SBE19 GRAZ CONFERENCE

COMPARATIVE ANALYSIS OF AN EXISTING PUBLIC BUILDING MADE FROM NATURAL BUILDING MATERIALS AND REFERENCE BUILDINGS DESIGNED FROM COMMON BUILDING MATERIALS

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Content

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Research questions

Building and constructions [1]

36%

of global final energy use

39%

of energy-related CO_2 emission

Proposed new constructions[1]

By 2060 230 billion m^2 new building (every year 1 Japan)

Proposed change of construction and operation [2]

	2008	2050
Construction	15%	43%
Operation	82%	50%

What are the environmental benefits of using natural building materials?

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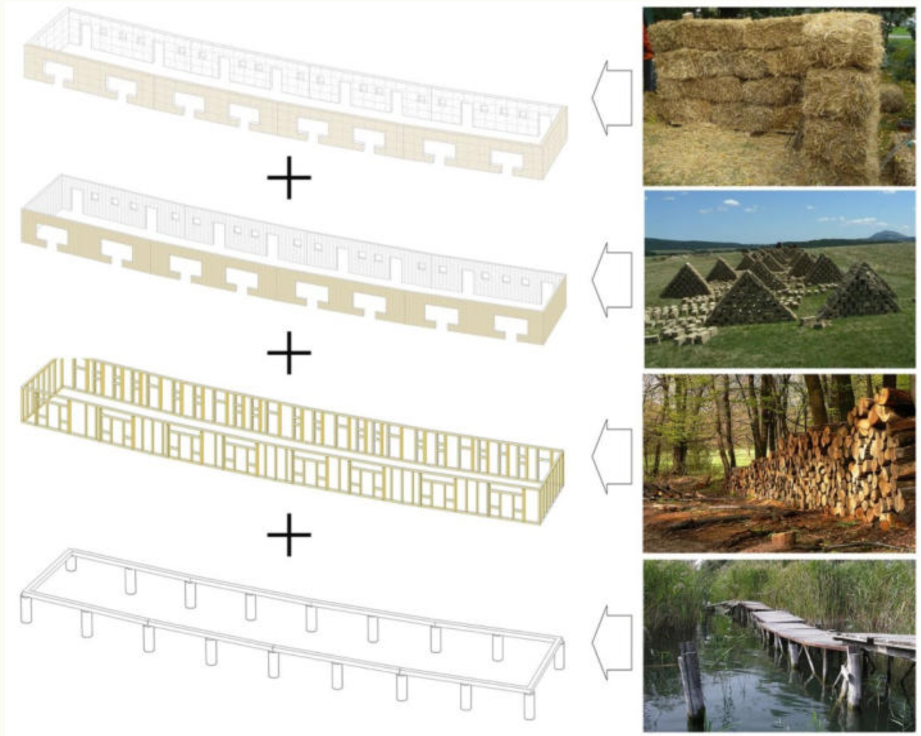
The realised case study building



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Examined variations of case study building (both public and dwelling function)

	Realized building	Imagined building 2010 fulfils the energetic requirements from the year 2010	Imagined building 2019 fulfils the energetic requirements from the year 2019
Main constructions and HVAC system	- Pile foundation, - Wall: wood frame, adobe brick and straw bale insulation U=0,15 - Roof: 25 cm rock wool insulation U=0,15 - Floor: 5 cm EPS, 15 cm XPS insulation U=0,33 - Openings: wood frame, triple glazing U=0,8 - H, HWS: wood chip boiler - No air-conditioning	- Pile foundation, - Wall: brick wall U=0,45 - Roof: 15 cm rock wool insulation U=0,24 - Floor: 6 cm EPS, insulation U=0,49 - Openings: double glazing U=1,4 - H, HWS: gas boiler - No air-conditioning	- Pile foundation, - Wall: brick wall with 10 cm EPS U=0,22 - Roof: 25 cm rock wool insulation U=0,15 - Floor: 12 cm EPS, insulation U=0,3 - Openings: wood frame, triple glazing U=0,8 - H, HWS: condensing gas boiler - No air-conditioning

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Operating parameters

Public building

- average air-change rate: 1,16 1/h
- internal heat gain: 7 W/m^2
- correction factor because of intermittent use: 0,4
- net specific energy demand of lighting: 6 kWh/m^{2}yr
- reducing factor of lighting: 0,6
- Net specific energy demand of hot water supply: 7 kWh/m^{2}yr.

