Klemens Leutgöb
e7 Energie Markt Analyse GmbH

Lorenzo Pagliano
Paolo Zangheri
Politecnico di Milano, e-ERG

Cost optimality – Brake or Accelerator on the way to nZEB

eceee 2013

Cost optimality in the EPBD recast

- **Art. 5 of the recast Energy Performance of Buildings Directive (EPBD, Directive 2010/31/EU) requires EU Member States to take into account cost optimality when defining energy performance requirements**
- **COMMISSION DELEGATED REGULATION (EU) No 244/2012 of 16 January 2012 supplementing Directive**
  - methodological approach
  - calculation periods
- **In many areas national flexibility**
  - construction cost, maintenance cost
  - life-times of building elements
  - discount rates
  - energy prices and future trends

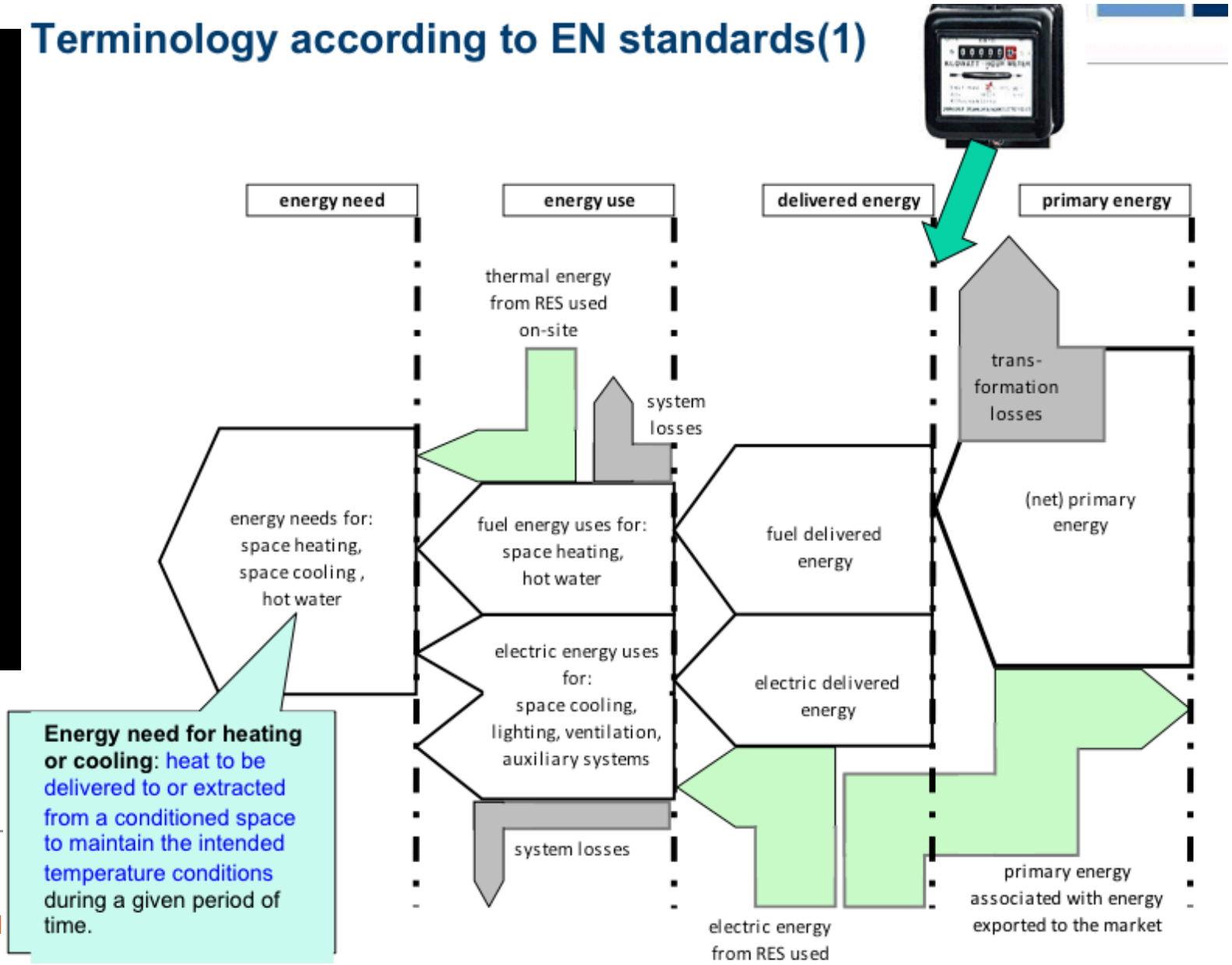
Klemens Leutgöb, e7
Lorenzo Pagliano, Paolo Zangheri, e-ERG

Energy performance calculation

Common terms and definitions are e.g. in UNI EN ISO 13790
A list of all the EN standards is presented in the "Umbrella Document"

Diagram taken from the "cost-optimal methodology", (produced by eERG)

