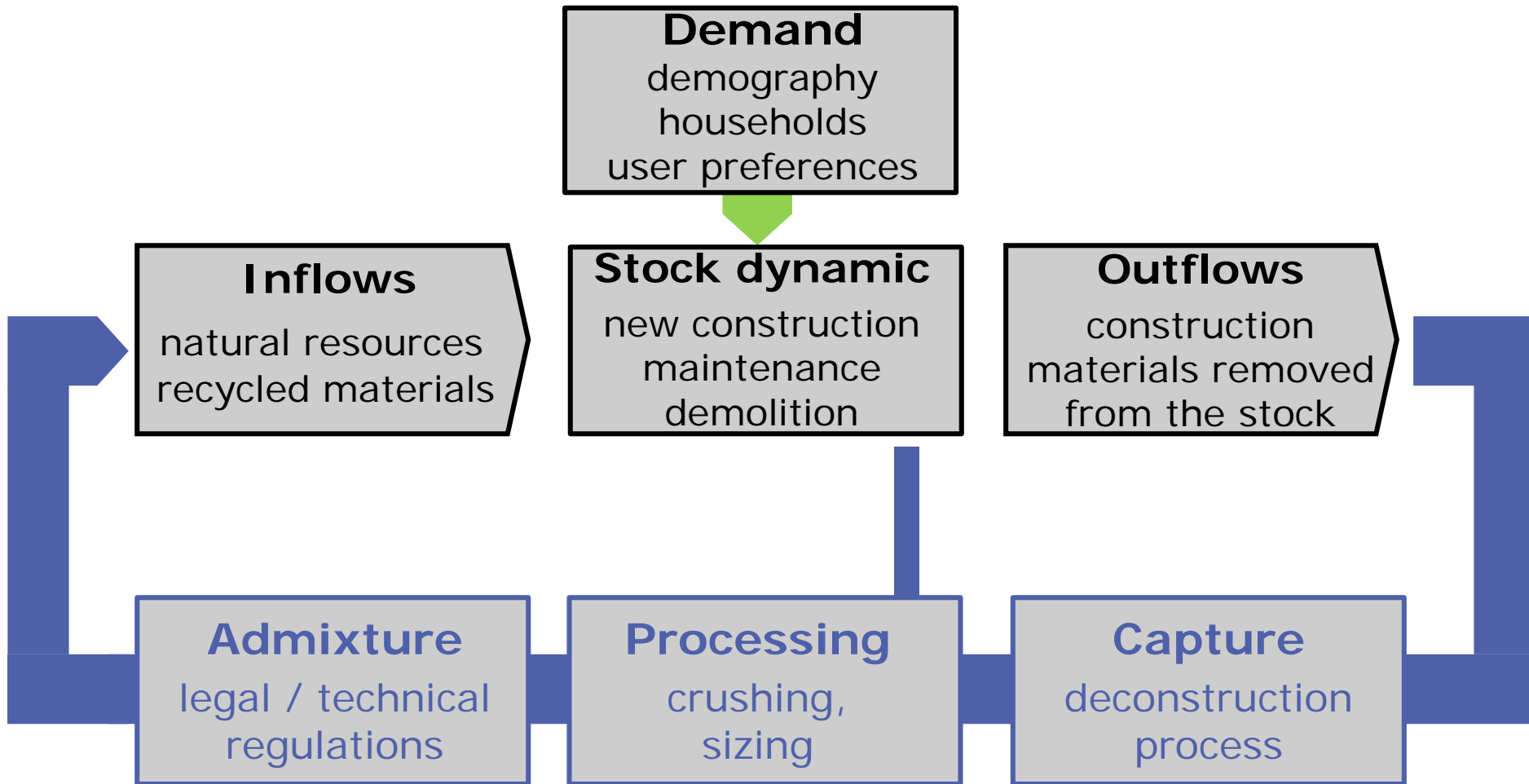


Material Flow Analysis of stocks and flows to assess CDW recovery potential

Clemens Deilmann, Georg Schiller,
Karin Gruhler, Regine Ortlepp



From MFA to “Continuous” MFA



Recycling from Buildings to Building Construction

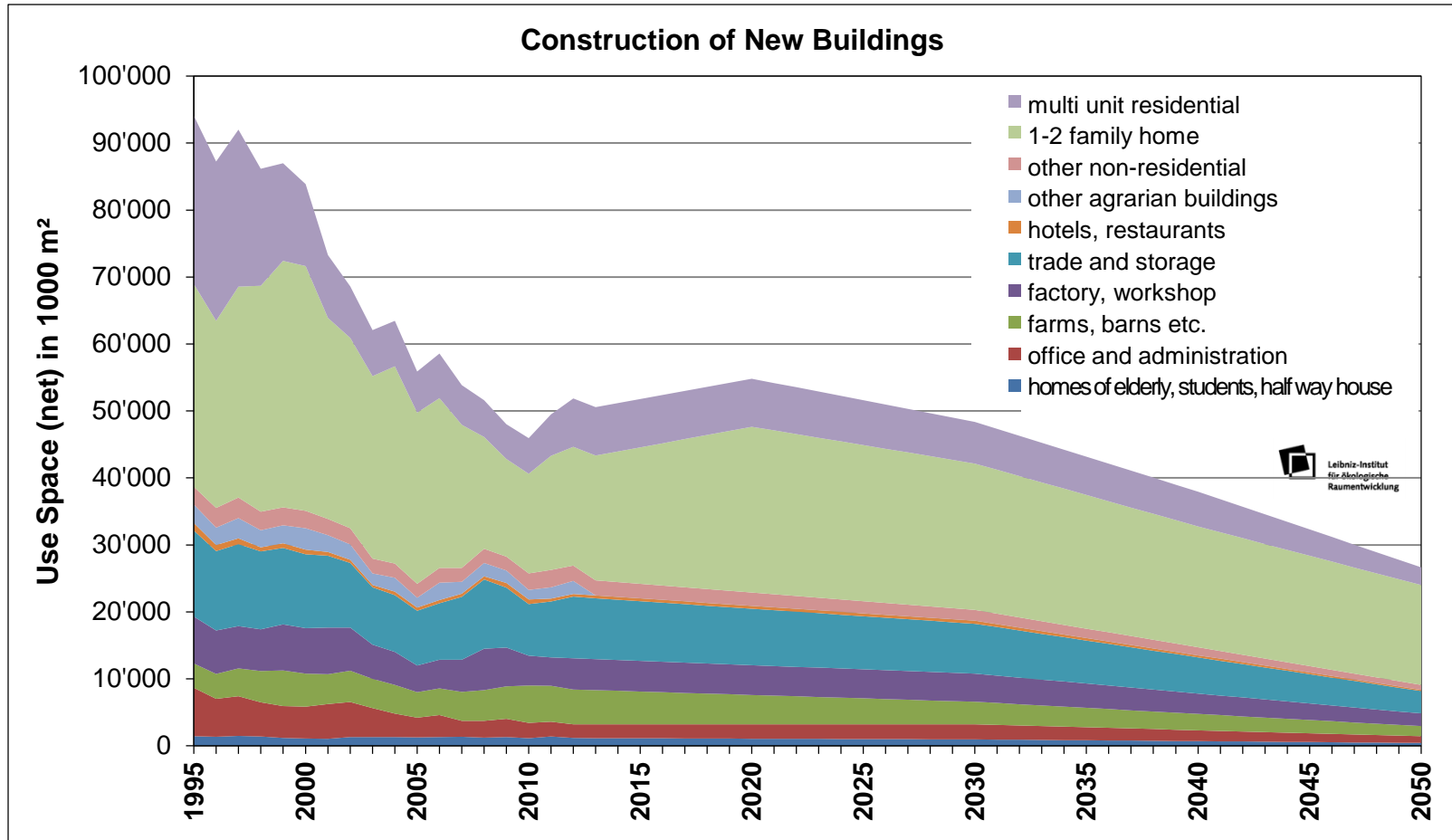
Results of a BBSR Project „ Sensitivitätsstudie zum Kreislaufwirtschaftspotenzial im Hochbau“

