Gerhard Hofer
e7 Energie Markt Analyse GmbH

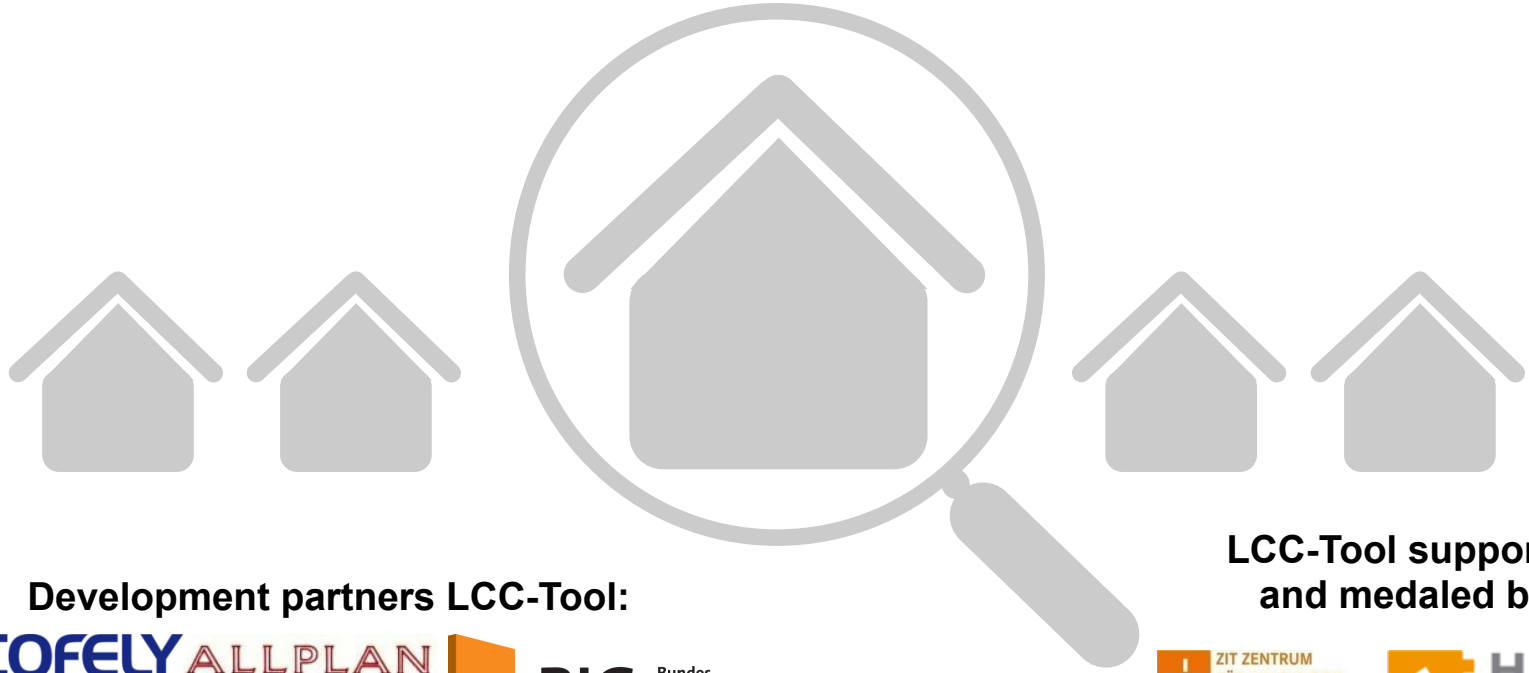
Calculating life cycle cost in the early design phase to encourage energy efficient and sustainable buildings

e7 Energie Markt Analyse GmbH

- **Research and consulting company, Vienna, Austria**
- **Established in 2007, before at Austrian Energy Agency**
- **Thematic fields**
  - Energy efficient and sustainable buildings
  - Energy economics
  - Climate and energy policy

Calculating life cycle cost in the early design phase to encourage energy efficient and sustainable buildings

A LCC Method and Tool



Development partners LCC-Tool:

PORR, COFELY GDF SUEZ, ALLPLAN - Die Umweltmanager -, BIG Bundes Immobilien Gesellschaft

LCC-Tool supported and medaled by:

ZIT ZENTRUM FÜR INNOVATION UND TECHNOLOGIE Die Technologieagentur der Stadt Wien., HAUS der Zukunft

