IEA EBC Annex 56
Cost-effective energy and carbon emission optimization in building renovation
EBC

Int. Sustainable Building Conference 2013, Graz, 26 September 2013

Finding the Balance between Measures Reducing Energy Demand and Measures Based on Renewable Energy Sources in Building Renovation

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Background and context

- Research done in the framework of Annex 56 of IEA EBC (Energy in Buildings and Communities) Programme:
  - *«Cost effective energy and carbon emissions optimized building renovation»*
- Eracobuild project INSPIRE:
  - *«Integrated strategies and policy instruments for retrofitting buildings to reduce primary energy use and GHG emissions»*
  - Adaption of calculation tool developed within Eracobuild project INSPIRE for generic calculations within IEA Annex 56

Acknowledgments

- Research is financially supported by the Swiss Federal Office of Energy

- Data on reference buildings and national framework conditions were collected by Annex 56 collaborators from AT, DK, NO, PT and CH

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Introduction

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- Until now, standards and regulations focus mainly on energy efficiency and are primarily designed for new buildings
- However, renewable energies might achieve environmental objectives more cost-effectively, especially in the case of building renovation

➔ **Goal**: To explore the effects and find the balance between energy efficiency and RES-measures which optimizes ecological benefits, taking into account costs

➔ Investigation by modelling renovation packages to determine their impacts on costs, reduction of carbon emissions and reduction of primary energy consumption

Methodology of impact assessment (1)

- **Energy assessment:**
  - Primary energy consumption, based on consumption of energy carriers, national primary energy conversion factors and output of renewable energy systems on site
  - Possibility to include embodied energy use
- **Economic assessment:**
  - Dynamic economic assessment (annuity method)
  - Based on real prices and interest rates
  - Increasing future energy prices: +30% till 2050
  - Real interest rate: 3%/a

Methodology of impact assessment (2)

- **Economic and ecological impacts of energy related renovation measures:**
  - Determined by comparison with a non energy related building renovation option for the same building, called «anyway renovation»
  - **Anyway renovation**: Restores full functionality of the building for the next period of use (15-30 years)
  - Comparison with existing building without any refurbishment is economically not adequate: Costs of anyway upcoming renovation need to be included to have an equal situation regarding building functionality

Inputs for generic calculations

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1 typical SFH & 1 MFH (per country)

Inputs (per country)

	Austria	Denmark	Norway	Portugal	Switzerland
Generic building characteristics					
Climate conditions					
Energy prices	Ø real prices 2010–2050 Default increase: +30% until 2050				
Emission factors of energy carriers **Primary energy conversion factors**					
Costs for renovation measures	Life cycle costs on a yearly basis real costs, real interest rates				
Embodied emissions per measure					
Embodied primary energy consumption					

