Data and tools for profitability evaluation of measures for enhancement of the energetic quality of residential buildings

Thomas Lützkendorf and Kai Mörmann, KIT
Andreas Enseling and Eberhard Hinz, IWU

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RENTCAL
European Rental Housing Framework for the Profitability Calculation of Energetic Retrofitting Investments

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Data and tools for profitability evaluation of measures for enhancement of the energetic quality of residential buildings

KIT Karlsruher Institut für Technologie
Thomas Lützkendorf, Kai Mörmann
Karlsruhe Institute of Technology, Centre for Real Estate

IWU
Andreas Enseling, Eberhard Hinz
Institute for Housing and Environment, Darmstadt

Agenda

1. Introduction
2. Empirical Cost Study Germany
3. Proposal I: EXCEL Tool for Profitability Assessment
4. Proposal II: Monte-Carlo-Simulation
5. Conclusion

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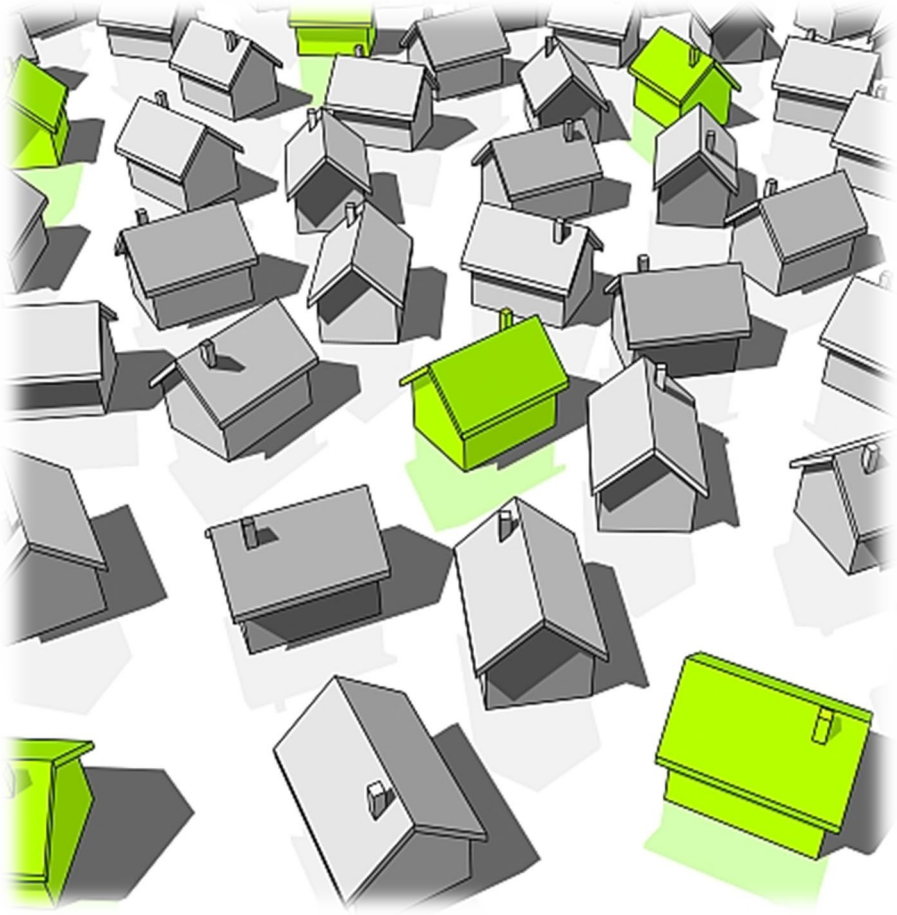
Context and current situation