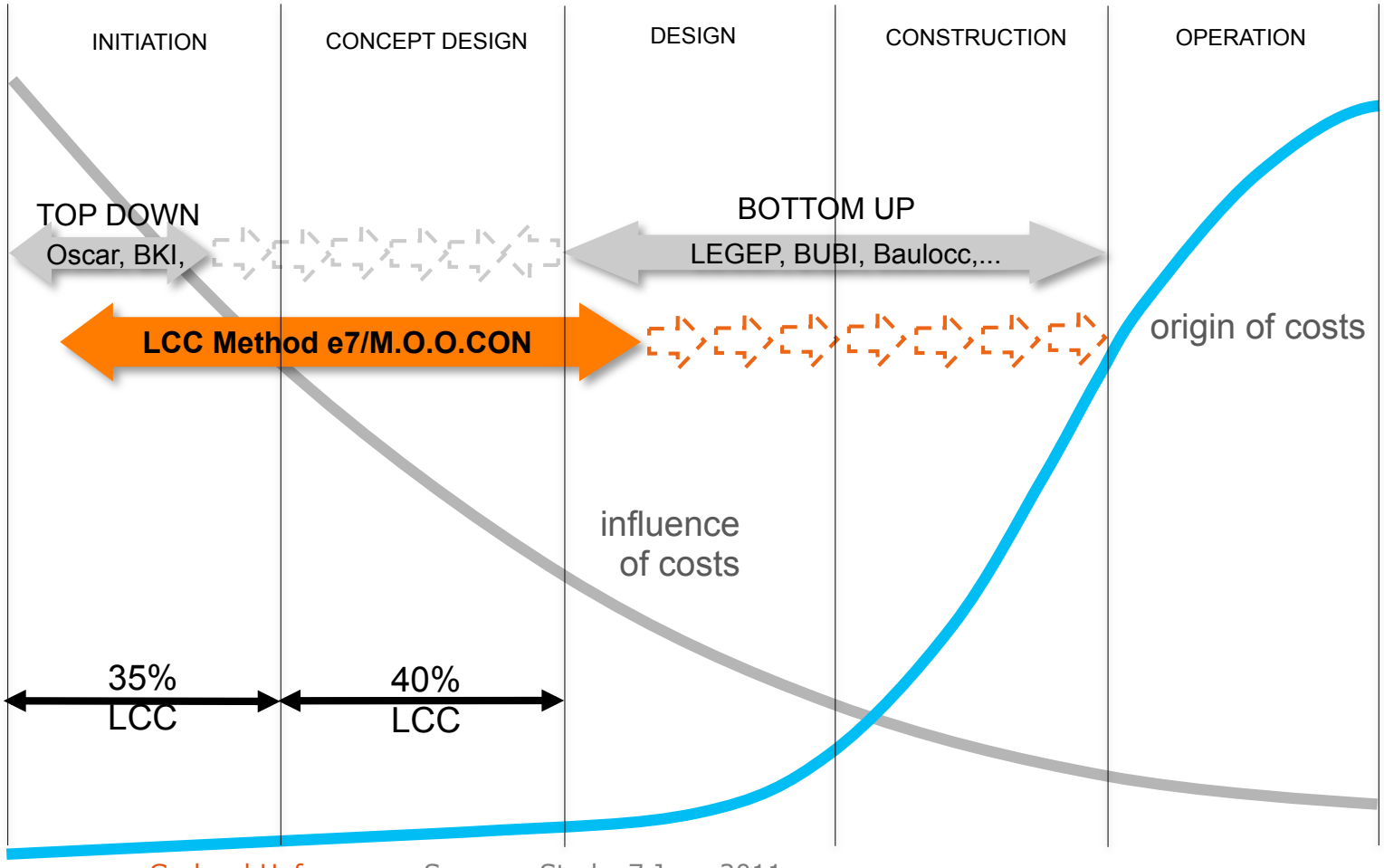
Background

- **More energy efficient building designed**
  - European regulations: EPBD, EPBD2
  - Trend to sustainable buildings: certificates such as LEED, DGNB, Total Quality Building, klima:aktiv, ...
- **More information on energy demand in design process**
  - Definition of building energy standard in initiation: e.g. passive house
  - Calculation based on data of building design possible
- **Little information of impacts on life cycle cost**
  - Project initiation: little or no information on LCC at project start
  - Design phase: no quick LCC calculation during design phase, comparison of several scenarios based on holistic approach difficult

LCC Method and Tool

Current State of LCC-Tools

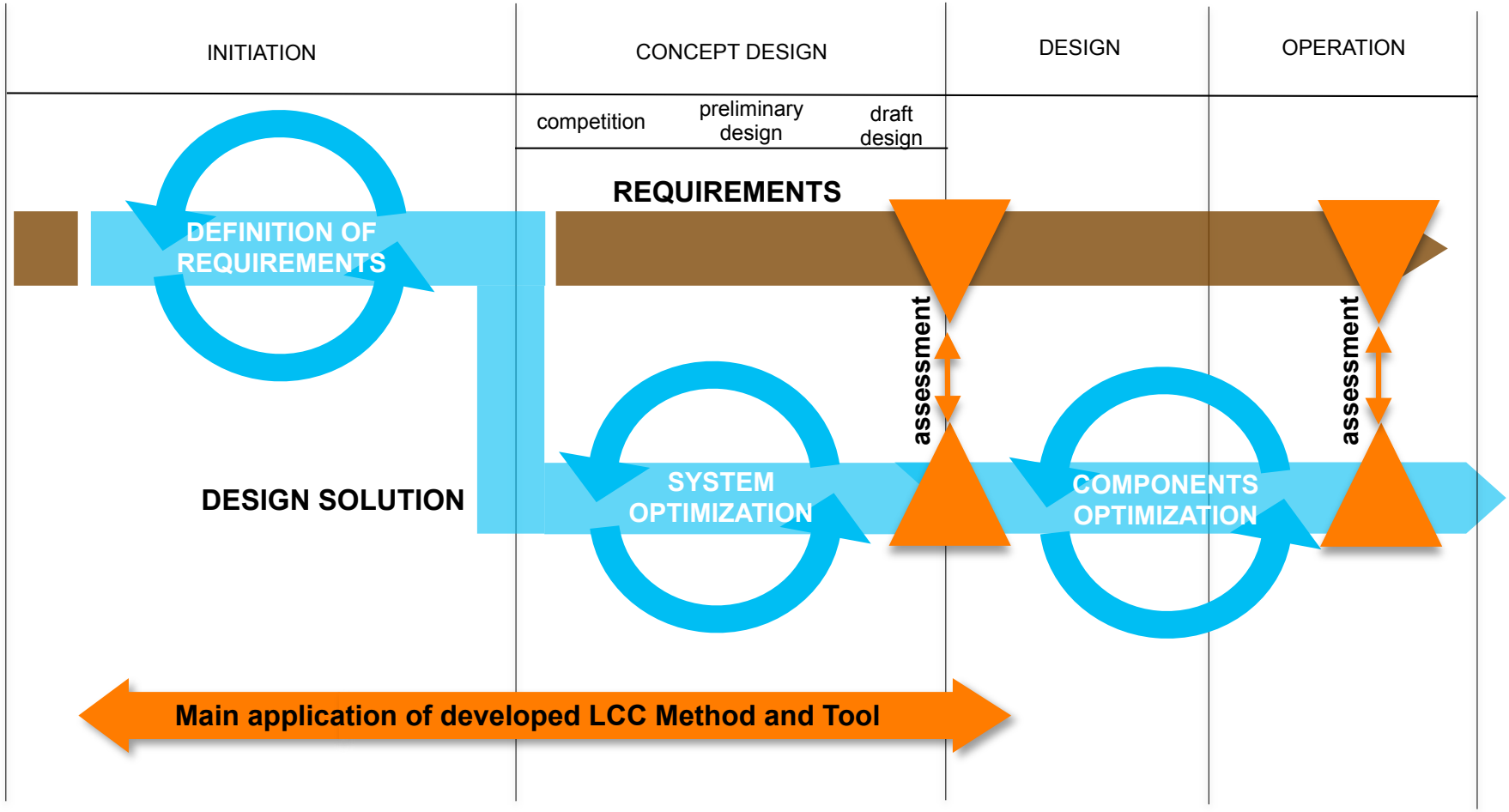
75 % of costs can be influenced in the early design phase



