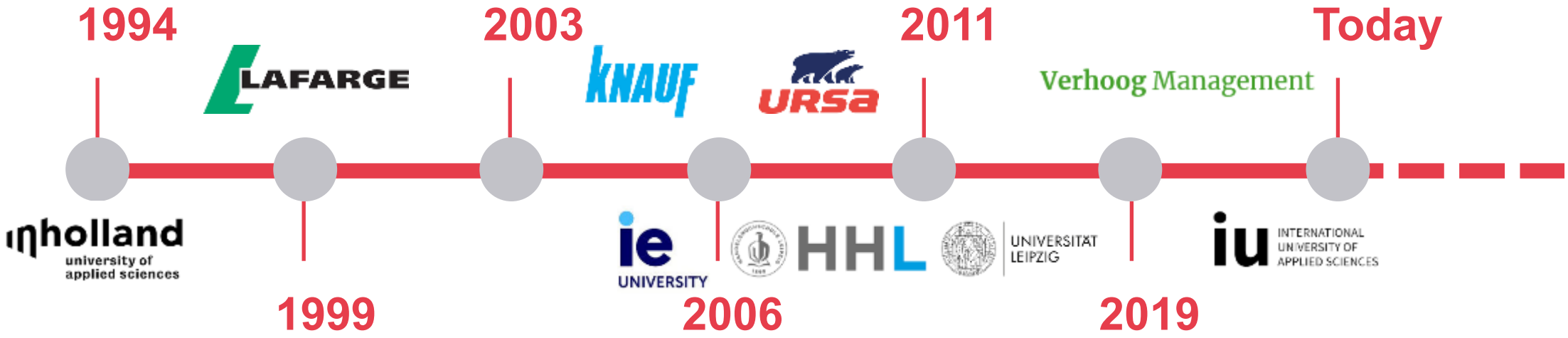
PROF. DR. MART VERHOOG

Simulation in Action: Designing Robust Urban Energy Strategies in a Changing World

The 17th International Conference on Advances in System Modeling and Simulation SIMUL 2025

PROF. DR. MART VERHOOG

- Worked for over 15 years as a marketing consultant and held various roles in the building materials industry across the Netherlands, Germany, and Belgium.
- Holds a Bachelor in Economics, an MBA in General Management, and a PhD in Marketing from HHL Leipzig; completed Executive Education at IE Madrid.
- Led the Research Centre for Municipal Energy Economics (FKE) at Leipzig University before taking up a professorship at IU International University of Applied Sciences
- Continues to work as an independent consultant and lives near Bonn, Germany with his wife, two children, and a dog.



Simulation in Action: Designing Robust Urban Energy Strategies in a changing World

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GEFÖRDERT VOM

Bundesministerium
für Bildung
und Forschung

DELITZSCH AND LEIPZIG IN THE FREE STATE OF SAXONY, GERMANY

Photo: C. Maurer / City of Delitzsch

Photo: R. Kühn / University of Leipzig

Source: Google Maps

UNIVERSITÄT LEIPZIG

Forschungsstelle Kommunale Energiewirtschaft

HELMHOLTZ ZENTRUM FÜR UMWELTFORSCHUNG UFZ

KEM

Leipziger Institut für Energie

SWD STADTWERKE DELITZSCH

THE BMBF COMPETITION "ENERGY-EFFICIENT CITY"

Phase 1 (submission of 72 sketches of ideas):

completed in August 2008

Phase 2 (selection of 15 concepts):

Development of the implementation concepts

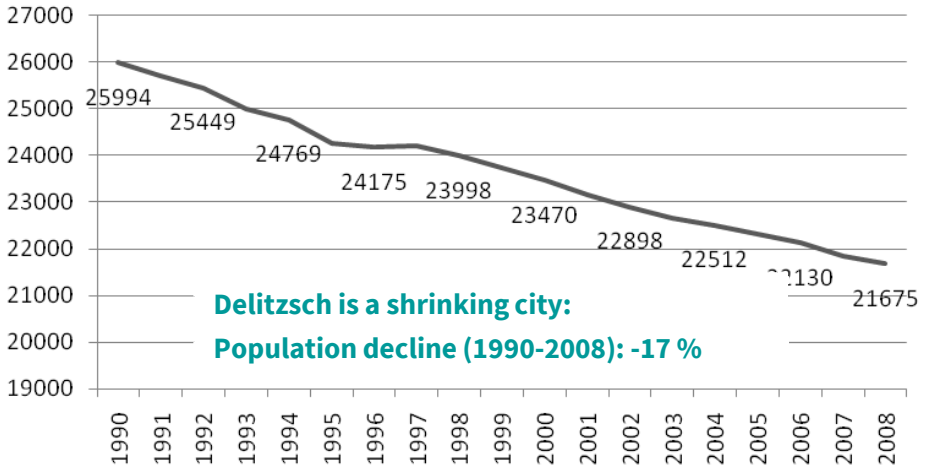
(1.6.2009 – 31.5.2010, funding volume 200,000 €)

Phase 3 (selection of 5 implementation concepts):

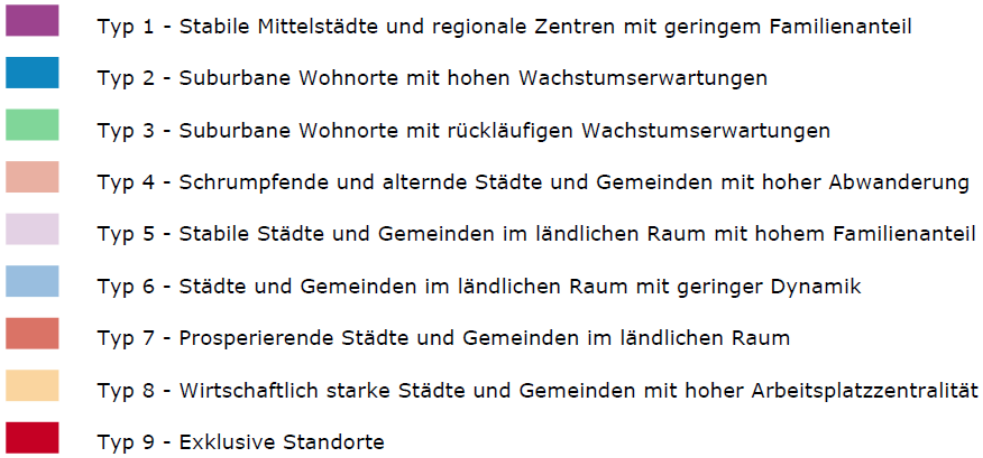
Delitzsch, Essen, Magdeburg, Stuttgart and Wolfhagen

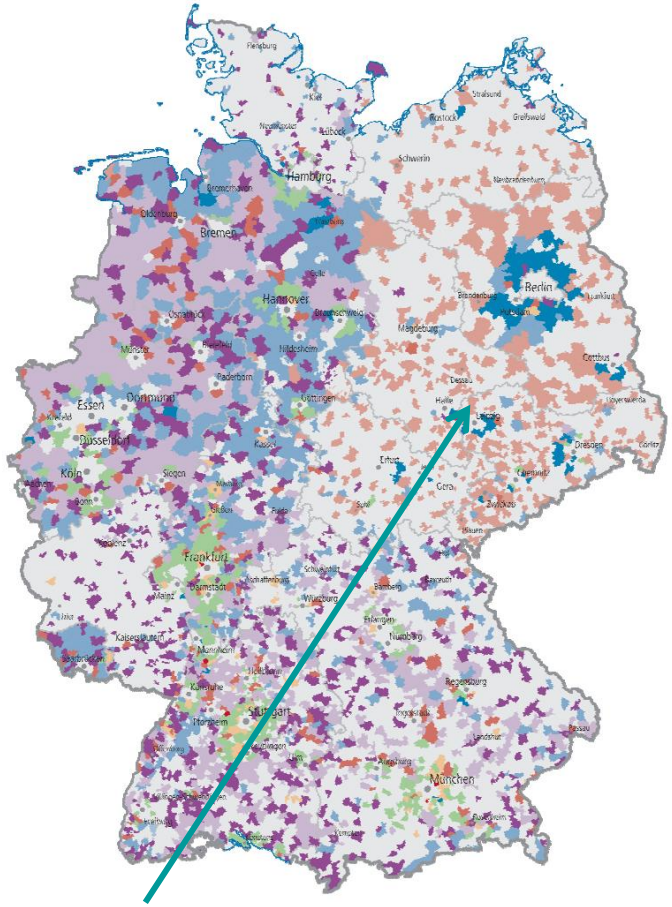
(1.6.2011 – 30.5.2016, funding volume 3.1 million €)

DELITZSCH: CITY IN DEMOGRAPHIC CHANGE



Population development Delitzsch urban area





Delitzsch is a typical representative of demographic type 4 of the Bertelsmann Foundation's cluster analysis.