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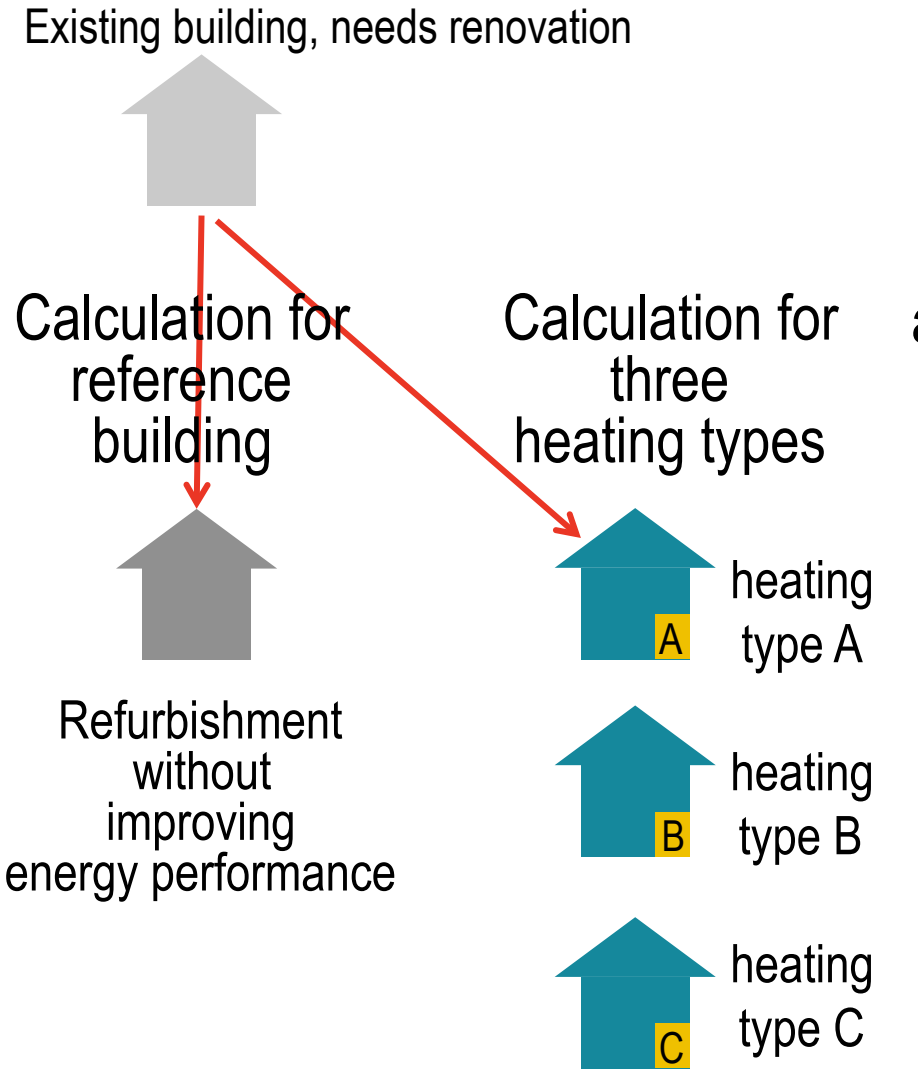
Calculation procedure



and nine renovation packages (M1 to M9)