LCC Method and Tool

Application of LCC in the design process

cost-optimization across all phases



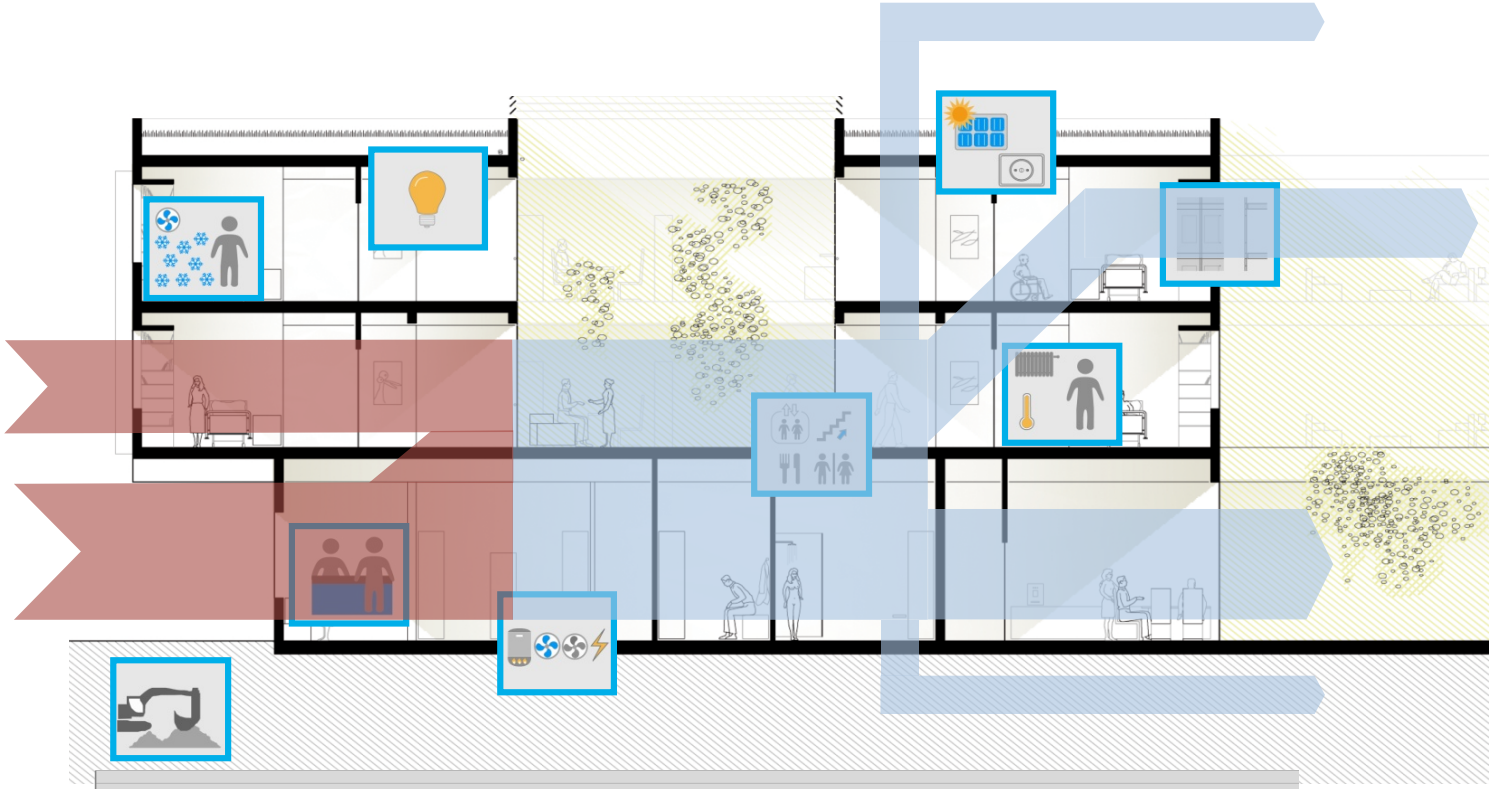
LCC Method and Tool

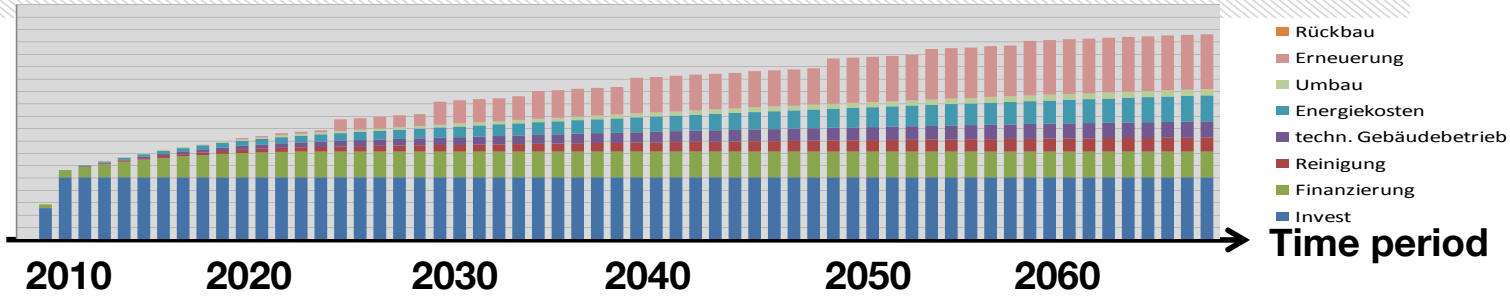
Research questions

INITIATION	CONCEPT DESIGN	DESIGN	CONSTRUCTION
NO BUILDING DESIGN, JUST REQUIREMENTS	BUILDING DESIGN AVAILABLE		
Which requirements cause which investment/ operating and energy costs? **Which defaults and characteristic values are important for planning?** **Which LCC are to be expected by the design specifications?**	**Which LCC are to be expected due to design?** **Which costs result from systems and component decisions in building and building services?** **Which optimization can be achieved without loss of quality?**		

LCC Method and Tool

Elements of the LCC Method



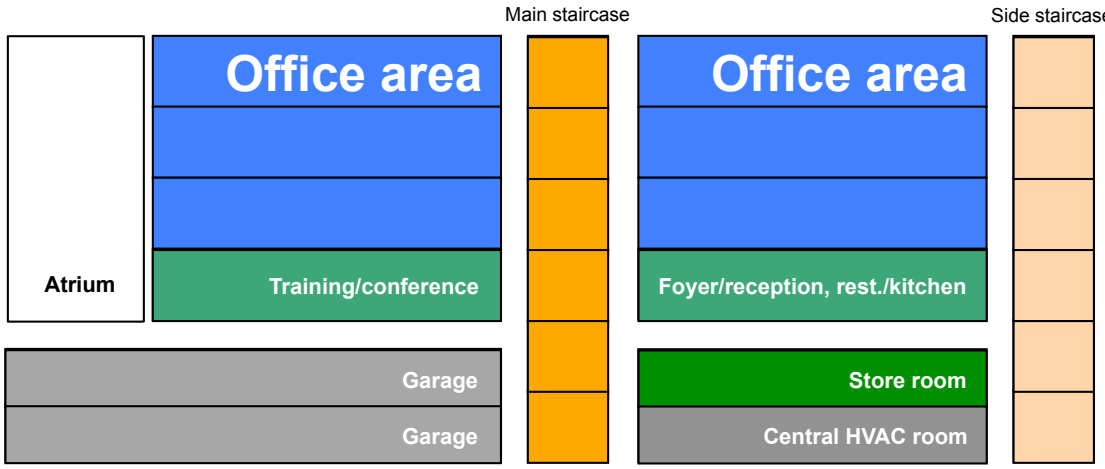


LCC Method and Tool

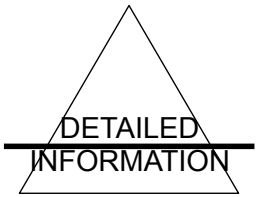
Building Elements

Relevance of
area, costs,
system decision (quality)

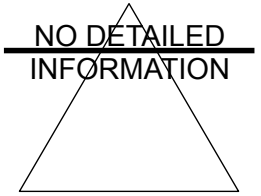
Gives level of detail
Costs area
Element



- Area with high standardization (office): **element / quality**



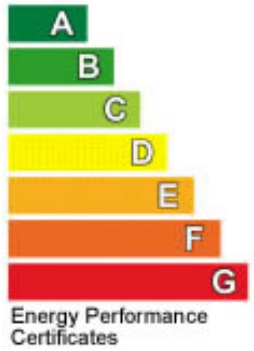
- Special areas, low standardization: **costs ranges / quality**