- **Buildings Activities in Germany until 2050**
- **Materialflow of Building Construction Activities**
- **Recycling Quota for 16 Product Groups**
- **Recycling Potential of Construction Activities 2050**

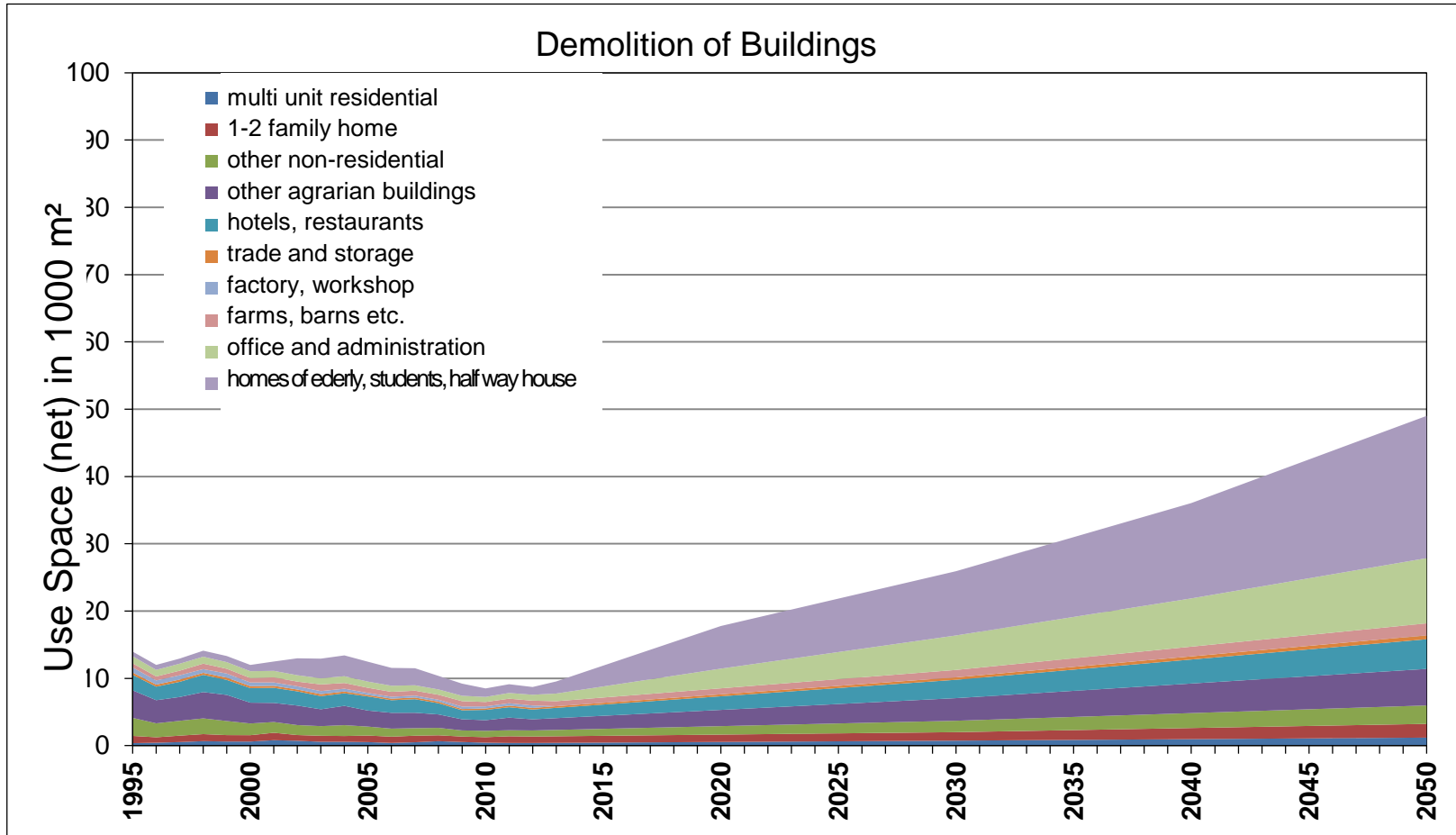
Construction Activity-Assumptions

- Basis: 12. Coordinated Populationforecast (StaBu 2009). Variante 1-W1 ("medium" population, Migration +100.000 per year).
- Number of **Households** determines **Dwelling Unit Construction** (Increase until 2025 thereafter falling)
- Estimation: Dw-**Increase** (ca. 4,2 Mio. Dw 2011-2030 , ca. 2,8 Mio. Dw 2031-2050 und Dw-**Loss** (ca. 2,6 Mio. Dw 2011-2030, ca. 4,7 Mio. Dw 2031-2050)
- **Non-Residential-Buildings**: New construction, demolition of Buildings divided by **Population**... and for 2030/2050 multiplied by population forecast.
Problem: Population -14 %, Stock + 25 % from 3,0 to 3,7 Billion m² floorspace = +40 % increase in „floorspace-use“ per Inhabitant, incl. vacancies... ?? Therefore **Increase-Limitation 30 %** (less new construction, higher demolition-rate per Inhabitant).