Residential building

- average air-change rate: 0,5 1/h
- internal heat gain: 5 W/m^2
- correction factor because of intermittent use: 0,9
- net specific energy demand of lighting: 0 kWh/m^{2}yr,
- reducing factor of lighting: -
- Net specific energy demand of hot water supply: 30 kWh/m^{2}yr.

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LCA calculations for all 6 variations

Database manager

Own developed Excel based software

Data sources: Ecoinvent 2.0

Examined indicators:

- non-renewable cumulative energy demand (CED, n.r.) [MJ]
- global warming potential (GWP100a, CML 2001) [kg CO2-eq]
- acidification potential (AP, CML 2001) [kg SO2-eq]

Környezetterhelés építés, felújítás során

	Kummulatív energiaigény [MJ/év]	Felmelegedési potenciál [kg/év]	Savasodási potenciál [kg/év]
Falazat	1394,53	82,72	0,51
Lapostető	0,00	0,00	0,00
Padlásfödém	6183,31	401,27	2,23
MINDÖSSZESEN	**31 251,71**	**2 219,16**	**17,72**

Környezetterhelés használat egy éve során

	fogyasztás [kWh/a]	Kummulatív energiaigény [MJ/év]	Felmelegedési potenciál [kg/év]	Savasodási potenciál [kg/év]
elektromos áram	3070,22	39 945,09	1 897,30	5,70
csúcson kívüli elektromos áram	0,00			
földgáz	0,00	0,00	0,00	0,00
tüzelőolaj	0,00			
szén	0,00			
fűtőművi távfűtés	0,00			
távfűtés kapcsolt energiatermeléssel	0,00			
tűzifa, biomassza	11329,56	987,77	51,53	0,27
megújuló energia	1427,70	297,87	15,01	1,14
MINDÖSSZESEN	**15827,48**	**41 230,74**	**1 963,84**	**7,11**

Környezetterhelés egy évre vetített értéke

Realized 2010			2019.02.01
	Kummulatív energiaigény [MJ/év]	Felmelegedési potenciál [kg/év]	Savasodási potenciál [kg/év]
Létesítési, bontási életfázis környezetterhelése	31 251,71	2 219,16	17,72
Használati életfázis környezetterhelése	41 230,74	1 963,84	7,11
Teljes életciklus környezetterhelése	**72 482,44**	**4 182,99**	**24,83**

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LCC calculations for 4 variations

Method: EN 15459

Main basic parameters:

- calculation period: 30 years,
- discount rate, excluding inflation 4%,
- long-term energy price escalation: 2% for electricity and wood and 2.8% for natural gas,
- 50 HUF/kWh for electricity,
- 8,3 HUF/ kWh for wood chips,
- 16 HUF/kWh for natural gas.

Database manager

Own developed Excel based software

Bekerülési költségek - C_I [eFt]

	bekerülési költség alsó érték [eFt]	bekerülési költség felső érték [eFt]	bekerülési költség közép érték [eFt]
Falazat	4016,320	6572,160	5294,240
Lapostető	0,000	0,000	0,000
Padlásfödém	9622,426	10777,208	10199,817
MINDÖSSZESEN	**90950,53485**	**117042,2413**	**103996,398**

Várható üzemeltetlési költségek - $C_{a,I}(j)$

	fogyasztás [kWh/a]	bruttó egységár [Ft/kWh]	várható éves fogyasztás [eFt/a]	éves árnövekedés mértéke [%]
elektromos áram	3070,220	50,000	153,511	2
csúcson kívüli elektromos áram	0,000	29,000	0,000	
földgáz	0,000	16,000	0,000	2,8
tüzelőolaj	0,000		0,000	2,8
szén	0,000		0,000	2
fűtőművi távfűtés	0,000		0,000	
távfűtés kapcsolt energiatermeléssel	0,000		0,000	
tűzifa, biomassza	11329,561	8,300	94,035	2
megújuló energia	1427,700	0,000	0,000	0
MINDÖSSZESEN	14399,781		247,546	

Teljes életciklus alatti költségek

Vizsgált életciklus - [a]	30
Valós diszkont ráta - R_R	4
Diszkont faktor - $R_d(i)$	0,3083
Beruházási költség - C_I [eFt]	103 996,398
Üzemeltetési költség - $\Sigma C_a \times R_R$	5 683,470
Felújítási költség [eFt]	27 002,165
Maradványérték - $V_{f,\tau}(j)$	7 567,049
Globális költség (közép érték)- $C_g(\tau)$ [eFt]	129 114,984

