Material stocks of the non-residential building sector: The case of the Rhine-Main-Area

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Workshop
Characterizing the built environment stocks: methods and case studies

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BMBF

Research Project PRRIG

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TECHNO-ECONOMIC POTENTIAL OF THE RECOVERY OF RAW MATERIALS FROM THE INDUSTRIAL AND COMMERCIAL BUILDING STOCK (PROJECT PRRIG)

April 2013 – June 2016

Partners:

- TU Darmstadt
  (Dep. Material Flow Management and Resource Economy, Dep. Landmanagement, Institute for construction site management)
- Industry: Adam Opel AG, re2area

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OPEL

Re2area

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Project area: Rhine-Main-Area

Regionalverband FrankfurtRheinMain http://www.region-frankfurt.de/

- **Inhabitants**: ca. 5.5 million
- **area**: ca. 14 000 km²

- Polycentric structure
- Sectors: financial sector, logistics, media and IT, chemistry, automotive engineering
- Institutions for education and culture

source: F.A.Z. – Wolfgang Elmies

Approach in PRRIG

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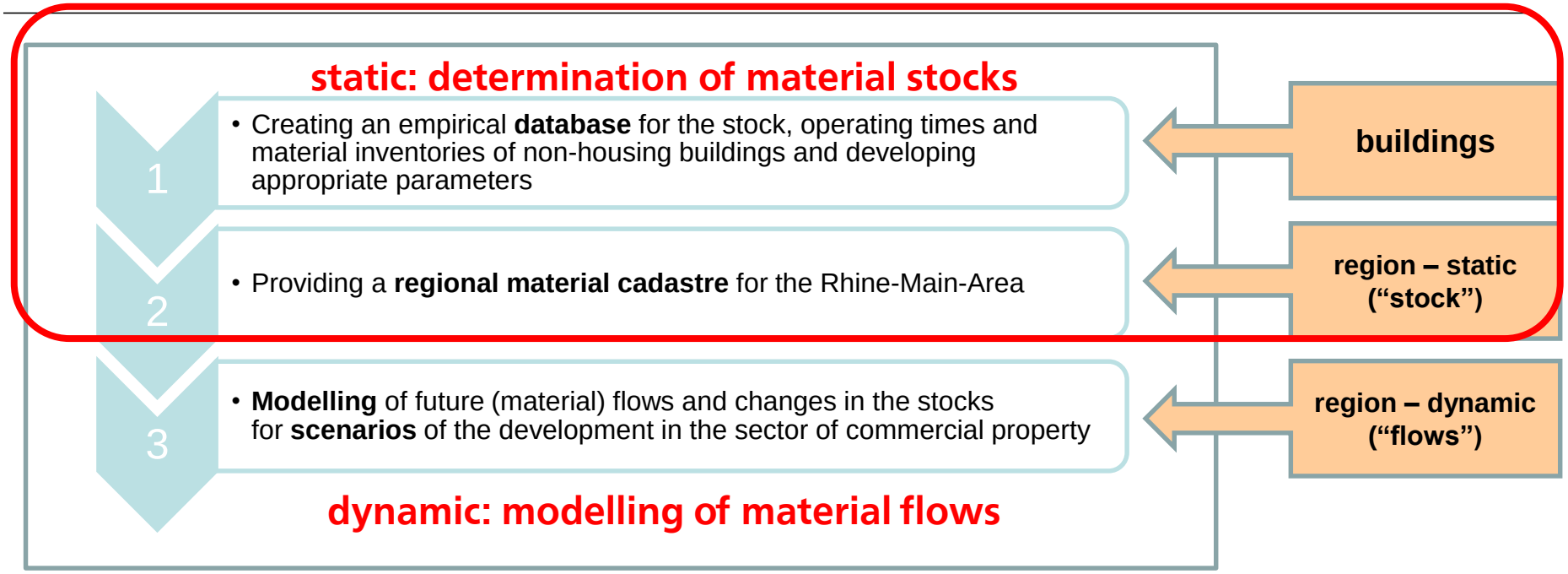