New Construction of Buildings

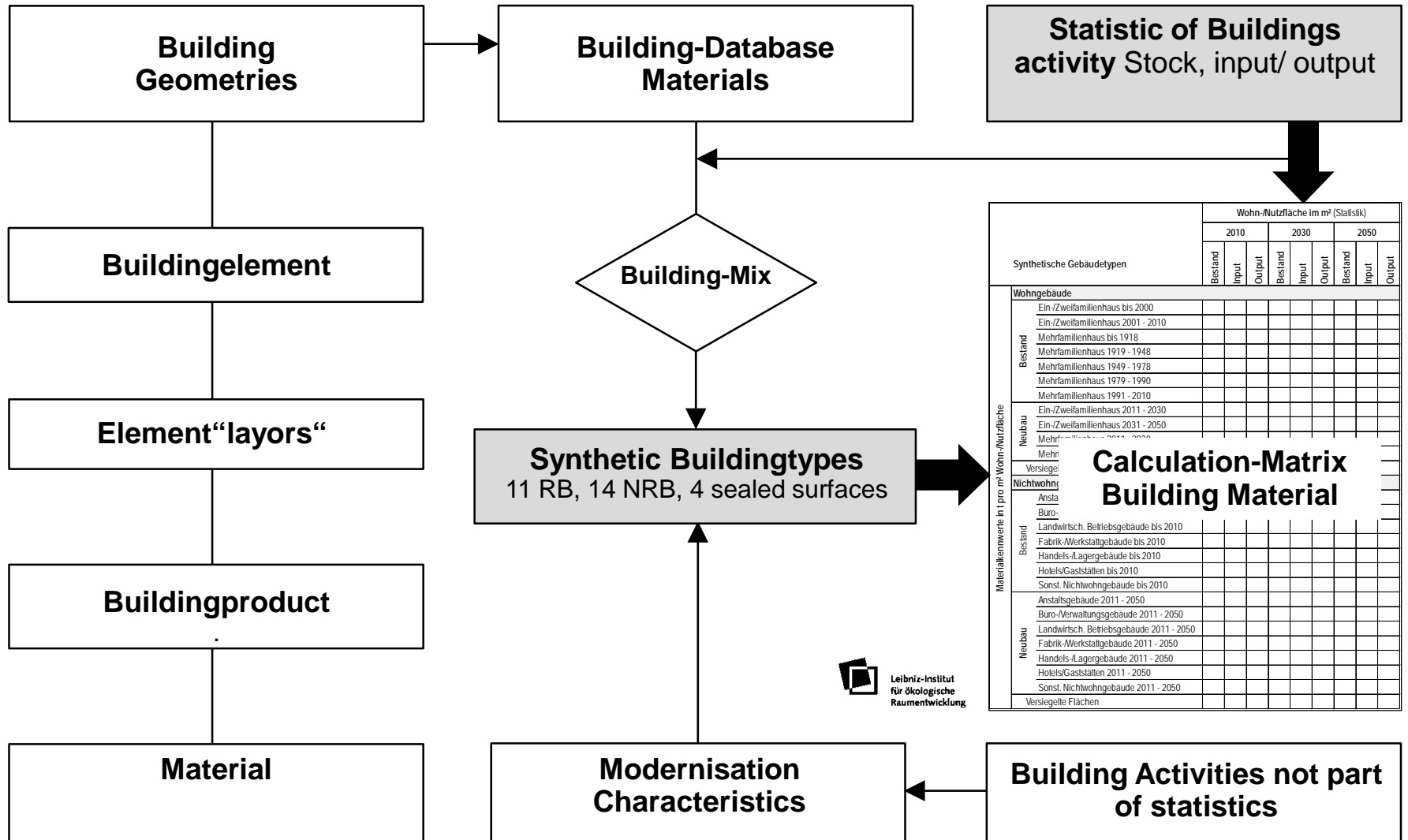


Demolition of Buildings



- **Buildings Activities in Germany until 2050**
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Material-Flow Modell



Material-Flow Modell - Assumptions

- **Existing Building Stock 2010, New Construction & Demolition**
modeled by 11 RB-, 14 NRB-, 4 sealedSurfaces
- **Construction Waste (disfitt, damaged elements etc.)**
Average 3 % of new construction input, but 8 % in case of insulation, roofing layors; 15 % gypsumboard, wooden boards
- **New Units by Modification, Extentions, new usefunction**
8 % Dw (14% NRB Units) year 2010 (Statistic)
- **Loss of Units by modifications, unification, change of use**
4 % Dw (6% NRB Units) Year 2010 (Statistic)
of which 1/3 demolition, 2/3 changes / unifications

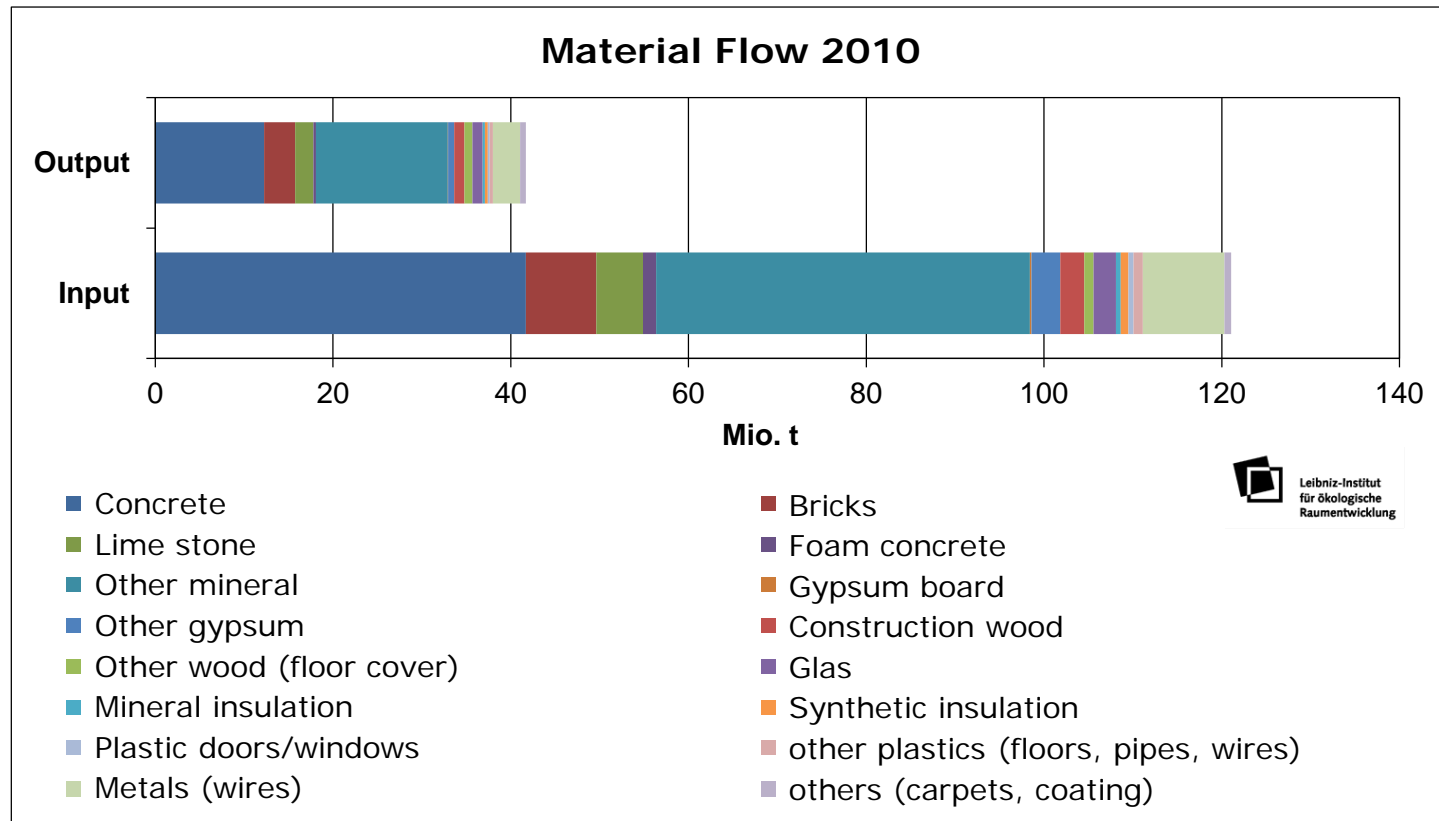
Material-Flow Modell - Assumptions

- **Loss beyond statistics** (demolition, changes, modifications) for 2010 + 100% of registered activities of which 15% demolition/ 85% modifications, NRB Units use dependent up to 50/50
- **Fillings/land modulation of new construction sites** (gravel/Sand ca. 1/3, 2/3 earth)
- **Sealed surfaces** (access pavings, parking, terrasses etc.)
4 open spacetypes along 7 urban structural types.
- **Modernisation** Residential Buildings SAN-Rate: 2,5 % per year.
Material-In/Output : 5,5 % und 5 %
Non Residential Buildings SAN-Rate: RB-similar Types 2 %, others 0,5 % per year. Material-In/Output : 5,5 % und 5 % RB-similar Types 2,5 % und 3 % others.