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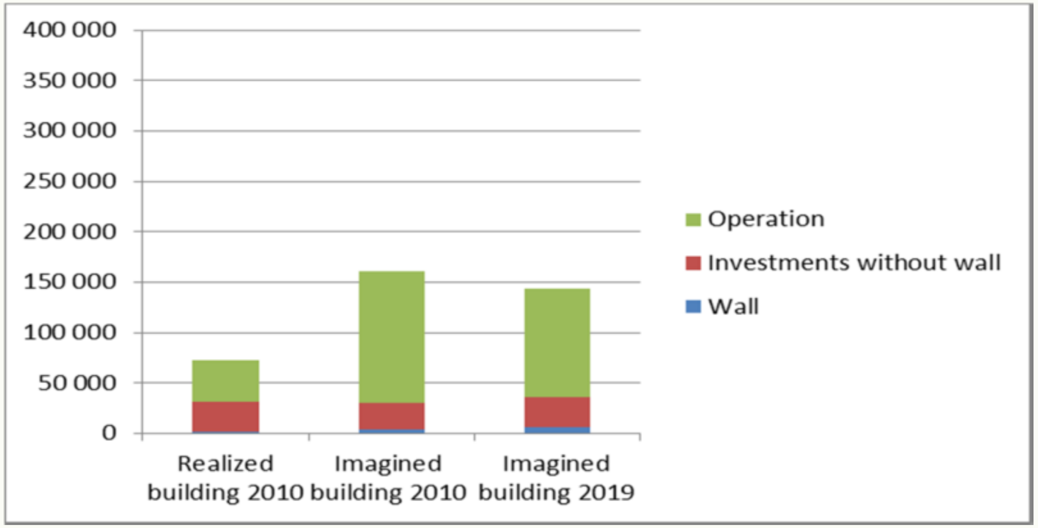
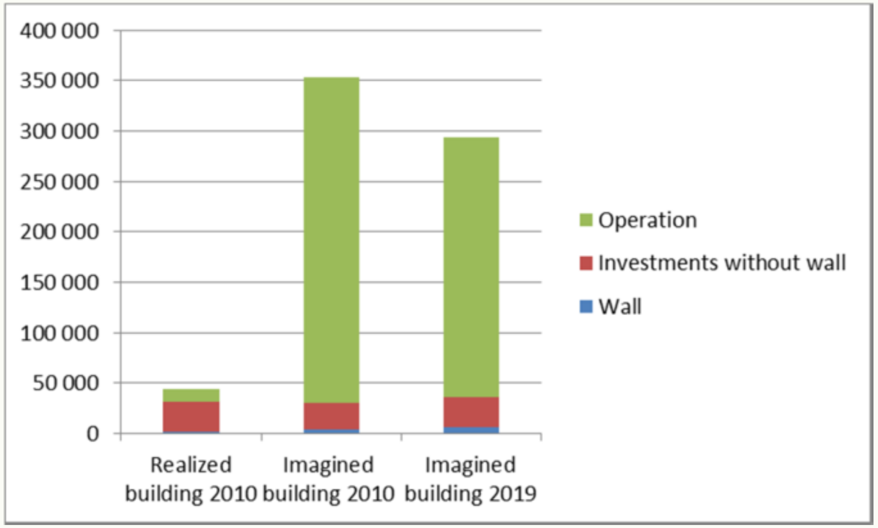
Cumulative energy demand [MJ/yr]