M1	M2	M3	M4	M5	M6	M7	M8	M9

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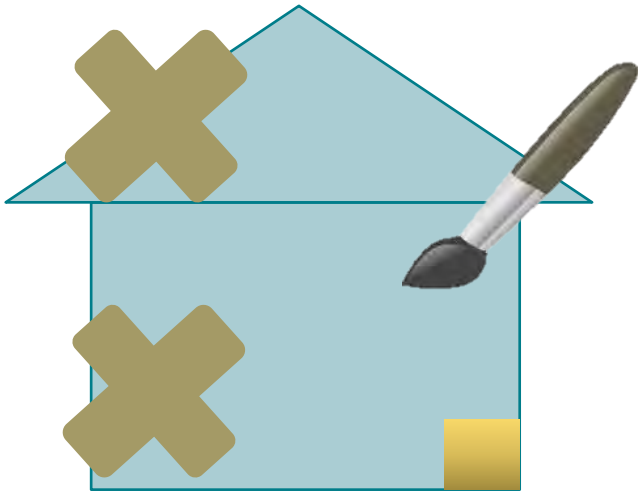
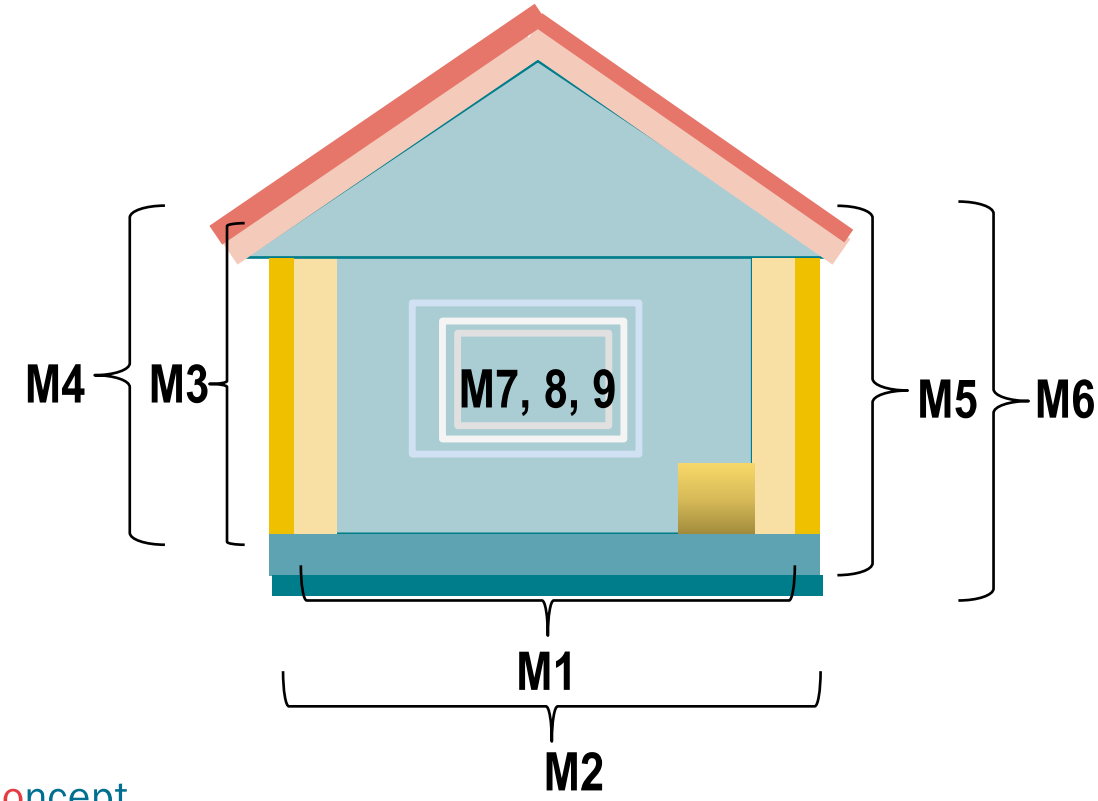
Switzerland: Reference refurbishment and renovation packages M1 to M9

Reference case:
non energetic refurbishment
with new oil heating system



New painting, new oil boiler
repair of roof, replacement of tiles

Nine renovation packages (M1 to M9)
for three heating types: Oil, geothermal heat pump, wood pellets heating