THE BMBF COMPETITION "ENERGY-EFFICIENT CITY"

"The strength of the concept of the University of Leipzig and the city of Leipzig Delitzsch lies in the development of an **interactive** and **adaptive** energy management system that involves **all stakeholders** in a differentiated way and **interacts** between the measures are taken into account in their **development over time."**

Press release, BMBF, 15.09.2010

CONTENTS

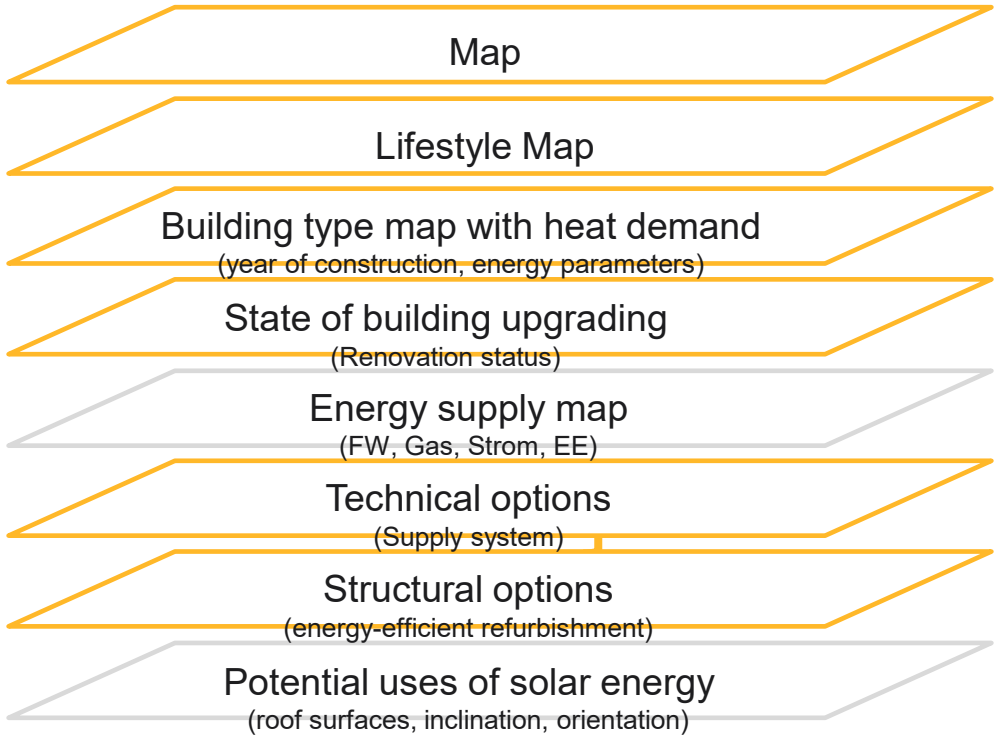
- Project objectives
- Master plan for municipalities
- Simulating the city:
  - Agent-based modeling of municipal energy systems
  - Moving and relocation behavior
  - Building stock and modernization options
  - Energy-related investment behaviour
- Interventions:
  - Target group-specific approach
- Effects for the city of Delitzsch
- Knowledge transfer

PROJECT OBJECTIVES

1. **Exemplary implementation of an actor-oriented and interactive energy management system** that can react flexibly to future changes in boundary conditions (energy prices, subsidy programs, etc.).
2. **System-integrated modelling of municipal energy supply in the** context of liberalised energy markets, increasing climate protection requirements and simultaneous demographic changes.
3. **Modelling of the co-evolution of the technical and socio-economic aspects of the urban habitat through** the development of agent-based models of urban development.
4. **Target group-specific (e.g. lifestyle-dependent) approach to stakeholders and service-related networking by innovative energy efficiency managers.**
5. **Development of robust and universally applicable strategies to increase energy efficiency and infrastructure adaptation in shrinking medium-sized cities.**

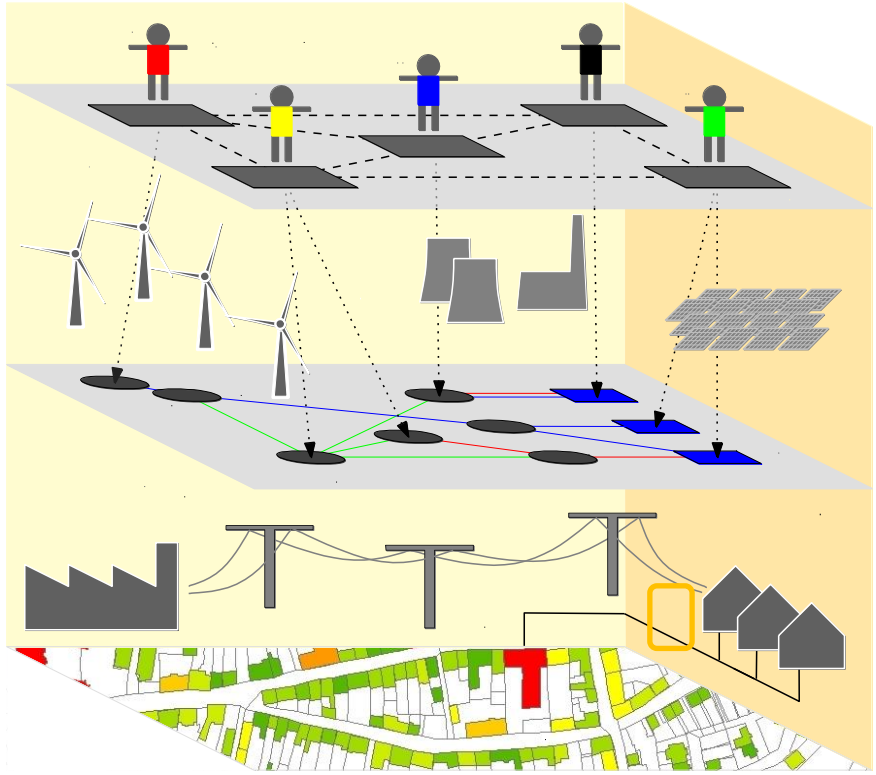
MASTER PLAN – INTERACTIVE AND GIS-BASED

The layers of the master plan



Source:
IIRM/KEM

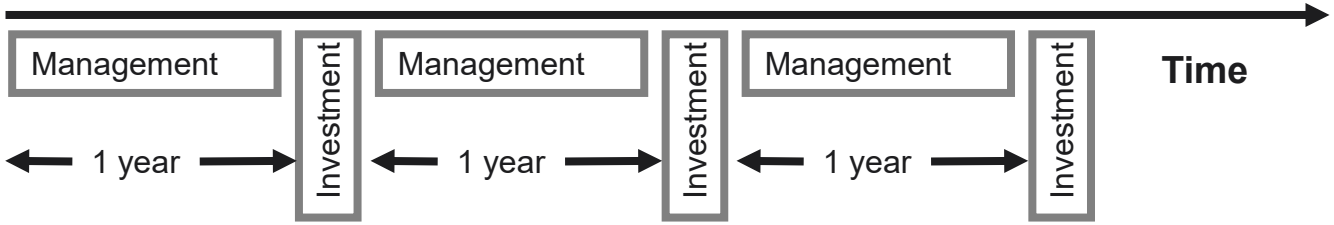
SIMULATING THE CITY: AGENT-BASED MODELING OF MUNICIPAL ENERGY SYSTEM



Agent-based modelling of the socio-economic actor level

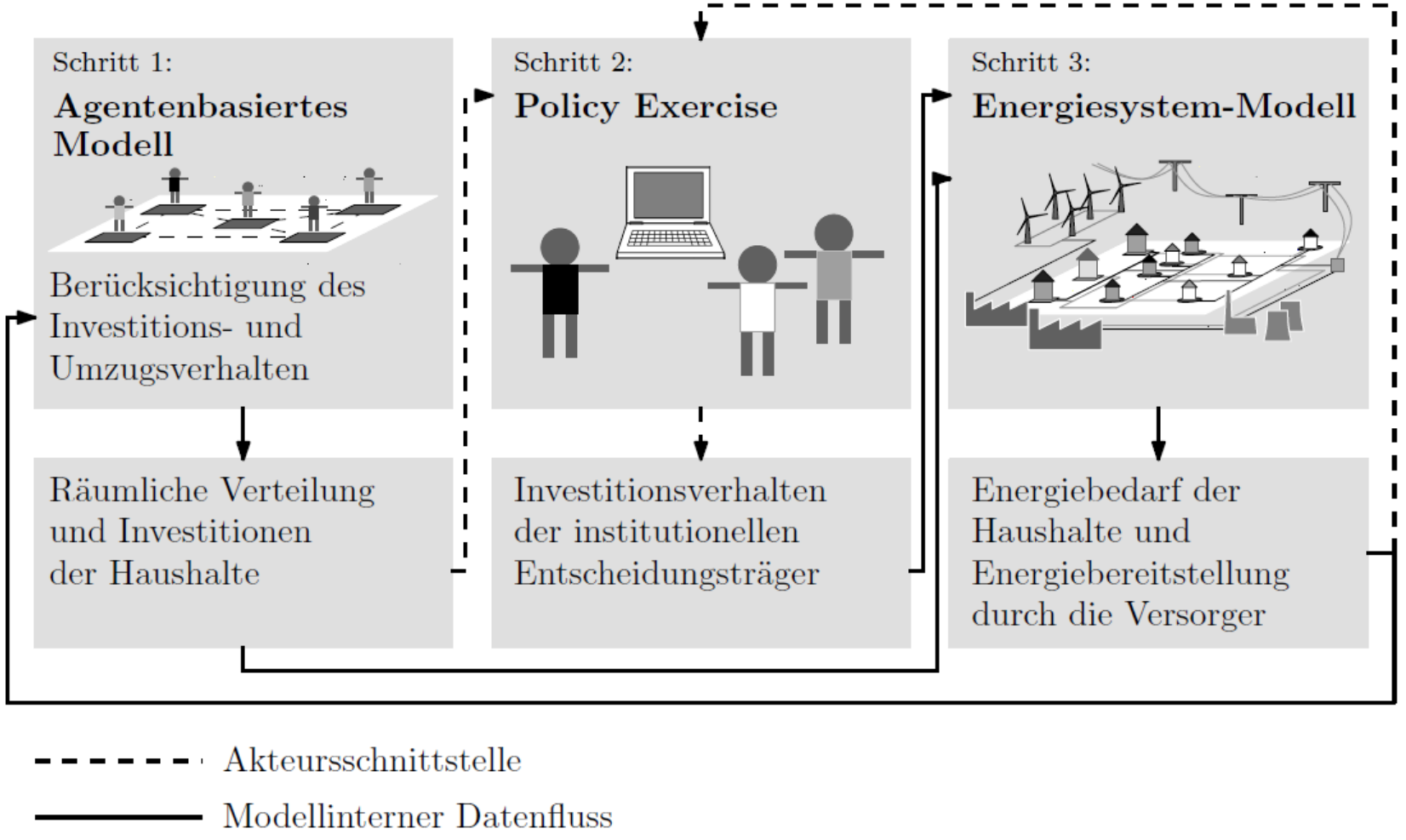
Temporal high-resolution modelling of the energy supply system

