Comparative analysis for the refurbishment of the high-rise concrete building stock based on life cycle assessment scenarios

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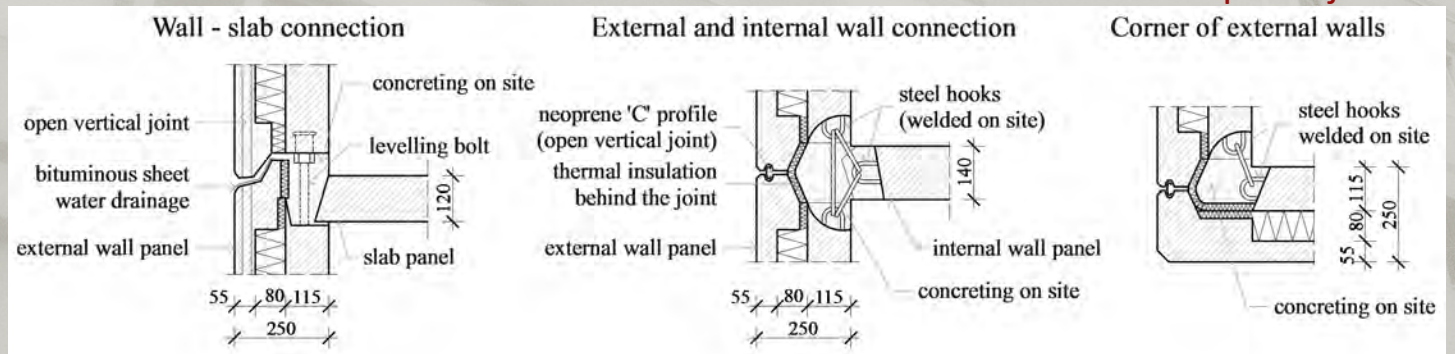
Goal of the study

- „Demolish of retrofit?”
- Evaluation the environmental impacts of the refurbishment of the **existing high-rise large panel residential buildings** in Hungary and the contribution of the different life cycle phases of refurbishment, maintenance, operation and disposal.
- Different scenarios was compared to support the decision making.

The reinforced concrete precast large-panel construction method

- based on the Soviet technology
- 30-35 000 flats/year,
- altogether 510 000 flats (app. 13.5% of the people)
- mainly 4 and 10 storey high blocks
- high energy consumption: 200-230 kWh/m^2 year
- district heating

panel joints



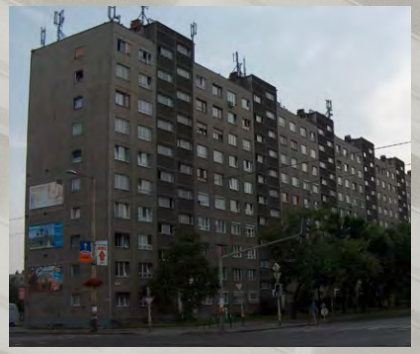
Methodology

- Comparative analysis of refurbishment options based on Life Cycle Assessment
- Typology of the building stock
- Performance of the determined types
- Mitigation potential