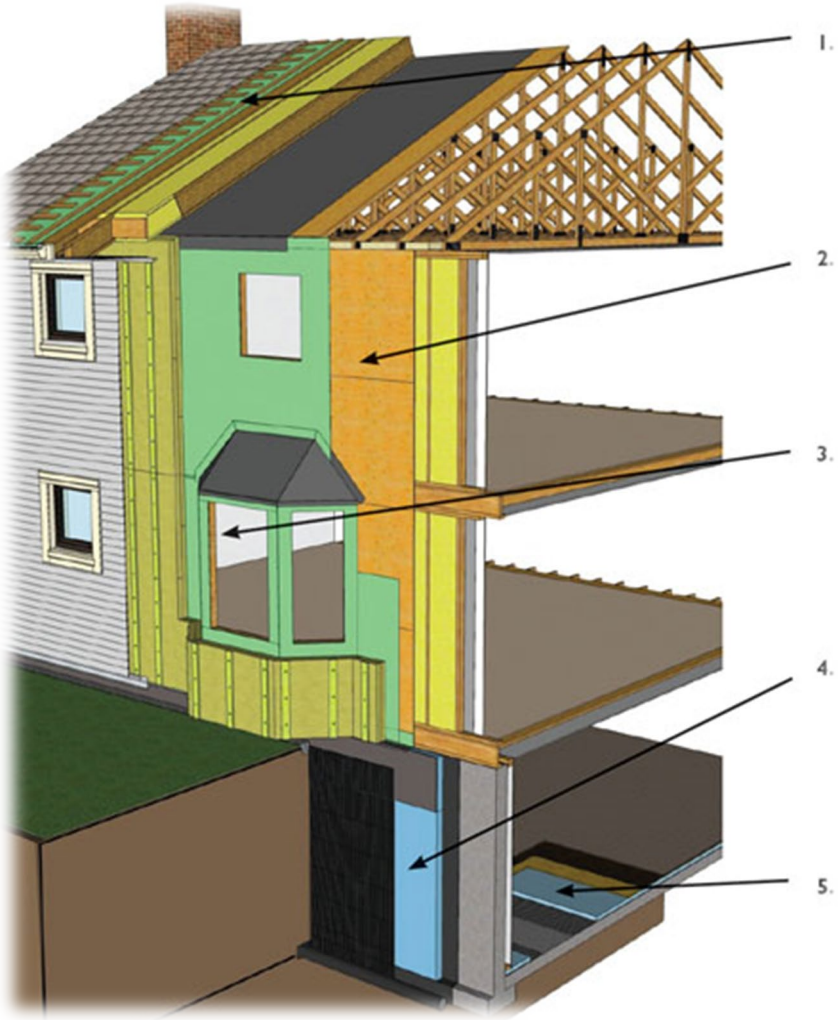
Improving the energy performance of the existing building stock is one of the main ways to reach national and international climate protection targets.



https://grist.files.wordpress.com/2010/07/home-energy-efficiency-retrofit-istock.jpg

Context and current situation

There are several opportunities for energy efficiency improvements but their technical feasibility needs to be examined and their economical advantages need to be evaluated.



