K21 + soil/water heat pump
10. K15 + cogeneration of heat and power

# Practical work – Case studies

- CASE EUPEN – Row house
  - As build (Passive House Renovation)
    - E26-K17
  - Low energy renovation
    - E60-K33
    - E40-K30
  - Standard renovation
    - E87-K44



- Based on PHPP-file
- **Alternatives to be put in accordance with Technical Guideline**
- **Prices & cost data: to be double-checked: practice vs. reference data**

# Practical work – Case studies

- Development of evaluation tool
  - Scope - Indicators
    - Comparison of concepts: Total Present Value
    - Comparison of components: €/m² or €/kWh
  - Cost Breakdown Structure
    - Investment cost (energy relevant, VAT, DIY, primes, …)
    - Energy cost (EPB/PHPP)
    - Replacement & Maintenance cost (install.)
    - Rest values included or not? Resale Value ?
    - Externalities / other costs ?

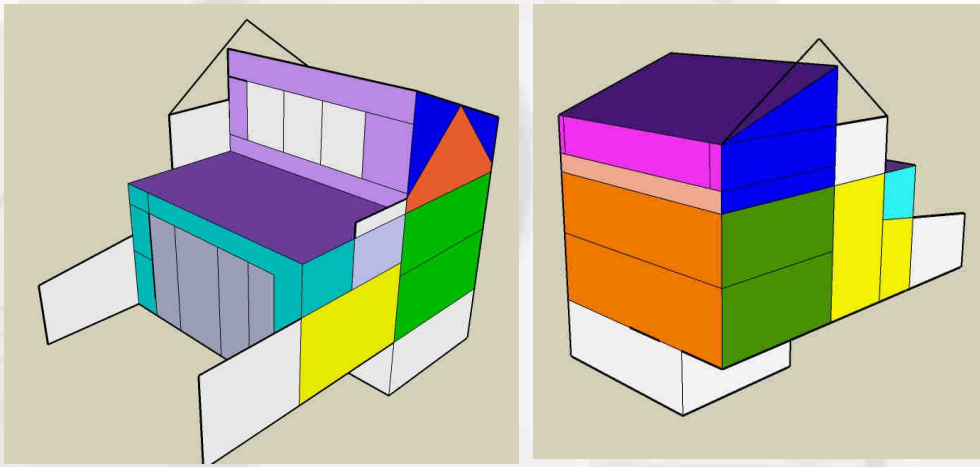
# Practical work – Case studies

- Data used
  - 30 years, 5% (+ correction for inflation)
  - Energy prices (market, per kWh)
  - Energy price evolution: +3.2% & +4.3% (above inflation) - different scenarios
  - DATABASE in progress – focus on RENOVATION cost data (extra & hidden)