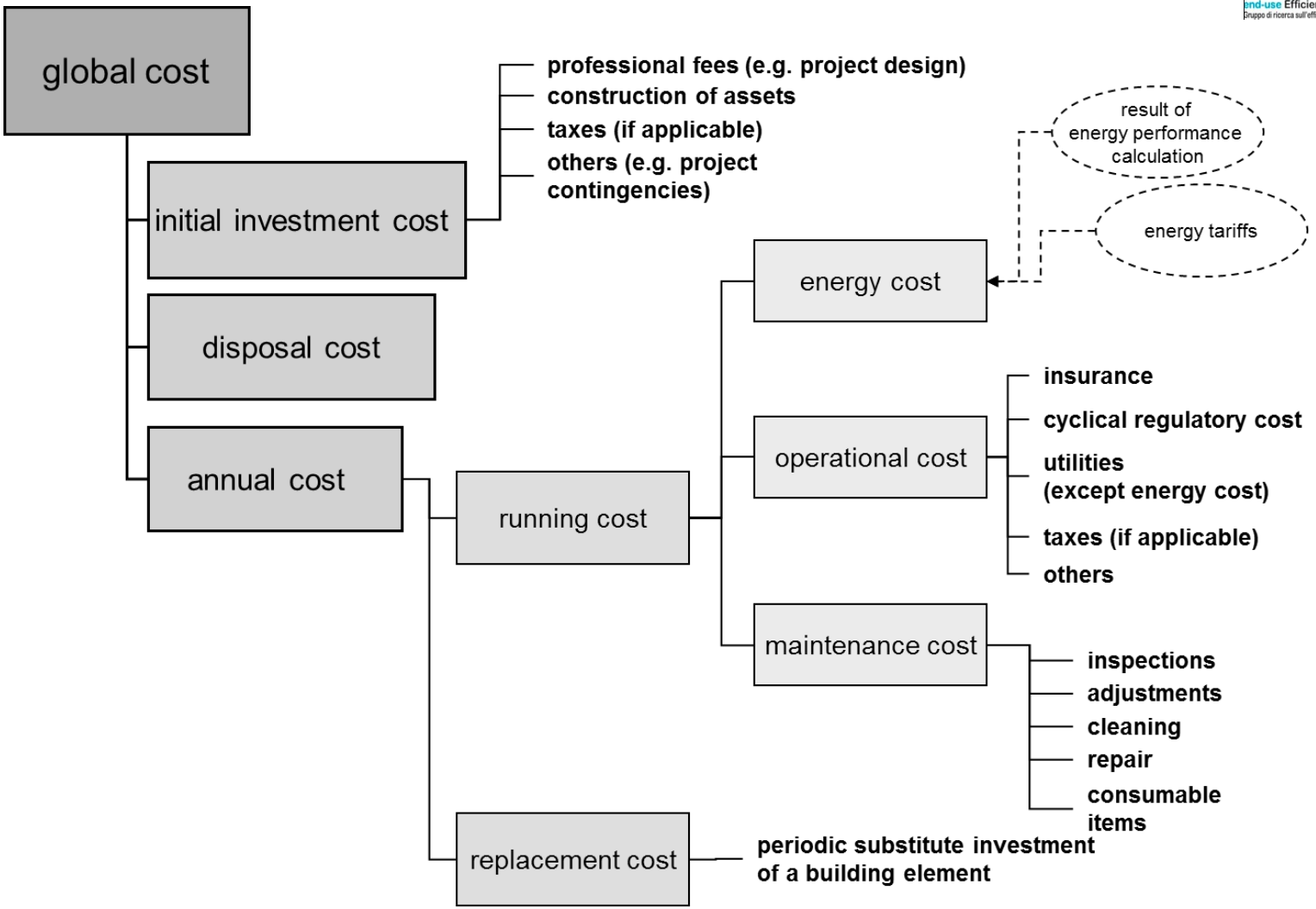
Terminology according to EN standards(1)



Energy need for heating or cooling: heat to be delivered to or extracted from a conditioned space to maintain the intended temperature conditions during a given period of time.