Possible building categories: office, school, hotel, nursing home

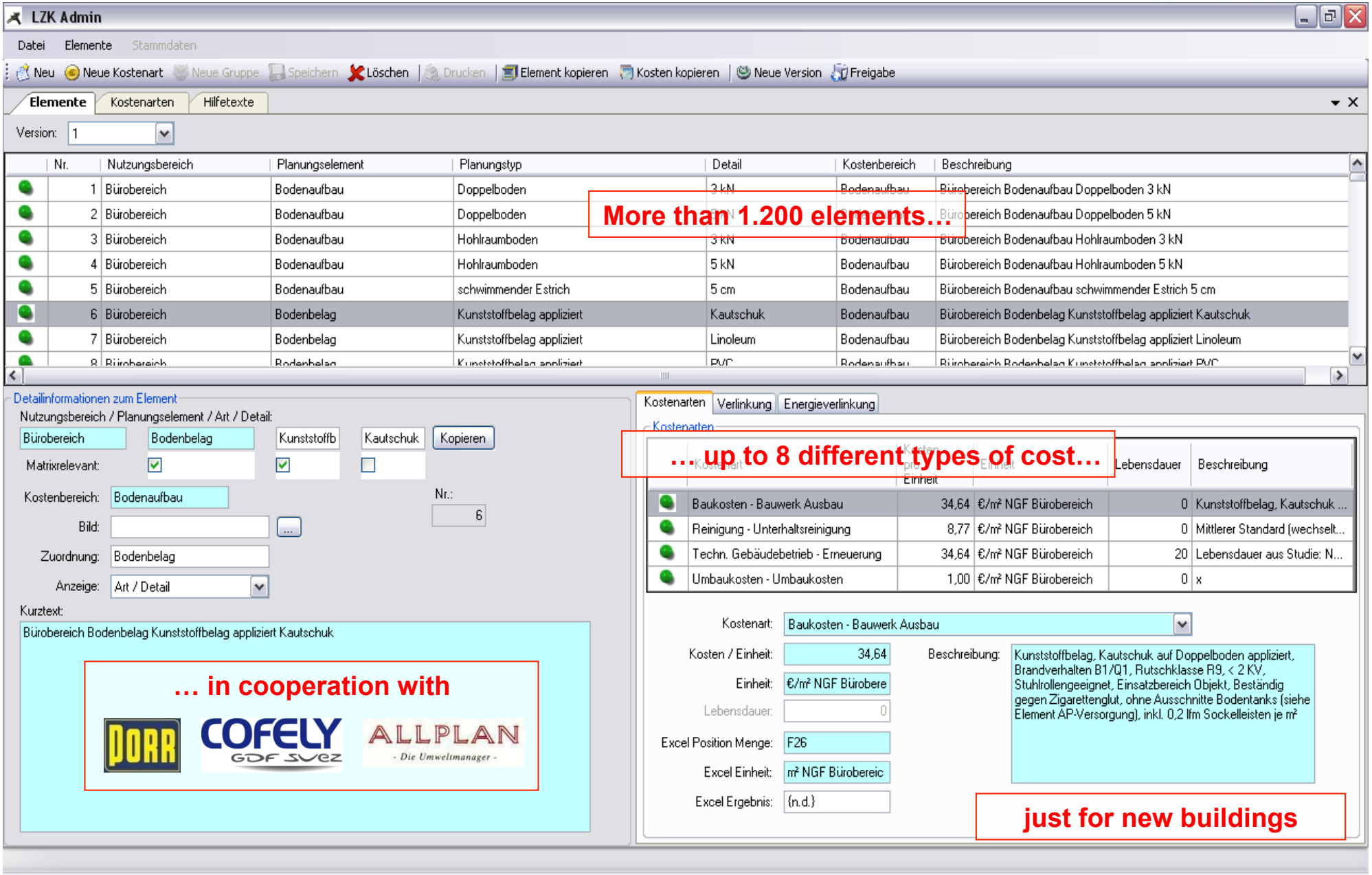
LCC Method and Tool

Energy calculation

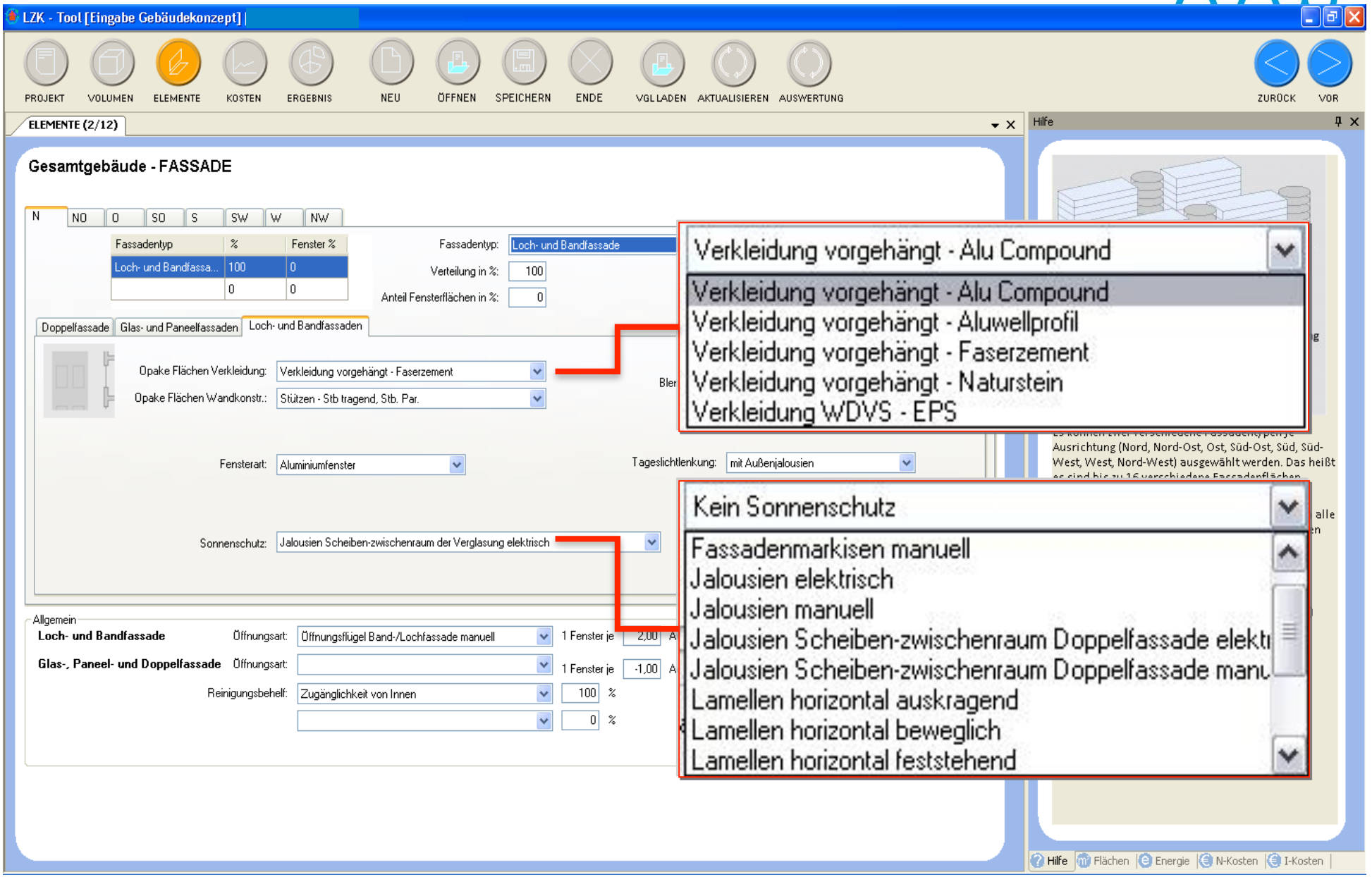


- **Calculation based on EN ISO 13790**
  - Monthly balance method
  - European standards for Energy Performance of Building
  - Application based on national standards in Austria
- **Modifications**
  - \- No detailed input data necessary
  - \- No detailed calculation besides office area
  - \+ daylight calculation incorporated
  - \+ calculation of thermal mass based on real components
  - \+ calculation of internal load based on specific assumptions
  - \+ calculation of the overall energy consumption (including energy using products in the building)