  - Transparency
  - Sensitivity analysis
  - Variability – non-deterministic

# Practical work – Case studies

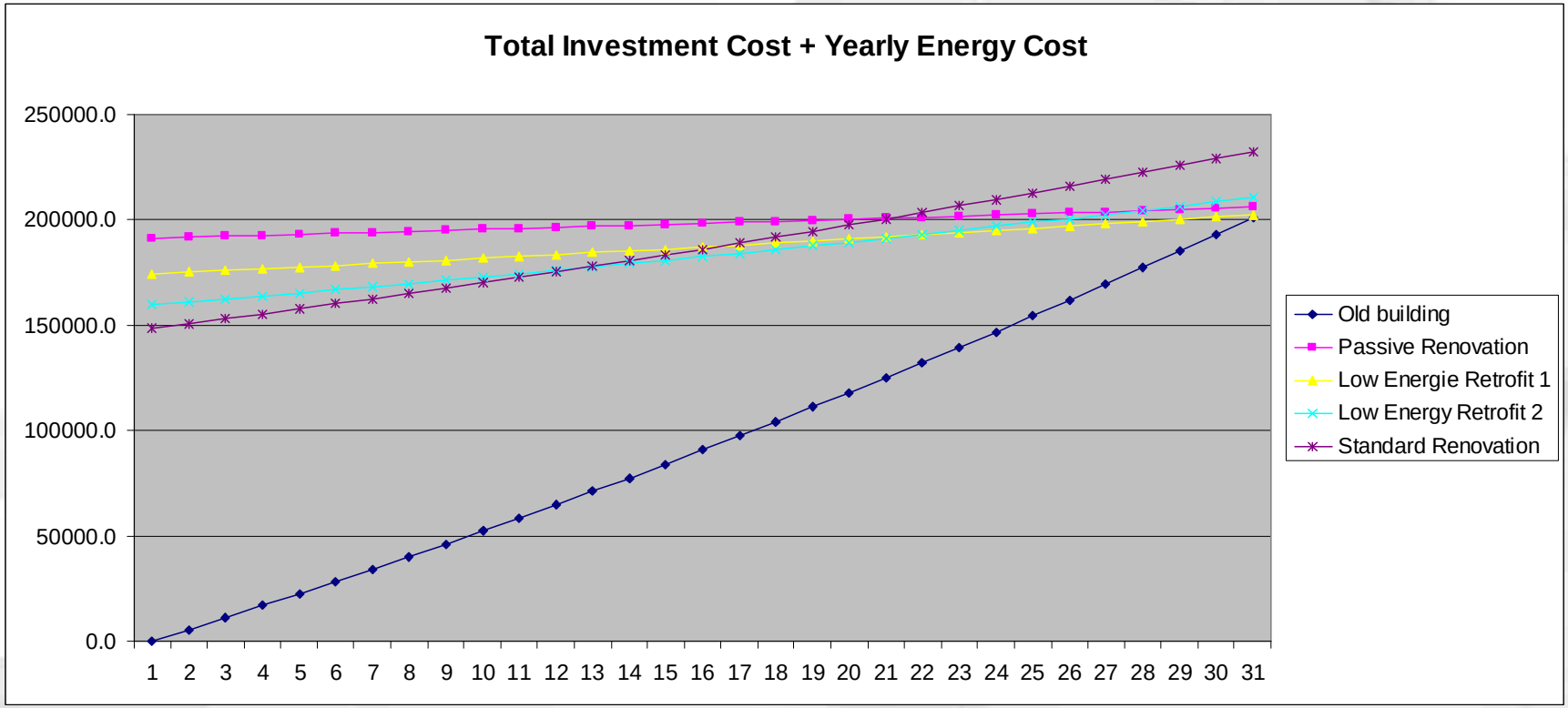
- CASE EUPEN – Row house
  - As build (Passive House Renovation)
    - E26-K17
  - Low energy renovation
    - E60-K33
    - E40-K30
  - Standard renovation
    - E87-K44



- Based on PHPP-file
- **Alternatives to be put in accordance with Technical Guideline**
- **Prices & cost data: to be double-checked: practice vs. reference data**