Local location



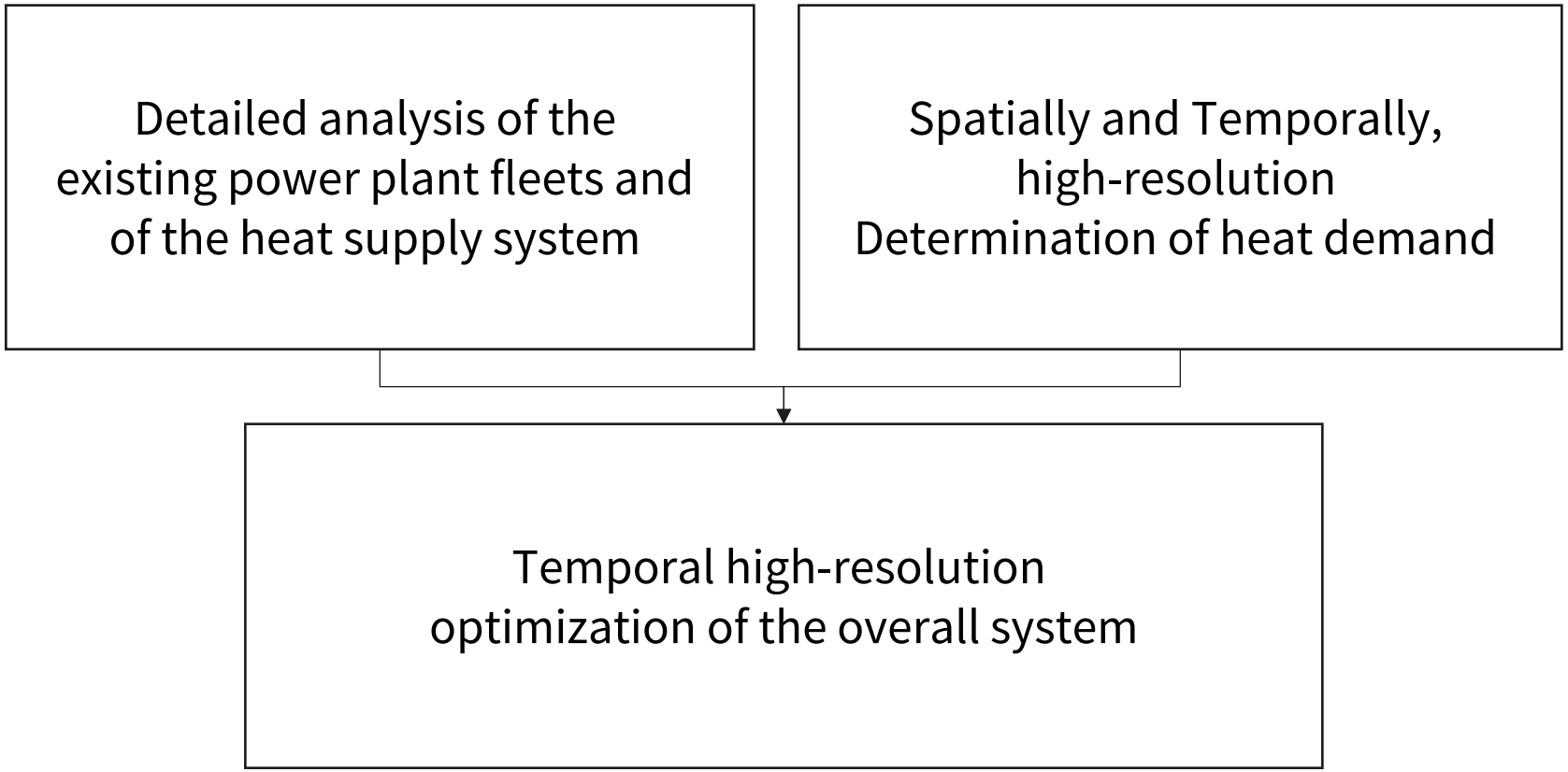
Source: T. Wittmann/T. Bruckner (2007): Agent-based Modelling of Urban Energy Systems, Business Informatics