Combining the geospatial approach (“top-down“) with a building-related approach (“bottom-up“)

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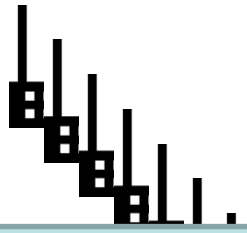
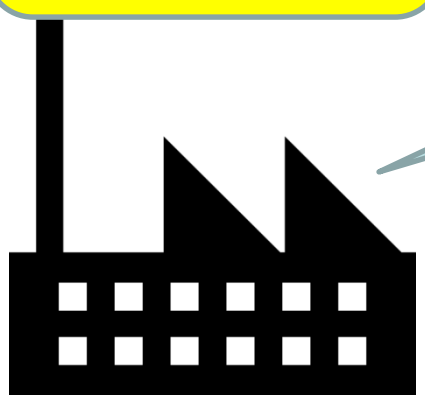
is part of a building stock
- location
- region
…

Connecting information via buildingtypology

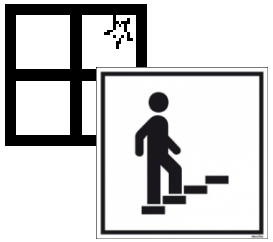
”bottom-up“

examination of real buildings





A building…



”top-down“

evaluation of geospatial information

…has components
- walls
- windows
…

Buildingtypology: function and age-class

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11 categories for non-housing buildings:

- office and administration
- factory
- commercial, retail and service
- warehouse
- hotels and restaurants
- education and research
- transport facilities
- health care
- sport facilities
- supply and disposal
- agriculture and farm

8 age-classes:

- Before 1918
- 1919 – 1948
- 1949 – 1957
- 1958 – 1968
- 1969 – 1978
- 1979 – 1994
- 1995 – 2001
- From 2002

Building-related approach: data collection

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Examination of **19 non-housing buildings** (in use as well as in demolition):

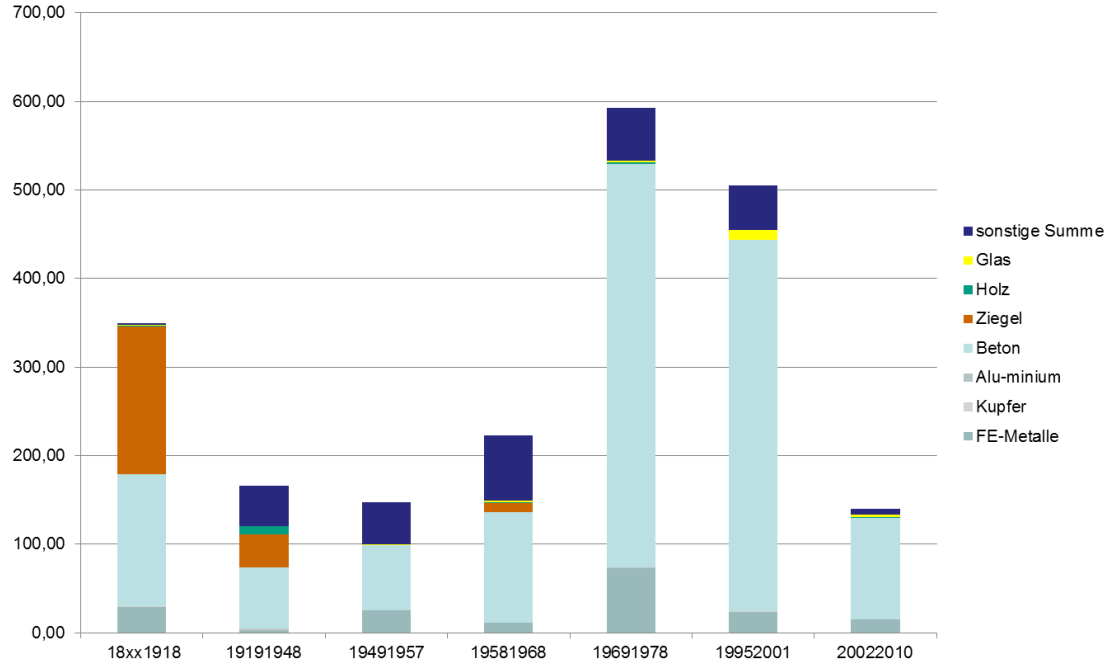
- function:
  - office and administation
  - factory
  - warehouse
- year of construction:
  - between 1908 and 2014
- constructiontypes:
  - framework with different infills
  - solid buildings (masonry, concrete)





