Innovative building technologies and technical equipment towards sustainable construction – a comparative LCA and LCC assessment

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Session 5.6: Green Construction Technologies (2)

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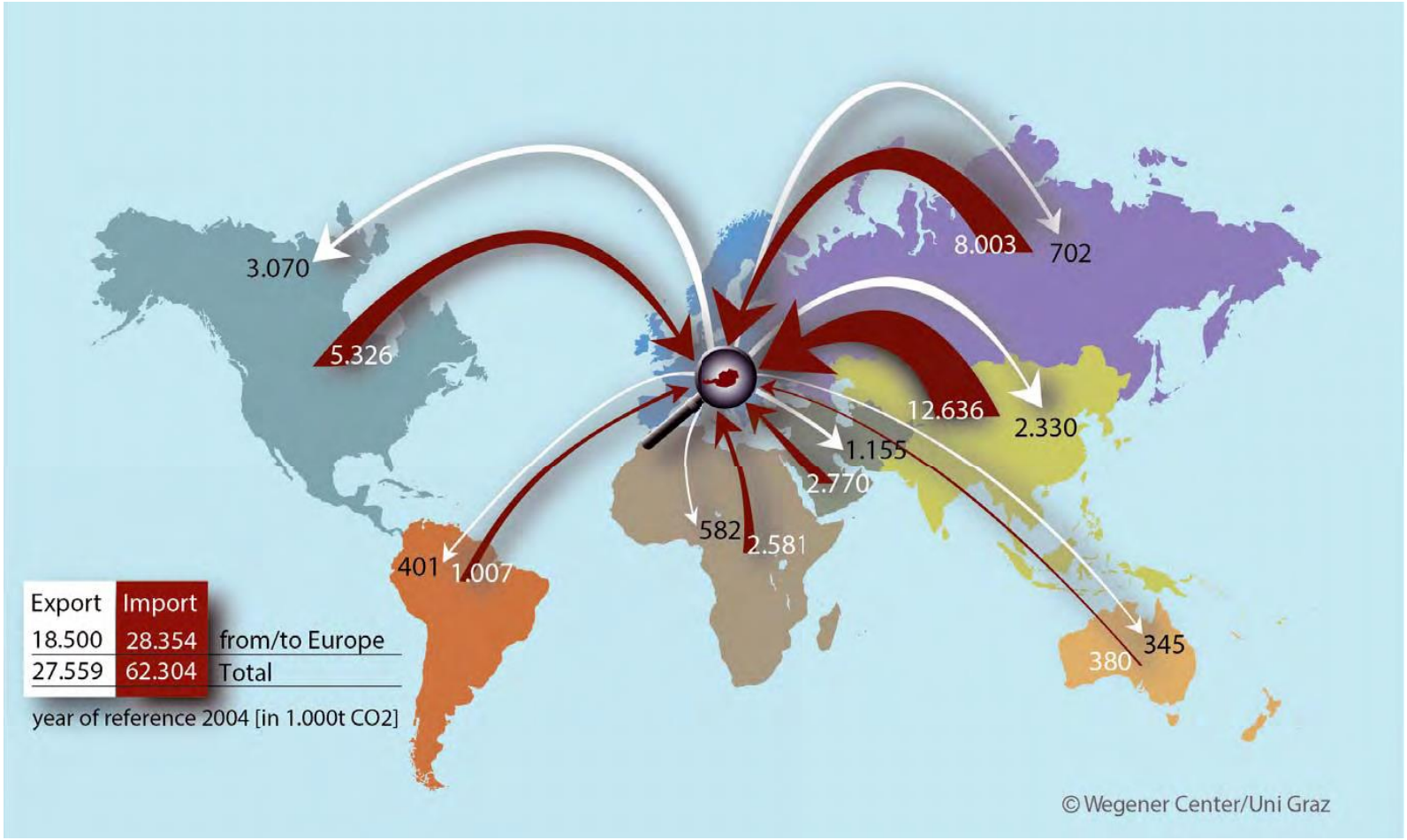
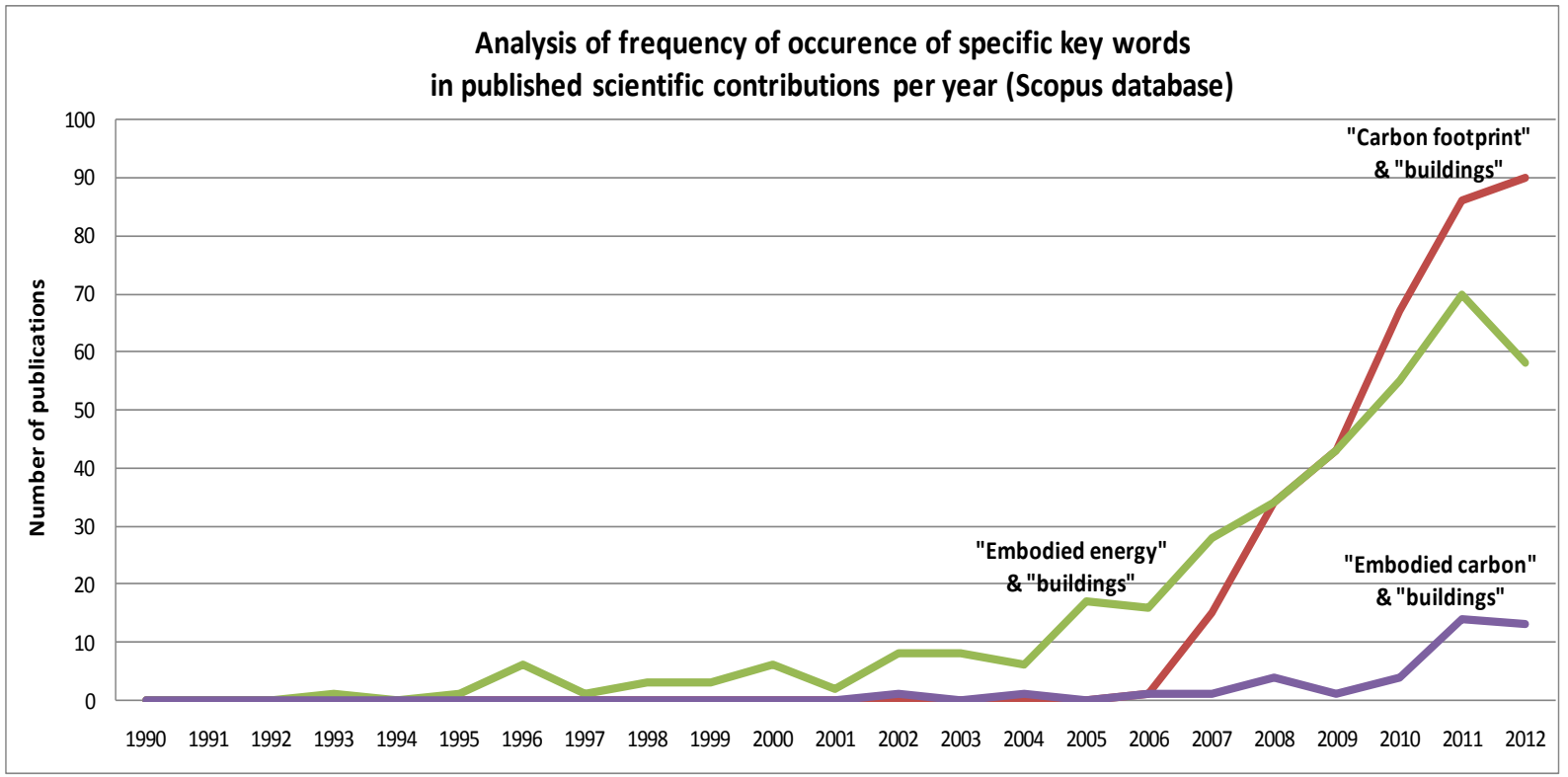
Photo Credit: One prediction of where rising sea levels will end up at Cottesloe Beach, Western Australia. Copyright: go_greener_oz (Flickr)