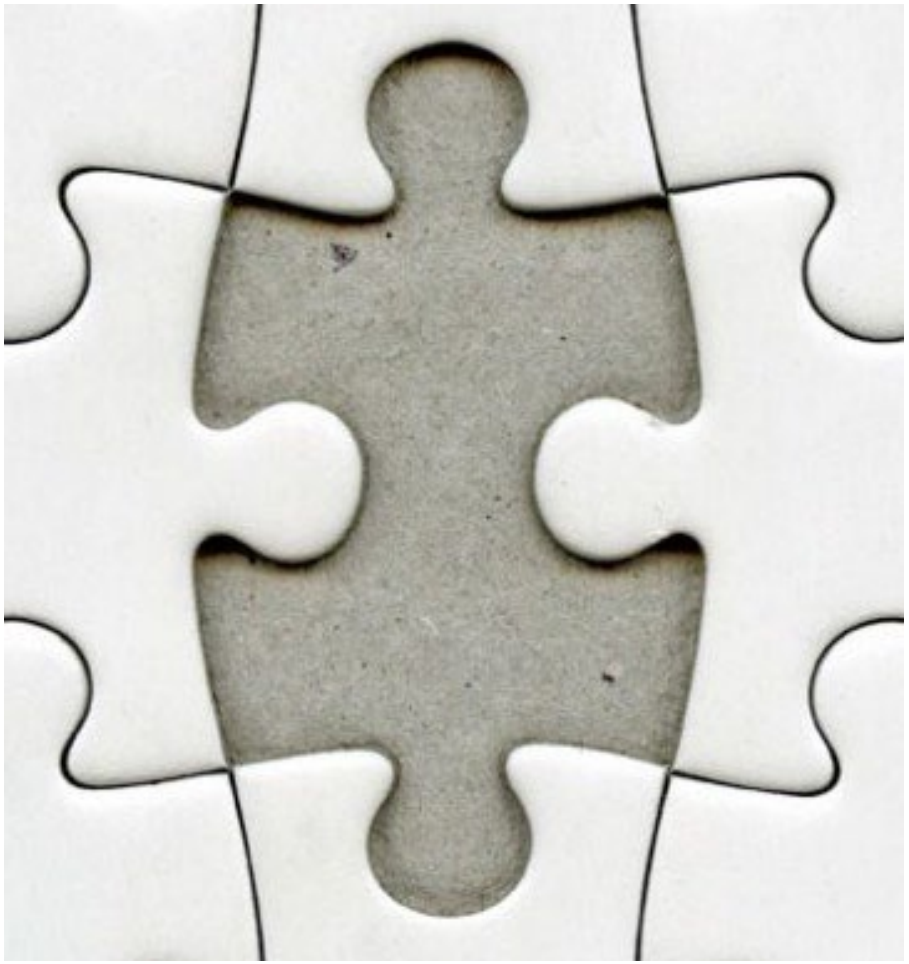
http://www.cmhc-schl.gc.ca/fr/co/relo/fedore/images/AYH_71_Figure1_E_small.jpg

Main questions

- Which energy efficiency measures are profitable in the case of residential buildings?
- Which methods for analysing the economic advantages of such measures should be applied?
- What are the main input data and what about their uncertainty?
- Which input data are available for individual decision makers?
- What could a tool look like to deal with uncertain input data?

One of the problems …

- Reliable input data, especially regarding costs, are important for the profitability analysis of individual decision takers
- … but are often not available or out-of-date



https://www.linkedin.com/pulse/amelia-packager-missing-data-imputation-ramprakash-veluchamy

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Cost Study Germany

Carried out by IWU on behalf of Federal Building Ministry (2015)

- Database: energy saving measures on 1177 buildings (built examples; mainly from KfW funding programmes)
- investment volume building measures (KG 300): 41.4 Mio. € / 264.500 m²
- investment volume system measures (KG 400): 16.0 Mio. € / 942 measures
- regression analysis with “typical“ costs of energy saving measures

Kosten energiesparender Maßnahmen im Wohngebäudebestand 1

NATIONALE KLIMASCHUTZ INITIATIVE

IWU

INSTITUT WOHNEN UND UMWELT GmbH

Forschungseinrichtung des Landes Hessen und der Stadt Darmstadt

Rheinstraße 65
64295 Darmstadt
Tel. 0 61 51 / 29 04-0
Fax 0 61 51 / 29 04-97
eMail: info@iwu.de

Kosten energierelevanter Bau- und Anlagenteile bei der energetischen Modernisierung von Altbauten