- Case study: Budapest, Kelenföld housing estate

	(KESKENY) SÁVHÁZ				(SZÉLES) SÁVHÁZ	PONTHÁZ		FÜLES HÁZ		
alaprajz										
kód	hőhidas	Ky	TB-51	1032		A10	KB-512	füles4	Kf/10	C3
házgyár	1. Budapesti HGY	2. Budapesti HGY	Békéscsaba HGY	1. Budapesti HGY	1. Budapesti HGY	1. Budapesti HGY	Békéscsaba HGY		2. Budapesti HGY	Debreceni HGY
szintszám	Alagsor + Fsz + 9em	Pince + Fsz + 10em	Alagsor + "Fsz" + 4 em	Fsz + 4em	Alagsor + Fsz + 9em	Fsz + 10em	Fsz + 10 em	Alagsor + (magas) Fsz + 4em	Pince + Fsz + 10em	Alagsor + Fsz + 10em
épület (attika) magasság (m)	28,9	33,3	18,8	16,0		33,5	32,4	20,6	31,5	34,5
nettó szintterület (m2)	25 160.4	10 861.9	3 787,4	0.0		6 721.2	2 549,3	4 4 6.5	4 049.0	5 468,3
szekciószám	többszekciós	többszekciós	többszekciós	többszekciós	többszekciós	1 szekció	többszekciós	többszekciós	1 szekció	1 szekció
alaprajzi elrendezés	sávház, 3fogat	sávház, 4fogat függőfolyosós	sávház, 3fogat	sávház, 2fogat	sávház, 6fogat	pontház, 10fogat ("lábasház")	pontház, 4fogat	fülesház, 4fogat	fülesház, 6fogat	fülesház, 8fogat

Budapest, Kelenföld housing estate



Terraced panel building with narrow strip blocks

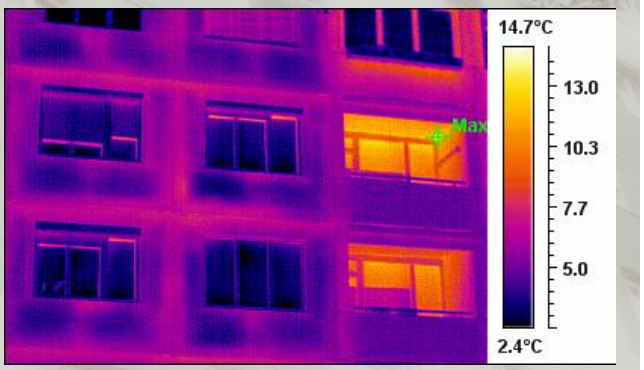
Detached building (A10)

‚Building with ears' (Kf10)

Built: 1968-75 (early phase)

Mainly 10 storey apartment buildings, some 15-storey high-rise buildings and 1 or 2 storey service buildings.

Altogether 53 apartment buildings (8 500 flats)



Life Cycle Assessment

- Functional unit:
  - high-rise apartment building in Budapest, Hungary to provide housing for additional 100 years.
- Excel-based tool
- Ecoinvent v2.0 inventory database (Hungarian electricity mix!)
- District heating mix
- Energy consumption: according to the 7/2006 TNM decree

  (energy demand for lighting was neglected)
- Lifetime: 80 years, remaining life-time is 40 years more

- Normalization

Life cycle

PRODUCTION
- Materials
- Transport
- Energy need for construction

OPERATION
- Operation (energy demand of the building service systems)

MAINTENANCE
- Materials
- Transport
- Energy need for construction and deconstruction
- Disposal of the replaced materials

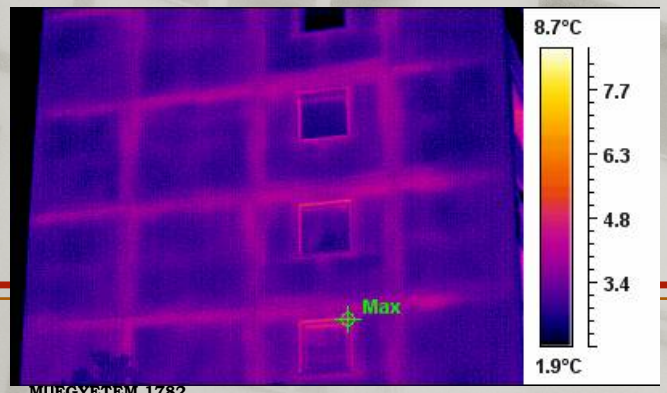
REFURBISHMENT
- Materials
- Transport
- Energy need for construction and deconstruction
- Disposal of the replaced materials