LCC Method and Tool: Database



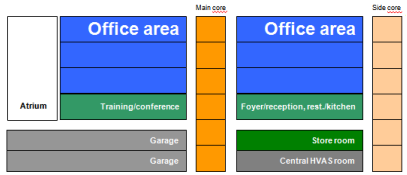
LCC Method and Tool: User interface



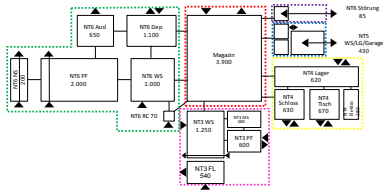
LCC Method and Tool
Approach summary

MEASURE

- Aggregation of elements
- Variable degree of detail
- Algorithms

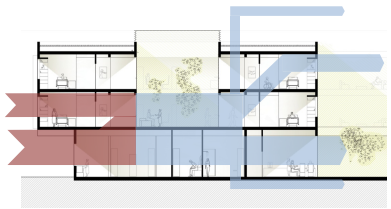


- Virtual building model



- Building elements with cost database

- Integrated energy calculation (consumption, load)



RESULT

REDUCTION OF INPUT-EFFORT

→ APPLICATION DURING DESIGN PROCESS

LCC CALCULATION FROM INITIATION OF THE PROJECT ONWARDS

INTERACTION BUILDING SHELL (FACADE) AND BUILDING SERVICES

ENERGY AND LCC OPTIMIZATION IN THE EARLY DESIGN PHASE

Example 1

Architectural competition nursing home

COMPETITION WORKS

lig landes immobilien gesellschaft steiermark

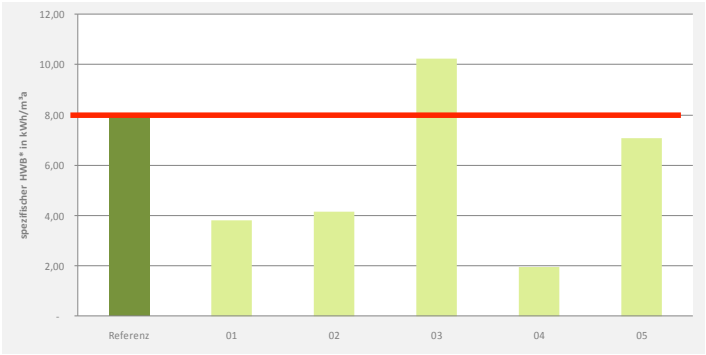
Example 1

Architectural competition nursing home

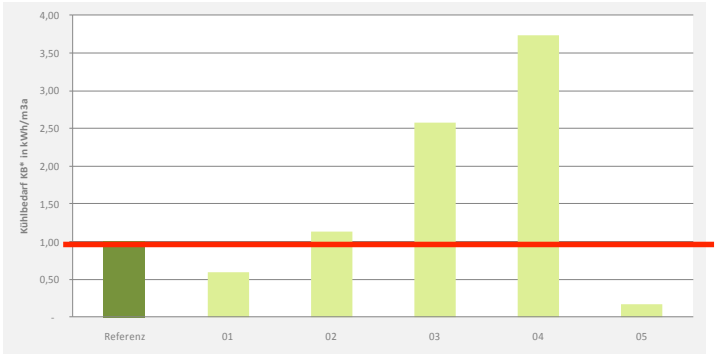