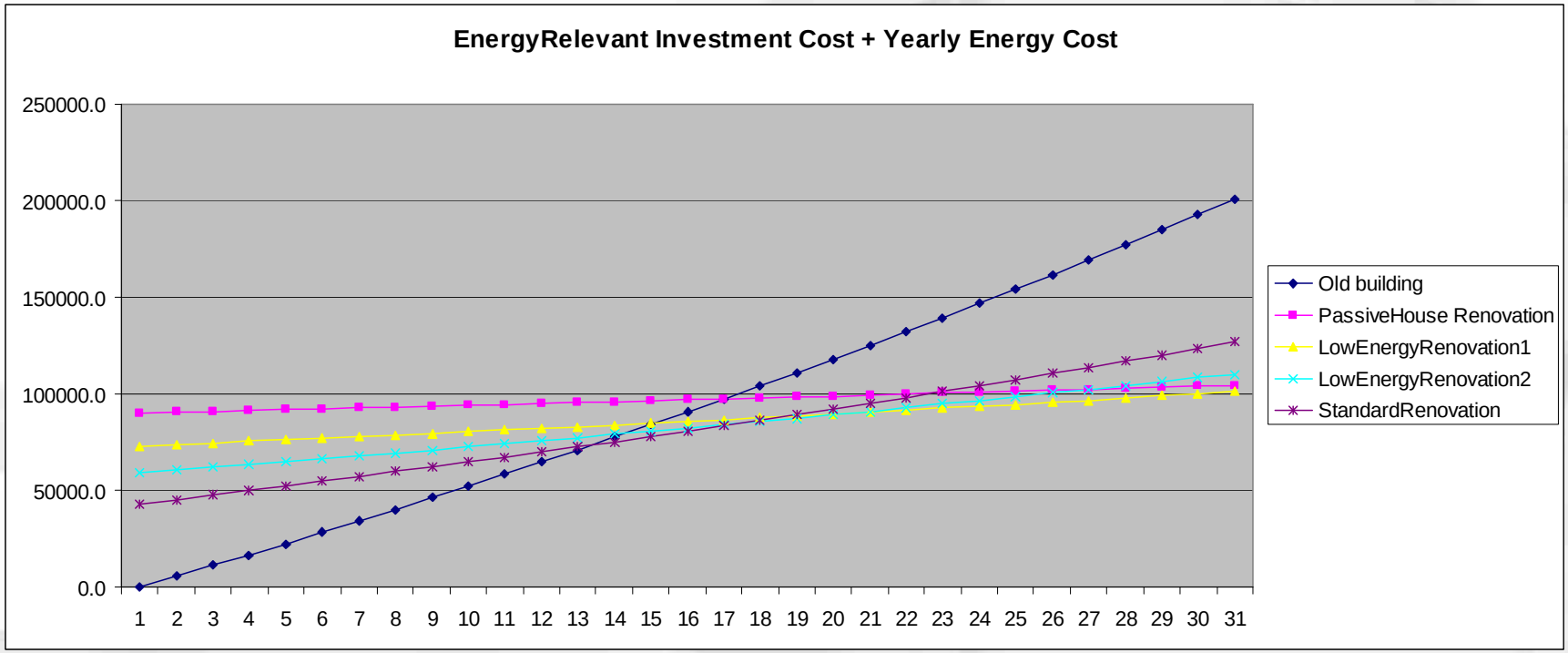
# Practical work – Case studies

**! Preliminary results !**



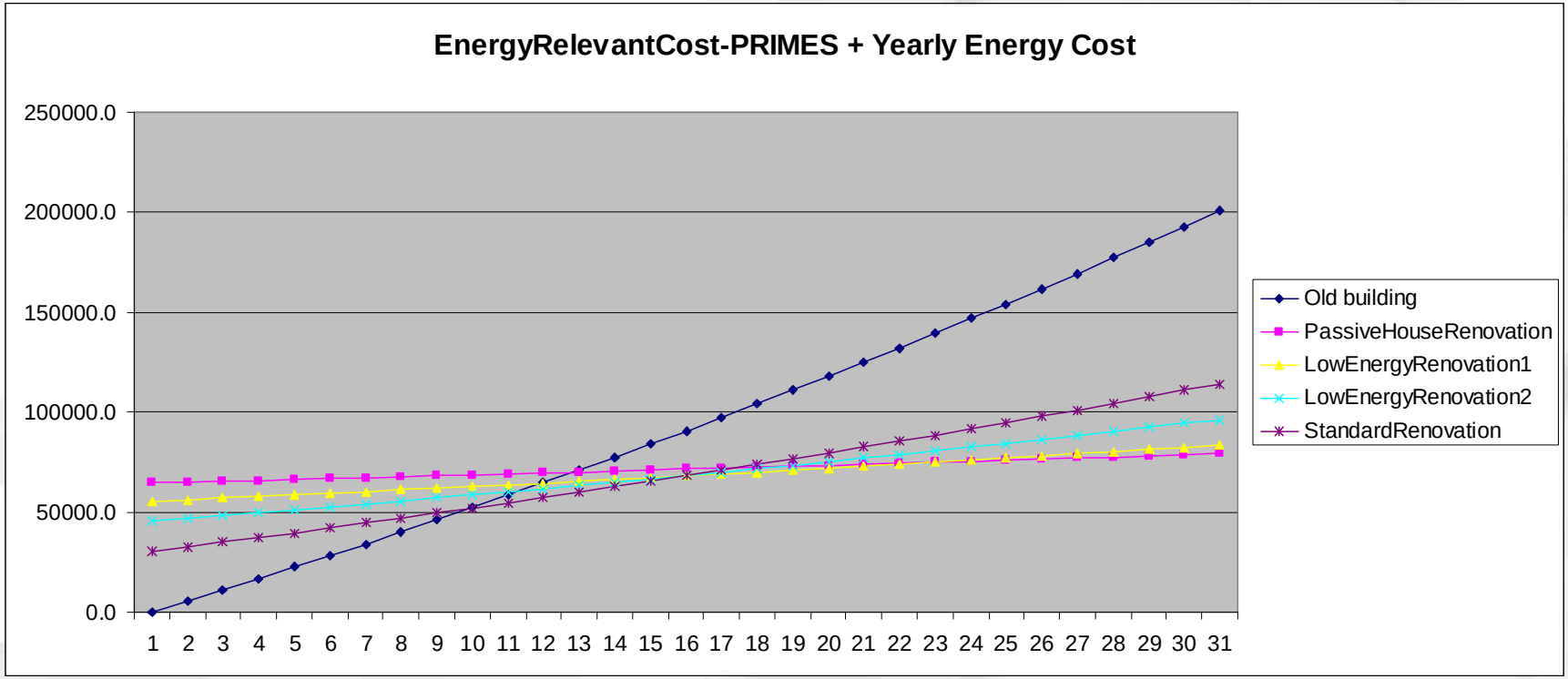
# Practical work – Case studies

**! Preliminary results !**



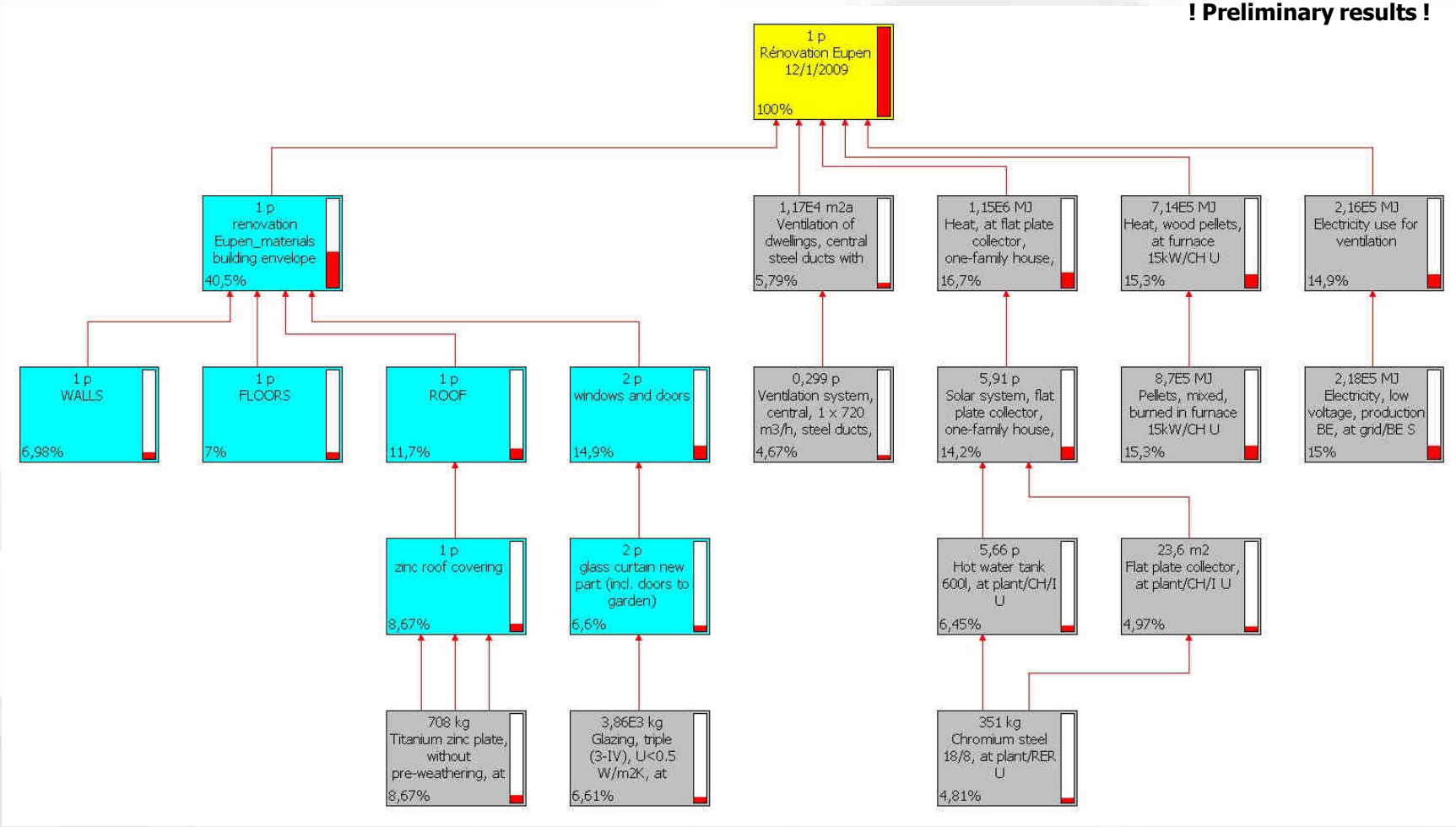
# Practical work – Case studies

**! Preliminary results !**



# Case studies
# Environmental impact assessment

**! Preliminary results !**




Single score - EcoEndicator 99 H **– Renovation to PH Standard of a row house**

# Conclusions on literature review

- Individual energy saving measures
  - = cost effective, good payback time (< 10y)
  - Cost efficiency increases when:
    - There was no energy efficient building component before: The higher ΔU, the better the economical profit