CO_2 flows from and to Austria due to trade [1]



[1] H. Schnitzer, W. Streicher, K.W. Steininger, T. Berger, C. Brunner, A. Passer, et al., Austrian Panel on Climate Change (APCC) - Austrian Assessment Report 2014 (AAR14), in: H. KROMP-KOLB, N. NAKICENOVIC, K. STEININGER, A. GOBIET, H. FORMAYER, A. KÖPPL, et al. (Eds.), Austrian Panel Clim. Chang. - Austrian Assess. Rep. 2014, Verlag der Österreichischen Akademie der Wissenschaften, 2014: p. 1097. http://hw.oeaw.ac.at/7699-2 (accessed October 2, 2014).

Growing interest – Trends



Source: Lützkendorf T., SB13 Graz, IEA Energy in Buildings and Communities Programme Implementing Agreement Annex 57, -Evaluation of Embodied Energy and Carbon Dioxide Emissions for Building Construction

"embodied energy" & "buildings"

"embodied carbon" & "buildings"

"carbon footprint" & "buildings"

EBC

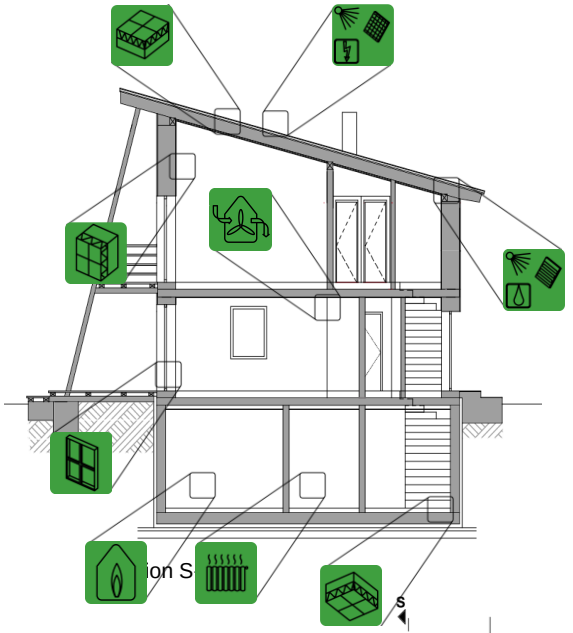
Energy in Buildings and Communities Programme

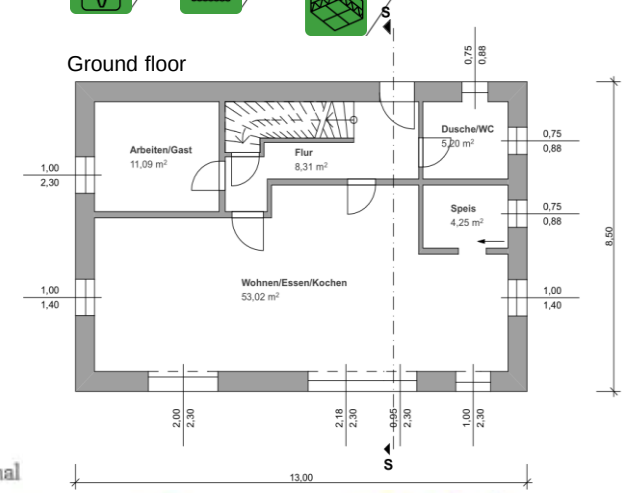
Aim of the project

- Sustainability assessments include the assessment of environmental and economic performance
- However: Lack of the influence of different **construction techniques, technical building equipment** and **energetic standards**, reflecting the existing technical variety

The case study - single family house in 45 variations

- Construction technique (brick, concrete, wood-chip concrete and prefab timber wood construction)
- Heating demand (low to plus energy)
- HVAC technical building systems (pellets, heat pump, solar heating and photovoltaic)
- -> Model that represents the existing technical variety





External Wall

Top floor ceiling

Basement floor ceiling

Window

Controlled ventilation with heat recovery

Energy supply

Energy-efficient equipment

Solar thermal collectors (hot water & heating)

Photovoltaic

Design options: construction and insulation materials

Construction material		Insulation type with symbol			
		EPS	Rock wool insulation	Wood-fibre insulation	Without additional insulation
Brick	B	E			1
Concrete	C	E			
Mantle block (wood-concrete)	M	E		W	1
Wood solid	Ws		R		
Wood-frame construction	Wf		R		