Endbericht

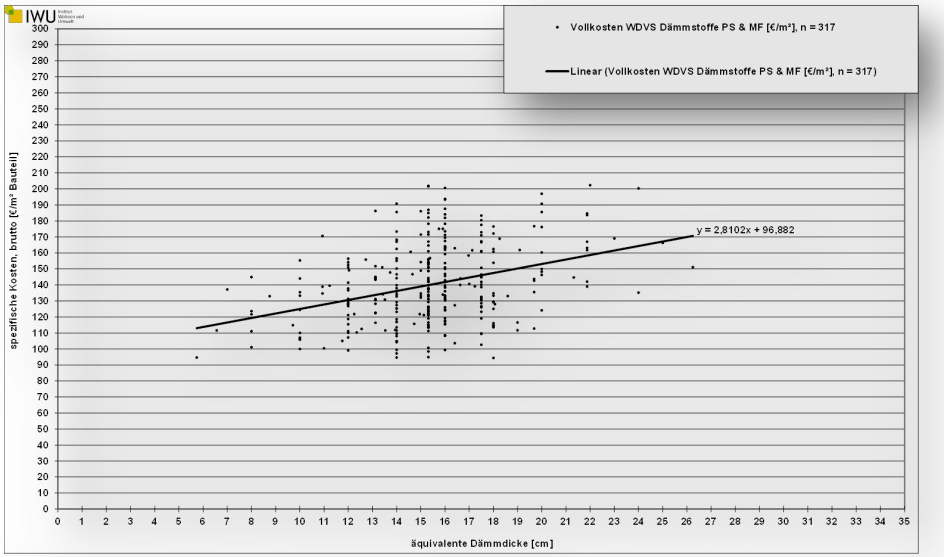
Autor: Eberhard Hinz, Institut Wohnen und Umwelt

Auftraggeber: Bundesministerium für Umwelt, Naturschutz, Bau und Reaktorsicherheit

Darmstadt, den 10.08.2015

Cost Study Germany

- In practice, there are major price differences for the same measures that depend on the specific local situation
- Large cost ranges can be observed: in a single project the costs of energy saving measures can be much higher or lower than the “typical costs“



Cost function: wall insulation

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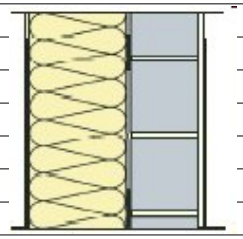

- Vollkosten WDVS Dämmstoffe PS & MF [€/m²], n = 317
- Linear (Vollkosten WDVS Dämmstoffe PS & MF [€/m²], n = 317)

y = 2,8102x + 96,882
R²=0,1195

investment cost insulation (15 cm): 139 €/m² surface area

spezifische Kosten, brutto [€/m² Bauteil]

äquivalente Dämmdicke [cm]

Range of values for construction cost

Measure (thermal envelope)	Low cost per m ²surface area	Typical cost per m² surface area	High cost per m² surface area
Wall insulation (15 cm)	113 €/m²	139 €/m²	165 €/m²
Roof insulation (18 cm)	147 €/m²	201 €/m²	255 €/m²
Upper ceiling insulation (20 cm)	42 €/m²	64 €/m²	85 €/m²
Floor insulation (8 cm)	26 €/m²	41 €/m²	55 €/m²
Triple glazed windows	390 €/m²	420 €/m²	455 €/m²

Price level: 1/2015; definition of ‘low’ and ‘high’ costs based on 95% confidence interval for regression coefficients; lambda: 0,035 W/mK; all cost figures include 19% value added tax

Cost Study Germany

- It has to be determined, which share in financial expenditure is attributable to repairs that were necessary anyway (‘anyway costs’ – no improvement of energy efficiency); and
- which share is attributable to actual energetic improvements (‘additional energy-related costs’ – improvement of energy efficiency)
- Investment costs (15 cm wall insulation): **139 €/m² surface area**
- in the course of an **anyway necessary renewal:**
  - **anyway costs: 77 €/m²** (e.g. removing old render, applying new render, new painting etc.)
  - **energy-related costs: 62 €/m²** (e.g. adding insulation, reducing thermal bridges, roof overhang extension etc.)
- Cost ranges for the ‘additional energy-related costs’ can be observed

Cost function: wall insulation

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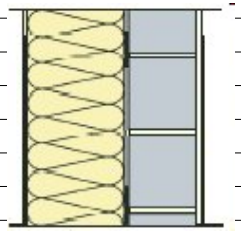