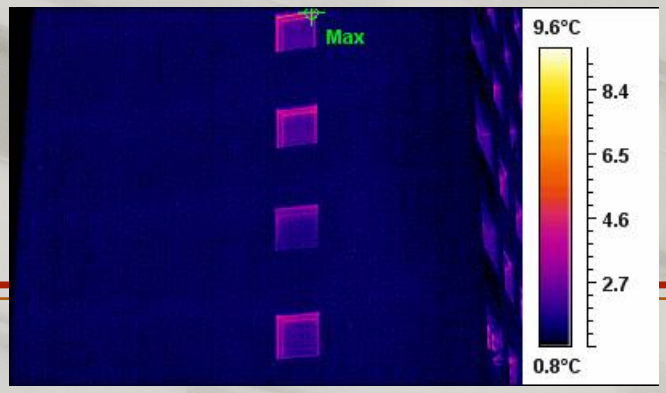
END OF LIFE
- Energy need for demolition
- Transport
- Disposal of materials according to their end-of-life scenario

Remaining life span

- Additional thermal insulation on the external walls:
  - decrease the expansion of the external concrete layer of the sandwich panels;
  - hide the panel joints:
    - the further corrosion of welded steel elements is prevented (or slowed down);
    - the thermal bridge effect is reduced, with the risk of fabric damages.
- Due to the refurbishment,

  the expected life time increases by 20 years.





Possible scenarios

- **No overall renovation**, only maintenance work

  (remaining life time: 40 years)

- **Comprehensive refurbishment** to reduce operational energy need (prolonged remaining life time: 60 years)

- **Demolition and erection of a new building**

  (life time of new building: 80 years)

Comprehensive refurbishment

- **retrofit 1**

  thermal insulation of the building envelope (facade, flatroof, basement floor) and replacement of windows, according to the national regulations 99,74 kWh/m^2 a >> D

- **retrofit 2**

  increased thermal insulation level of the building envelope 90,42 kWh/m^2 a >> C

- **retrofit 3**

  retrofit 2 + modernization the heating system (thermostatic valves) and installing heat recovery ventilation 62,98 kWh/m^2 a >> A

- **retrofit 4**

  retrofit 3 + installing solar collectors 36,55k Wh/m^2 a >> A+

Demolition and erection of a new building

- **new building 1**

  high level thermal insulation and windows, heat recovery ventilation and heating system based on natural gas