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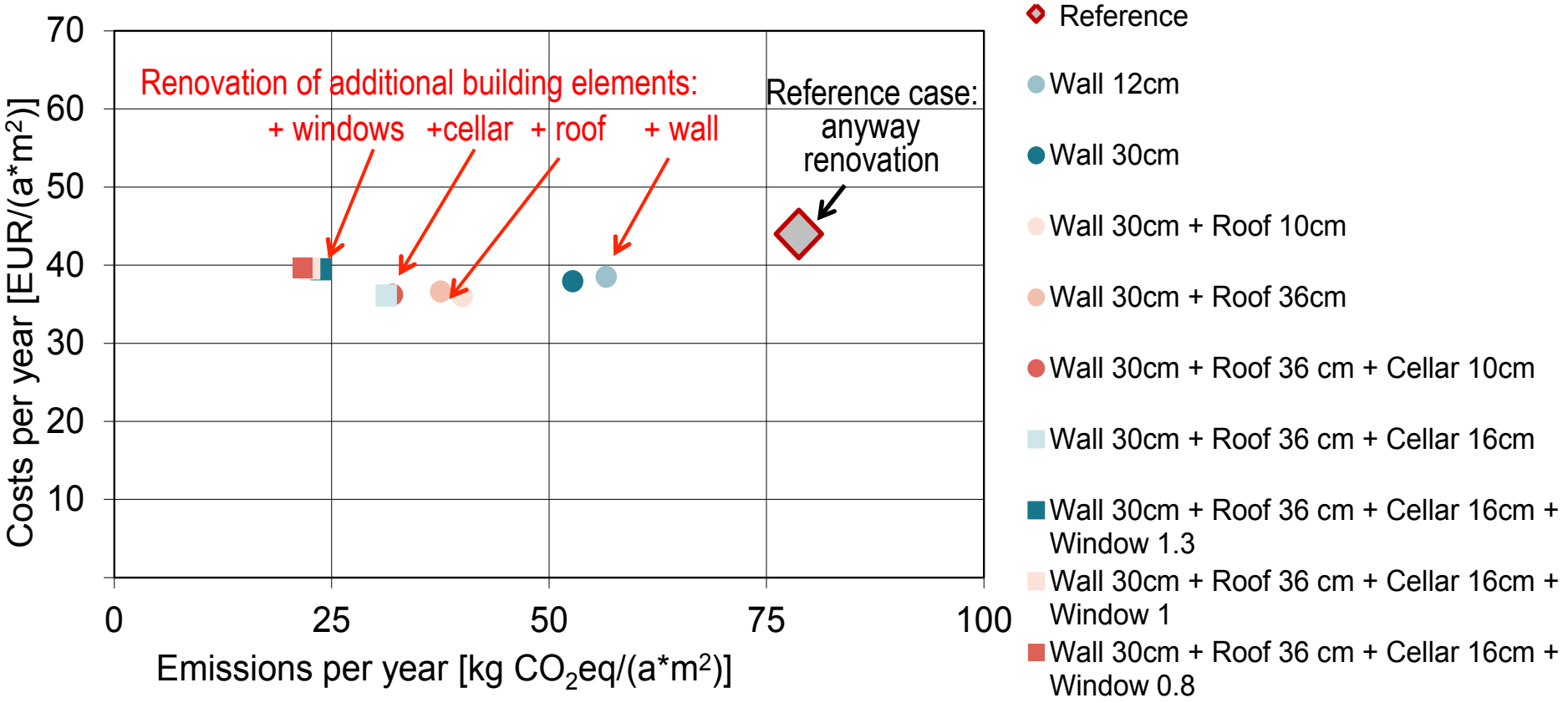
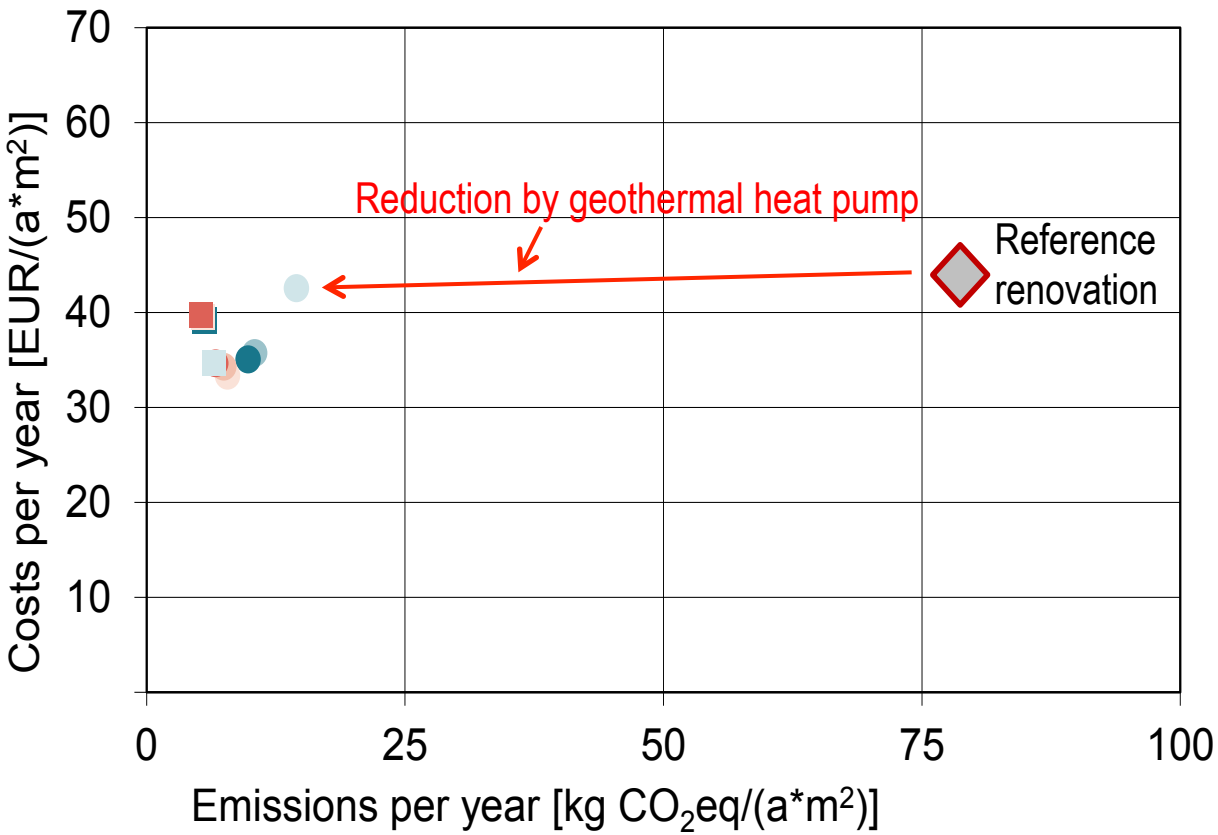
Effects on emissions: Oil heating system