MODELLING OF THE INTERACTION OF THE ACTORS



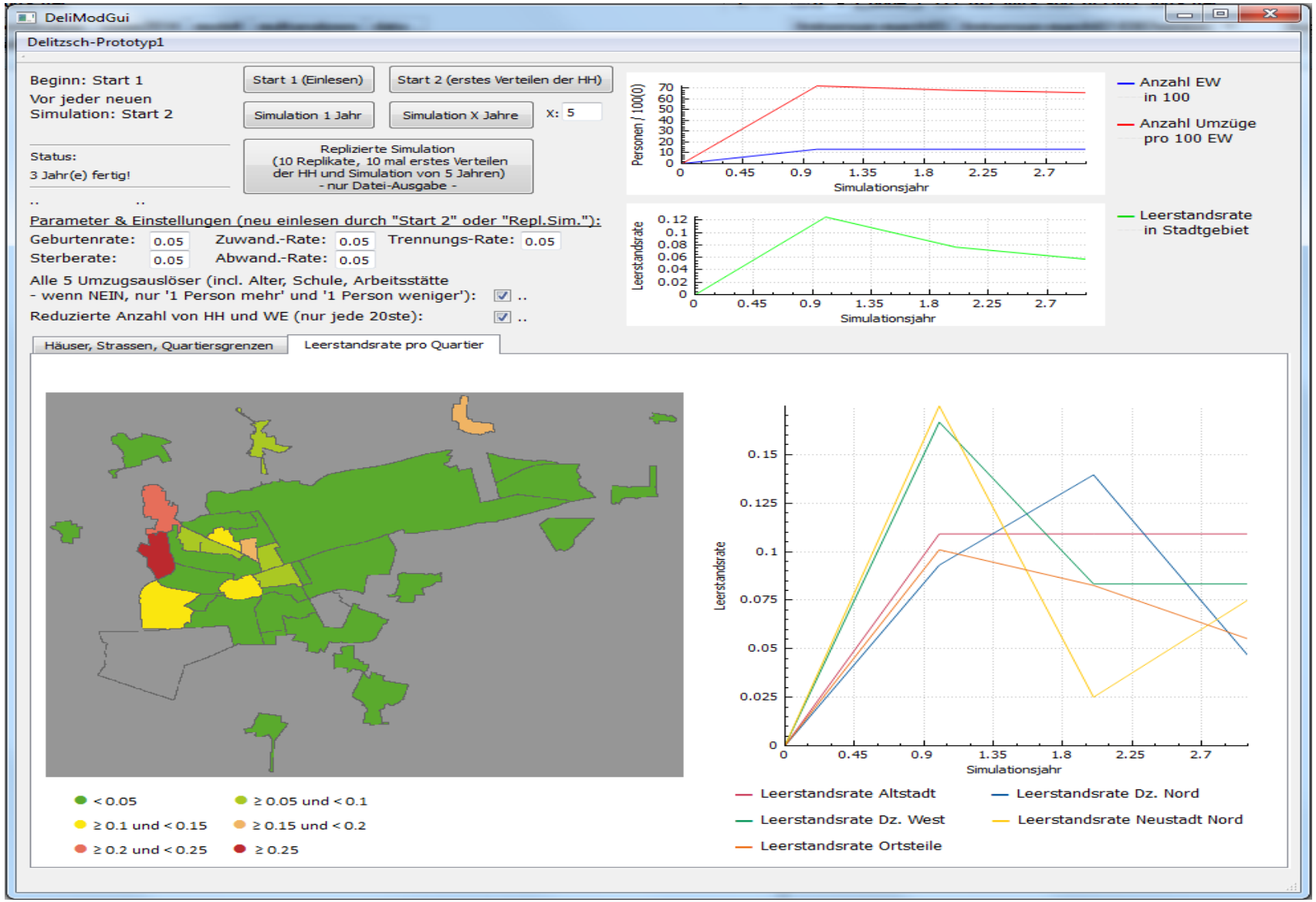
Source: UFZ/IIRM, own illustration

TECHNOLOGICAL DIMENSION



Source:
IIRM/KEM

MOVING BEHAVIOR FOR DELITZSCH



Source: UFZ

URBAN CHANGE AND RELOCATION BEHAVIOUR

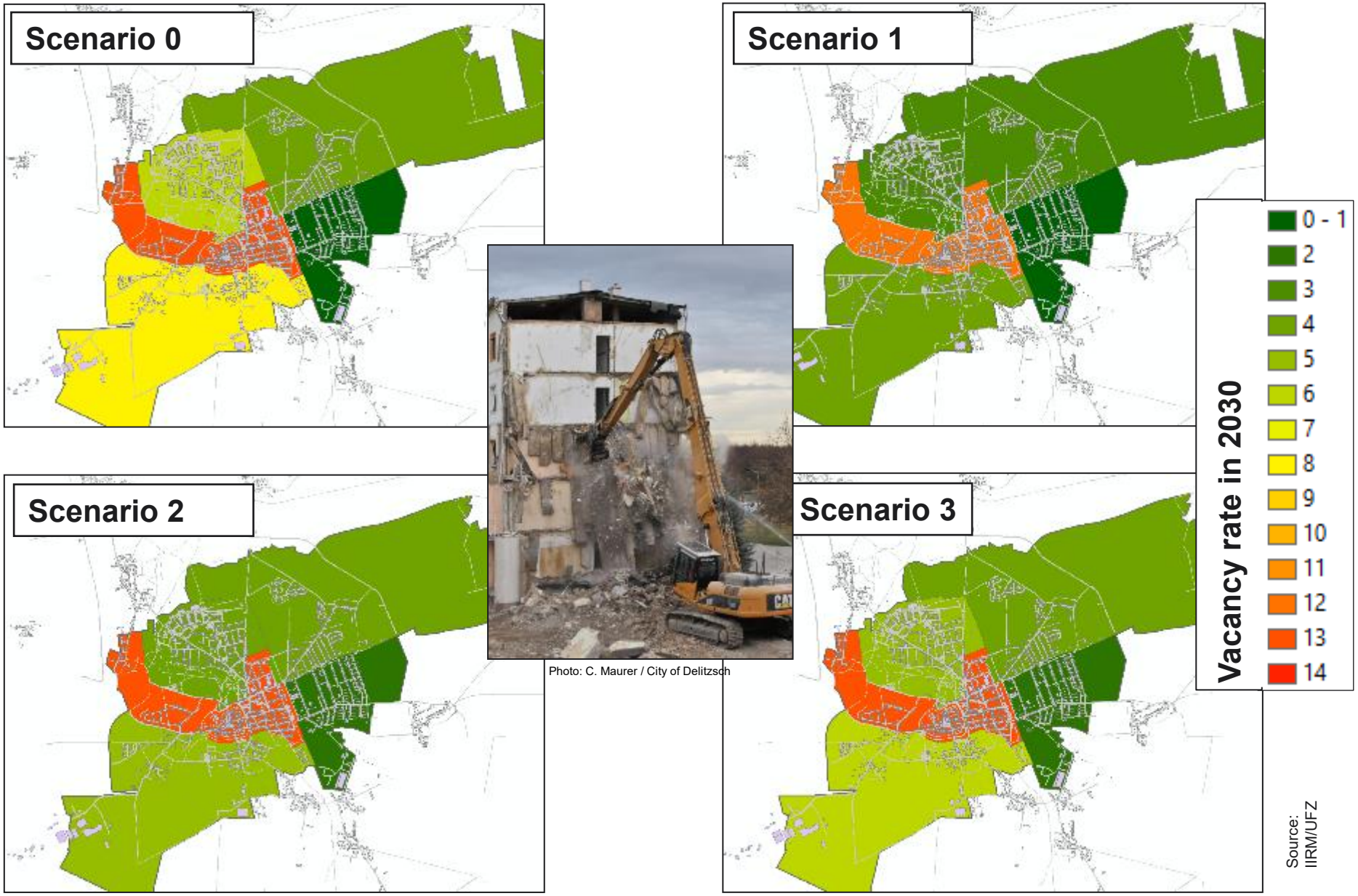
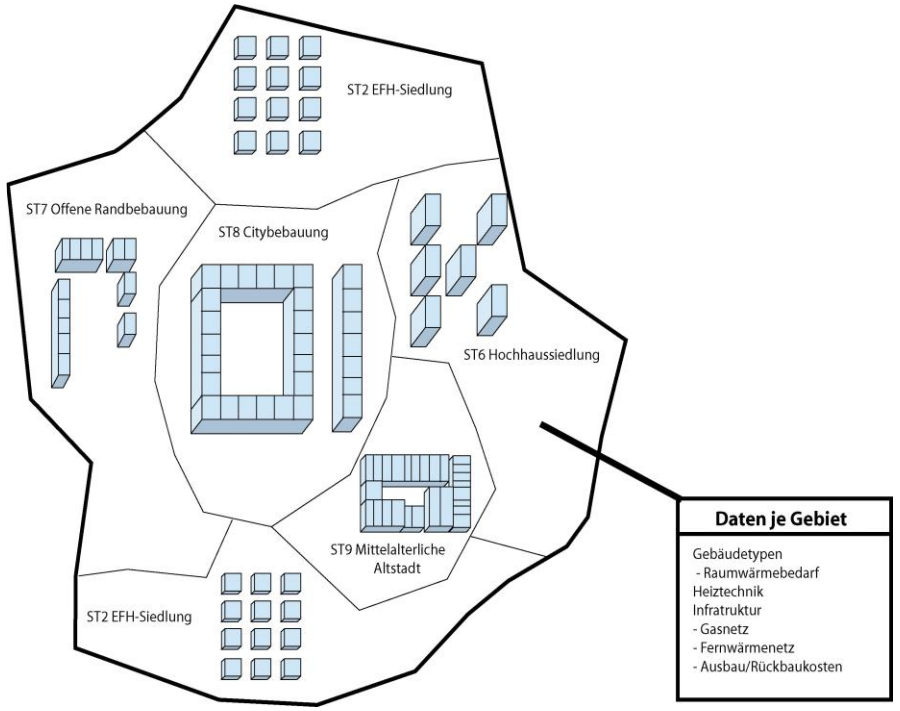
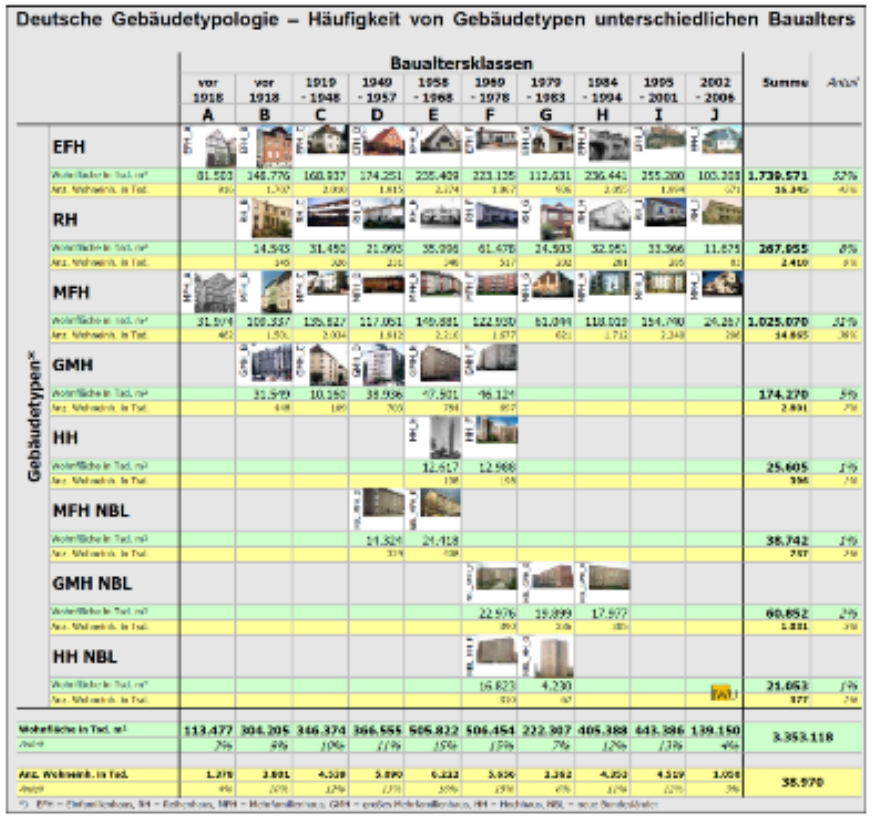


Photo: C. Maurer / City of Delitzsch

INFRASTRUCTURE DATA (SPATIAL DIMENSION)

The city of Delitzsch was analyzed in terms of urban development with the help of different typologies: settlement type and building type.





Source: IWU

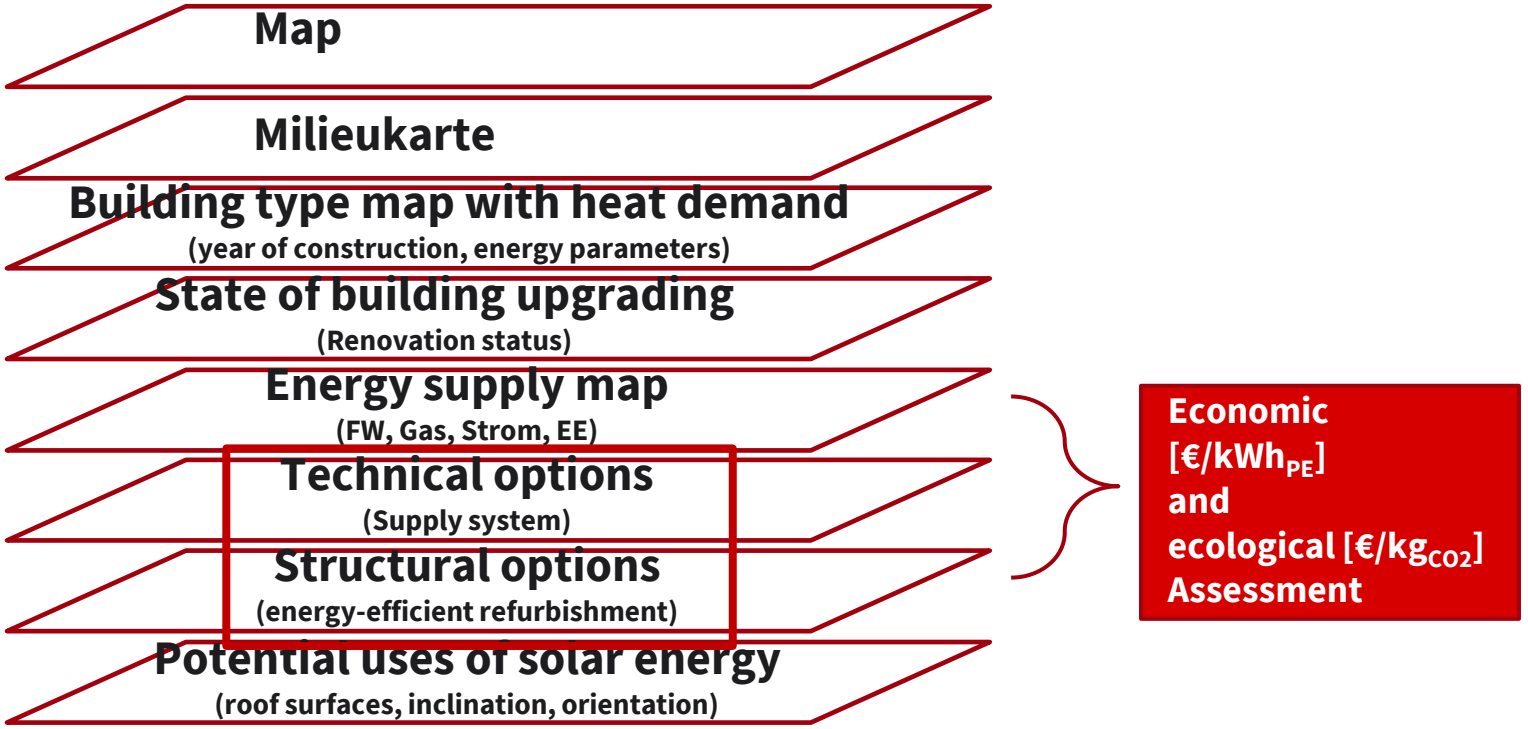
INFRASTRUCTURE DATA (SPATIAL DIMENSION)

In the project, different data on the building stock in the city of Delitzsch were collected.