2010 Stock, Input, Output, RC

Total Building Materials / Products	Stock	input	2010		RC Amount
			output		
	Mio. t	Mio. t	Mio. t		in Mio. t
Concrete	6388,564	41,708	12,228		0,167
Brick	1874,387	7,905	3,489		0,000
Limestone	1231,589	5,252	2,055		0,000
Foam Concrete	178,758	1,500	0,300		0,000
Other Mineral Products	3484,658	42,055	14,850		2,523
Gypsum Board	9,820	0,168	0,032		0,000
Other Gypsum	159,003	3,244	0,680		0,000
Construction Wood	295,754	2,710	1,130		0,000
Other woodboards, floors	39,450	1,017	0,908		0,041
Glas	334,236	2,518	1,171		0,378
Glas/Stone-wool-Insulation	65,223	0,550	0,235		0,148
synthetic insulation	83,023	0,874	0,343		0,087
PVC Windows / Doors	82,911	0,591	0,209		0,077
Other plastics (floor, cabel..)	68,333	1,012	0,354		0,010
Metals (incl. wires)	898,428	9,206	3,059		4,603
Others (carpets, coatings,..)	62,133	0,757	0,650		0,000
Gesamt	15256,272	121,066	41,693		8,036

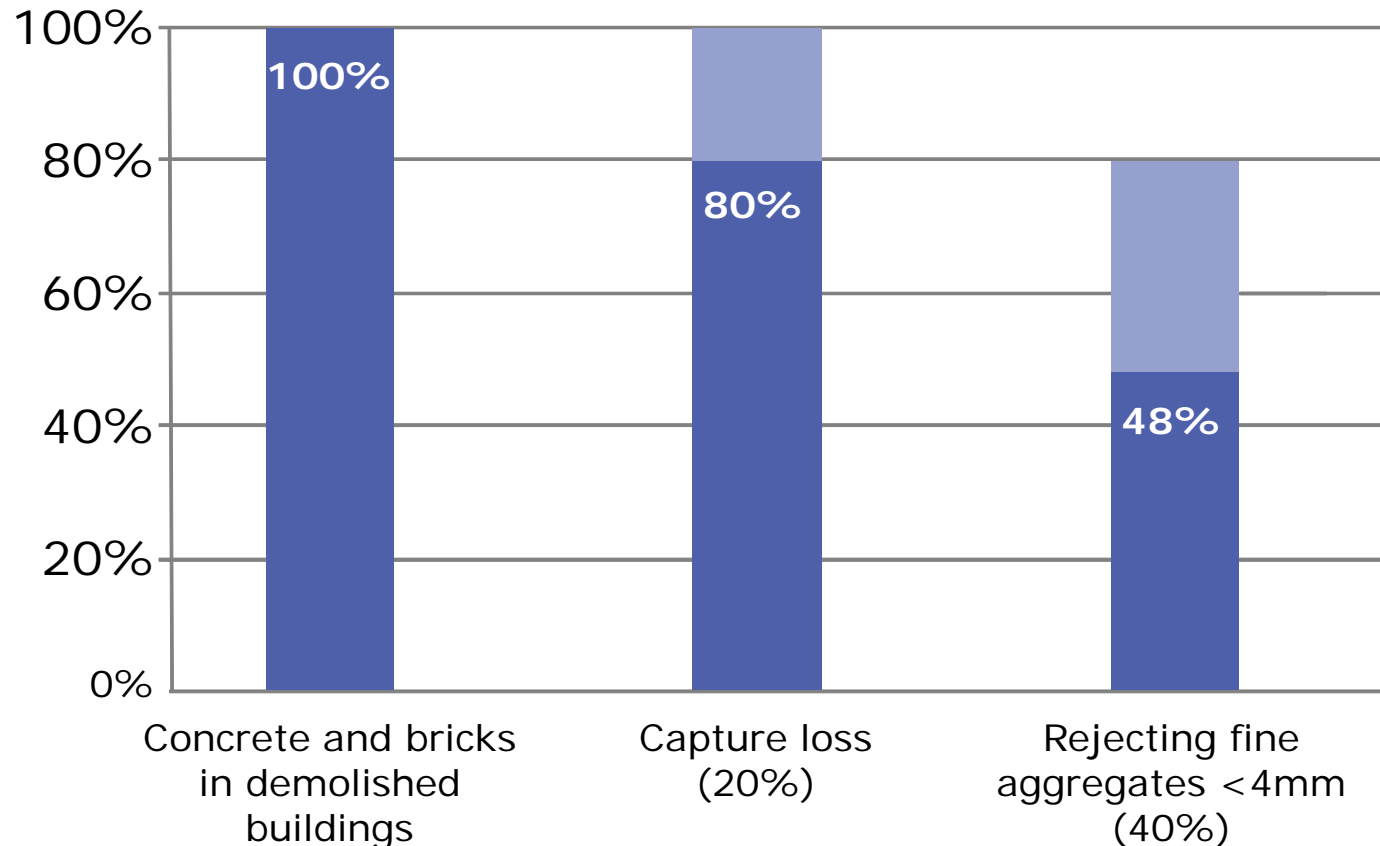
2010 Stock, Input, Output



- **Material-Flow Modell for Germany (UBA –Project)**
- **Buildings Activities in Germany until 2050**
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Capture and processing

■ Reduction of material outflow (usable)