Sources:
Britta Miekley, Jan Wöltjen (TU Darmstadt)

Results of the building examination: specific material contents



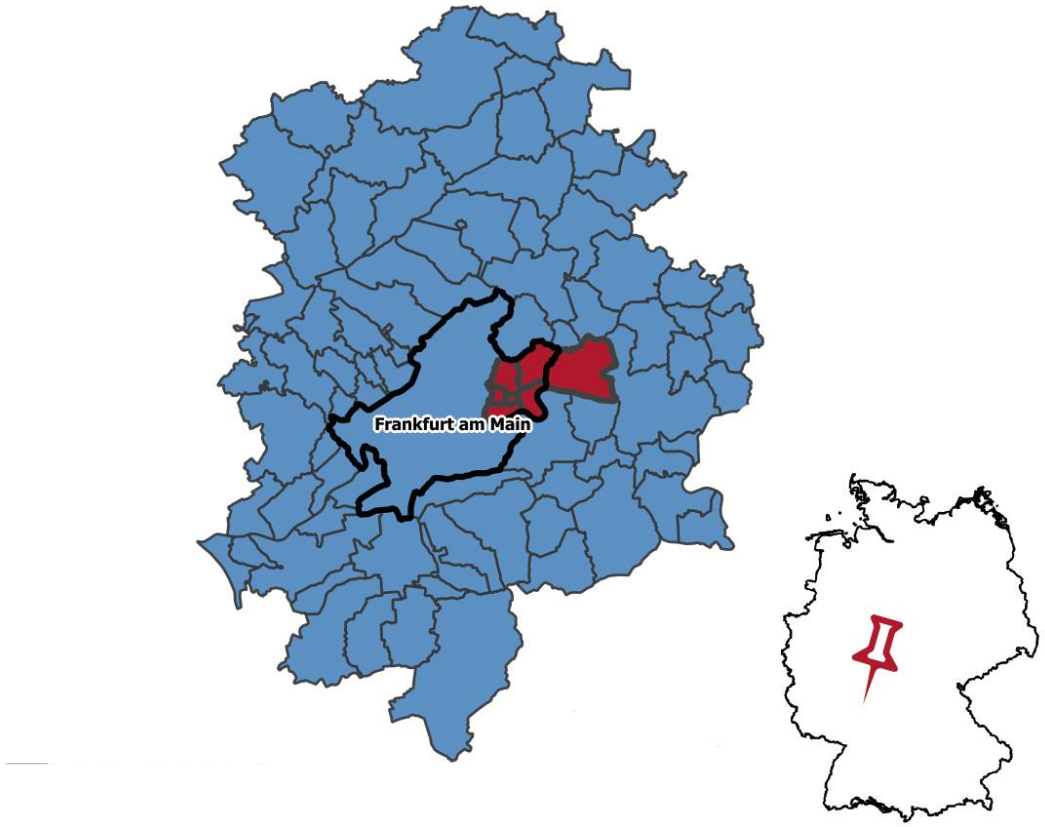
Example:
Material contents in kg/m³ gross volume for examined buildings, in order of their age-class