On the one hand, this was the type of building (see above) and on the other hand, the condition of the building (see below)

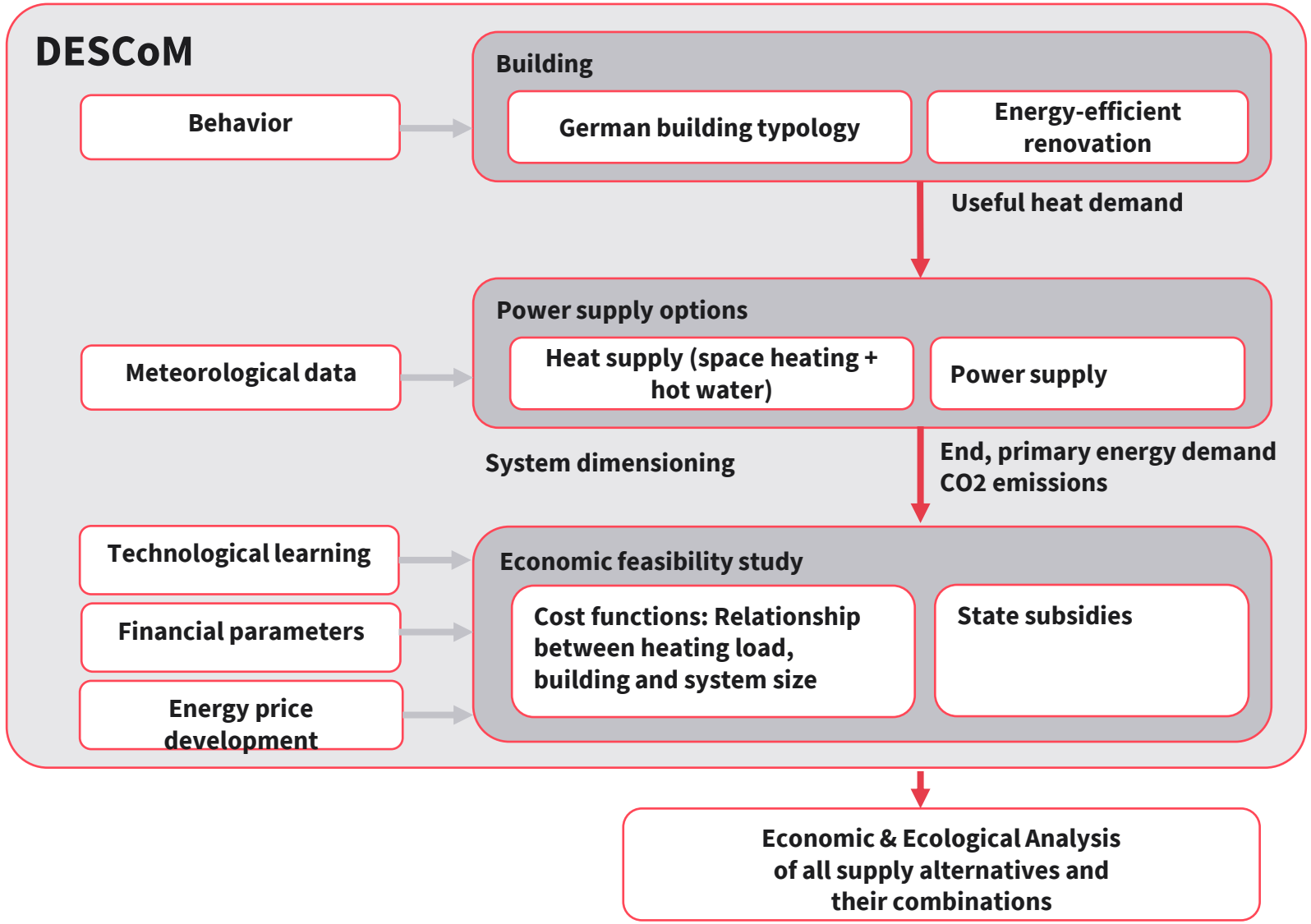
THE INTERACTIVE GIS-BASED MASTER PLAN

The layers of the master plan



Source:
IIRM/KEM

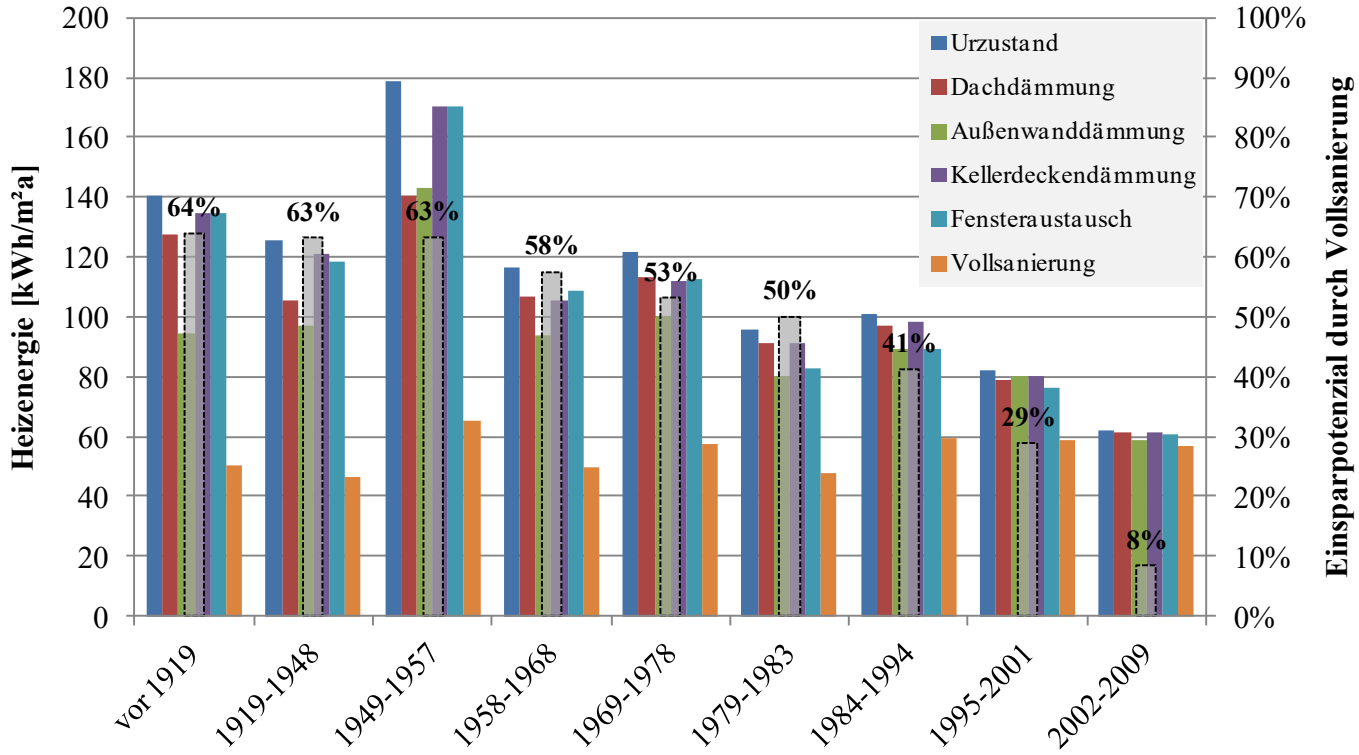
DECENTRALIZED ENERGY SUPPLY CONCEPTION MODEL



Source: IIRM

MODERNIZATION OPTIONS

The best modernization options were modeled for all building types:



Source: IIRM

ABM OF REFURBISHMENT INVESTMENT BEHAVIOR

INTERNATIONAL UNIVERSITY OF APPLIED SCIENCES

Sympathy towards certain techniques - Top 2 values - Deviation in percentage points

Techniques Deviation in percentage points	Total	KET	LIB	PER	EPE	PRA	SÖK	BOOM	BETWEEN	PRE	HOT
Triple glazing of windows (window insulation)	93	-1	2	0	-1	1	0	0	1	-7	0
Insulation of individual parts of the building (e.g. roof, façade, etc.)	93	2	0	-1	0	-7	1	2	0	-9	2
Solar collectors for heating and hot water preparation (solar thermal energy)	86	-1	3	3	6	-2	0	-6	-4	1	3
Insulation according to low-energy house standard (better than legally required)	85	-5	4	1	3	-2	5	2	-5	-11	0
Photovoltaic system (solar cell)	82	-4	5	1	8	3	3	-4	-7	-6	4
Condensing boiler technology	82	1	-3	4	3	-3	-6	4	5	-17	-1
Double glazing of the windows	81	-1	-2	0	-1	-1	-3	0	4	4	8
Low-temperature boilers	81	-3	2	1	7	0	0	2	5	-14	-9
Geothermal energy as a heating source (geothermal energy/air heat)	74	-5	4	3	13	4	-2	-9	-2	-10	10
Insulation according to passive house standard (no heating is required)	73	-5	6	0	-1	-3	0	-2	4	-7	5
In-house combined heat and power plant (micro combined heat and power)	70	-6	0	3	9	8	1	-1	-4	-1	5
Gas heating system	66	6	-2	3	-5	-1	-2	1	-5	2	-4
Wood heating system (pellets, chips, logs)	65	-5	-1	3	7	6	8	-4	1	-10	1
District heating/ local heating connection	46	3	-3	1	0	6	2	-5	-1	-8	6
Oil heating system	32	3	-2	-6	2	8	-4	2	0	1	3
Column Average	73,75	72,42	74,54	74,74	77,08	74,81	73,85	72,52	73,18	67,69	75,87
Weighting factor		1,018	0,989	0,987	0,957	0,986	0,999	1,017	1,008	1,090	0,972