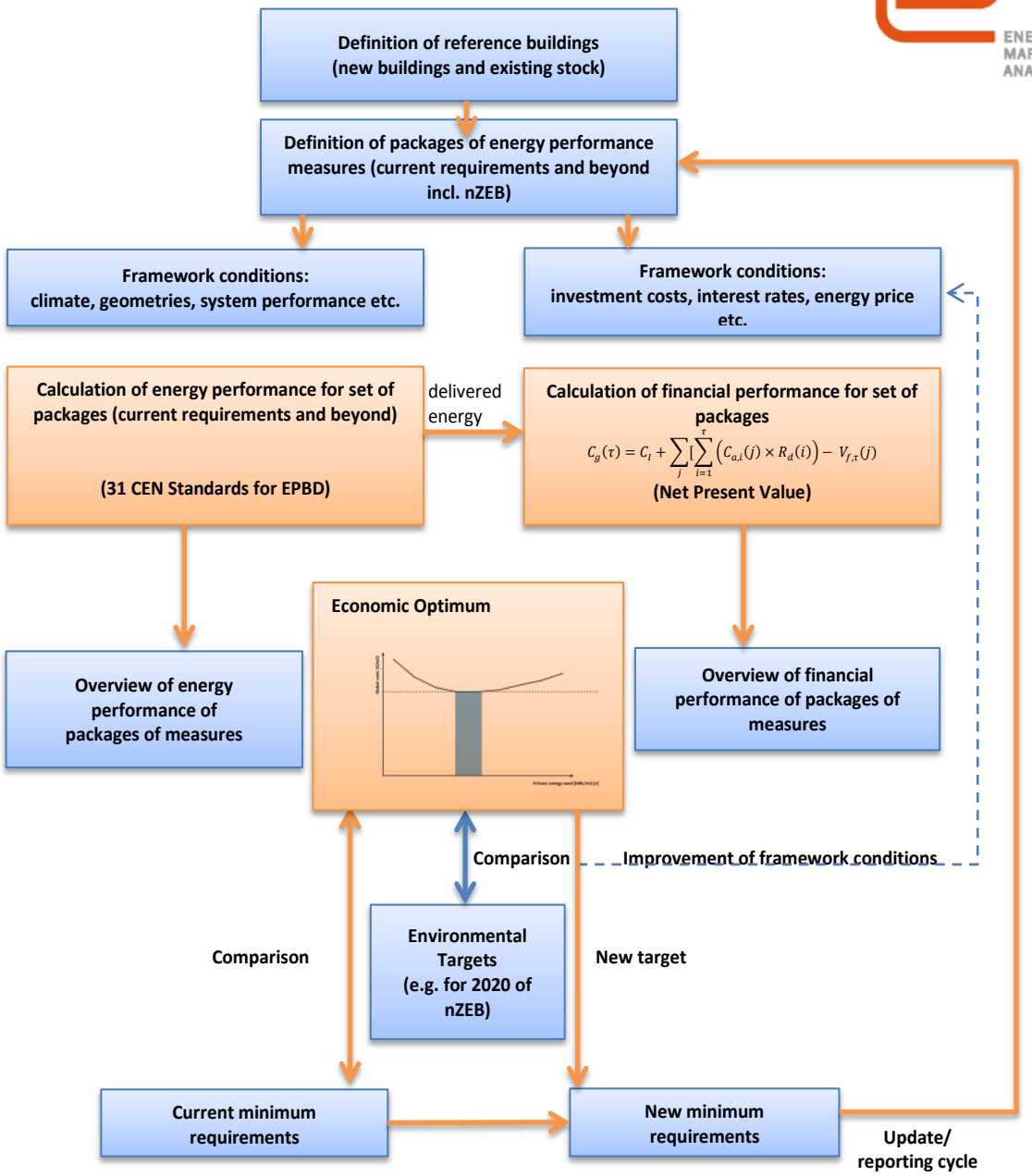
Klemens Leutgöb, e7
Lorenzo Pagliano, Paol

Cost categories to be taken into account



Klemens Leutgöb, e7
Lorenzo Pagliano, Paolo Zangheri, e-ERG

Overview on the process



source: Ecofys for BPIE

Klemens Leutgöb, e7
Lorenzo Pagliano, Paolo Zangheri, e-ERG

Example No. 1
Office buildings in different climates new construction

Reference Building

Table 25. Reference office building: configuration for new buildings (for Paris and Budapest)[15]..

For new buildings		Office building
Building geometry	N° of floor =	4
	A/V ratio =	0,47 m^2/m^3
	Orientation:	S/N
	Area of N façade =	262 m^2
	Area of N façade =	128 m^2
	Area of N façade =	262 m^2
	Area of N façade =	128 m^2
Shares of window area on the building envelope =		16%
Floor area m^2 (as used in building code) =		924 m^2 net floor area
Description of the building	Construction materials:	Hollow brick, concrete, air gap, plaster
	Typical air infiltration rate[16]:	Ach = 1 h^{-1}
	Use pattern:	Typical
	Age:	Typical for year 2010
Description of the average building technology	U value of wall =	0,32 W/m^2K
	U value of roof =	0,30 W/m^2K
	U value of basement =	0,33 W/m^2K
	U value of windows =	2,00 W/m^2K
	g value of windows (in absence of solar shading) =	0,6
	Technical building systems:	Standard gas boiler, not insulated distribution, radiators, low efficient chiller, mechanical ventilation
	Passive systems:	No solar shading device[17]