Design options: Technical systems

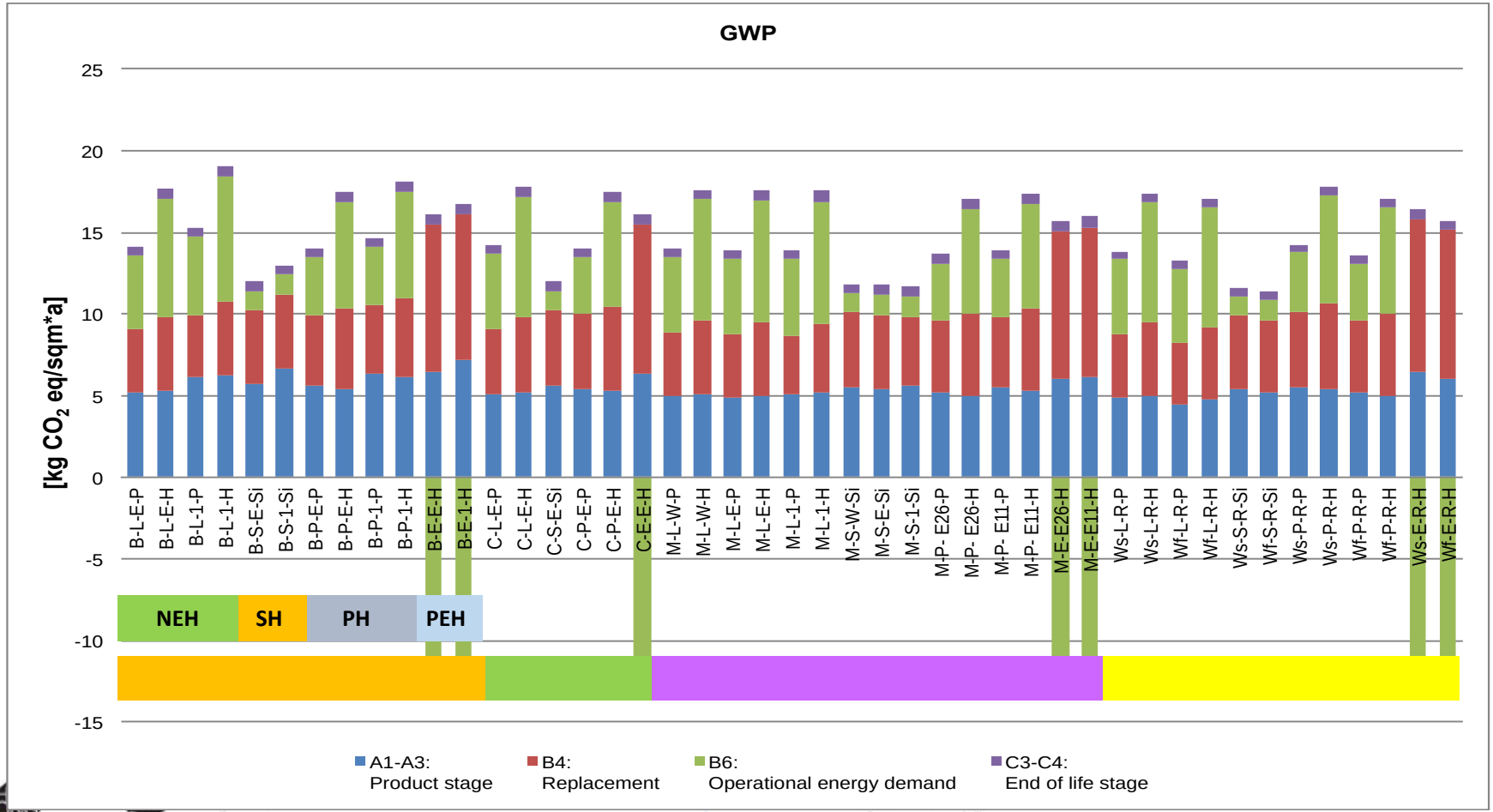
Technical system	Low-energy standard			Passive-house standard		
	40 [kWh/m²a] HWB_{ref}			10 [kWh/m²a] HWB_{ref}		
	x-L-x-**H**	x-L-x-**P**	x-S-x-**Si**	x-P-x-**H**	x-P-x-**P**	x-E-x-**H**
Pellet boiler		Pellet boiler 10 kW	Single item (logs) 25 kW		Pellet boiler 10 kW	
Heat pump	Ground-water 10 kW_{th}			Compact unit Air-Air 1.8 kW		Compact unit Air-Air 1.8 kW
Solar thermal panels			Panel area 45 m²			Panel area 10 m²
PV panels						61 m² PV panels, 6 kWp
Floor heating	yes	yes	yes		yes	
Additive system (backup)				Electric radiator 6 units		Electric radiator 6 units
Mechanical ventilation incl. heat-recovery				yes	yes	yes
Storage system (heating and hot water)	170 l Buffer storage	1000 l Heating storage 200 l WW-storage	7000 l Heating storage 300 l WW-storage	200 l Buffer storage	1000l Heating storage 200 l WW-storage	500 l WW-storage