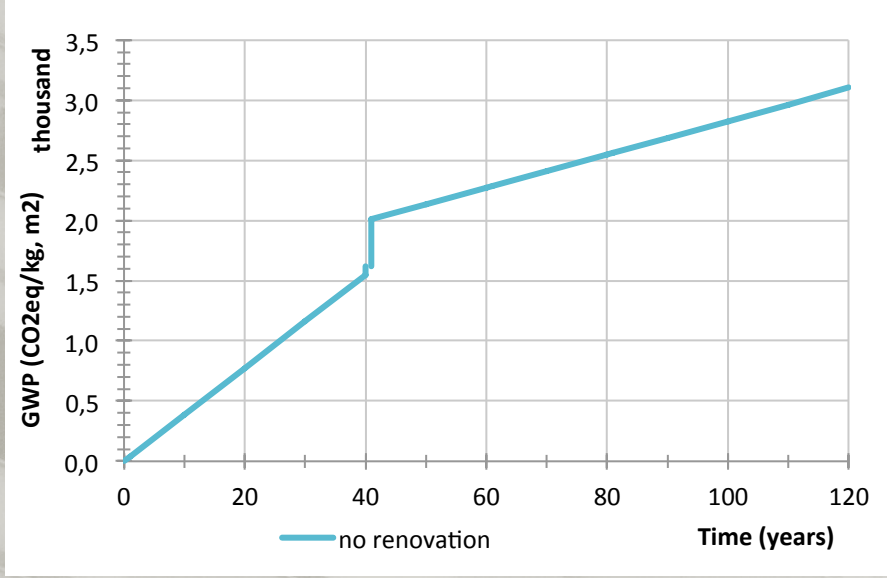
  45,32k Wh/m^2 a >> A+

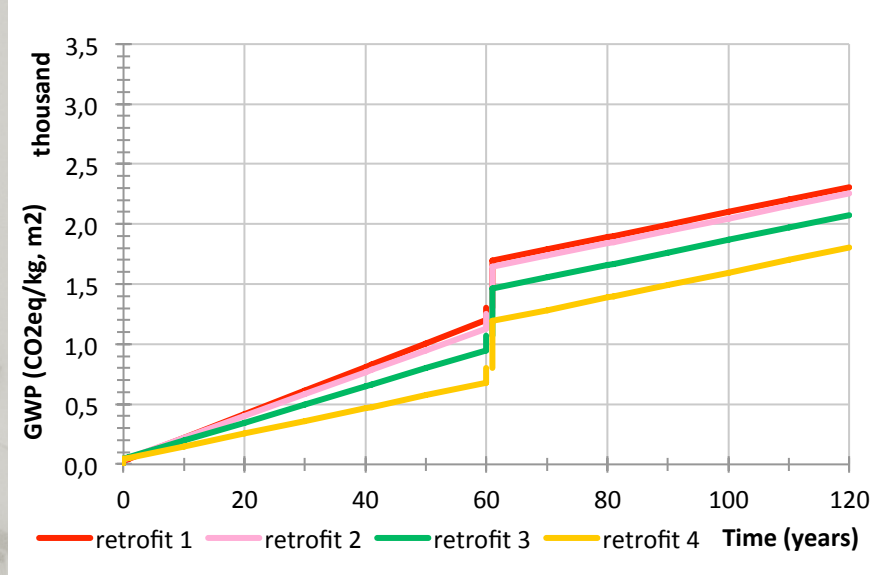
- **new building 2**

  new building 1 + solar energy use for DHW

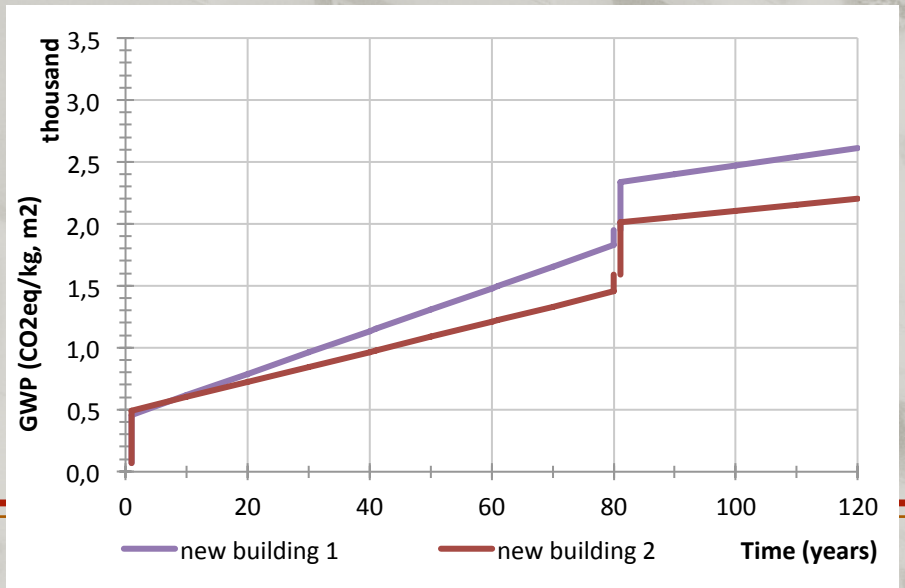
  20,16k Wh/m^2 a >> A+

Global warming potential – ‚building Kf10'