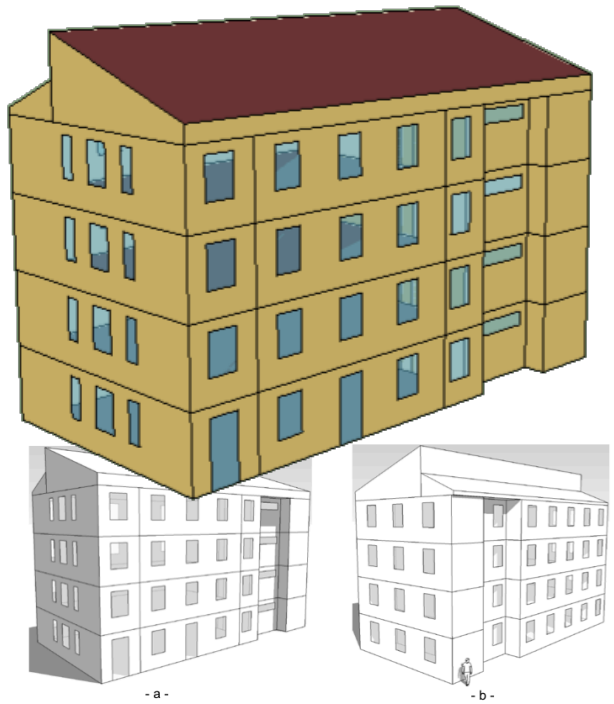


Figure 47. Perspective views of the reference building: a) North and West façades; b) South and East façades.

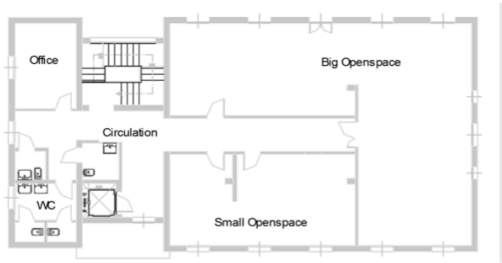


Figure 48. Floor plan of the reference office building.

Klemens Leutgöb, e7
Lorenzo Pagliano, Paolo Zangheri, e-ERG

Variants of envelope and passive features

Table 27. Envelope families considered in this analysis: South - West

Package	Measure	SOUTH: Catania (IT)						WEST: Paris (FR)					
		Family 1		Family 2		Family 3		Family 1		Family 2		Family 3	
"e"	Roof U-value [W/m²K]	low: "-"	1.5	medium-low: "o-"	0.38	medium-high: "o+"	0.2	low: "-"	1.5	medium: "o"	0.3	high: "+"	0.1