Methods

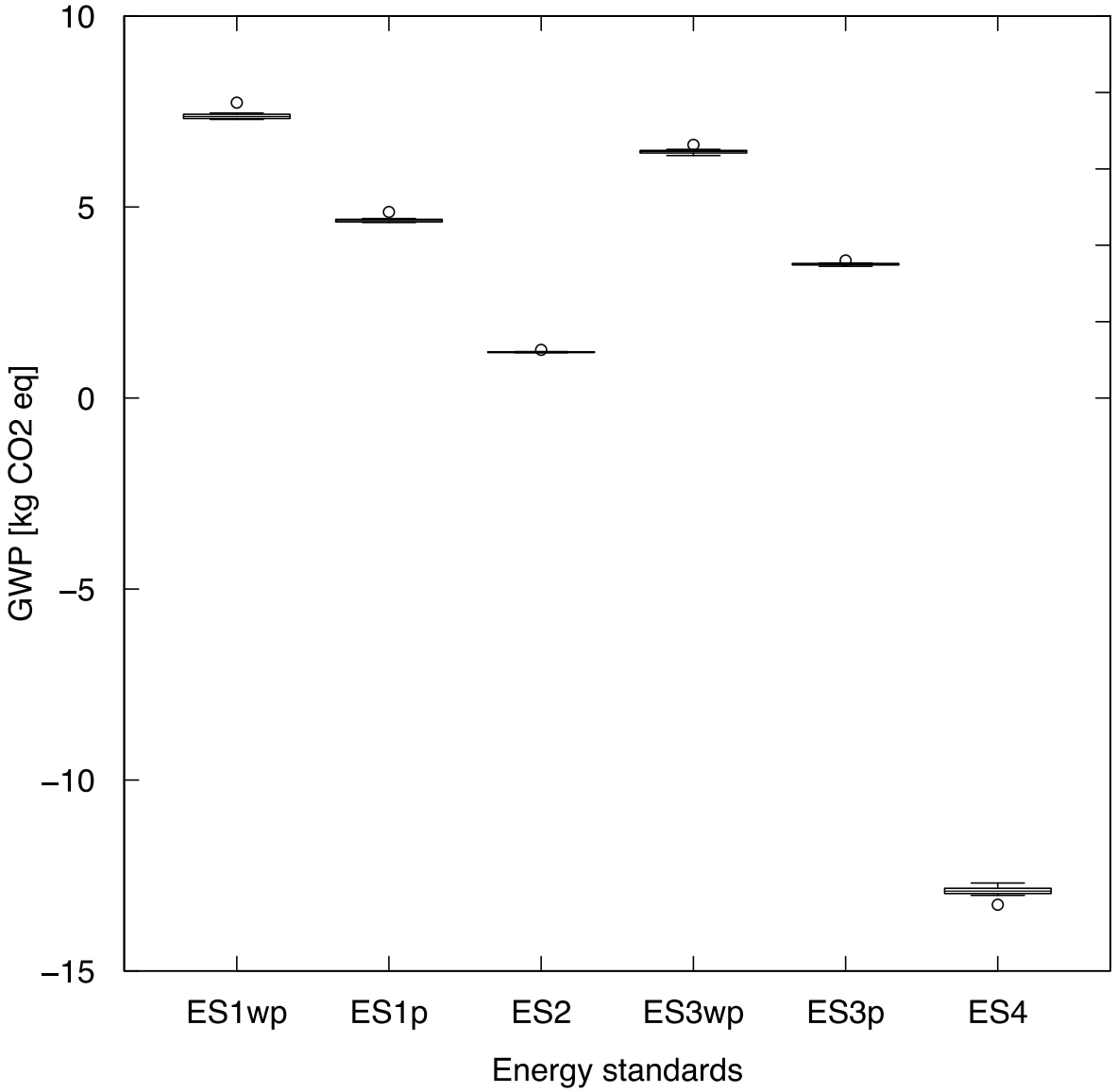
- Life cycle assessment (LCA)
  - Bill of quantities, energy performance …
- Life cycle costing (LCC)
  - Detailed cost calculations

A 1-3 Product stage			A 4-5 Construction process stage		B 1-7 Use stage							C 1-4 End of life stage			
A1 Raw material procurement	A2 Transport	A3 Production	A4 Transport	A5 Construction	B1 Use stage	B2 Maintenance	B3 Repair	B4 Replacement	B5 Refurbishment	B6 Operational Energy use	B7 Operational Water use	C1 Deconstruction	C2 Transport	C3 Waste processing	C4 Disposal

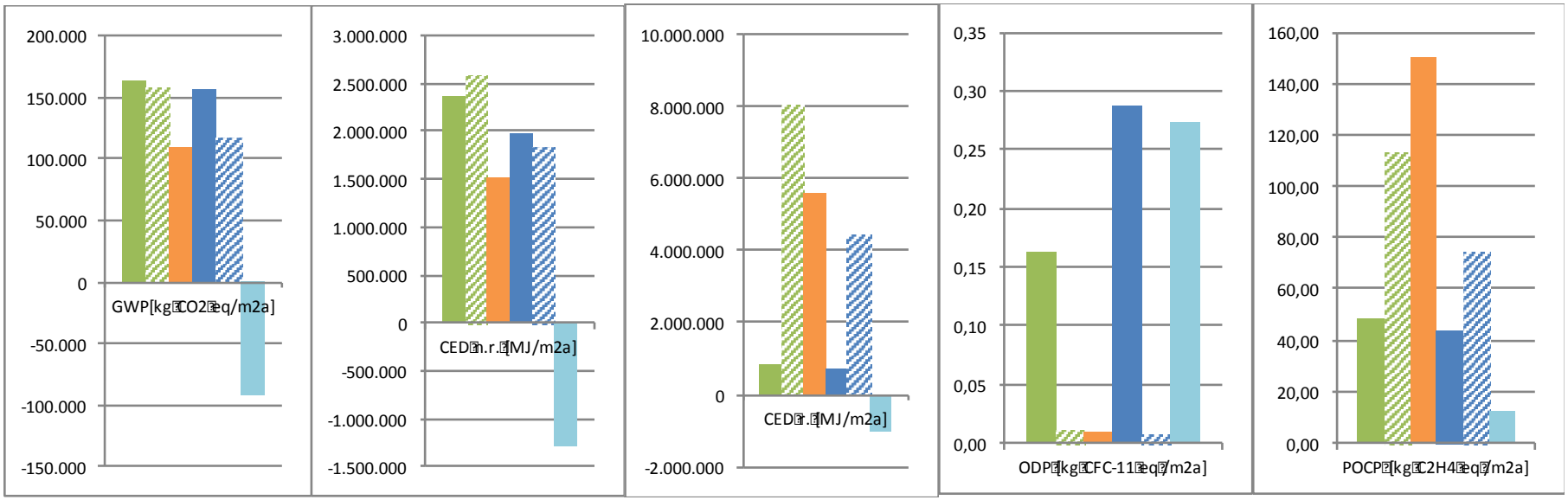
Global Warming Potential [kg CO_2/sqm*a]