- Vollkosten - hohe Kosten
- Vollkosten WDVS Dämmstoffe PS & MF [€/m²], n = 317
- Vollkosten - niedrige Kosten
- energiebedingte Mehrkosten - hohe Kosten
- nach Kostenfunktion berechnete energiebedingte Mehrkosten
- energiebedingte Mehrkosten - niedrige Kosten
- Linear (Vollkosten WDVS Dämmstoffe PS & MF [€/m²], n = 317)
- Linear (nach Kostenfunktion berechnete energiebedingte Mehrkosten)

investment cost insulation (15 cm): 139 €/m² surface area

'anyway costs: 77 €/m²

Energy-related costs: 62 €/m²

spezifische Kosten, brutto [€/m² Bauteil]

äquivalente Dämmdicke [cm]

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EXCEL Tool for profitability assessment

Simple tool for the profitability assessment of (retrofit) measures:

- based on a calculation of equivalent energy prices;
- supports dealing with cost ranges;
- provides an estimation for which maximum financial expenditure profitability is still given; and
- can be used for the procurement of building services and the scoping of funding programmes.

EXCEL Tool for profitability assessment

Equivalent energy price (€ or Cent per kWh):

- dynamic approach
- calculated by dividing the annual additional energy-related costs through the quantity of saved energy per year
- a refurbishment investment is profitable if the price for the unit of saved energy – the equivalent energy price - is lower than the expected future energy price

EXCEL Tool for profitability assessment

Variant: Improvement of an exterior wall from U = 1,20 W/m²K to U = 0,20 W/m²K

Anyway-costs in Euro/m²	Investment costs in Euro/m² surface area for 15 cm wall insulation (polystyrol)							
	100,00	110,00	120,00	130,00	140,00	150,00	160,00	170,00
	Equivalent energy price in Cent/kWh (final energy)							
0,00	8,08	8,88	9,69	10,50	11,31	12,11	12,92	13,73
10,00	7,27	8,08	8,88	9,69	10,50	11,31	12,11	12,92
20,00	6,46	7,27	8,08	8,88	9,69	10,50	11,31	12,11
30,00	5,65	6,46	7,27	8,08	8,88	9,69	10,50	11,31
40,00	4,85	5,65	6,46	7,27	8,08	8,88	9,69	10,50
50,00	4,04	4,85	5,65	6,46	7,27	8,08	8,88	9,69
60,00	3,23	4,04	4,85	5,65	6,46	7,27	8,08	8,88
70,00	2,42	3,23	4,04	4,85	5,65	6,46	7,27	8,08
80,00	1,62	2,42	3,23	4,04	4,85	5,65	6,46	7,27
90,00	0,81	1,62	2,42	3,23	4,04	4,85	5,65	6,46
100,00	0,00	0,81	1,62	2,42	3,23	4,04	4,85	5,65

Calculation period: 30 a; discount rate: 3%/a (real);
expected future energy price: 8,6 Cent/kWh

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Example: Profitability assessment by Monte Carlo analysis

Input data and assumptions for an **example** of:

1 m² exterior wall + thermal insulation system (polystyrene, λ=0,035 W/mK) with a target-U-value of 0,24 W/(m²K);

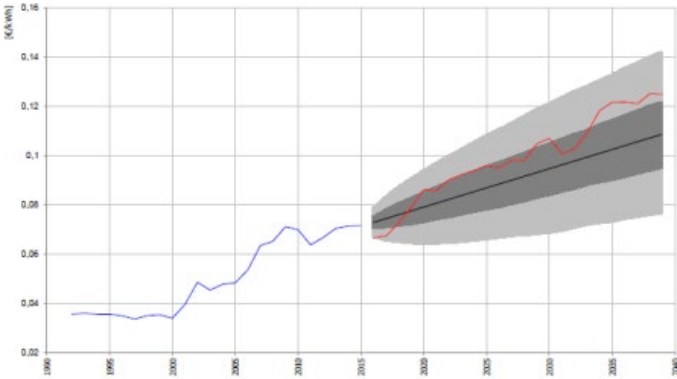
no public funding; no increase in operating expenses; implemented within an anyway retrofit measure; discount rate: 3% p.a.; calculation period: 25 years

investment cost function according to (BMVBS/IWU 2012): additional cost = 2,431€/cm · X cm insulation + 15€