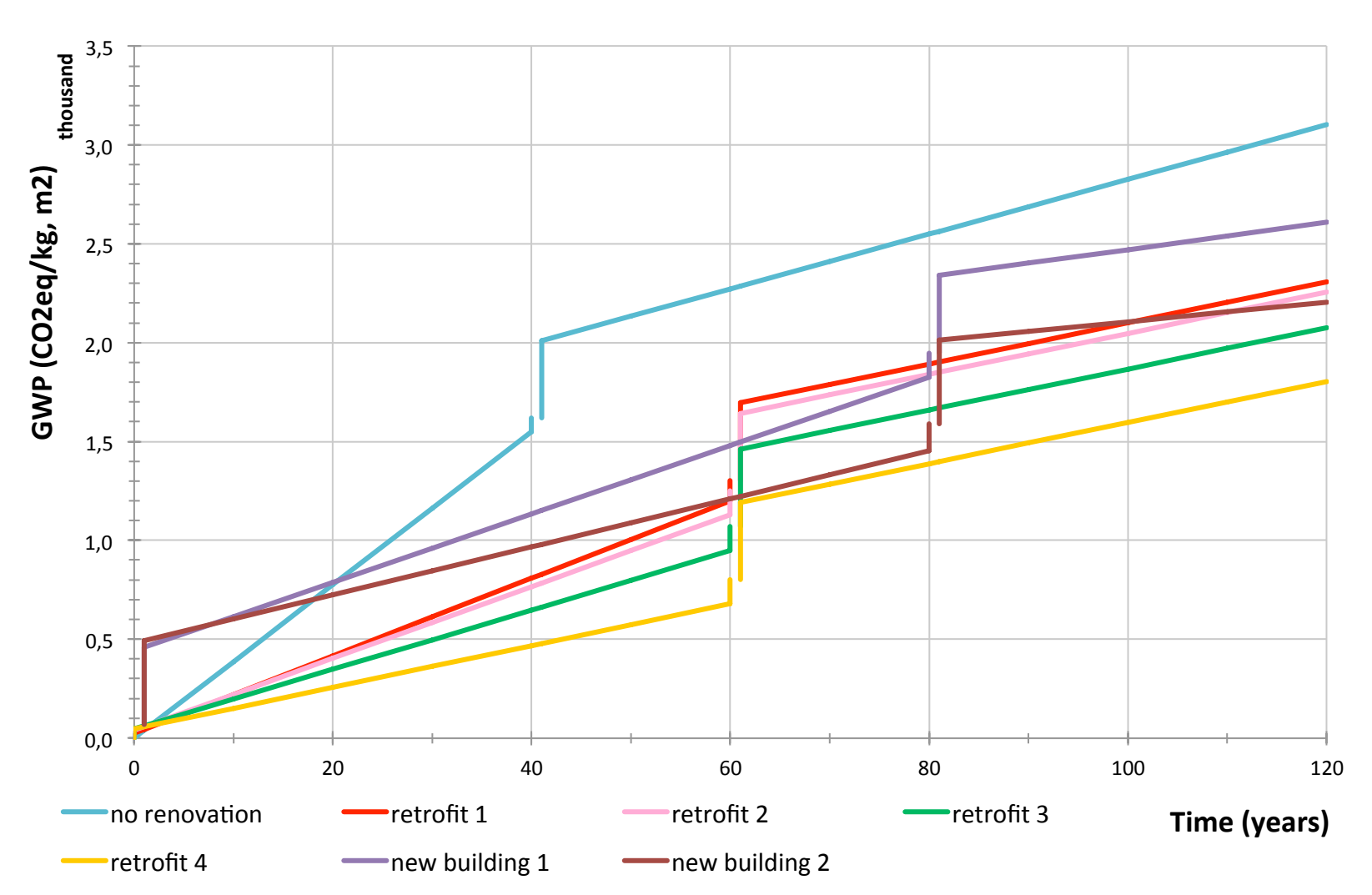




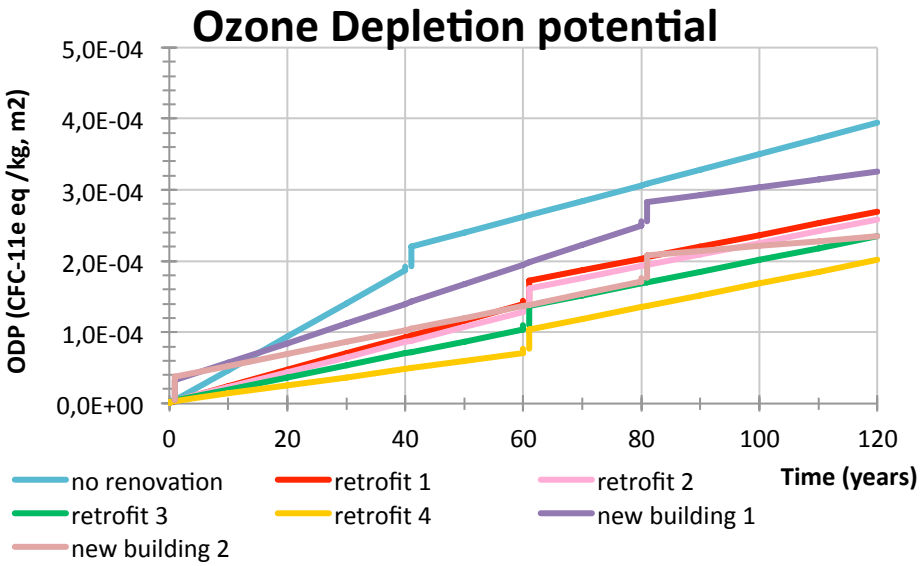
Each scenarios are similar in case of all the types.
The results of ‚Kf10' building.