Public building

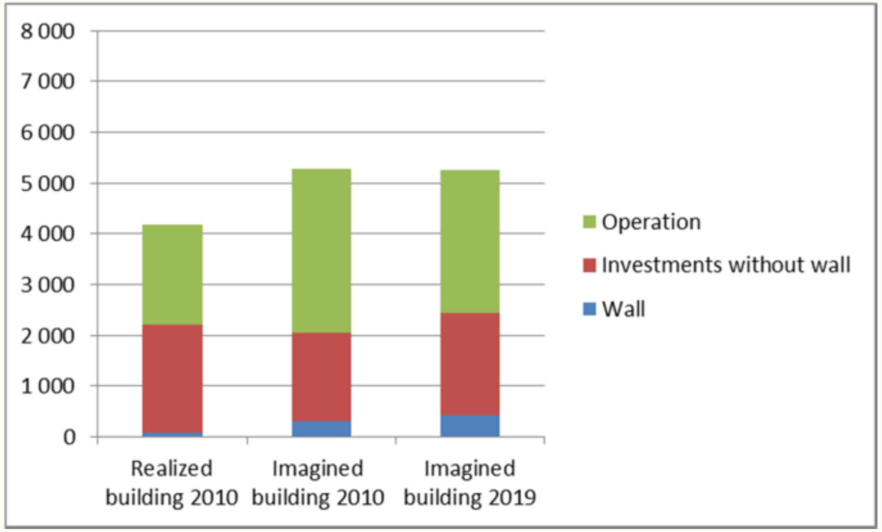


Residential building

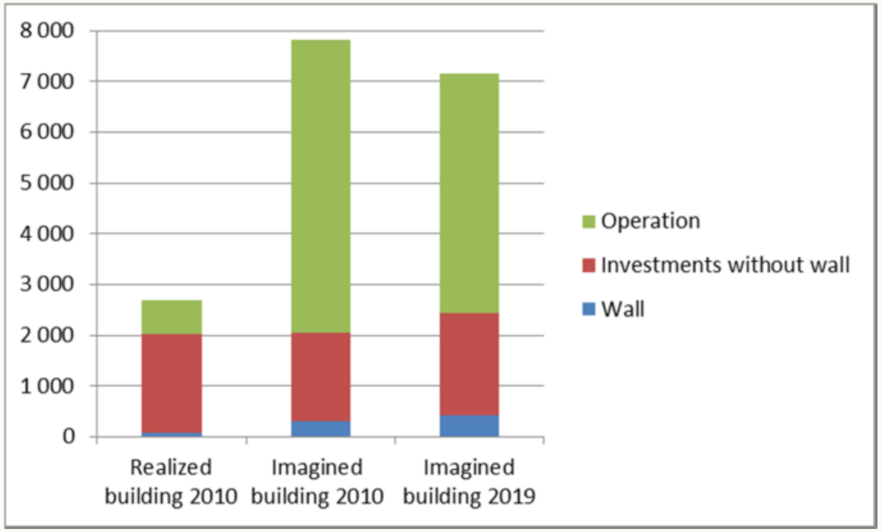


Global warming potential [kg CO_2-eq/yr]

Public building



Residential building



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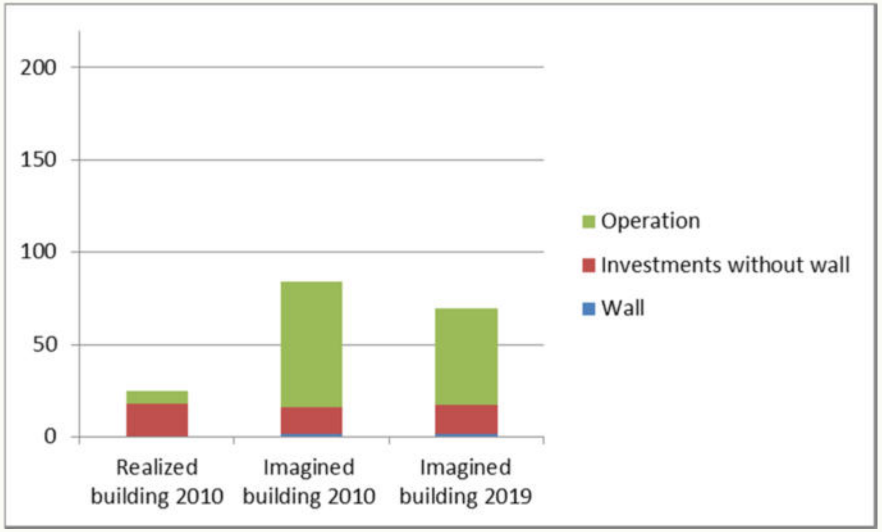
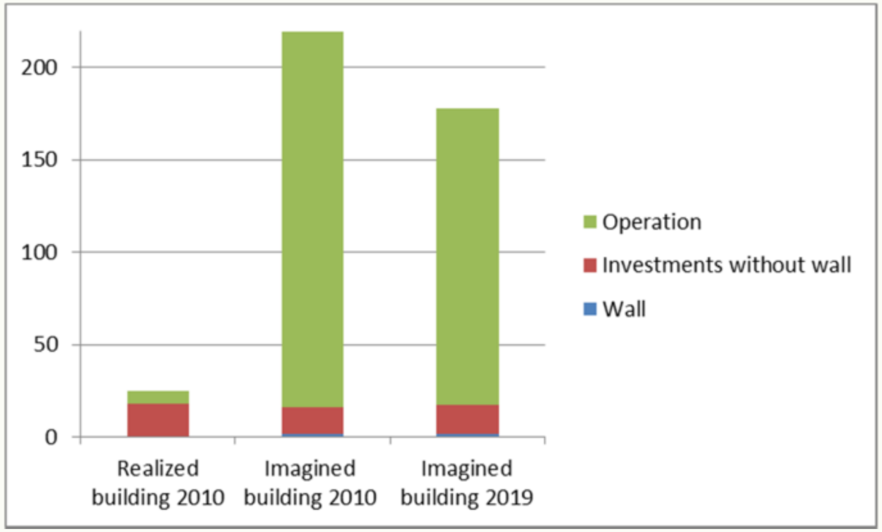
Acidification potential [kg SO_2-eq/yr]