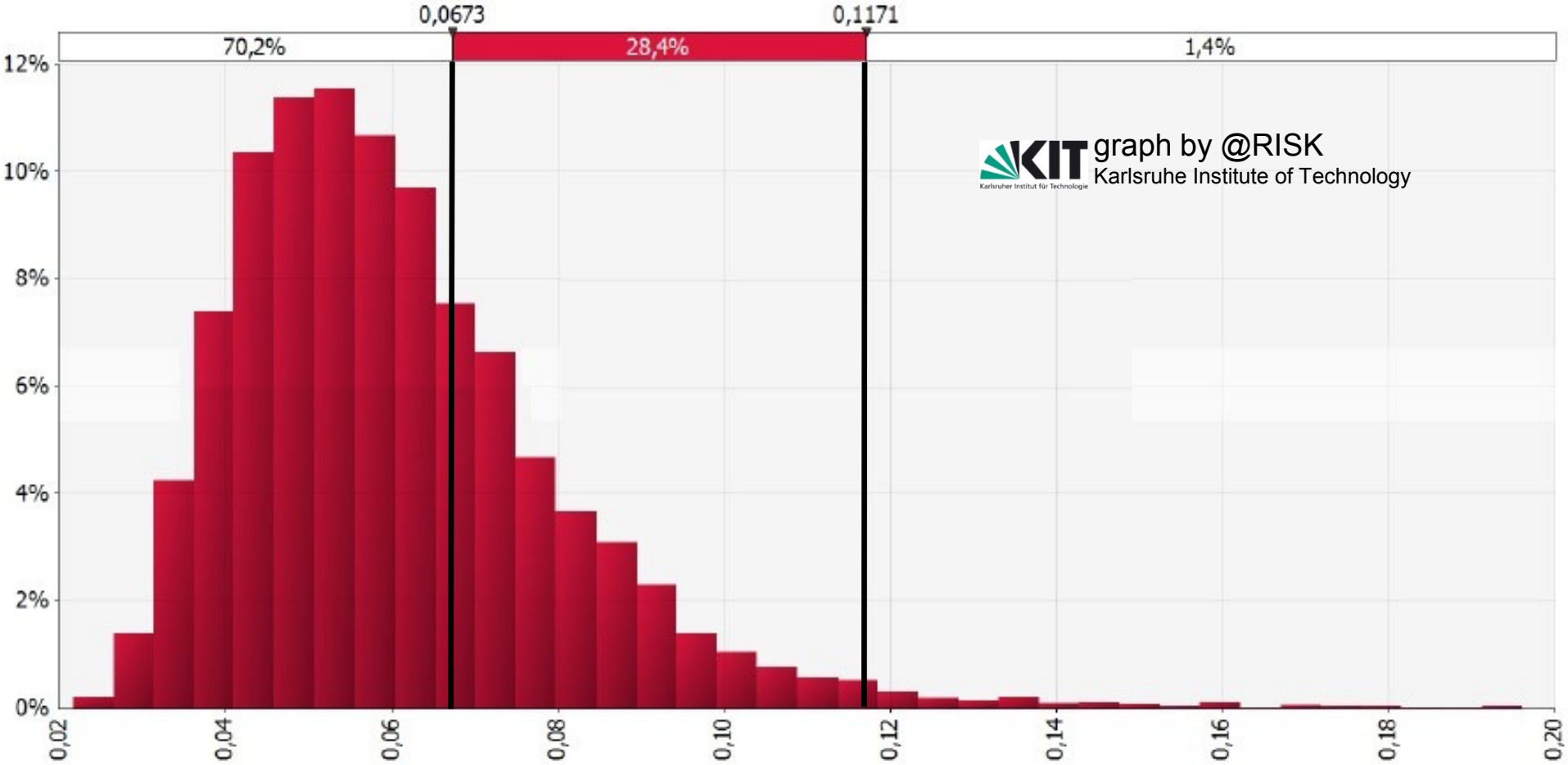
expected energy prices were derived from an interpolation based on historical development of natural gas prices as average over 25 years

parameters varied in Monte Carlo simulation:

- additional energy-related cost
- heat transition coefficient before/after measure
- day degree factor
- annual use efficiency η



Example: Profitability assessment by Monte Carlo analysis



Probability distribution of **expected equivalent energy prices** for a single measure (thermal insulation system) and 2,5/97,5-percentile interval for expected future energy prices. Source: Rouven Christ 2015, p. 50, KIT

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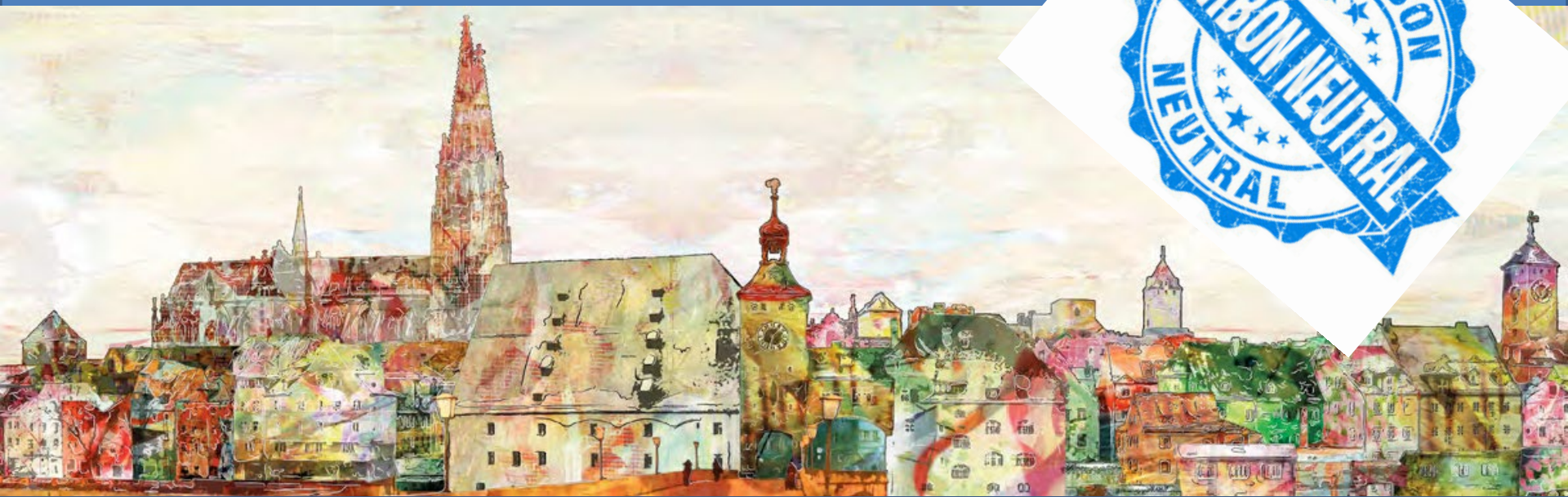
Conclusion

- Profitability analysis of energetic refurbishment should be based on reliable input data
- Investment cost ranges instead of average cost values should be considered
- In RentalCal a sensitivity analysis for investment costs will be part of the risk analysis
- Outlook: consequences for regulatory law: economically feasible if in 100 % of cases profitable?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Thank you very much for your attention!

Thomas Lützkendorf, Kai Mörmann, Andreas Enseling, Eberhard Hinz

Contact: thomas.luetzkendorf@kit.edu; a.enseling@iwu.de