ENERGY EFFICIENCY

by using IEAA Tool

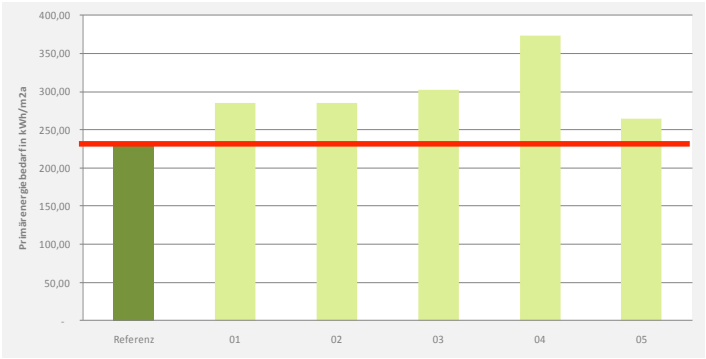
HEAT DEMAND



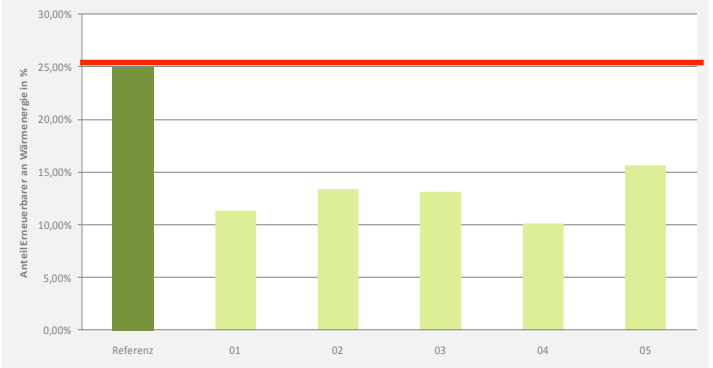
EXTERNALLY INDUCED COOLING DEMAND



PRIMARY ENERGY DEMAND



SOLAR COVERAGE

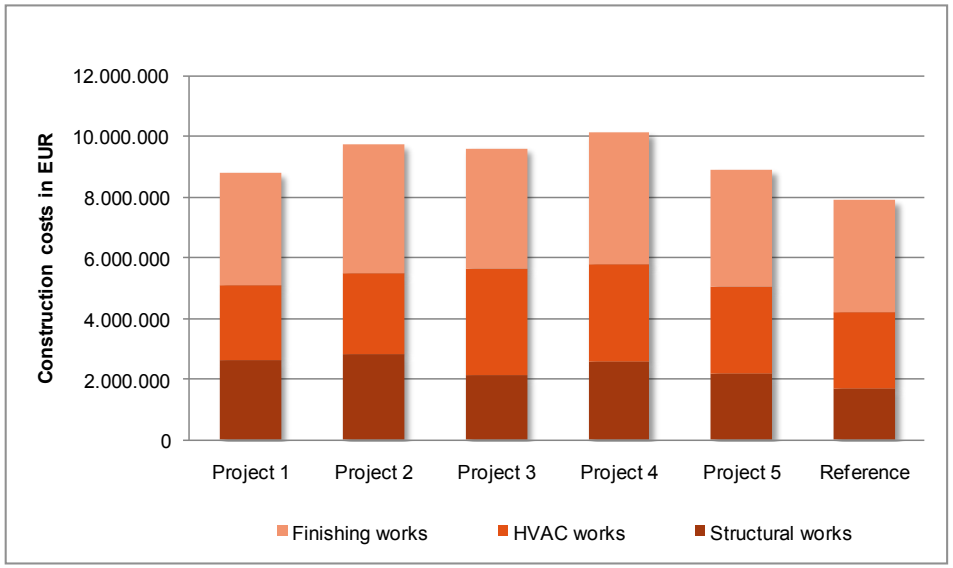


Example 1

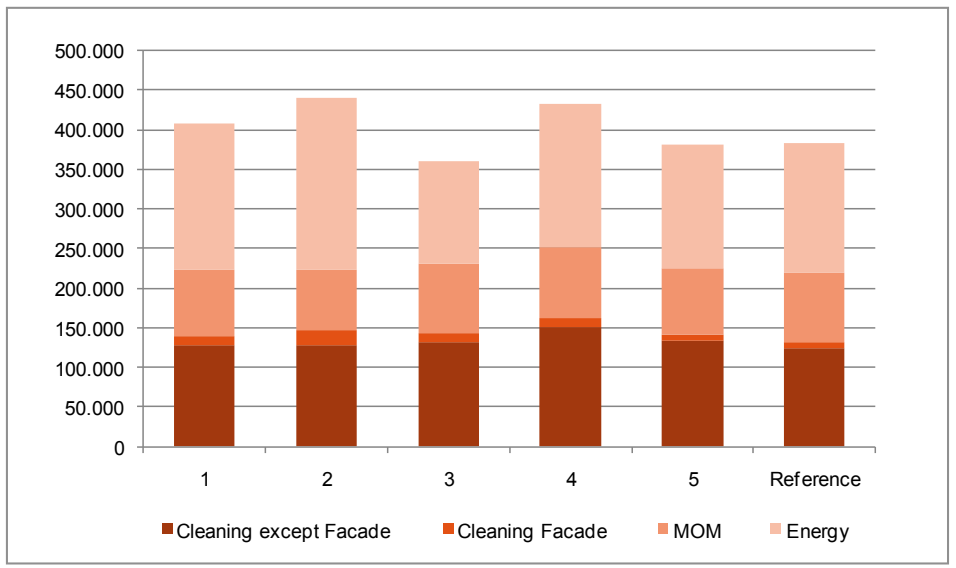
Architectural competition nursing home

LCC-ANALYSIS

CONSTRUCTION COSTS



OPERATING COSTS

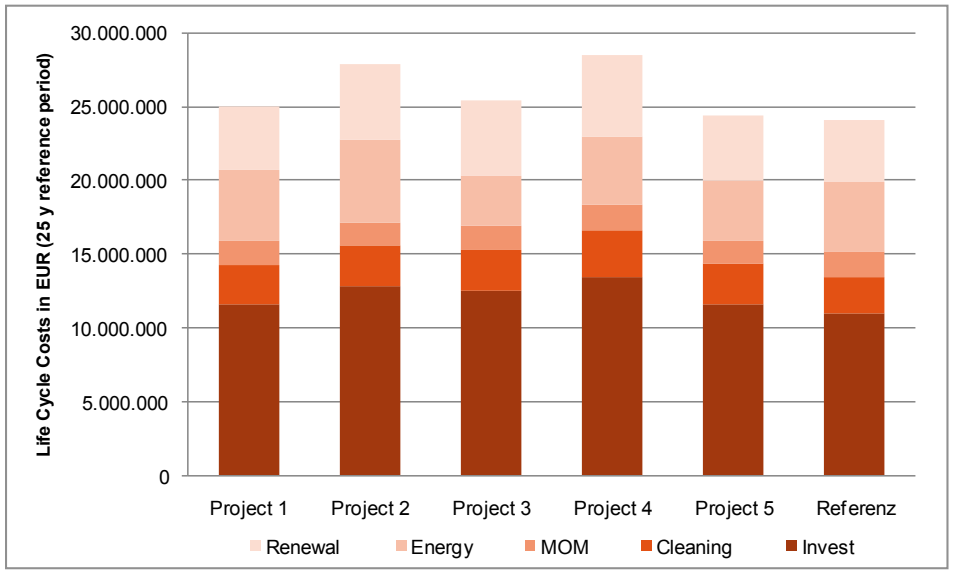


Example 1

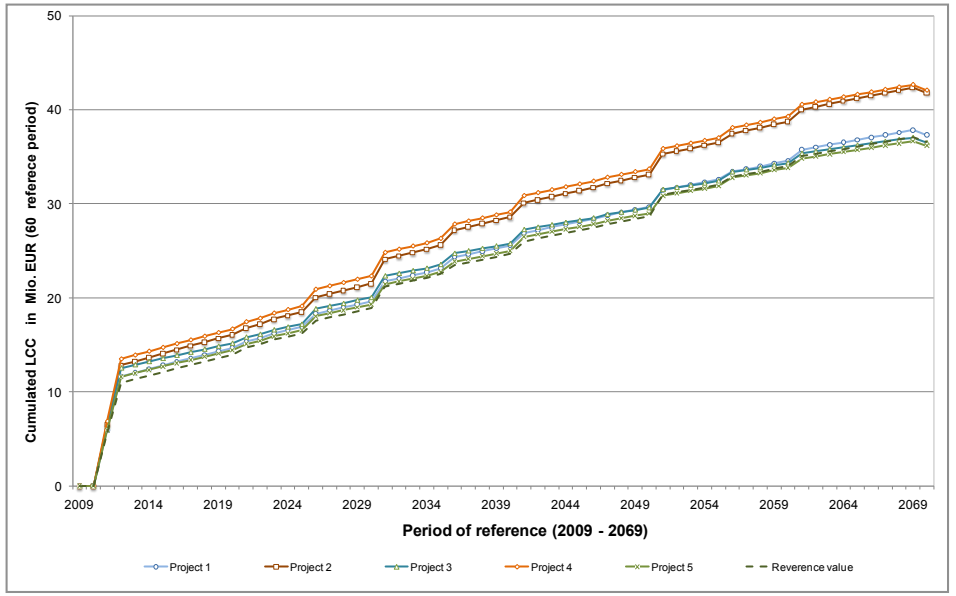
Architectural competition nursing home

LCC-ANALYSIS

LIFE CYCLE COSTS IN 25 YEARS REFERENCE PERIOD



DEVELOPMENT OF LIFE CYCLE COSTS

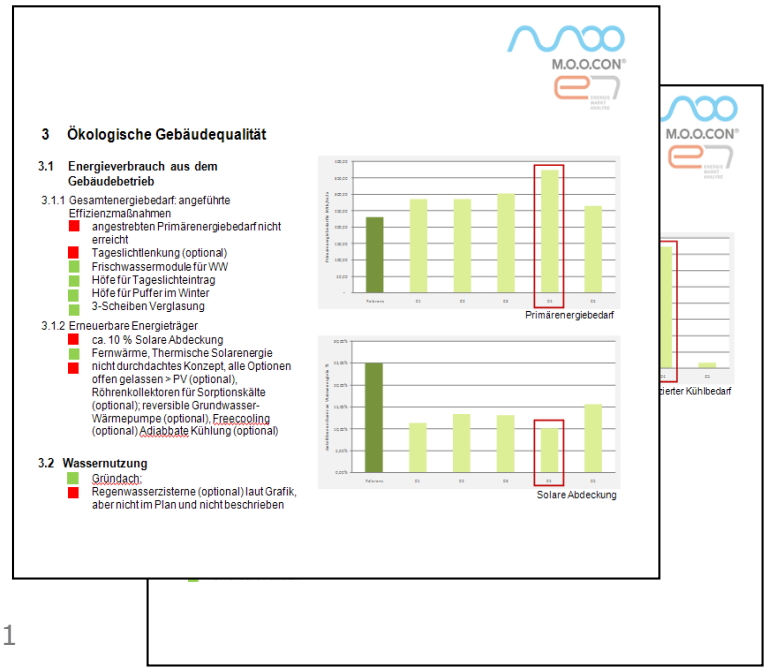


Example 1

Decision of competition

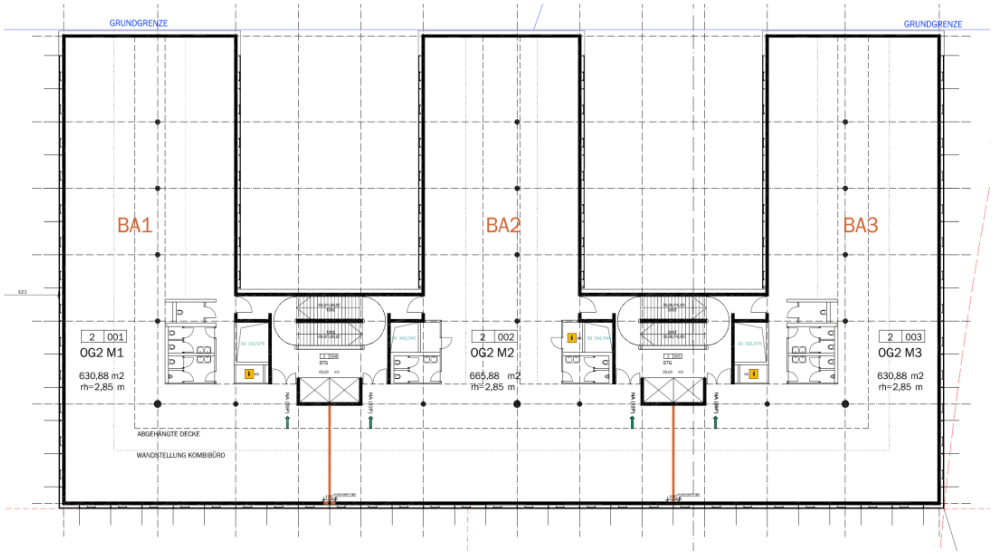
	1	2	3	4	5
technical quality					
sociocultural quality					
ecological quality					
economic quality					

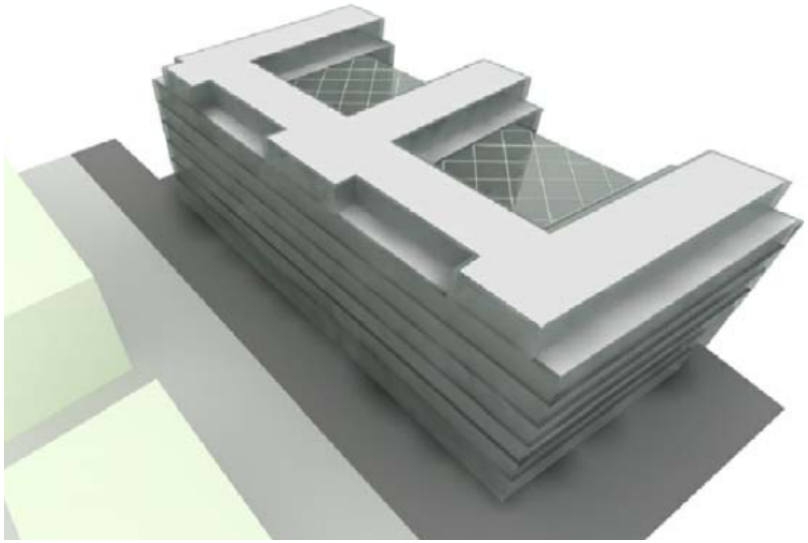