	Wall U-value [W/m²K]		1		0.48		0.23		1		0.32		0.14
	Basement U-value [W/m²K]		2.1		0.49		0.26		2.1		0.32		0.2
"w"	Window U-value [W/m²K]	low: "-"	5.2	medium-low: "o-"	3	medium-high: "o+"	1.4	low: "-"	3	medium: "o"	2	high: "+"	0.8
	Air infiltration rate: ach [21] [h⁻¹]		0.8		0.5		0.3		0.8		0.5		0.1
"c"	Total solar transmittance (or g-value) (window + shading)	low: "-"	0.8	medium-high: "o+"	0.3	high: "+"	0.1	low: "-"	0.8	medium-low: "o-"	0.6	medium-high: "o+"	0.3
	Night natural ventilation rate [22]: ach [h⁻¹]		0		2		6		0		0		2
	Envelope reflectance		0.3		0.5		0.7		0.3		0.3		0.5

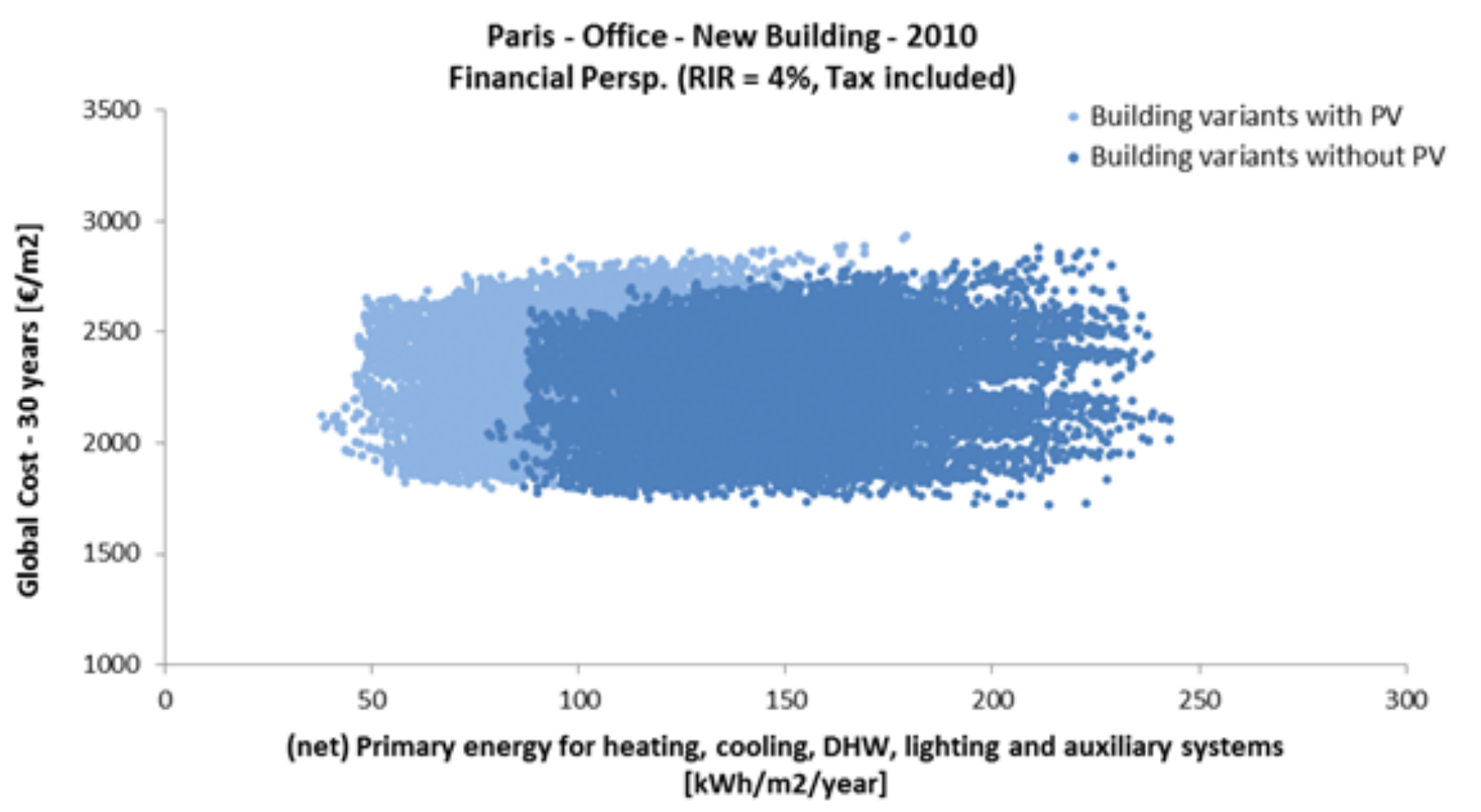
Klemens Leutgöb, e7
Lorenzo Pagliano, Paolo Zangheri, e-ERG