- values for kg materials/m³ gross volume is in general in the range of other studies (Kleemann et al. 2014, Ortlepp et al 2015)
- significant differences between individual buildings
- no statistical proof for a dominating influencing factor (function, age-class, constructiontype)

Geospatial approach

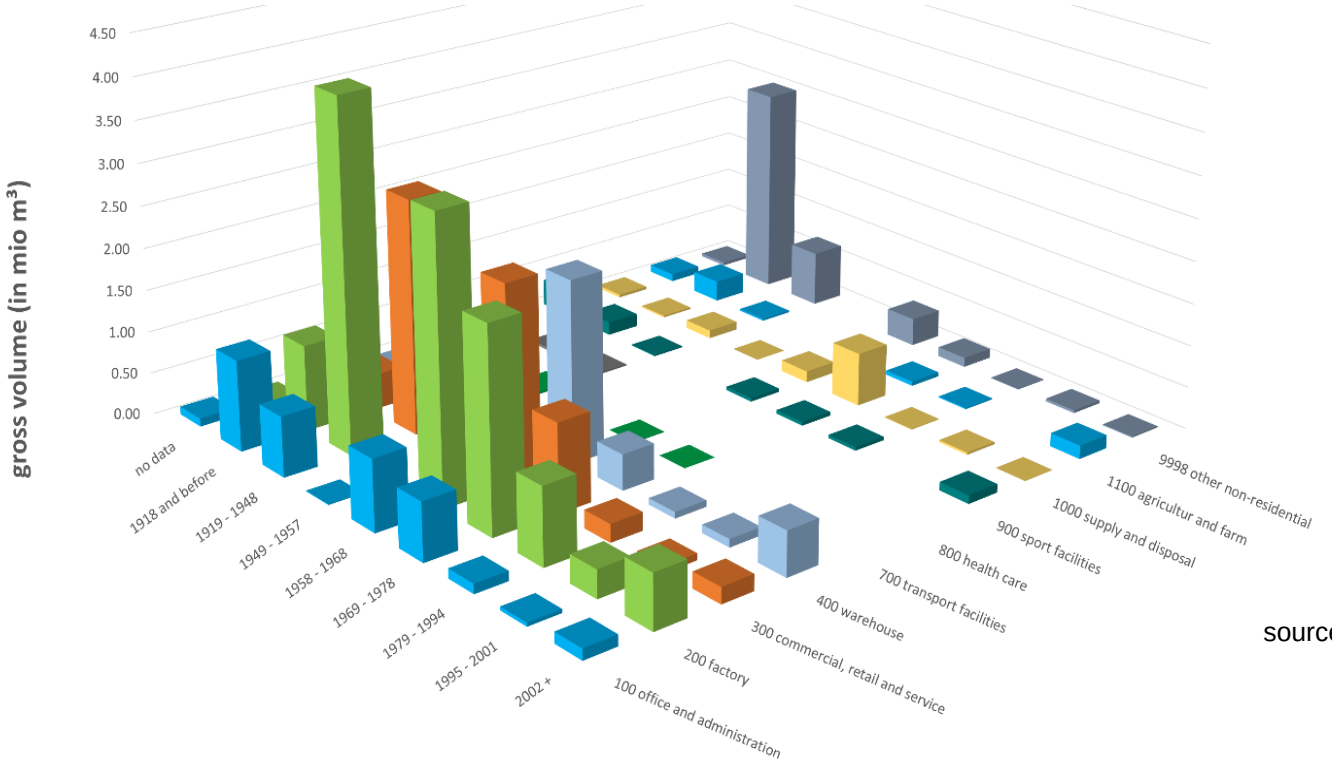
- **building location and size** from the ALKIS data model (German authoritative real estate information data for the state of Hesse)
- **function:** via transformation of the ALKIS category to the PRRIG buildingfunction
- **age-class**: geographical combination of the polygon-based information of the historical development (RegioMap) and the ALKIS-assignment for each building
  → rough estimation for the age of the first building activity, but without information about changes of the building stock