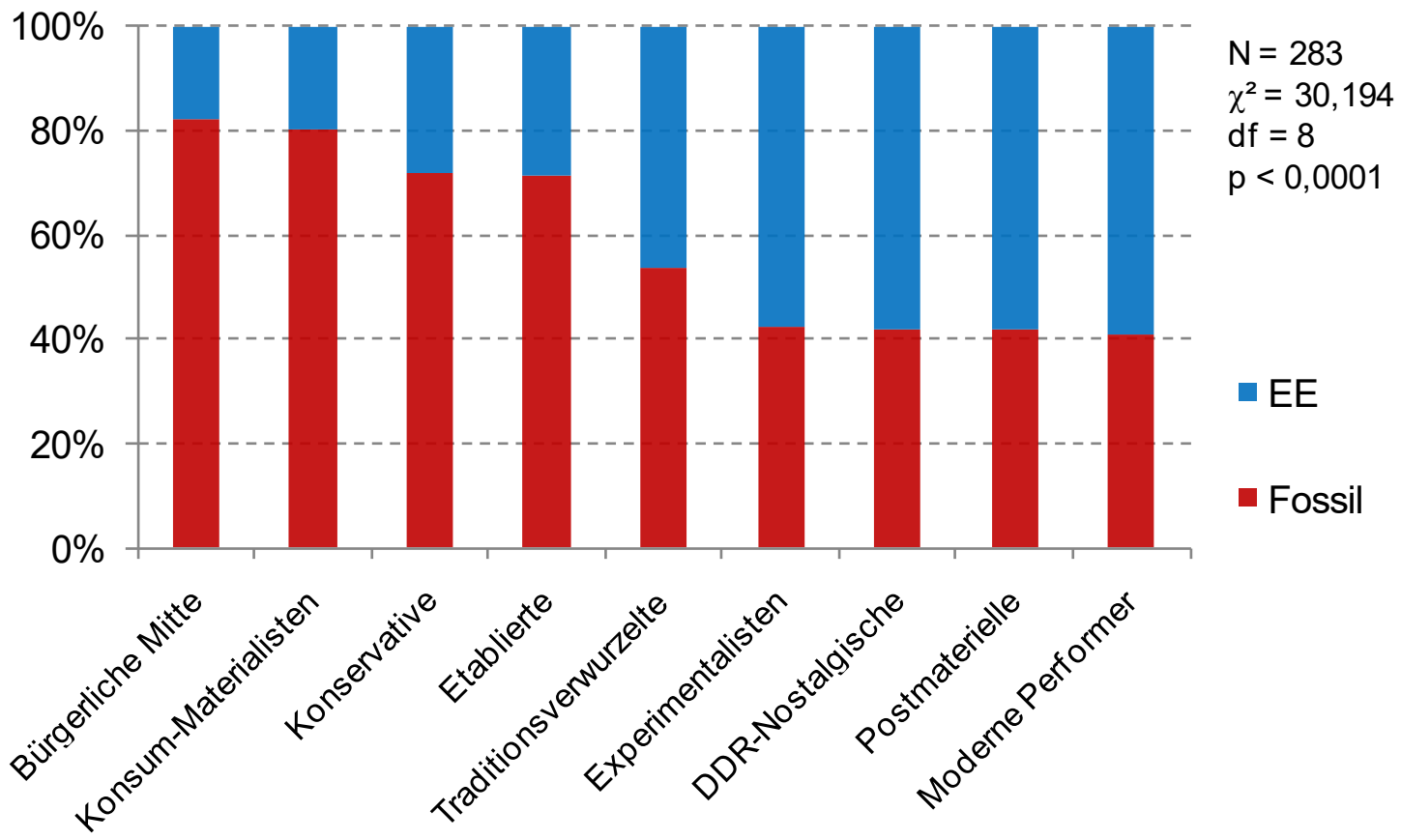
Above average
below average

KET = Conservative-Established LIB = Liberal-Intellectuals PER = Performer EPE = Expeditive PRA = Adaptive-Pragmatic
SÖK = Socio-ecological BÜM = Bourgeois Center TRA = Traditional PRE = Precarious HED = Hedonists

Source: Energy-efficient investments 2012; Basis: 2,017 cases, IIRM
Question: For each technique or measure, please also indicate how sympathetic you are to this measure or technique.

Source: IIRM

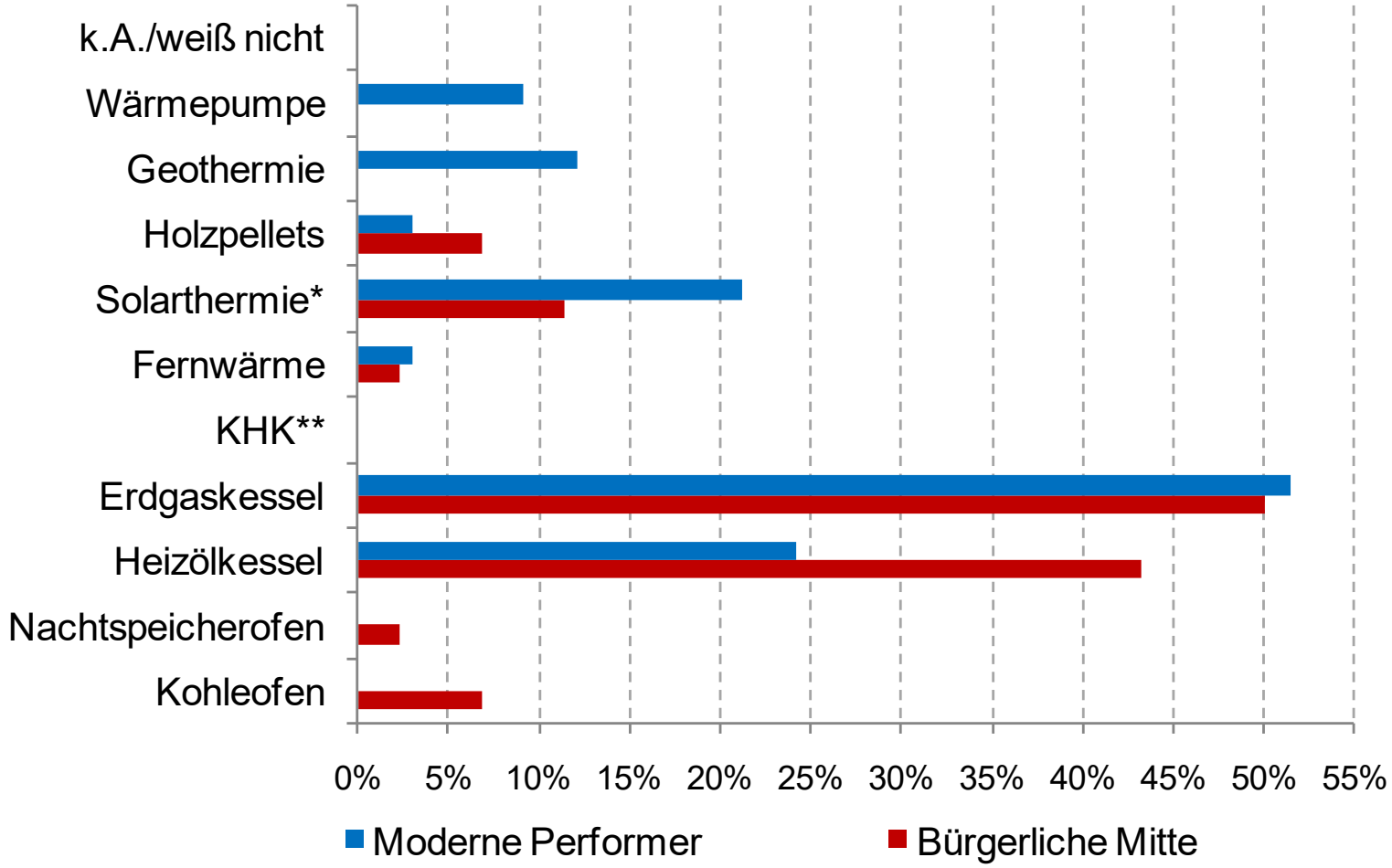
RELATIONSHIP BETWEEN LIFESTYLE (SINUS LIFESTYLE) AND CHOICE OF ENERGY SOURCE



Source: IIRM

Source: M. Gröger and T. Bruckner: Lifestyles and Investment Behaviour in the Heating Market, 7th International Energy Industry Conference at the Vienna University of Technology, 2011.

HEATING SYSTEMS IN EXISTING BUILDINGS



* nur Warmwasserbereitung; ** Kleinheizkraftwerk

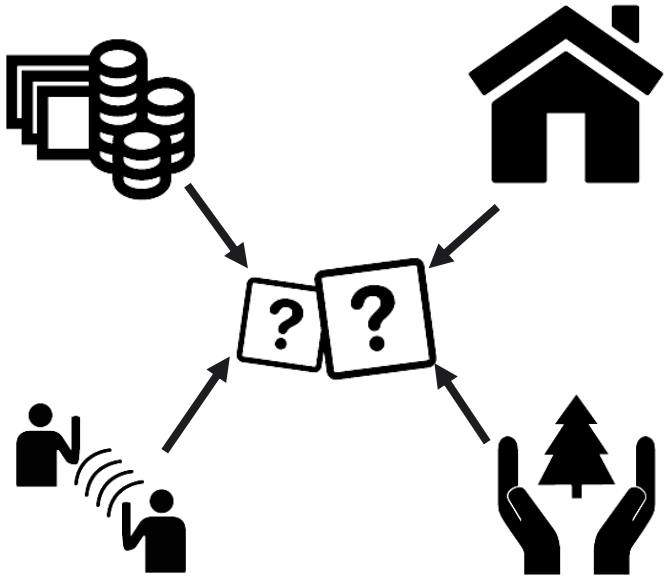
Source: IIRM

Source: M. Gröger and T. Bruckner: Lifestyles and Investment Behaviour in the Heating Market 7th International Energy Industry Conference at the Vienna University of Technology, 2011.