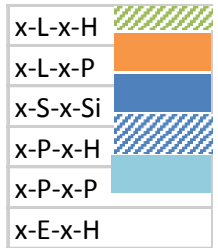


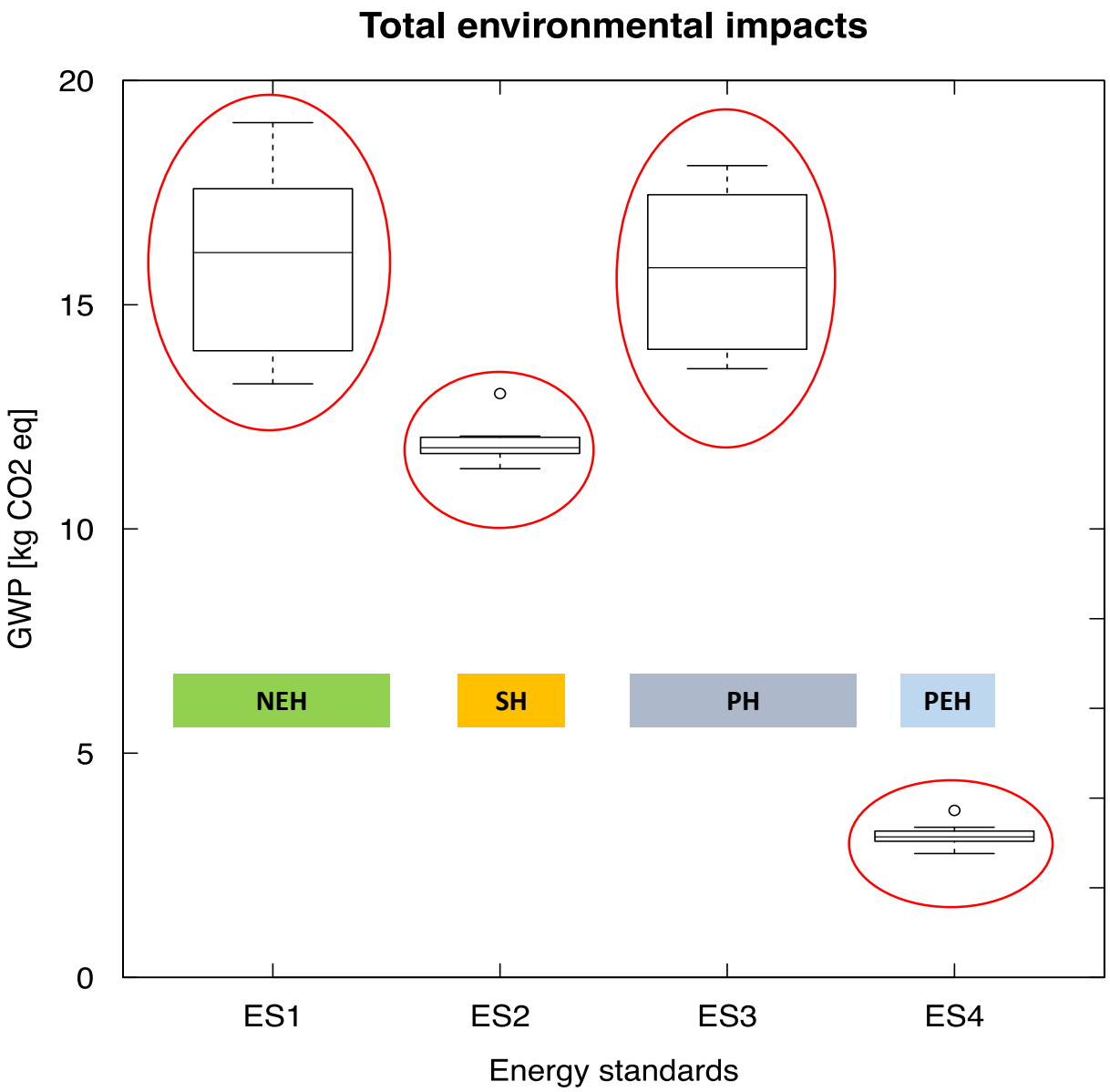
B6 environmental impacts



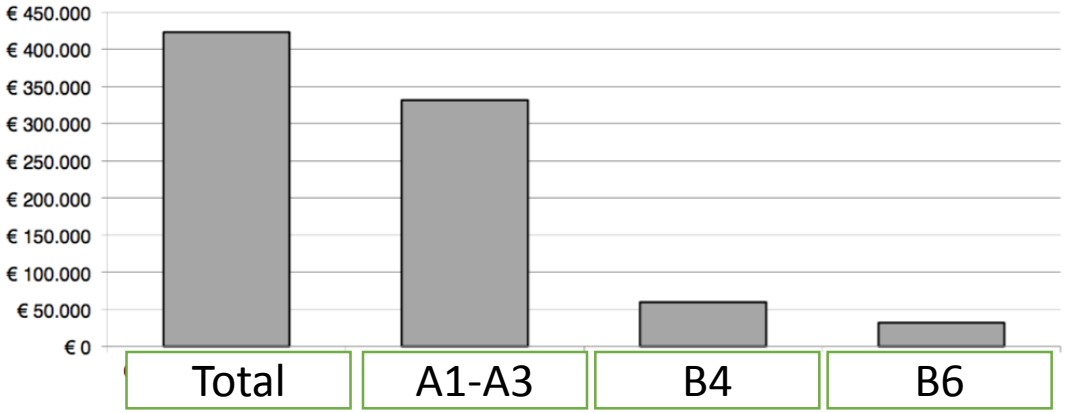
LCA results for the technical systems



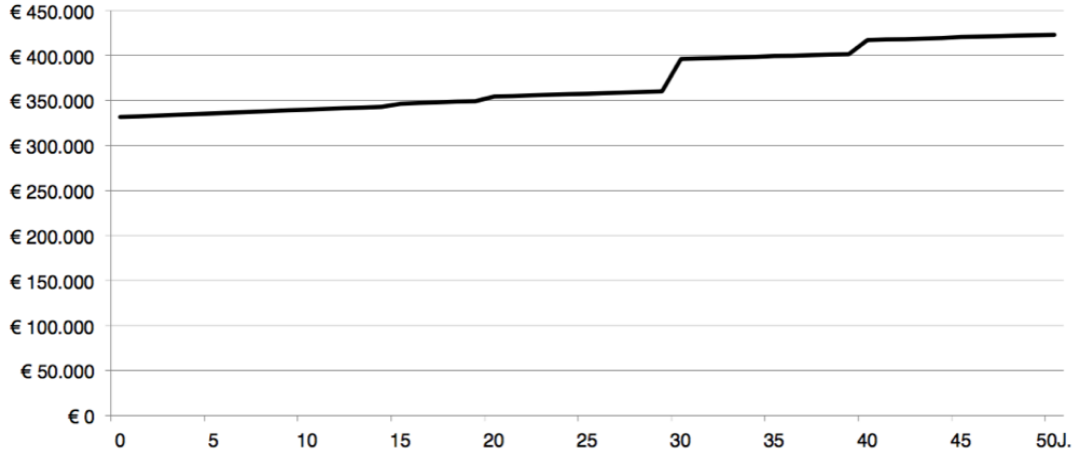



Total environmental impacts
GWP [kg CO2 eq]
20
15
10
5
0
NEH
SH
PH
PEH
ES1
ES2
ES3
ES4
Energy standards