Costs: Yearly life cycle costs for energy related measures +energy + maintenance

- Big steps when additional building element included in the package
- Additional thickness of insulation yields only little additional effect

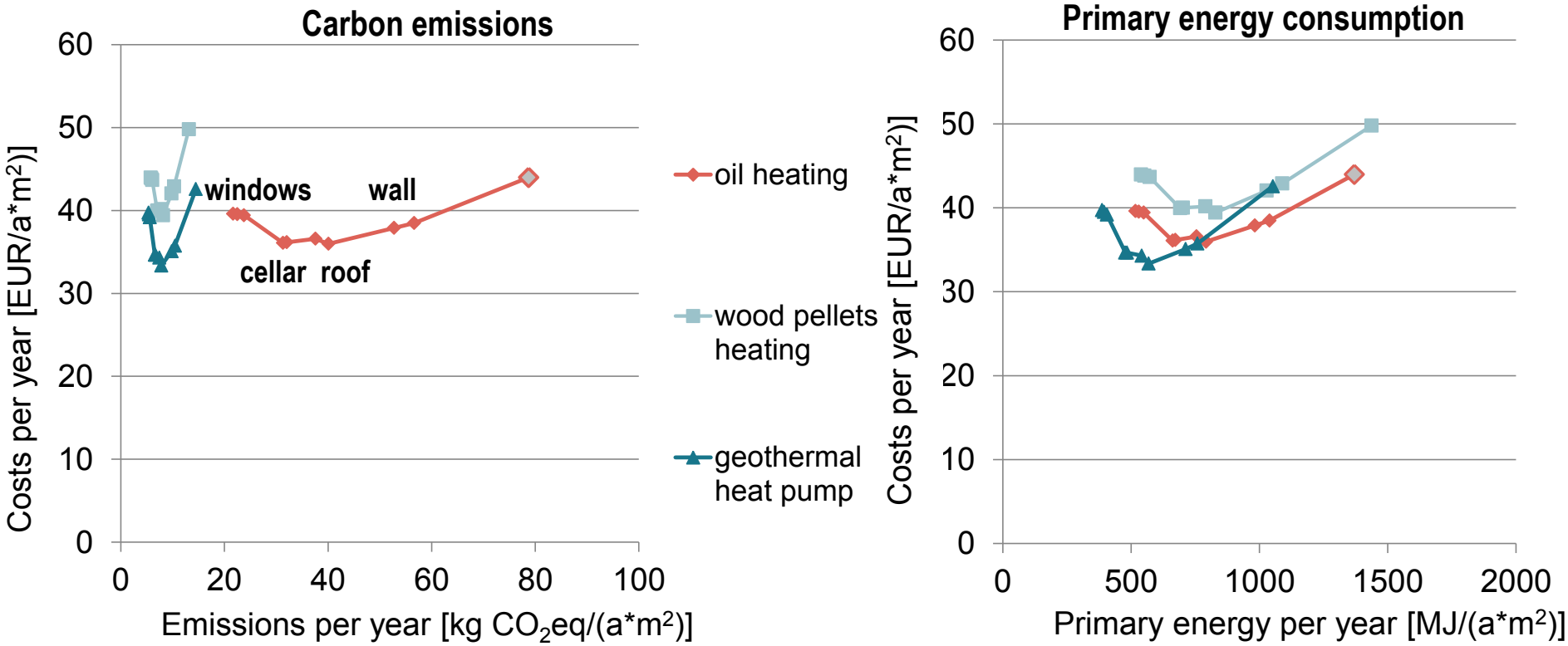
Effects on emissions: Geothermal heat pump