    - Energy saving measures are combined with other renovation measures (finishings, …)
    - A Rest Value is taken into account for insulation
  - Optimal curve (thickness – cost saving) is FLAT : wide range of optima
  - Optimal insulation level: 7-17 cm

# Conclusions on literature review

- Comparison of concepts with different ambition level
  - Conclusions are similar, despite the differences in methodology & data
  - the 'low energy concept' is considered more cost efficient than 'extremely low energy' or 'passive house' standard due to the elevated investment costs
  - Passive housing becomes the most interesting when energy prices would raise 10%/y
  - The optimum insulation level : between K25 & K35

WTCB

# Technologische dienstverlening duurzaam bouwen en duurzame ontwikkeling in het Brussels Hoofdstedelijk Gewest

**Prioritaire thema's :**

- Energieprestatie van gebouwen
- Rationeel watergebruik
- Akoestisch comfort
- Gevelrenovatie
- Toegankelijkheid en aanpasbaarheid

**Missie :**

- Directe technologische ondersteuning
- Vorming en informatie
- Marktverkenning, verspreiding en innovatiestimulering

**Doelgroep :**

Alle Brusselse ondernemingen actief in de bouwsector





Met de samenwerking van de Confederatie Bouw Brussel Hoofdstad

Met de steun van IWOIB

IWOIB
Instituut ter bevordering van het Wetenschappelijk Onderzoek en de Innovatie van Brussel

Lombardstraat 42
B-1000 Brussel

info@bbri.be
www.wtcb.be

+32 (0)2 655 77 11
+32 (0)2 653 07 29