Abstract from the protocol:
- useful areas ought to be reduced on program standard; the proposed HVAC-concept reduces operating costs;
- cooling requirements are quite high – proof of summery warming of atria under the aspect of an energy-optimized solution;
- cleaning expenditures are very high (due to atria) – optimization needed



Example 2

Preliminary draft of a passive house

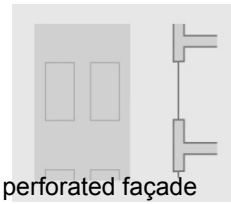


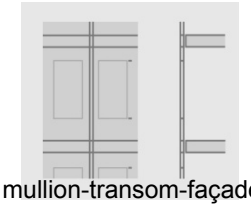


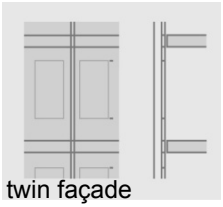
19.000 m^2 gross floor area, 650 employees

Example 2

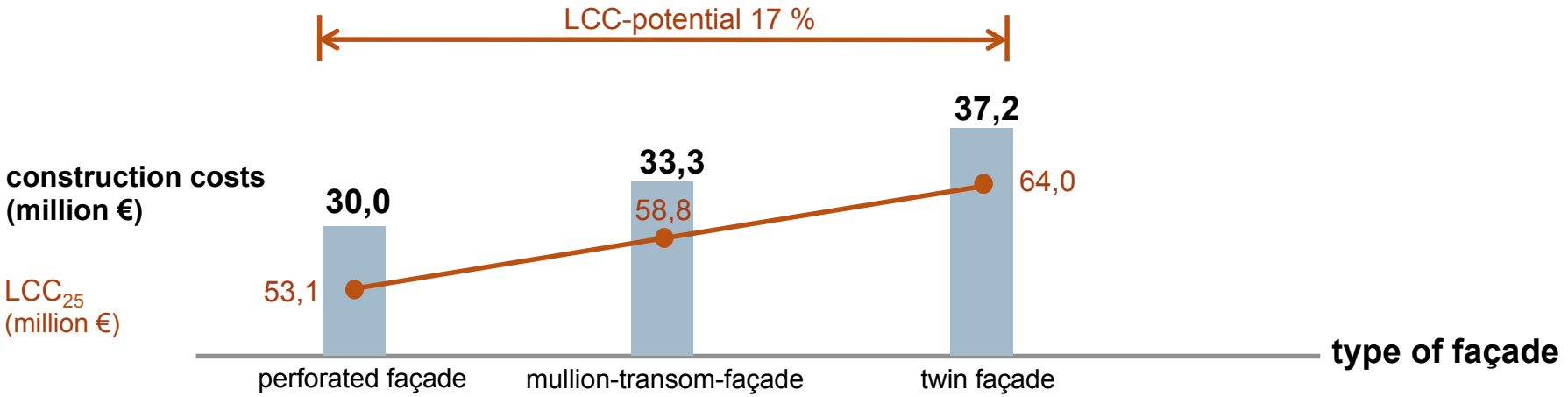
Simulation: façade


perforated façade


mullion-transom-façade


twin façade

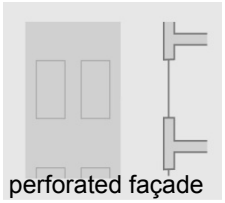
„passive house standard,“



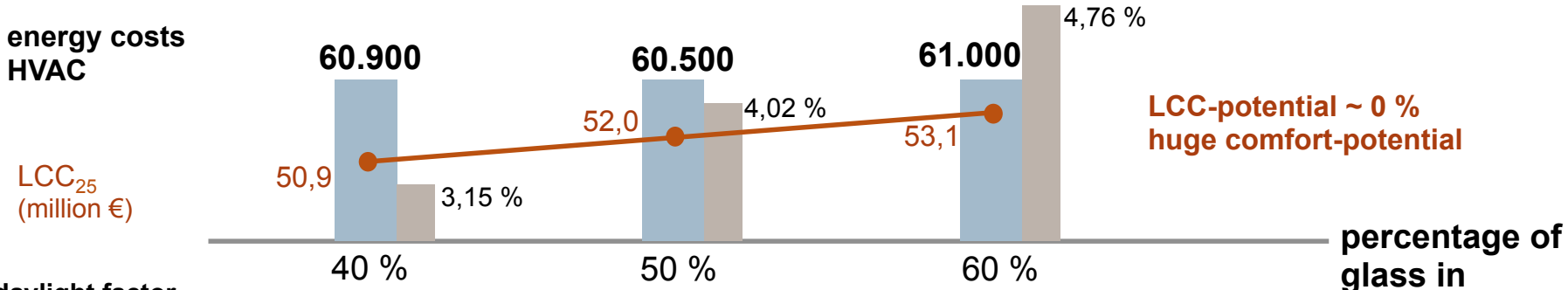
exterior cleaning (€/a)	17.800,-	30.400,-	43.000,-
energy costs (€/a)	17.000,-	18.000,-	20.000,-