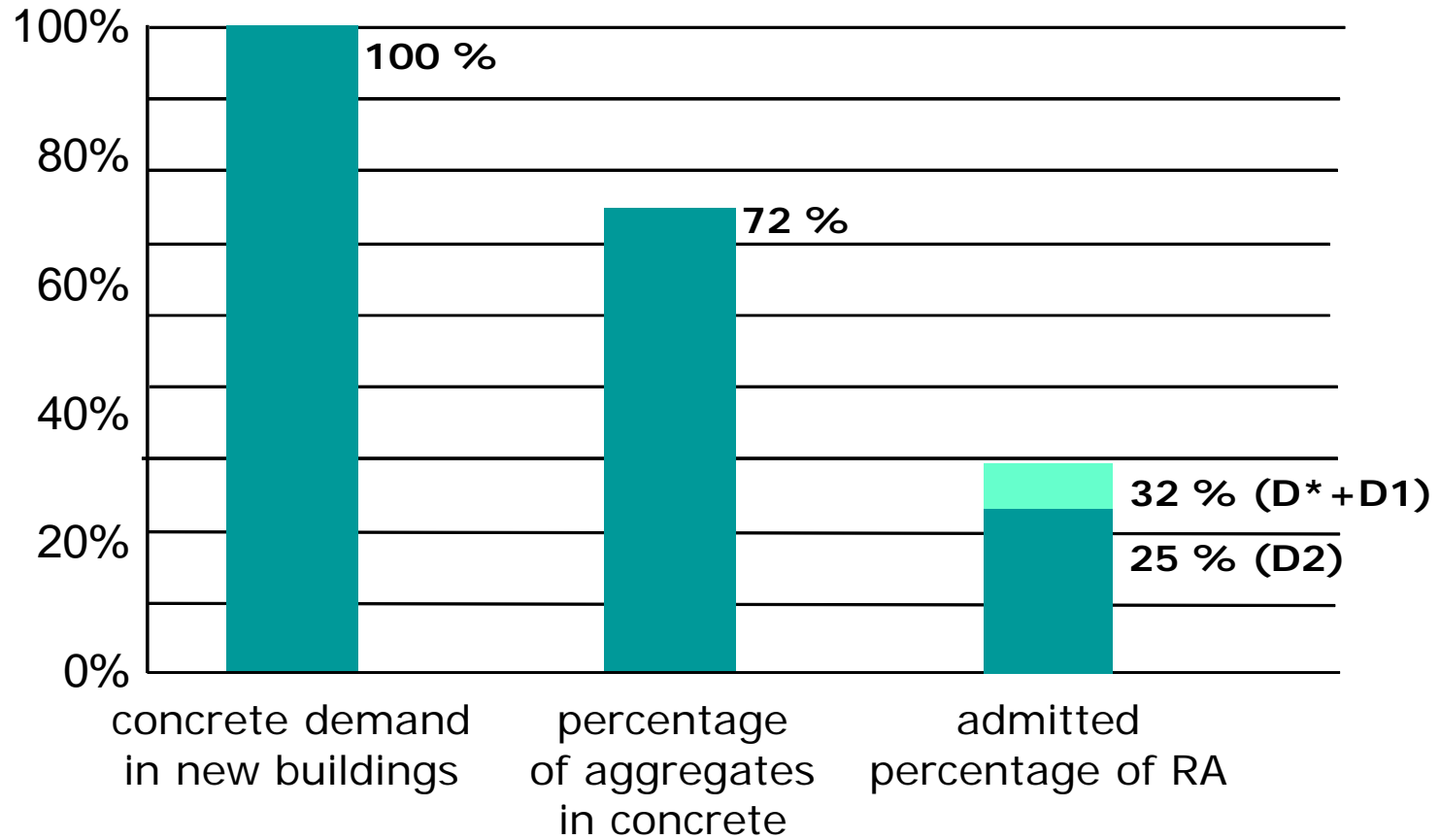
Admixture

Use of RA in concrete for new buildings

- Approach:
 - Current admissible German engineering standards
- Delivery types:
 - D1: 90 mass-% RCA+NA, 10 mass-% RMA
 - D2: 70 mass-% RCA+NA, 30 mass-% RMA
 - D*: 0 mass-% RMA (common use)
- Max. admitted use of RA in concrete
 - D1+D*: 45 vol-%
 - D2: 35 vol-%
(exposure classes X0, XC1–XC4 under EN 206:2013)

Admixture

■ Reduction for material inflow (usable)



Building Product	Recycling-Material Admixture in different Products for Construction (in %)		
	2010	2030	2050
Concrete	0,4	6,0	12,0
Bricks	0,0	10,0	15,0
Lime stone	0,0	5,0	5,0
Foam concrete	0,0	2,0	5,0
Other minerals	6,0	21,0	21,0
Gypsum boards	0,0	30,0	50,0
Other gypsum	0,0	0,0	5,0
Construction wood	0,0	0,0	0,0
Wood boards	4,0	10,0	20,0
Glas	15,0	25,0	35,0
Mineral. insulation, incl. ca. 40 % RockWool with RC 0, 15, 20	27,0	42,0	56,0
Synthetic insulation material	10,0	19,0	19,0
Plastic doors/windows	13,0	25,0	50,0
Other plastics/PVC-sheets/carpets	1,0	5,0	10,0
Metals (not part of the investigation)	50,0	60,0	70,0
Others	0,0	2,0	5,0

- **Material-Flow Modell for Germany (UBA–Project)**
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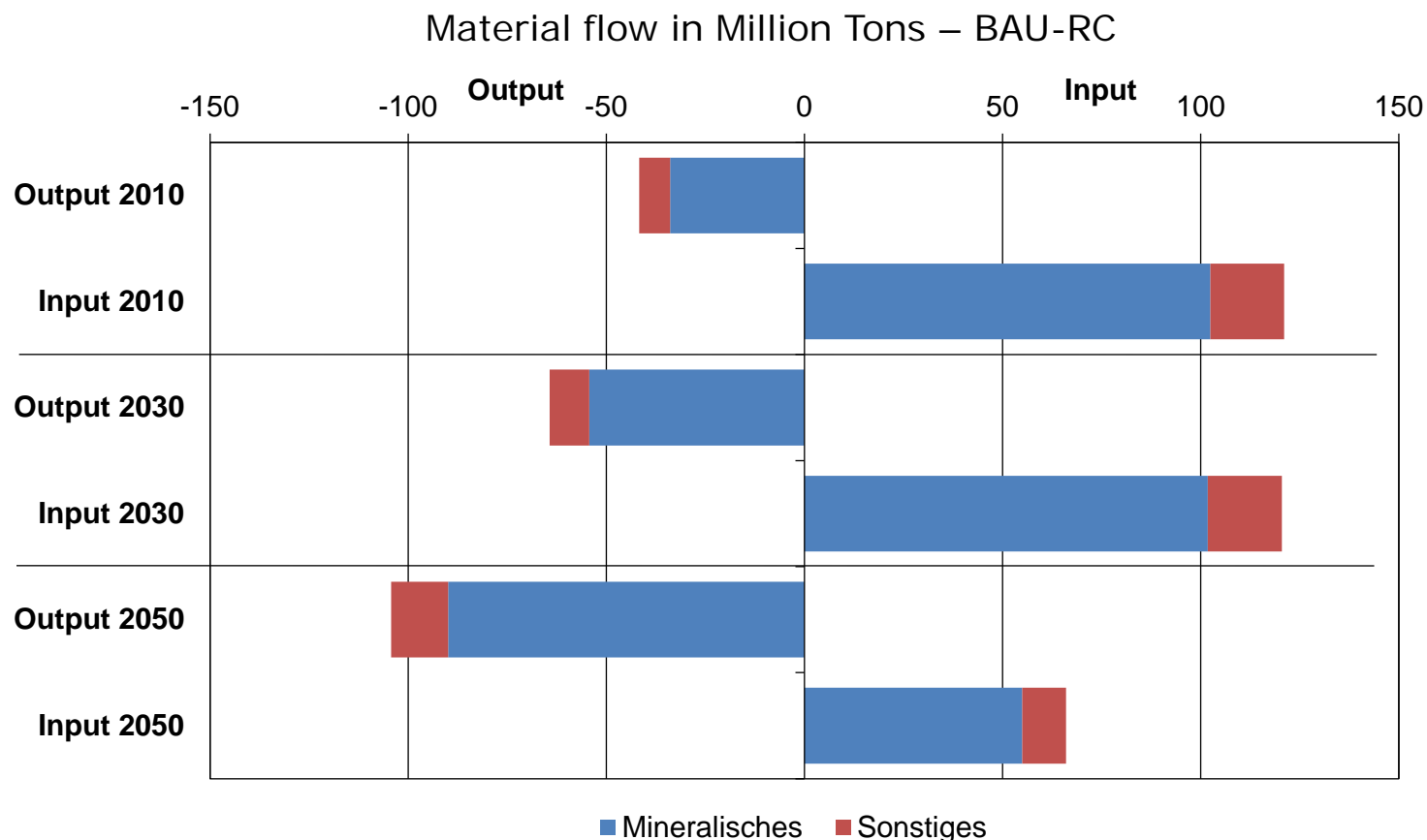
Sensitivity-Analysis