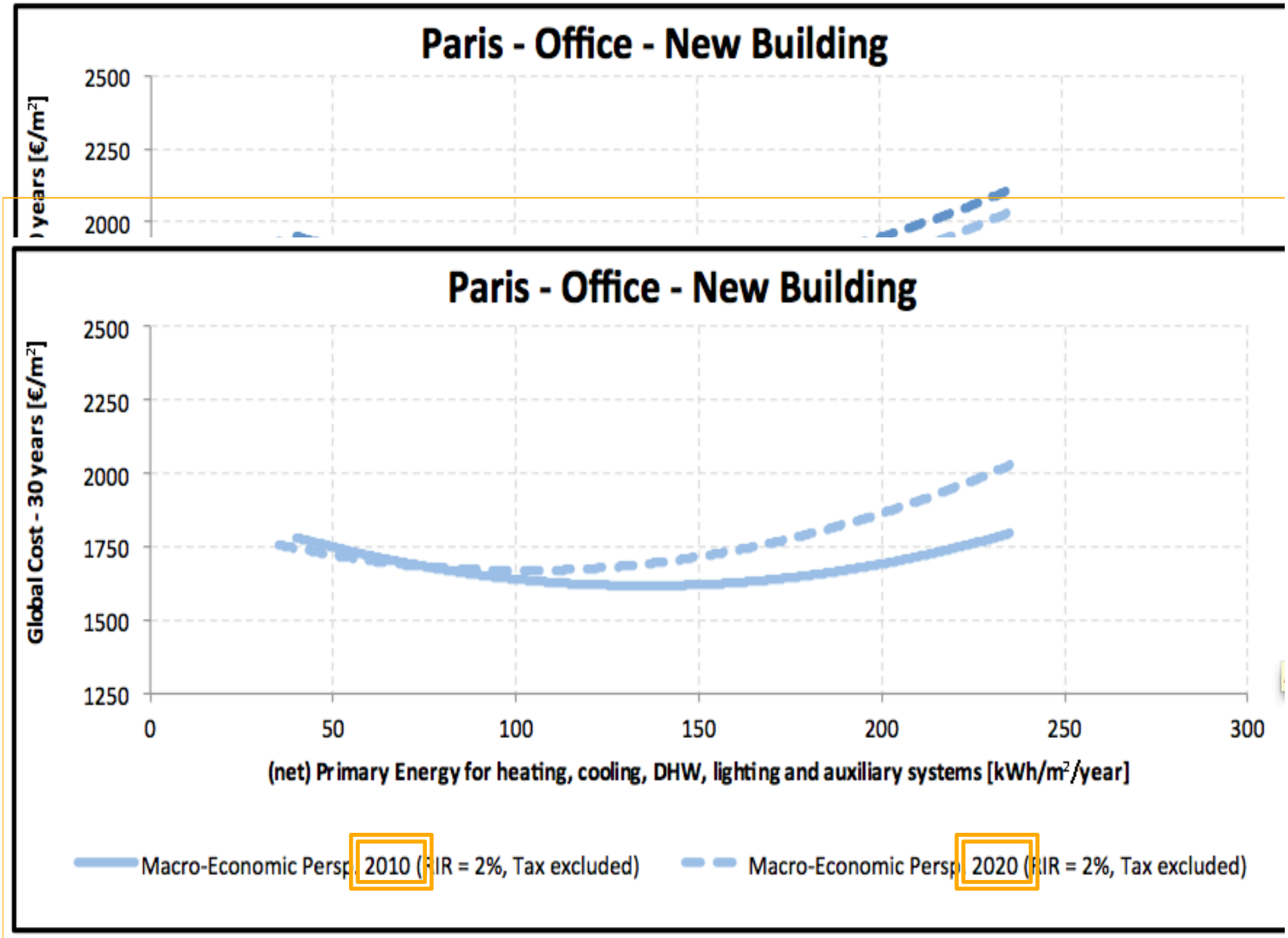
Other core assumptions

Table 32. Main input data of Paris context.

WEST: Paris (FR)	2010			2020		
Perspective	**Financial A**	**Financial B**	**Macro-economic**	**Financial A**	**Financial B**	**Macro-economic**
Real interest rate	4%	10%	2%	4%	10%	2%
Calculation period	30 years					
Primary/Delivered conversion factor for electricity	2.58			2.06		
Primary/Delivered conversion factor for natural gas	1					
Price of electricity (taxes excluded)	0.115 €/kWh$_{el}$			0.144 €/kWh$_{el}$		
Price of natural gas (taxes excluded)	0.053 €/kWh$_{th}$			0.066 €/kWh$_{th}$		
Price of electricity sold to the grid	0.048 €/kWh$_{el}$			0.059 €/kWh$_{el}$		
Real escalation rate of energy prices	2.5%					
Investment cost for new buildings not related to energy use (tax excluded)	1000 € (2010)/m^2			1000 € (2020) /m^2		
VAT	15%					
Taxes on electrical energy	24%					
Taxes on natural gas	20%					
Subsidies and incentives	excluded					
Taxes	included		excluded	included		excluded
Costs of avoided environmental damage (50	excluded		Included	excluded		Included

Results financial perspective




Paris - Office - New Building
Global Cost - 30 years [€/m²]
2500
2250
2000
1750
1500
1250
0
50
100
150
200
250
300
(net) Primary Energy for heating, cooling, DHW, lighting and auxiliary systems [kWh/m²/year]
Macro-Economic Persp. 2010 (RIR = 2%, Tax excluded)
Macro-Economic Persp. 2020 (RIR = 2%, Tax excluded)

Example No.2
Single family houses in Austria
new construction

Reference building

- **Simple form of the reference building**
  - gross floor area of 221 sqm
  - two storeys
  - surface-volume ratio of 0.68
  - window area: ~ 15%
- **construction type: brick structure plus insulation**
- **two variants of energy supply**
  - pellets boiler
  - heat pump