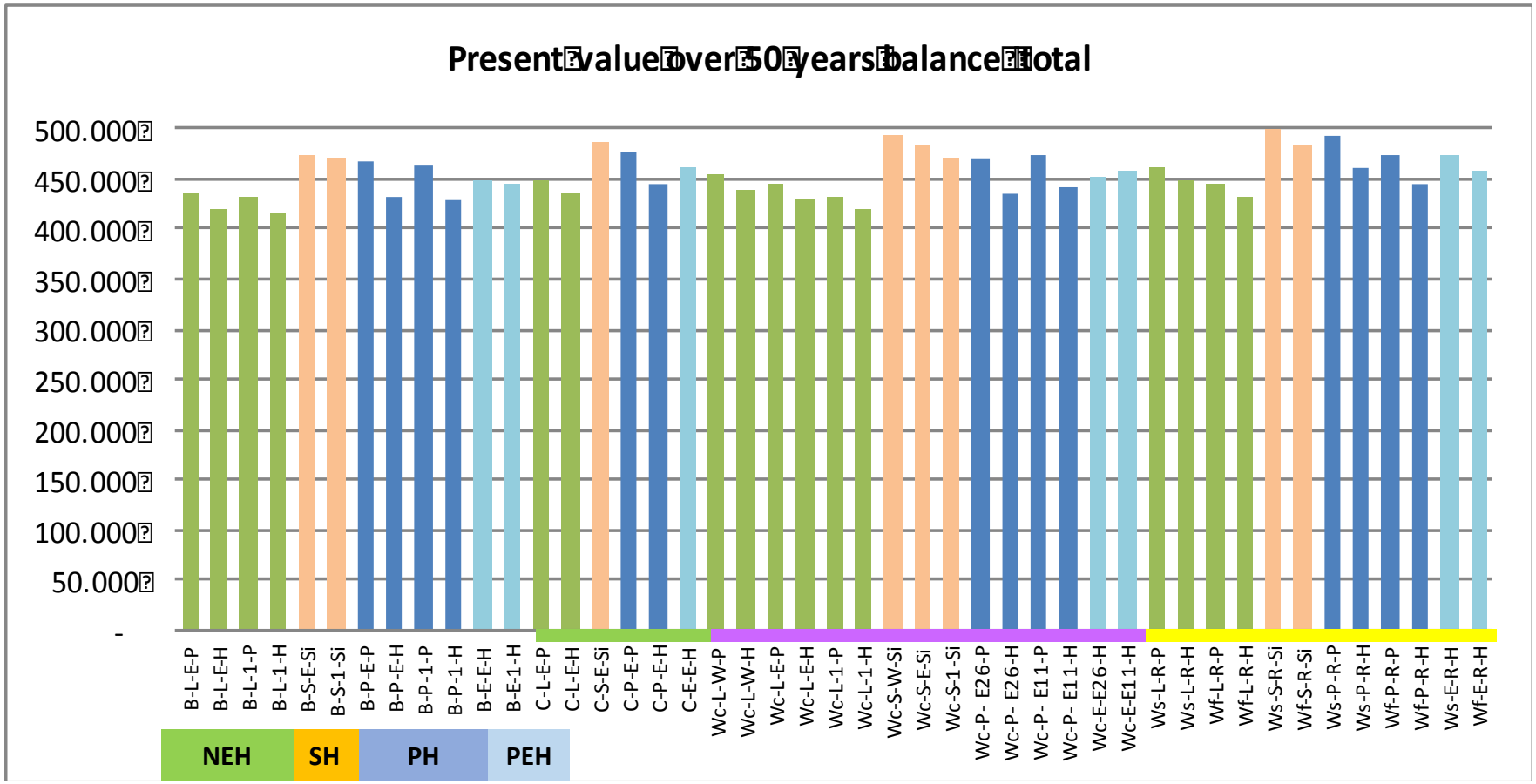
LCC


€ 450.000
€ 400.000
€ 350.000
€ 300.000
€ 250.000
€ 200.000
€ 150.000
€ 100.000
€ 50.000
€ 0
Total
A1-A3
B4
B6

NPV


€ 450.000
€ 400.000
€ 350.000
€ 300.000
€ 250.000
€ 200.000
€ 150.000
€ 100.000
€ 50.000
€ 0
0
5
10
15
20
25
30
35
40
45
50J.