Example 2

Simulation: percentage of glass



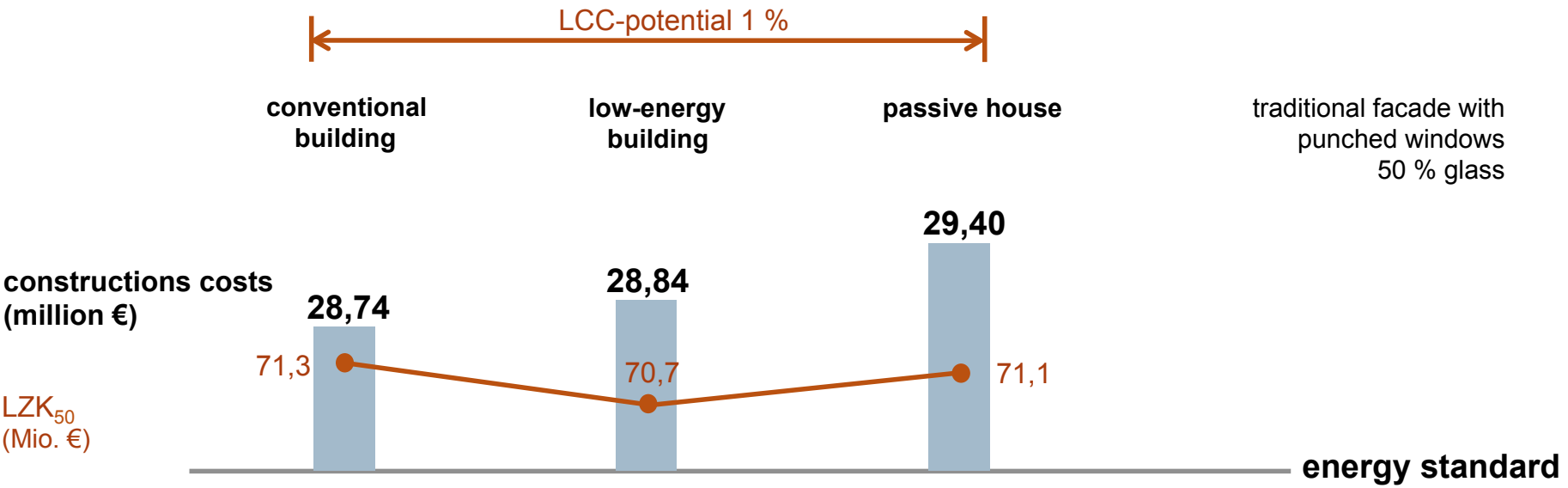
„passive house standard,“



daylight factor ÖNORM EN15193 for total building	3,15 %	4,02 %	4,76 %
construction costs (million €)	28,9	29,4	30,0
energy costs from			
• HVAC €/a	38.000,-	38.900,-	39.900,-
• electricity €/a	22.900,-	21.600,-	21.100,-
	60.900,-	60.500,-	61.000,-
cleaning costs €/a	14.500,-	16.200,-	17.800,-

Example 2

Simulation: energy standard



	conventional building	low-energy building	passive house
energy costs HKLE (€/a)	100.000,-	86.000,-	74.800.-
U-values			
covering	U= 0,26	U= 019	U= 0,13
glass	U= 1,65	U= 1,45	U= 0,8
constucion costs windows + wall cladding (without building shell)	3,62 Mio. €	3,64 Mio. €	3,93 Mio. €

Example 2
Comparison

- **passive house vs. conventional building**

construction costs difference: additional costs of ~ € 900.000,- (+ 3 %)

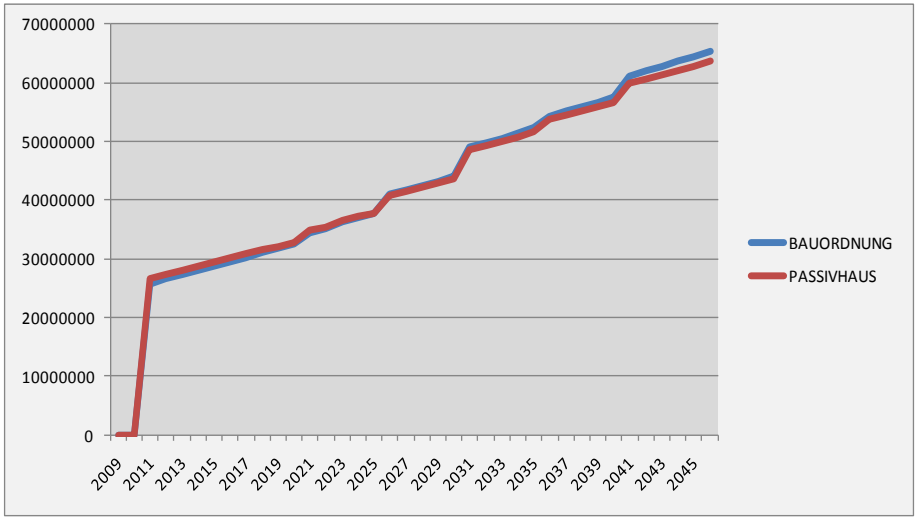
utilizations costs difference (full costs) reduced costs of € 47.500,-/a (- 6 %)

thereof energy costs difference (full costs) reduced costs of € 45.000,-/a (- 45 %)

payback period:

energy costs index	3 %	19 years*
energy costs index	5 %	17 years
energy costs index	7 %	15 years

*~parallel development



Definition standard building:

- district heating / conventional refrigerating machine
- windows / insulation-standard according to building regulations

Definition basic version:

- geothermal energy usage in combination with district heating and conventional refrigerating machine
- passive house: insulation standard and 3-pane-insulation

Summary

- **Further developments:**
  - LCC method and database also applicable for refurbishments
  - Incorporation of LCA calculation
- **Reliable prediction of investment and follow-up costs**
  - already applicable during the project initiation phase (space and functional program),
  - during early design phases
- **Cost basics for energy efficient optimization of buildings**
- **Methodical basis for calculation of cost optimal level**
- **Reliable and comprehensible fundamentals for decision making for energy efficient buildings**

Thank you for your attention

Gerhard Hofer
e7 Energie Markt Analyse GmbH
Theresianumgasse 7/1/8
1040 Vienna
Austria

T +43 1 907 80 26 - 55
F +43 1 907 80 26 - 10
gerhard.hofer@e-sieben.at
www.e-sieben.at