SIMULATION OF ENERGY-RELATED INVESTMENT BEHAVIOR

The following four influencing factors are taken into account when simulating investment behavior:

1 available Funds



3 Condition of the property

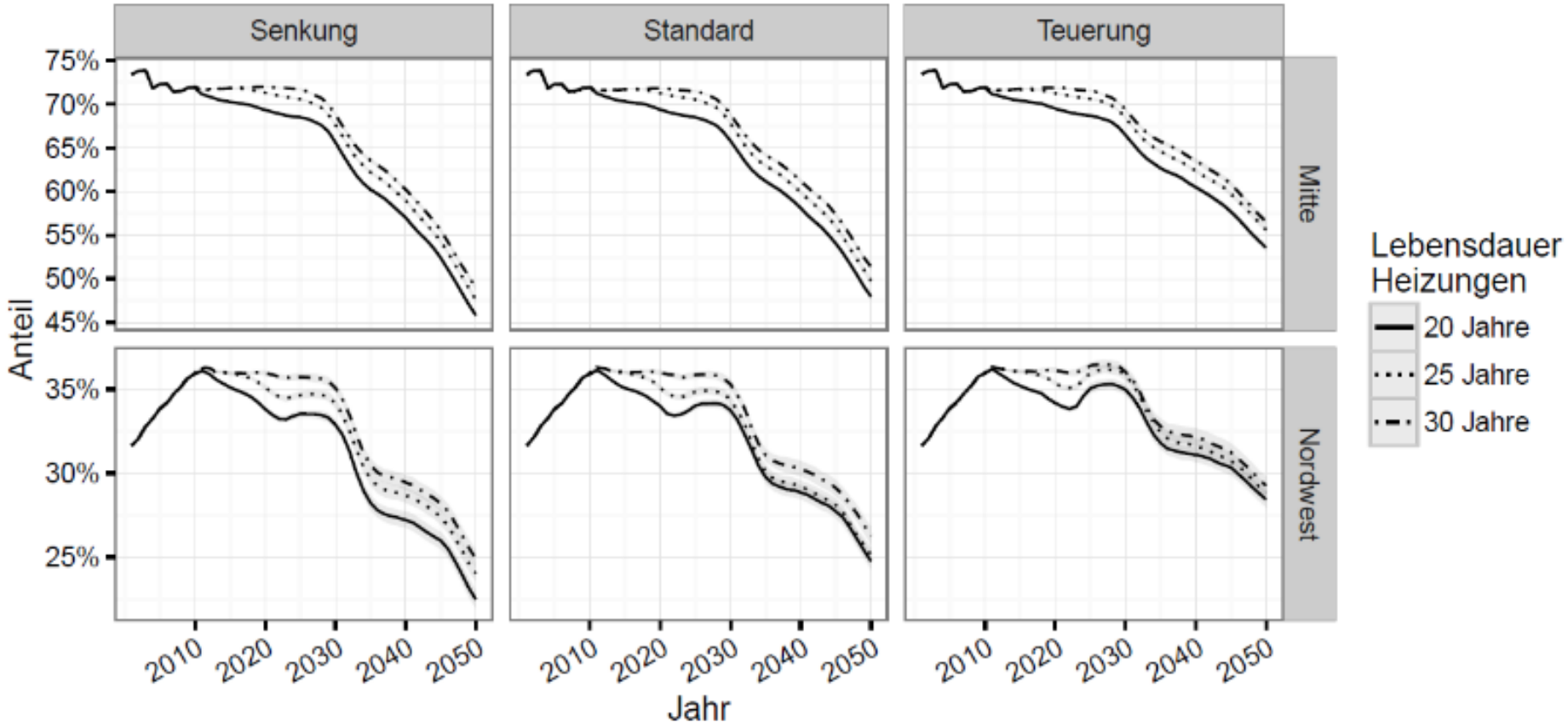
2 Exchange with neighbors on investments

4 Personal attitude to Efficiency

Source: IIRM

SIMULATING THE CITY (RELOCATION AND INVESTMENT BEHAVIOR)

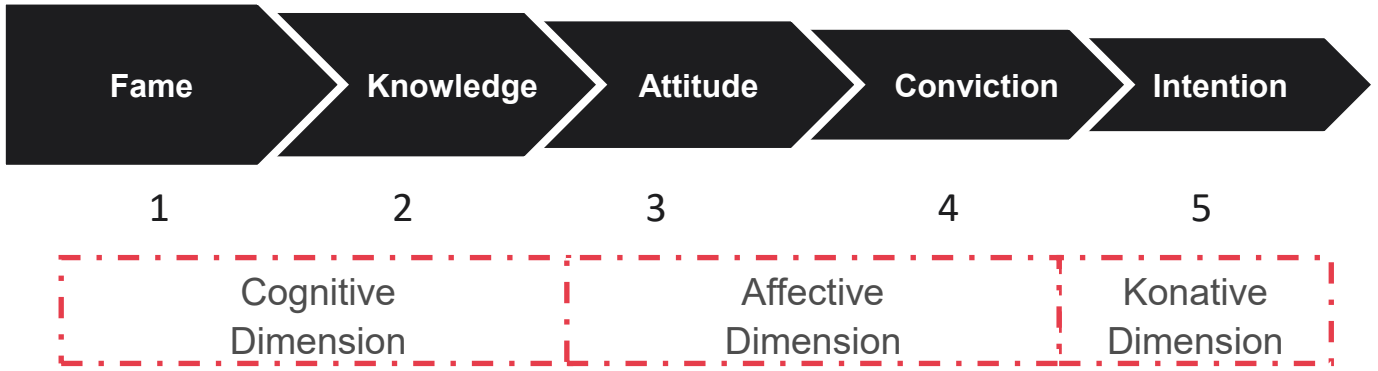
For all common energy sources (example here: gas)



Source:
IIRM/UFZ

TARGET GROUP-SPECIFIC APPROACH

Steps in the decision-making process regarding energy-efficient building renovation:



The hierarchy of effects model assesses the influence of lifestyle on different behavioural dimensions of energy-efficient building renovation and thus works out starting points for a target group-specific approach.

Source: IIRM

STARTING POINTS FOR COMMUNICATION AND INTERVENTIONS IN THE TEST DISTRICT

	1 Bekanntheit	2 Kenntnis	3 Einstellung	4 Überzeugung	5 Absicht
	hinsichtlich einer energetischen Gebäudesanierung				
Konservativ-etabliertes	99,0%	80,1%	51,0%	33,7%	14,9%
Liberal-intellektuell	99,7%	82,9%	57,9%	40,6%	13,3%
Performer	98,9%	79,5%	48,4%	32,9%	18,4%
Expeditives	98,4%	76,9%	52,3%	34,6%	16,6%
Adaptiv-pragmatisches	99,5%	69,0%	53,9%	42,4%	22,4%
Sozialökologisches	99,7%	80,0%	52,3%	36,2%	17,0%
Bürgerliche Mitte	98,5%	76,9%	44,1%	32,6%	11,8%
Traditionelles	99,0%	78,8%	44,5%	30,8%	10,6%
Prekäres	99,6%	64,4%	36,1%	20,6%	9,3%
Hedonistisches	92,8%	59,3%	33,7%	21,9%	12,2%

Transferraten

	1-2	2-3	3-4	4-5
Konservativ-etabliertes	80,9%	63,7%	66,0%	44,1%
Liberal-intellektuell	83,1%	69,8%	70,2%	32,8%
Performer	80,4%	60,9%	67,9%	56,0%
Expeditives	78,1%	68,1%	66,1%	47,9%
Adaptiv-pragmatisches	69,4%	78,1%	78,8%	52,7%
Sozialökologisches	80,3%	65,3%	69,2%	46,9%
Bürgerliche Mitte	78,0%	57,3%	74,0%	36,2%
Traditionelles	79,6%	56,4%	69,2%	34,4%
Prekäres	64,7%	56,1%	57,1%	45,0%
Hedonistisches	63,9%	56,8%	64,8%	55,9%

In the specific case of Delitzsch, interventions are carried out at the following points (in yellow)

Source: IIRM

Source: IIRM

Photo: City of Delitzsch

Photo: City of Delitzsch

Depending on the resident structure, citizens' energy meetings were held in residential districts, which were above all either informative or confidence-building or which had an effect on the intention to modernize.

Source: IIRM/City of Delitzsch

EFFECTS FOR THE LARGE DISTRICT CITY OF DELITZSCH







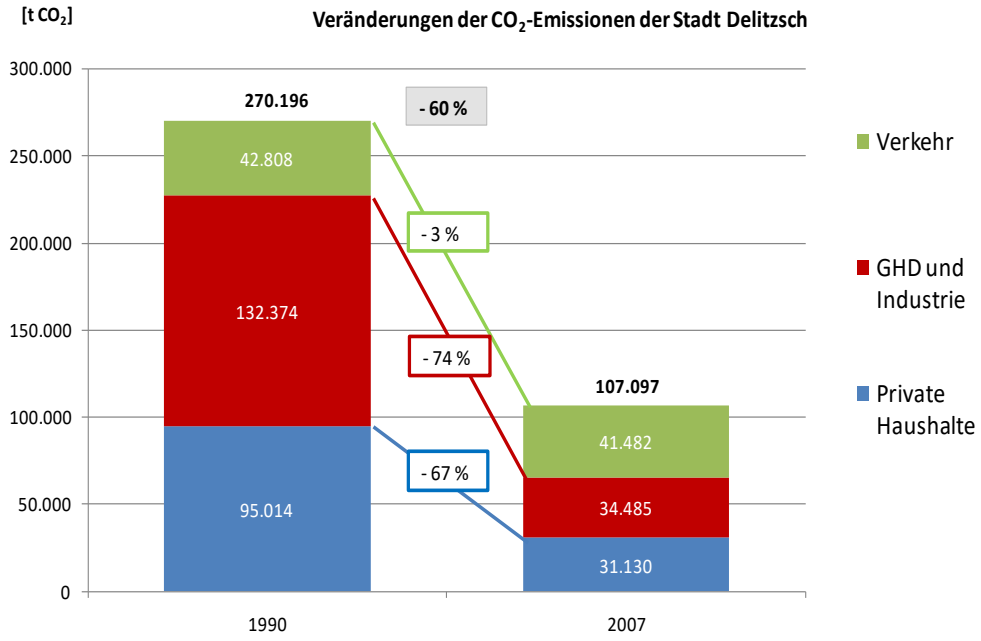





Photos: City of Delitzsch

DELITZSCH: REDUCTION OF CO_2 EMISSIONS

- Restructuring
- Thermal insulation / CHP
- Lignite ⊠ Natural gas
- Use of renewable energies (biomass power plants)