LCC Results overall / house



PEH PH SH NEH

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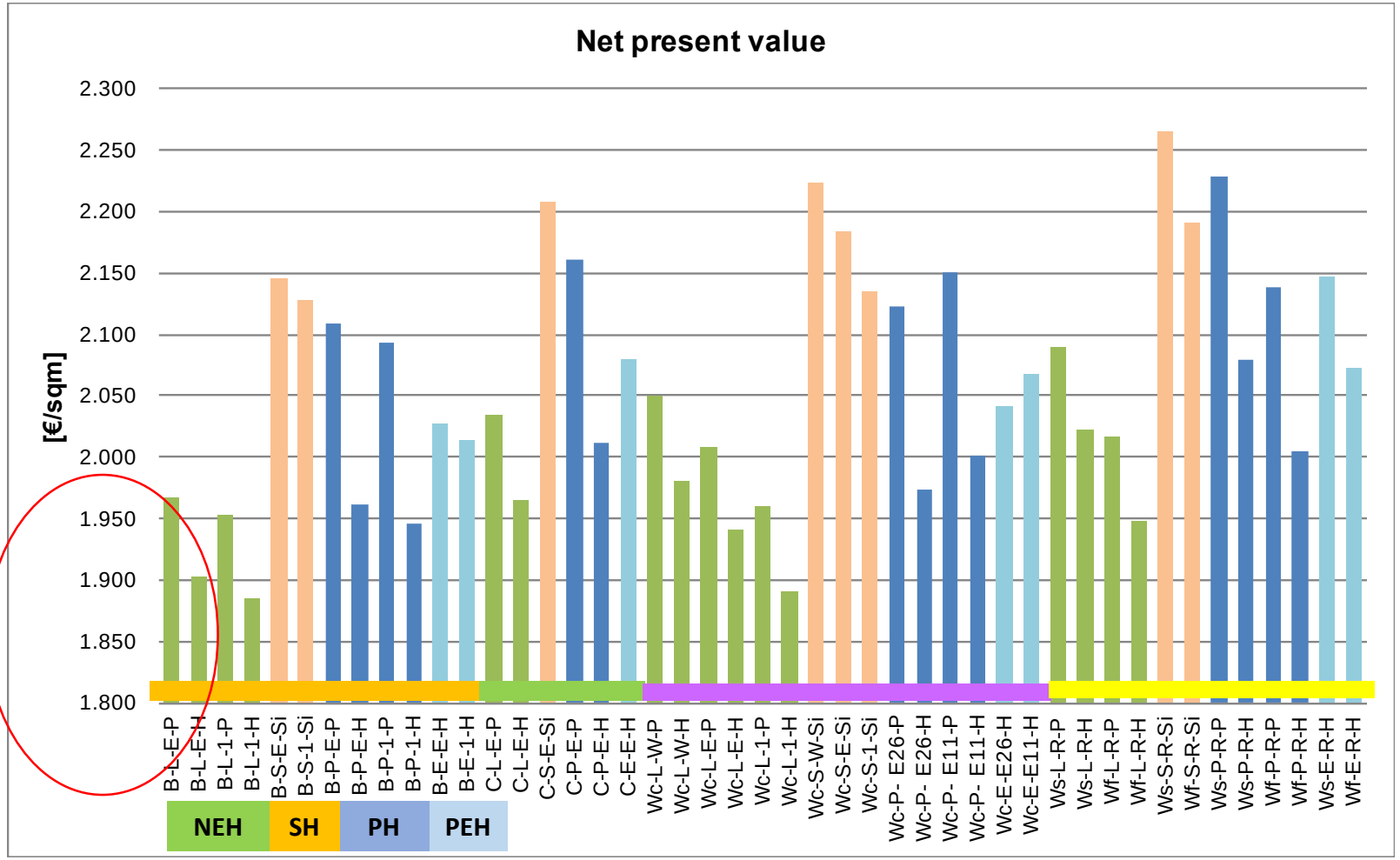
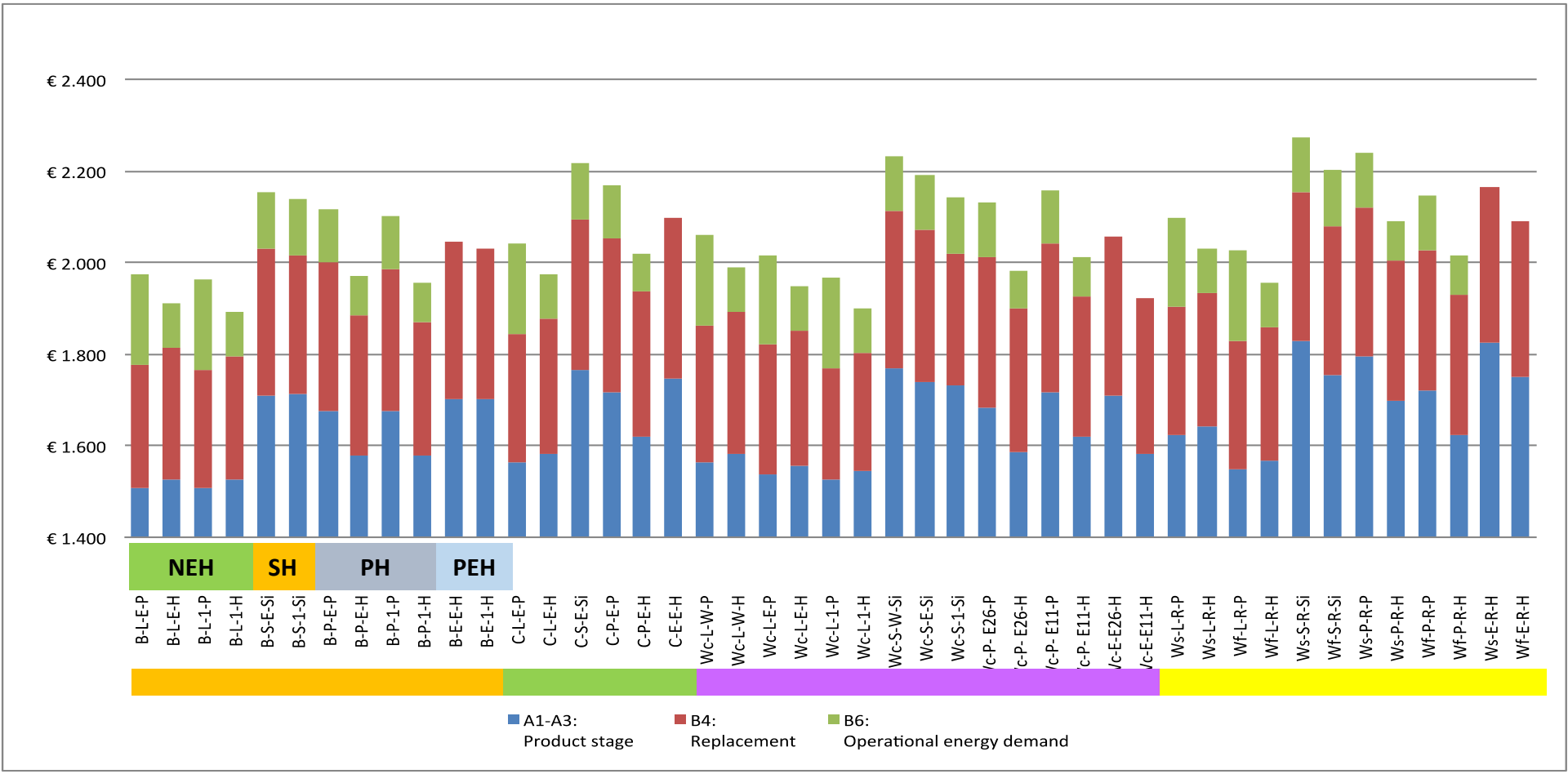
LCC results / sqm