Public building

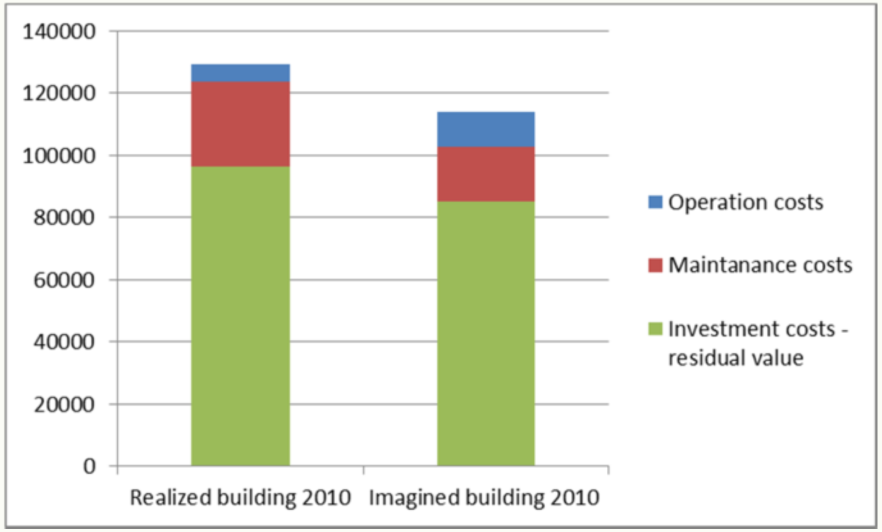


Residential building

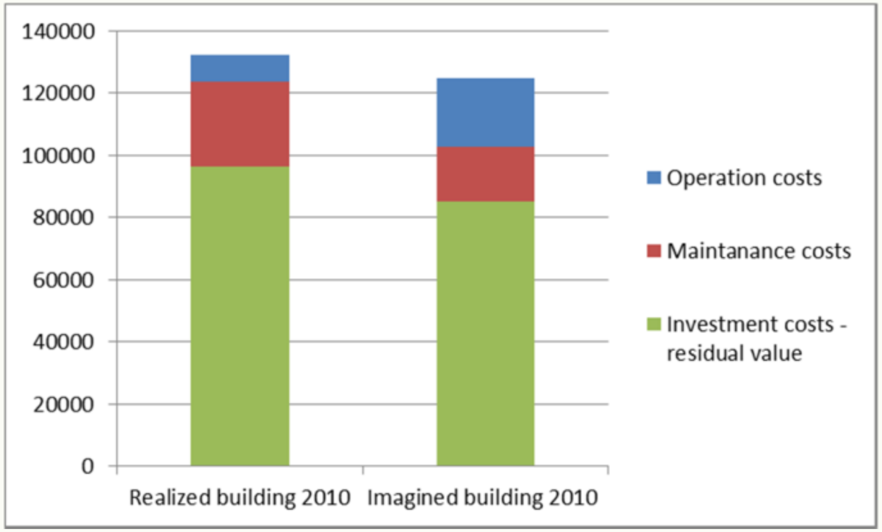


Global cost (LCC) [1000 HUF]

Public building



Residential building



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1) **Impact of the use of natural building materials on the wall structure is positive and significant.**

2) **Due to the higher energy requirements the environmental impact of constructions is increasing.**

	Realized building	**Imagined building 2010** fulfils the energetic requirements from the year 2010	**Imagined building 2019** fulfils the energetic requirements from the year 2019
CED [MJ/yr]	1394,53	4089,75	5766,36
GWP [kg CO_2-eq/yr]	82,72	314,41	413,65
AP [kg SO_2-eq/yr]	0,51	1,21	1,53