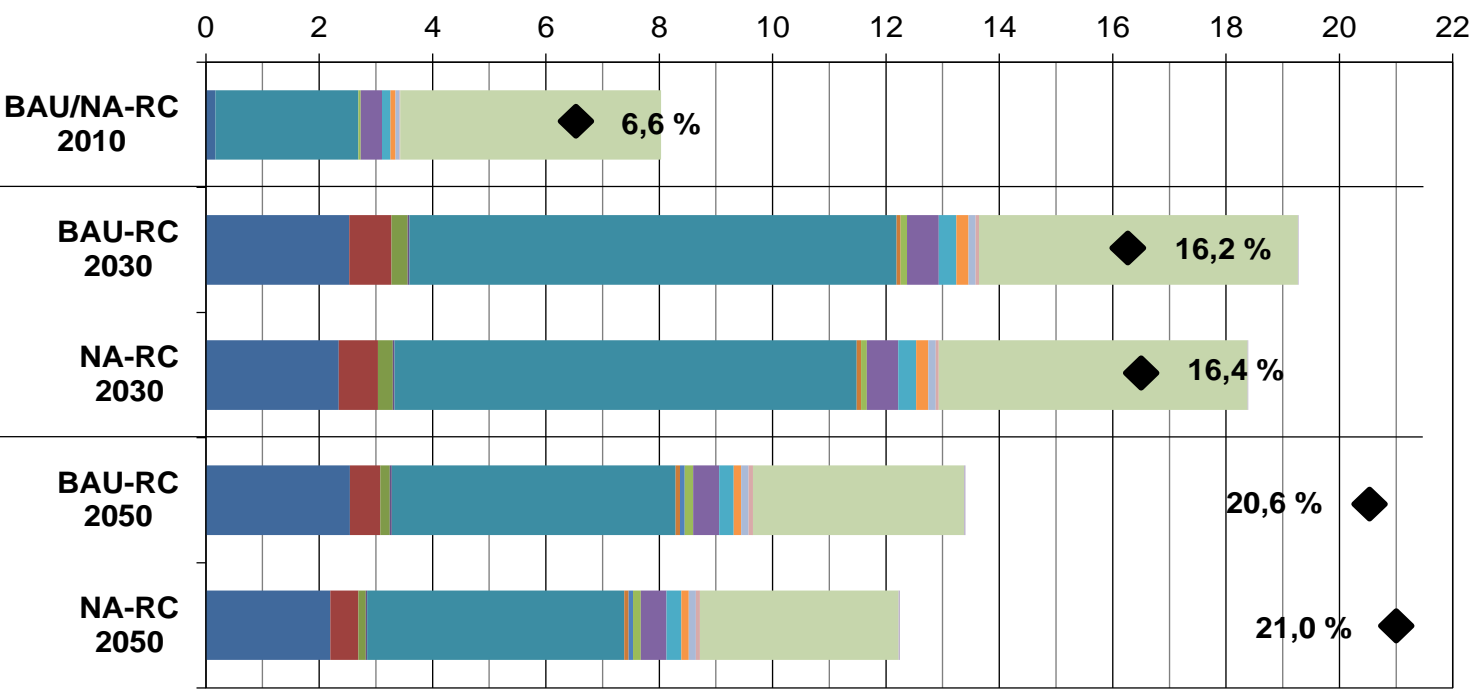
BAU, BAU-RC, NA, NA-RC

- BAU :** Construction-volume according Building-activities 2030-2050
RC-Quota 2010 unchanged until 2050
- BAU-RC:** as above, but optimistic expert setting of RC-Quota
- NA :** as BAU, but wood-construction SFH from 15 % to 30 %
MURBs from 2% to 15 %, concrete efficiency up 10 %,
Thermal Insulationmaterial +30 %
SFH construction -50 % accordingly more MURB Dw-Units
- NA-RC:** as above, but optimistic expert setting of RC-Quota

BAU-RC Output-/Input-Flow 2010-2050

Buildings





RC
in Mio. t

in %
of
input

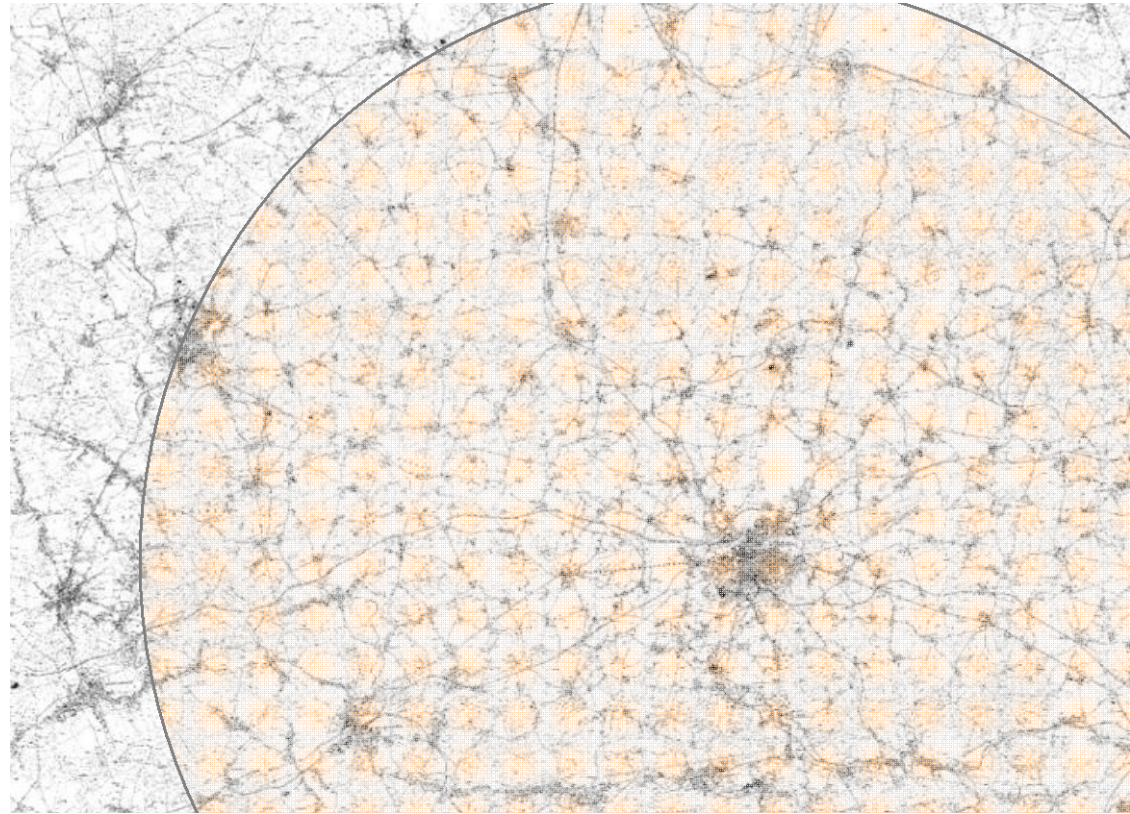
Buildings

- Concrete
- Bricks
- Lime stone
- Foam concrete
- Other mineral
- Gypsum board
- Other gypsum
- Construction wood
- Other wood (floor cover)
- Glas
- Mineral insulation
- Synthetic insulation
- Plastic doors/windows
- other plastics (floors, pipes, wires)
- Metals (wires)
- others (carpets, coating)