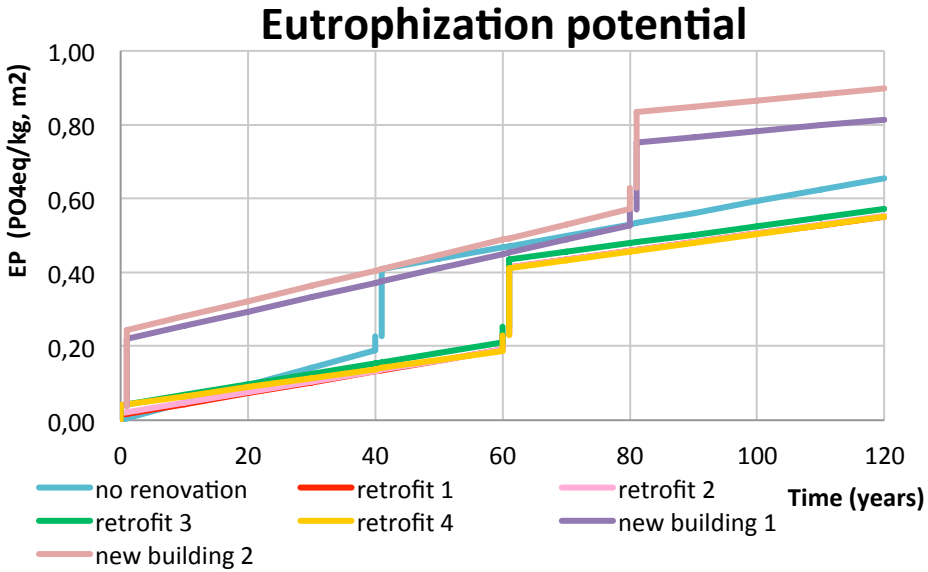


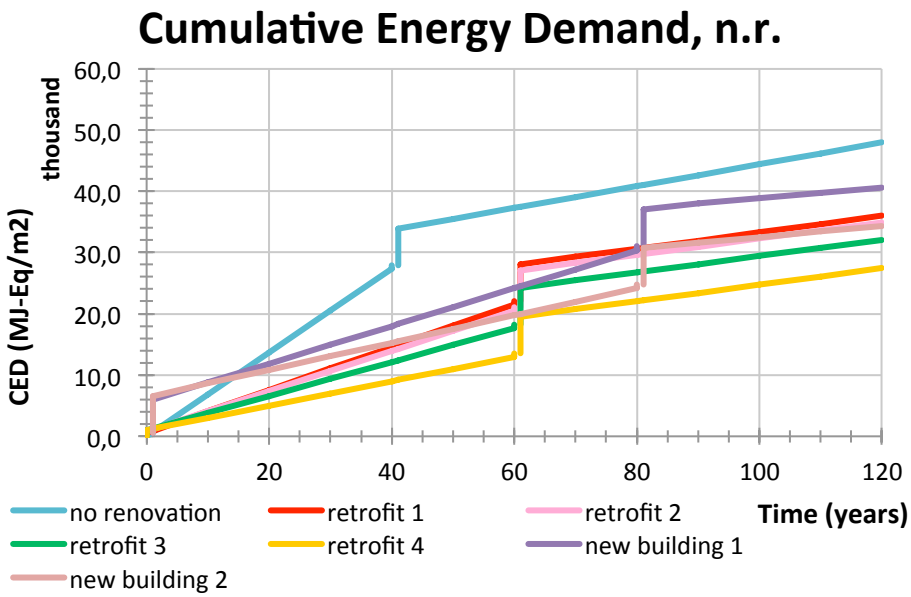
Global warming potential – ‚building Kf10'

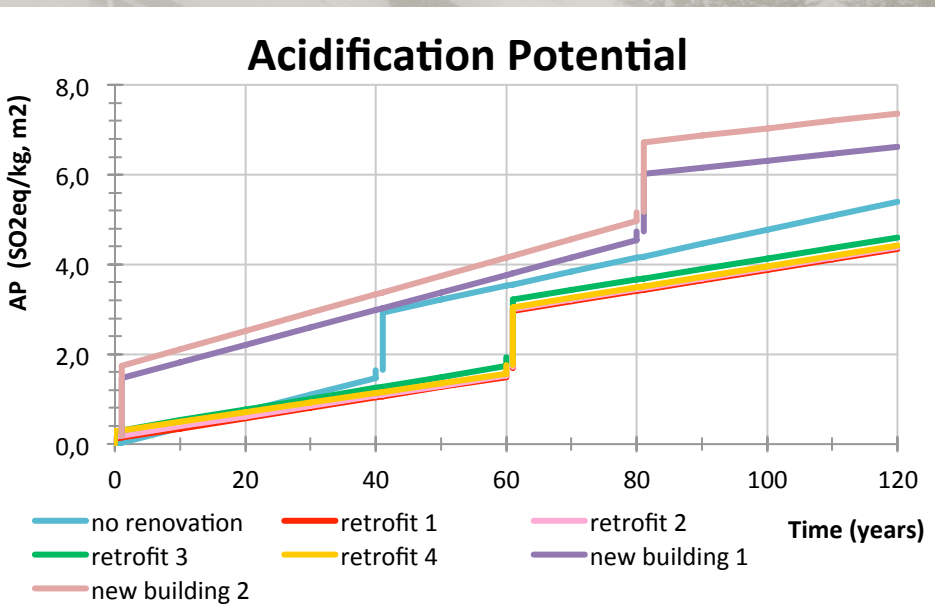


Other environmental indicators









Mitigation potential of Kelenföld

- Retrofit 1 scenario:
  - GWP: - 44,4 %
  - EP: - 26,7 %
- Retrofit 4 scenario:
  - GWP: - 64,6 %
  - EP: - 24,6%
- New building 1 scenario:
  - GWP: - 42,1 %
  - EP: + 5,3%

Conclusions

- The result depends on the analysed time period:
  - First 2-4 years: no overall renovation;
  - Until the 60years after the decision point: comprehensive retrofit (scenario: retrofit 4)
  - Longer term (60 to 80years) >>> high uncertainty
- Future regulations about the energy performance? Materials? Electricity mix?
- The analysed time period depends on the decision makers
  - investors vs. sustainability?
  - (local) governments? political decisions?

Thank you for your kind attention!

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