Case-study-area ”Frankfurt-East“



Rhine-Main-Area (blue) and case-study Frankfurt-East (red)
(Source: GeoBasis-DE / BKG 2014, OpenStreetMap)

Results of the geospatial approach: distribution of functions and age-classes



source: Schebek et al. 2016

15 (of 96 possible) combinations of function and age-class make up about 79% of the stock in m³ gross volume

Combining the approaches: determination of the material stocks

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Assumptions:

- The constructiontype is a significiant influence for material contents.
- A specific constructiontype is approximately identical in all age-classes.

Approach for each building function:

1. step: **specific material contents** for every constructiontype from the results of the building examinations (without distinction of age-classes)

2. step: estimation of the **share of constructiontypes** in each age-class

3. step: creation of **average specific material contents** for this **“mix” of constructiontypes**

4. step: **multiplication** of the average specific material contents with the m^3 gross volume of the particular function-age-class-combination

Results: material stocks, example office & administration

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		Exemplary material stock of office and administration buildings in the case study area by age classes and in total (in t)							
Co-hort	gross volume [m^3] in case study area	FE-metals	copper	alu-minum	concrete	masonry, brick & tiles	wood	glass	others
1918 and before	1 080 399	25 543	258	236	174 069	129 038	1 740	2 080	2 465
1919 - 1948	715 633	16 867	167	151	125 216	70 695	1 043	2 008	2 094
1949 - 1957	8 272	217	2	2	1 583	946	14	24	26
1958 - 1968	844 402	22 066	217	193	173 264	79 122	1 266	3 211	3 168
1969 - 1978	685 813	18 003	161	139	142 215	43 911	909	3 149	2 823
1979 - 1994	114 842	3 021	26	22	23 939	5 649	142	572	494
1995 - 2001	43 403	1 143	9	8	9 071	1 813	52	225	191
2002 +	129 888	3 429	27	22	27 288	3 499	144	724	594
total		90 289	867	773	676 645	334 673	5 310	11 993	11 855

Source: Schebek et al. 2016

Prospects

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- Area-covering implementation for determining the stocks (gross volume & materials) of the Rhine-Main-Area (or bigger)

- Dynamisation with a material flow analysis:
  - scenarios for the real estate market
  - calculation of material flows and changes in stocks

Sources

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Schebek et al. 2016:

Schebek, L., Schnitzer, B., Blesinger, D., Köhn, A., Miekley, B., Linke, H.-J., Lohmann, A., Motzko, Chr., Seemann, A. "Material Stocks of the Non-residential Building Sector: the Case of the Rhine Main Area“, in: Resources, Conservation & Recycling, Special Issue „Anthropogenic Stocks“, 2016, in press

Literature:

BMVBS (2013): Systematische Datenanalyse im Bereich der NWG– Erfassung und Quantifizierung von Energieeinspar- und CO2-Minderungspotenzialen. BMVBS-Online-Publikation 27/2013

Deutsche Wohngebäudetypologie, 2015. Beispielhafte Maßnahmen zur Verbesserung der 658 Energieeffizienz von typischen Wohngebäuden. Wohnen und Umwelt, Darmstadt

Kleemann et al. 2014: Kleemann, F., Lederer, J., Aschenbrenner, P., Rechberger, H., Fellner, J. A method for determining buildings’ material composition prior to demolition, Building Research & Information, 44:1, 51-62, doi: 10.1080/09613218.2014.979029 (print version from 2016).

Ortlepp et al. 2015: Ortlepp, R., Gruhler, K., Schiller, G. Material stocks in Germany's non-domestic buildings: a new quantification method, Building Research & Information. doi: 10.1080/09613218.2016.1112096

Thank you very much for your attention!

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Dynamic approach – the Material Flow Model