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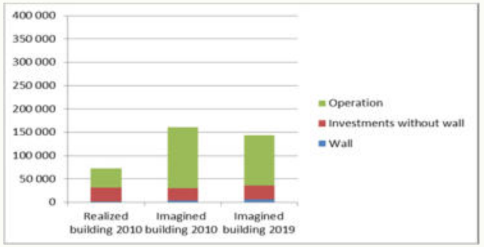
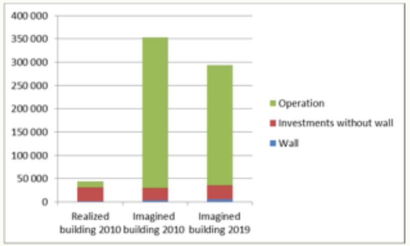
3) The environmental impact of wall structures is not significant compared to the environmental impact of the other structures and mechanical systems.

	Realized building	**Imagined building 2010** fulfils the energetic requirements from the year 2010	**Imagined building 2019** fulfils the energetic requirements from the year 2019
CED [MJ/yr]	31251,71	30146,88	36240,33
GWP [kg CO_2-eq/yr]	2219,16	2055,34	2440,71
AP [kg SO_2-eq/yr]	17,72	15,84	17,43

4) In the case study, the greatest environmental benefit is not connected to the construction phase but to the operation phase.





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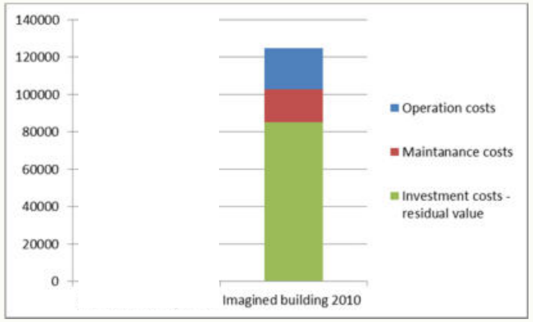
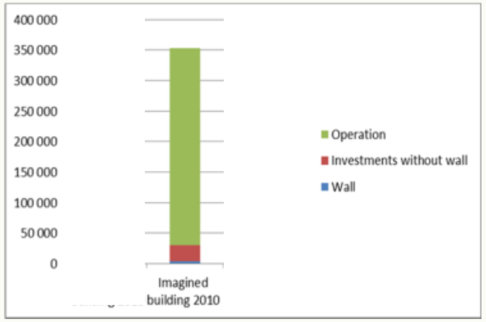
5) From the point of view of LCC analyses the phase of construction phase, while from the point of view of LCA analysis the operation phase is dominant at the common residential building.

LCC

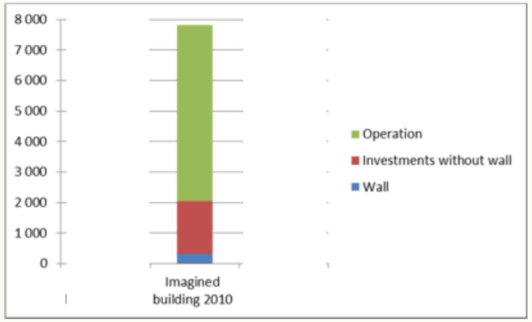


LCA

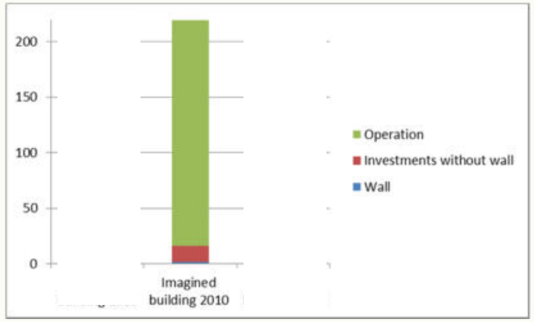
CED



GWP



AP



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6) **At present, the savings in environmental load by using natural materials is not significant in Hungary, but it is expected to become an increasingly important area in the future.**

References

[1] International Energy Agency. (2017). Global Status Report 2017. Global Status Report 2017

[2] Lawrence, M. (2016). Reducing the Environmental Impact of Construction by Using Renewable Materials. 3(3), 163–174. https://doi.org/10.7569/JRM.2015.634105

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Thank you for your attention!

Péter Medgyasszay

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