- Reference
- Geothermal heat pump
- Wall 12cm
- Wall 30cm
- Wall 30cm + Roof 10cm
- Wall 30cm + Roof 36cm
- Wall 30cm + Roof 36 cm + Cellar 10cm
- Wall 30cm + Roof 36 cm + Cellar 16cm
- Wall 30cm + Roof 36 cm + Cellar 16cm + Window 1.3
- Wall 30cm + Roof 36 cm + Cellar 16cm + Window 1
- Wall 30cm + Roof 36 cm + Cellar 16cm + Window 0.8

- Switch to RES: Significant emissions reduction.
- Insulation: Cost cut due to synergies with RES

Effects on emissions and on primary energy use



- Efficiency measures are relevant for primary energy consumption
- RES hardly influence number/ types of energy efficiency measures to achieve cost optimum but the level of the impact at the optimum

Preliminary conclusions (1)

- Highly decreasing marginal benefits of energy efficiency measures at the building envelope:
  - Once basic efficiency level is achieved, it is **more important how many building elements** are energetically renovated than how ambitious per element
  - ➔ A switch to **renewable** energy systems (RES) reduces **emissions** more significantly than further energy efficiency measures on the envelope
- Nevertheless: Energy **efficiency** is crucial to reduce primary energy **consumption:**
  - Good energy performance of envelope is crucial for comfort and building physics reasons
  - Synergies (not trade-offs) between RES and energy efficiency measures
  - ➔ Less peak energy demand because of energy efficency measures at the envelope means smaller and significantly cheaper RES

Preliminary conclusions (2)

- If net zero emissions is the target, it is cost effective to combine renewable energy sources with energy efficiency measures
- Validity of previous and preliminary hypotheses was confirmed for calculations with single-family reference buildings within 5 different country contexts
- The results remain sensitive in particular to the energy price and interest rate assumptions and to the energy performance of the buildings prior to renovation

Thank you!

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Verification of hypotheses for selected single-family reference buildings

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Hypothesis	AT	CH	DK	NO	PT
How many building elements are renovated is more important than «how many cm»	✓	✓	✓	✓	✓
A switch to RES reduces emissions more significantly than energy efficiency measures	✓	✓	✓	X	✓
RES measures do not change significantly cost optimal efficiency level, if reduction in size of heating system is taken into account	✓	✓	✓	✓	✓

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