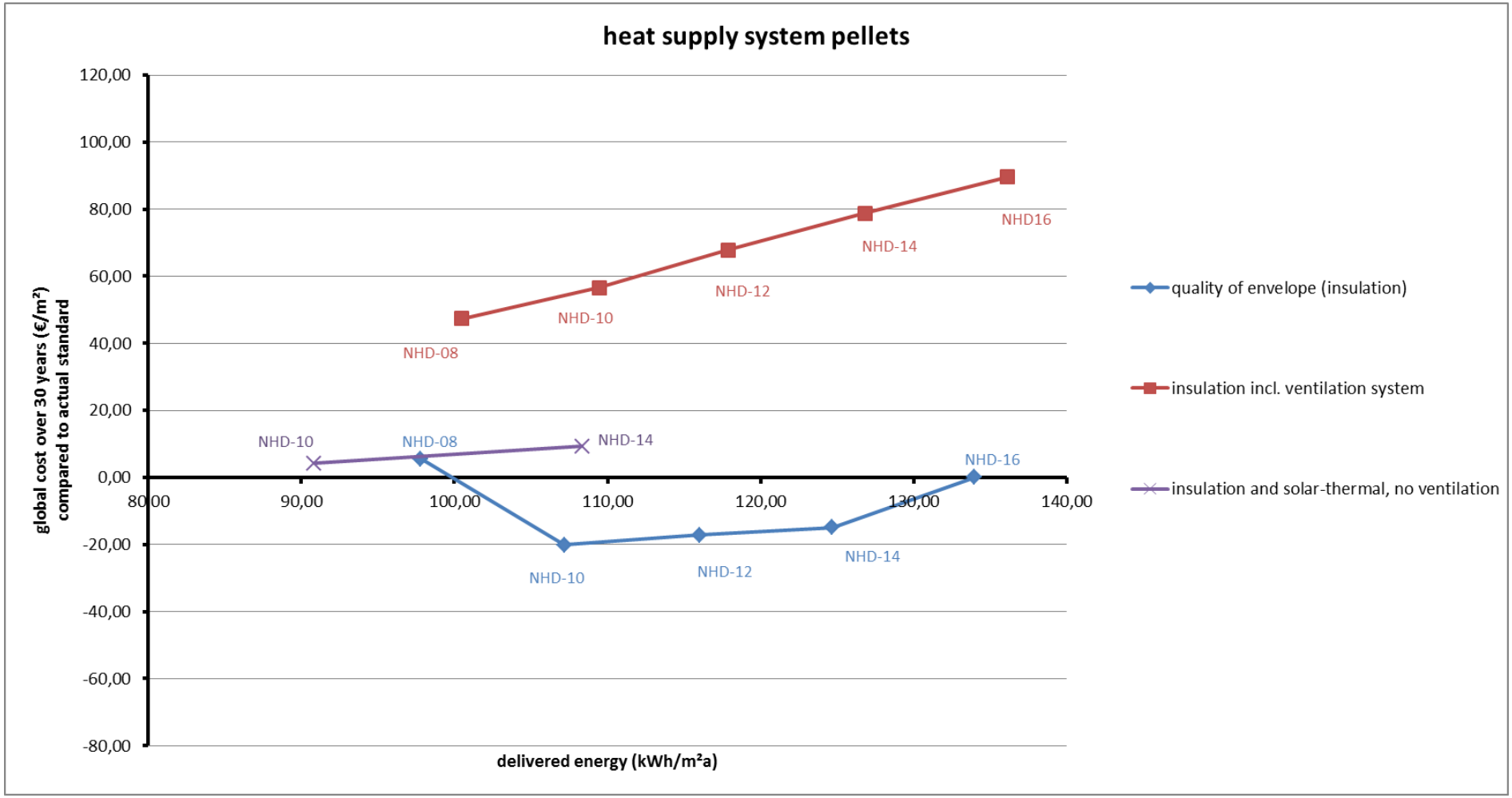
overview on variants

No.	quality of envelope	ventilation system	heating supply system	RES-solar
1	NHD-line 16	no	pellets	no
2	NHD-line 14	no	pellets	no
3	NHD-line 12	no	pellets	no
4	NHD-line 10	no	pellets	no
5	NHD-line 8	no	pellets	no
6	NHD-line 16	ventilation	pellets	no
7	NHD-line 14	ventilation	pellets	no
8	NHD-line 12	ventilation	pellets	no
9	NHD-line 10	ventilation	pellets	no
10	NHD-line 8	ventilation	pellets	no
11	NHD-line 16	no	heat pump	no
12	NHD-line 14	no	heat pump	no
13	NHD-line 12	no	heat pump	no
14	NHD-line 10	no	heat pump	no
15	NHD-line 8	no	heat pump	no
16	NHD-line 16	ventilation	heat pump	no
17	NHD-line 14	ventilation	heat pump	no
18	NHD-line 12	ventilation	heat pump	no
19	NHD-line 10	ventilation	heat pump	no
20	NHD-line 8	ventilation	heat pump	no
21	NHD-line 6,4	ventilation as heating system	heat pump	no
22	NHD-line 4,4	ventilation as heating system	heat pump	no
23	NHD-line 14	no	pellets	solar-thermal
24	NHD-line 10	no	pellets	solar-thermal
25	NHD-line 14	no	heat pump	PV
26	NHD-line 10	no	heat pump	PV