LCC Results / sqm / phase



Research perspectives

- Methodical issues (sensitivity & uncertainty):
- Accounting rules for energy delivery (i.e. 1:1, or?) & accounted energy supply mix (AT, EU, UCTE, ?)
- Dynamic LCA (e.g. changes in future energy supply mixes)
- Choice FU LCA vs. LCC (GFA vs. NFA)
- LCC-parameter (energy prices, discount rates, etc.)
- Data quality & methods are “ready to be included in “real life” decision making process!

Conclusions

- High optimisation **potential** - spread in LCC app. -20% vs. LCA -86%
- However, variation of the technical building equipment lead to a higher improvement potential then the use of different construction techniques (LCA)
- Results also indicate that the use of a plus energy standard does not prove to be optimal in all cases (LCA & LCC)
- “Ranked order” in LCA and LCC do not correspond
- ->No “one” best option in general

Thanks to all partners!

The authors would like to thank all partners from the research project “Ökovergleiche” which served as the basis for the case study in this paper.

Innovative Gebäudekonzepte im ökologischen und ökonomischen Vergleich über den Lebenszyklus

http://www.hausderzukunft.at/results.html/id6529

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Stay with
sustainability –
it is the only
way!

Thank you

Calculation parameters for LCC

Electricity price	**0,17 €/kWh**
Pellets price	0,25 €/kg
Wood price	0,16 €/kg
Discount rate	5,5 %
Inflation rate	2,0 %
Escalation rate	4,0 %

Assessed environmental indicators

Symbol	Indicator	Unit
AP	Acidification potential on soil and water	kg $(SO_2)^{2-}$ eq /m²a
EP	Eutrophication potential	kg $(PO_4)^{3-}$ eq /m²a
ODP	Ozone depletion potential	kg CFC-11 eq /m²a
POCP	Photochemical oxidants creation potential	kg C_2H_4 eq /m²a
GWP	Global warming potential	kg CO_2 eq /m²a
CED non ren	Cumulative energy demand non renewable	MJ /m²a
CED ren	Cumulative energy demand renewable	MJ /m²a

Schematic presentation of demand/supply balance of a Net ZEB

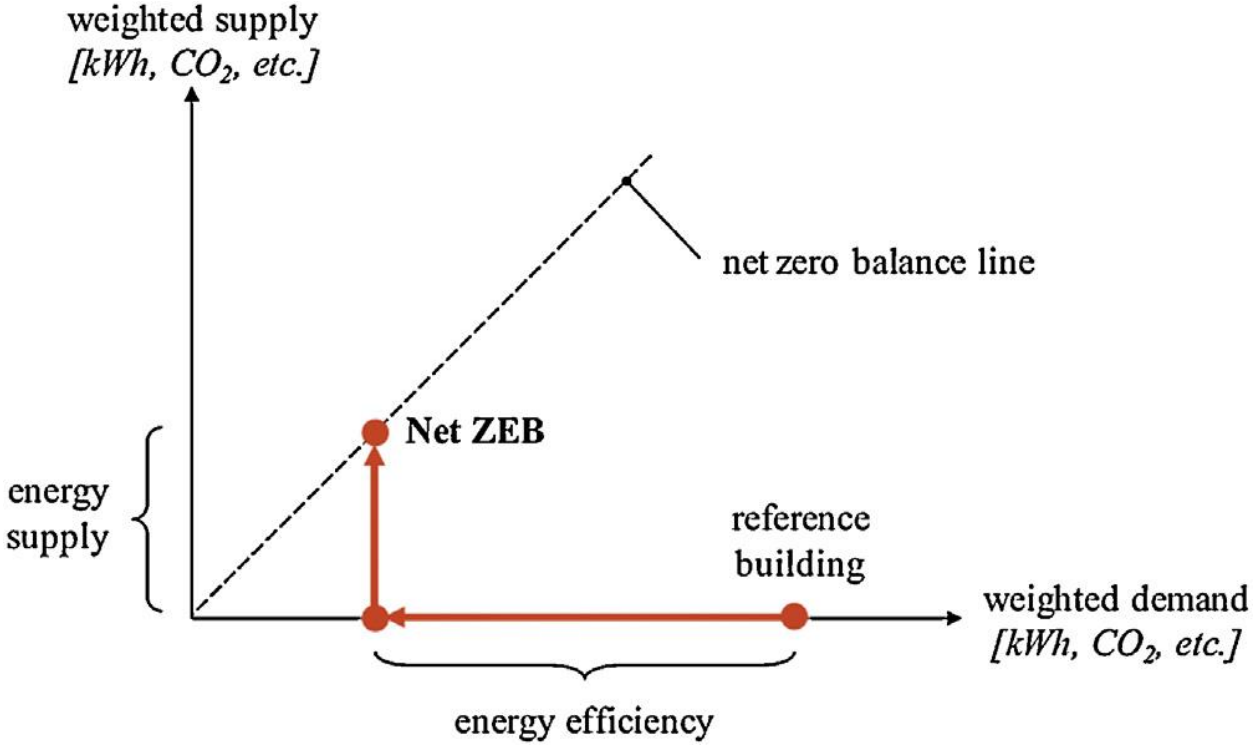

Fig. 1. Schematic presentation of demand/supply balance of a Net ZEB [11].

Net ZEB ... Net Zero Energy Buildings

Berggren, Björn ; Hall, Monika ; Wall, Maria: LCE analysis of buildings – Taking the step towards Net Zero Energy Buildings. In: Energy and Buildings Bd. 62, Elsevier B.V. (2013), S. 381–391 — http://dx.doi.org/10.1016/j.enbuild.2013.02.063