Comparison with the EU 20-20-20 target:

- **Primary energy consumption: - 24 %**
- **Share of renewable energies in electricity generation: 90%**
- **CO_2 emissions: - 60%**

Source: Institute of Energy, Leipzig

EFFECTS FOR THE LARGE DISTRICT CITY OF DELITZSCH

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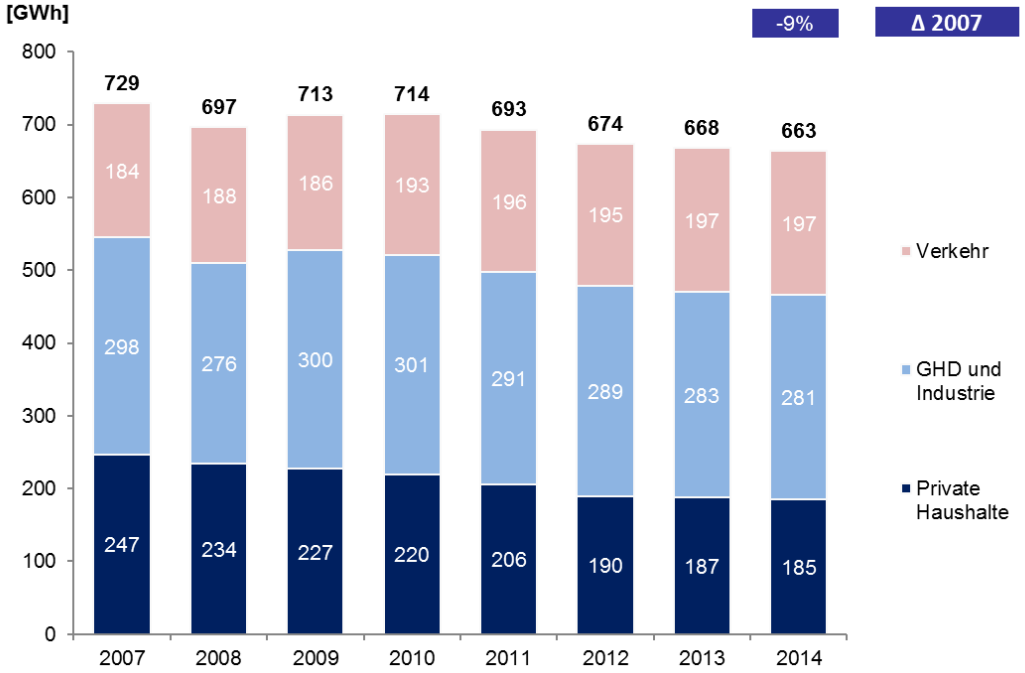
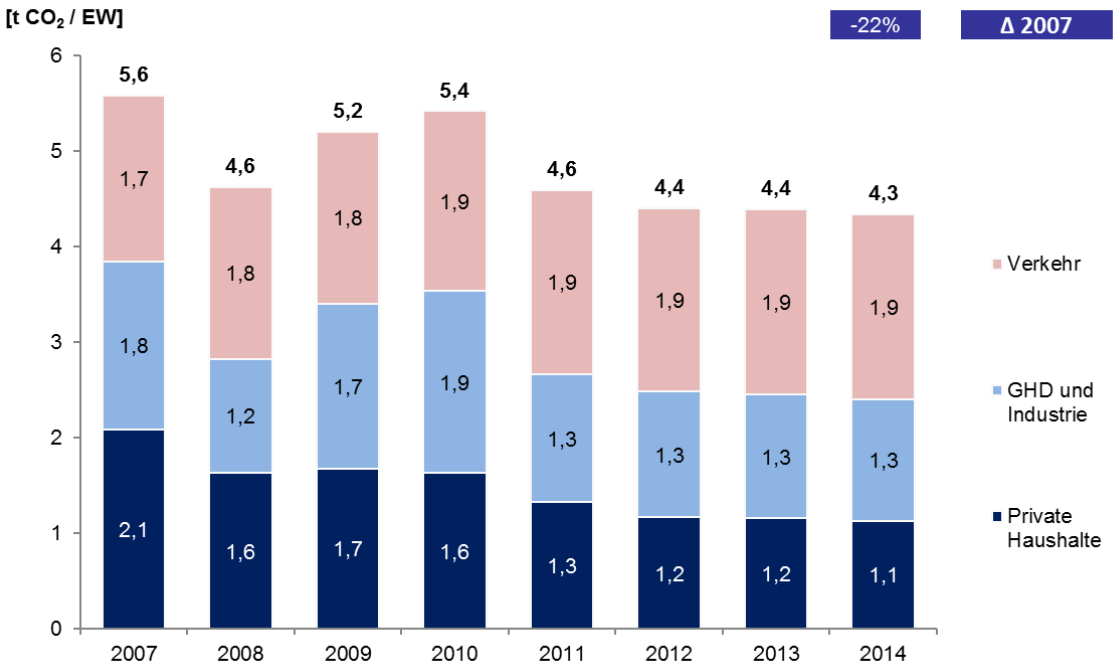
Since the start of the project (measured from 2007), 9% of final energy consumption and 22% of CO 2 emissions have been saved in 2014 in the large district town of Delitzsch.



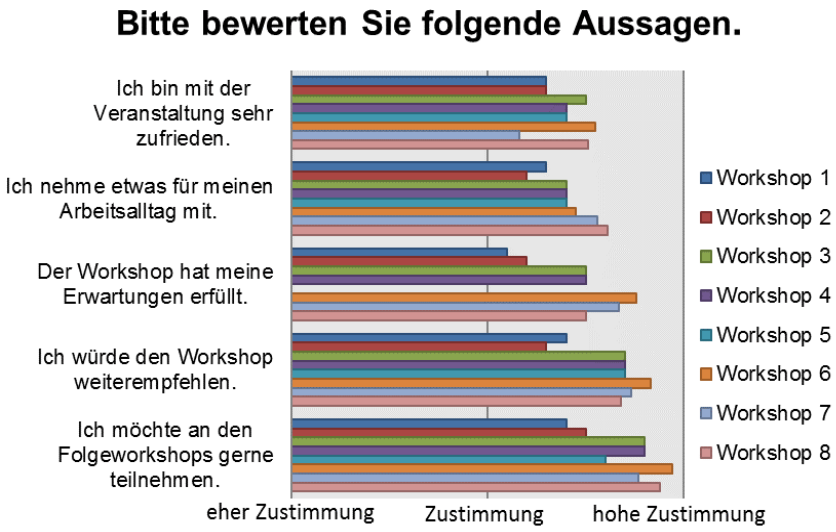


Source: IE

MUNICIPAL WORKSHOPS: KNOWLEDGE TRANSFER

Since 2013, a total of 8 municipal workshops took place at the University of Leipzig. 145 participants from 67 municipalities were familiarized with the research results (recurrence rate 51%). In addition, a further 39 institutions took part in the events.

WS	Date	Topic	TN
1	04.03.2013	Energy and climate protection concepts	15
2	09.07.2013	Energy and CO_2 balances	40
3	14.11.2013	Technical measures	35
4	20.03.2014	Implementation issues	39
5	22.09.2014	Energy and climate protection concepts	44
6	19.03.2015	Technical measures	36
7	10.09.2015	Approach and networks	29
8	07.03.2016	Evaluation and monitoring	44



Source: IIRM

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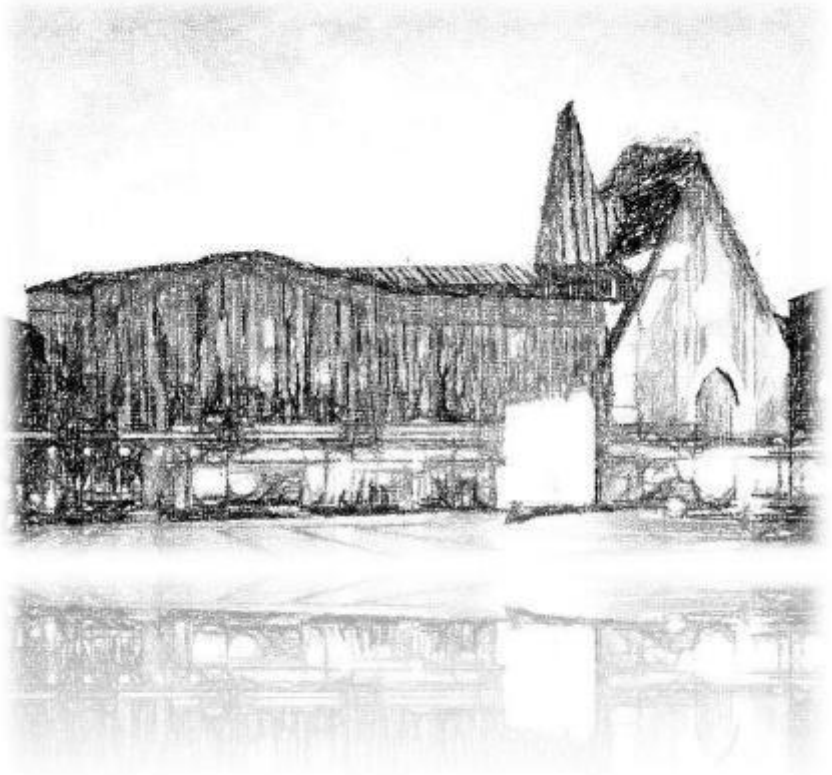

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