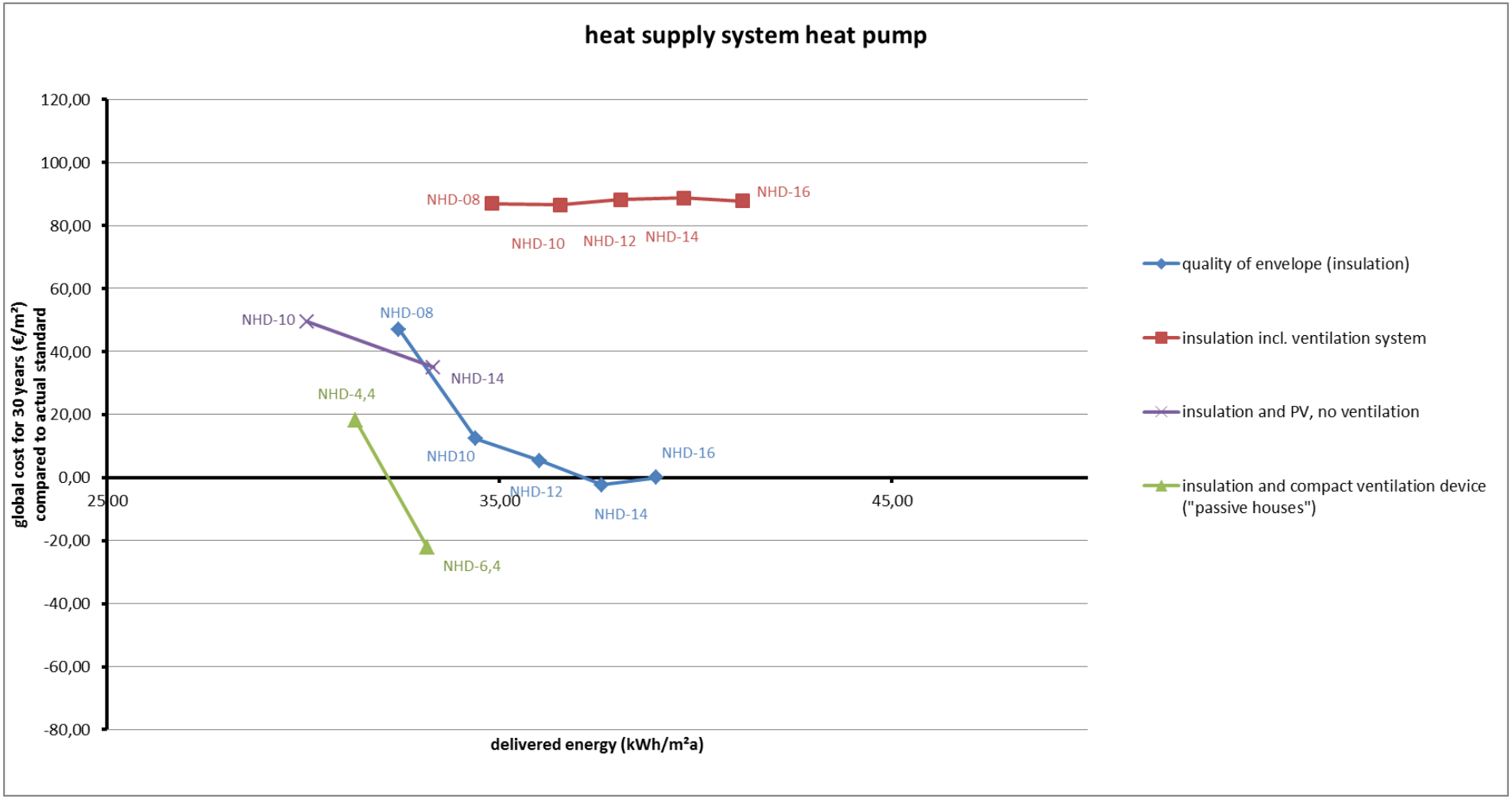
Main input paramters and assumptions

- **use of market-based construction costs widely discussed with relevant interest groups**
- **differentiated life-times for building elements**
  - insulation: 60 years
  - windows, heating and ventilation distribution systems: 35 years
  - heat supply (boiler, heat pump, central ventilation system, solar systems): 20 years
- **energy prices**
  - starting price pellets: 0,05 €/kWh
  - starting price electricity heat pump: 0,1655 €/kWh
  - yearly increase of 4% in real terms – as compared to ~ 2.8% according to EU ENERGY TRENDS TO 2030 (2009)
- **private investor's perspective → inclusion of VAT**
- **discount rate: 2% in real terms**

results for heat supply system pellets



results for heat supply system heat pump



assessment of driving factors

- **generally robust results → very little changes in sensitivity analyses**
  - lower energy price increase
  - higher discount rate
  - shorter life-times of some building elements
- **more observable changes in the results only if concentrated „bias into one direction“ for a bundle of input parameters**
- **more important: construction cost data →cost differences between different qualities**

Elements of a quality check for cost optimality calculations

Plausibility of results

- **Cost curves for comparable variants are rather flat**
  - difference in global cost < 100 €/sqm)
- **There exist cost-optimal solutions that are below actual building regulations**
- **comparative disadvantage of heating dominates climates**
  - In heating dominated climates the most energy efficient variants (“nZEB variants”) are not cost-optimal yet;
  - In Southern European climates (dominated by cooling) selected “nZEB variants” are already cost-optimal or very close to cost optimality;
- **energy carriers with low variable cost move cost optimum to “the right side”**
- **variants with higher comfort levels have higher global costs**
  - example: variants with ventilation systems

plausibility of driving input parameters and core assumptions

- **plausibility of the selected reference building**
  - size, shape, share of windows areas etc.
- **selection of variants**
  - most plausible variants covered?
  - nZEB variants covered?
- **quality of cost data**
  - market-based, consolidated information source
- **concentrated bias into one direction for a bundle of input factors**
  - relationship between energy price development and discount rate

Methodological short-comings

- **Completeness of the cost elements considered**
  - especially maintenance cost is often forgotten
- **Differentiation of life-times of building elements**
- **Provision for residual value**
  - can be checked through sensitivity analysis regarding to life-times

Conclusion: Brake or Accelerator towards nZEB

- **Expectation: cost optimality calculations should show economically viable room for further tightening of the building regulation**
  - (very) flat cost curves → no cost optimal point, but rather broad area of cost optimality
- **The very energy efficient solutions with considerable RES-share ("nZEB-variants") still have *slightly* higher global cost**
  - probably with exception Southern European climates
  - need for some political courage beyond the simple economical argument

Thanks for your attention!

Klemens Leutgöb
e7 Energie Markt Analyse GmbH

klemens.leutgöb@e-sieben.at
www.e-sieben.at

Lorenzo Pagliono
Paolo Zangheri
Politecnico di Milano, e-ERG

lorenzo.pagliano@polimi.it
paolo.zangheri@polimi.it