◆ RC-Quote in % am Ges.-Hochbau-Materialfluss

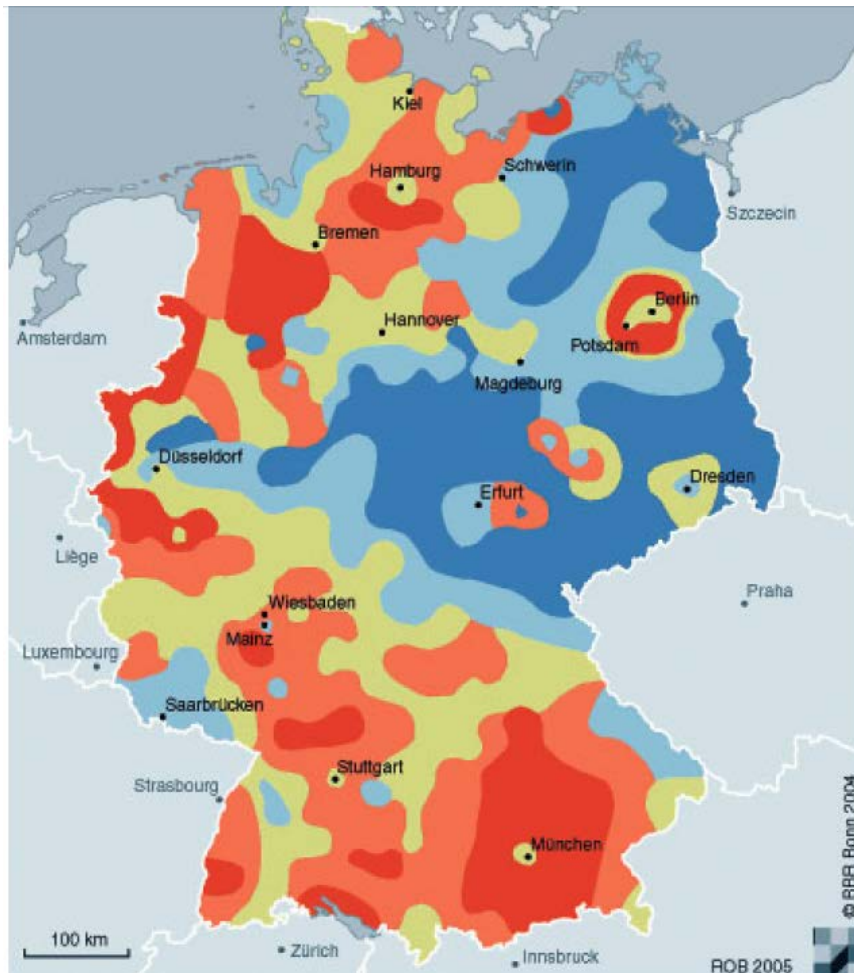
Regional differentiation

- Spatial borders of mineral materials market
- Economic transportation radius of recycled mineral materials:
~ 20 – 25 km



Regional differentiation

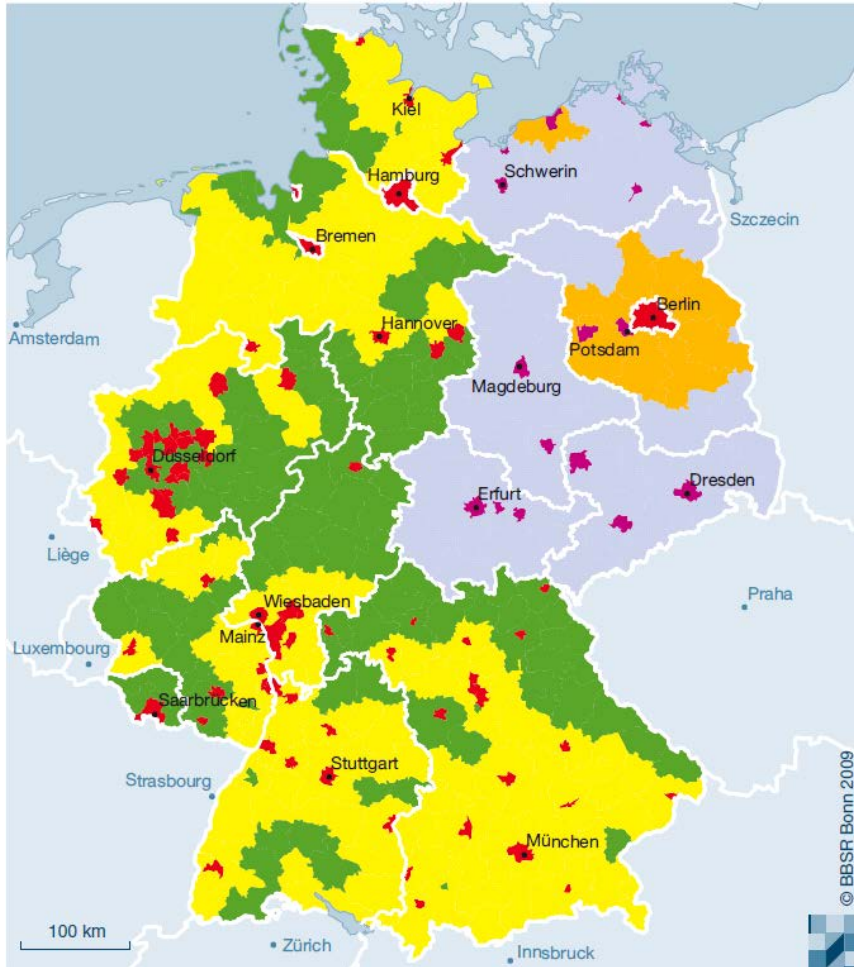
Spatial disparities:
growth and shrinkage



Population change
(2002 – 2020)

- strong shrinkage
- slight shrinkage
- stable
- slight growth
- strong growth

Regional differentiation



Regional types

West Germany:

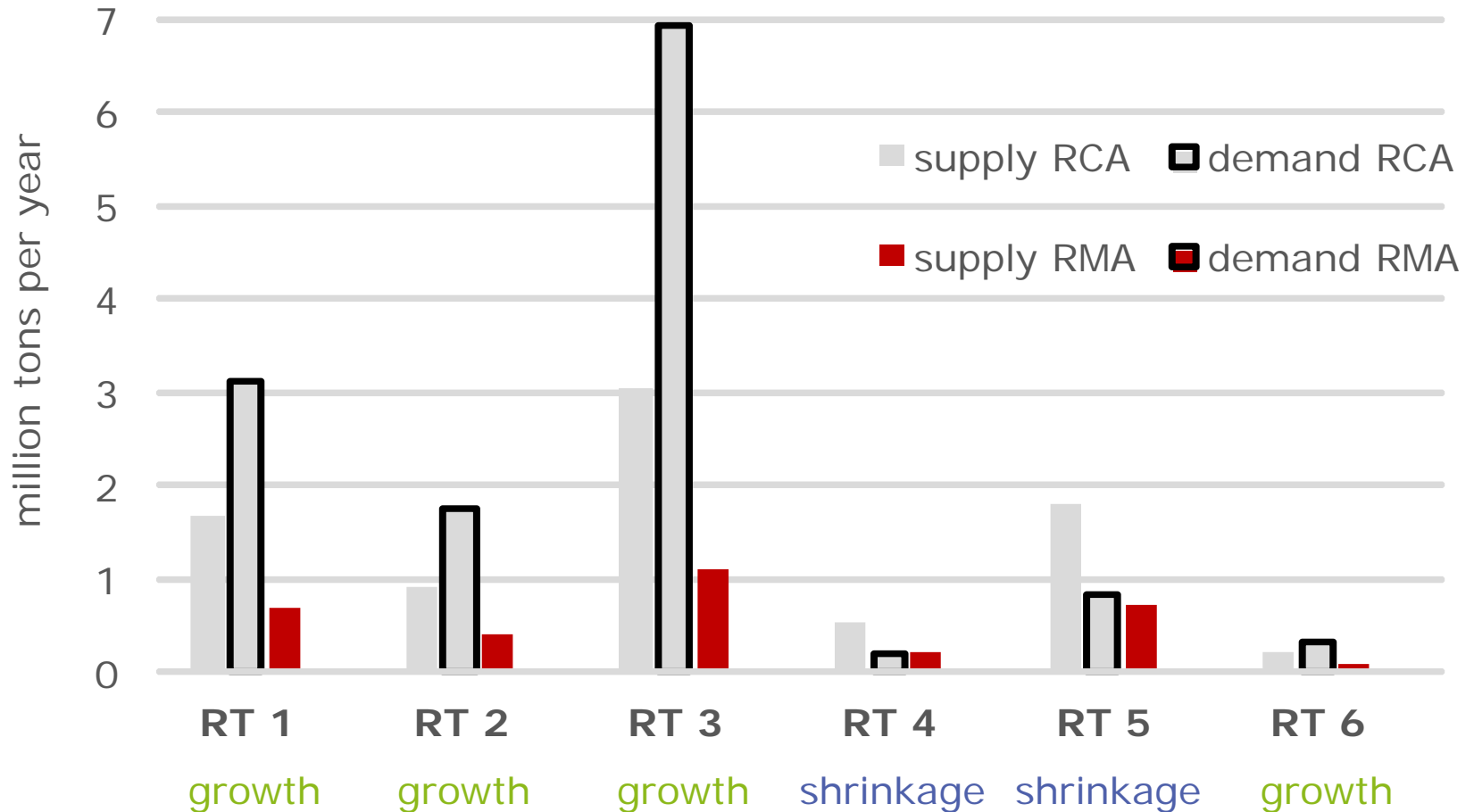
- RT1: core cities
- RT2: countries – low dynamics
- RT3: countries – high dynamics

East Germany:

- RT4: core cities
- RT5: low density peripheral areas
- RT6: hinterland countries with tendencies of suburbanization

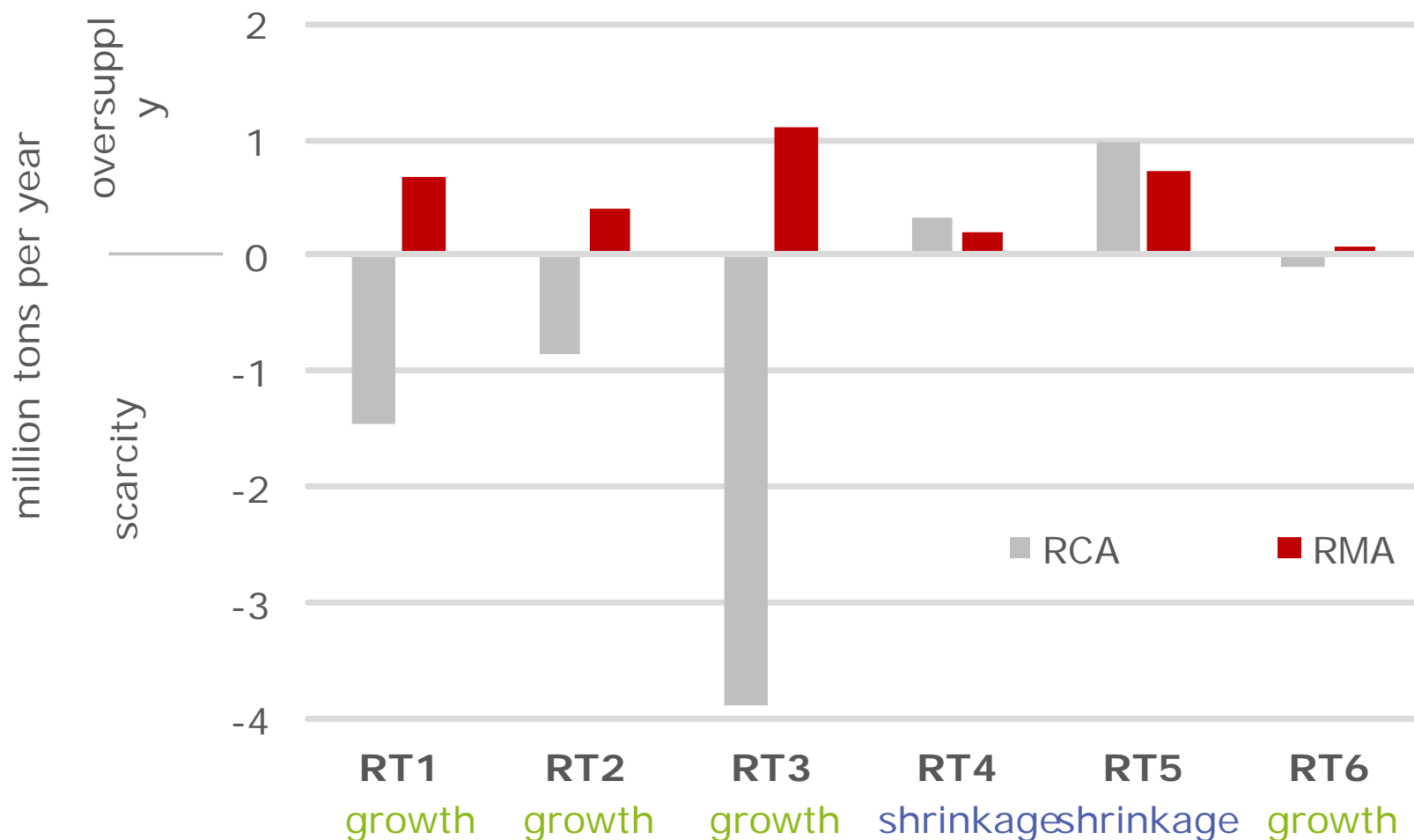
Regional supply and demand (D^*)

100% RCA

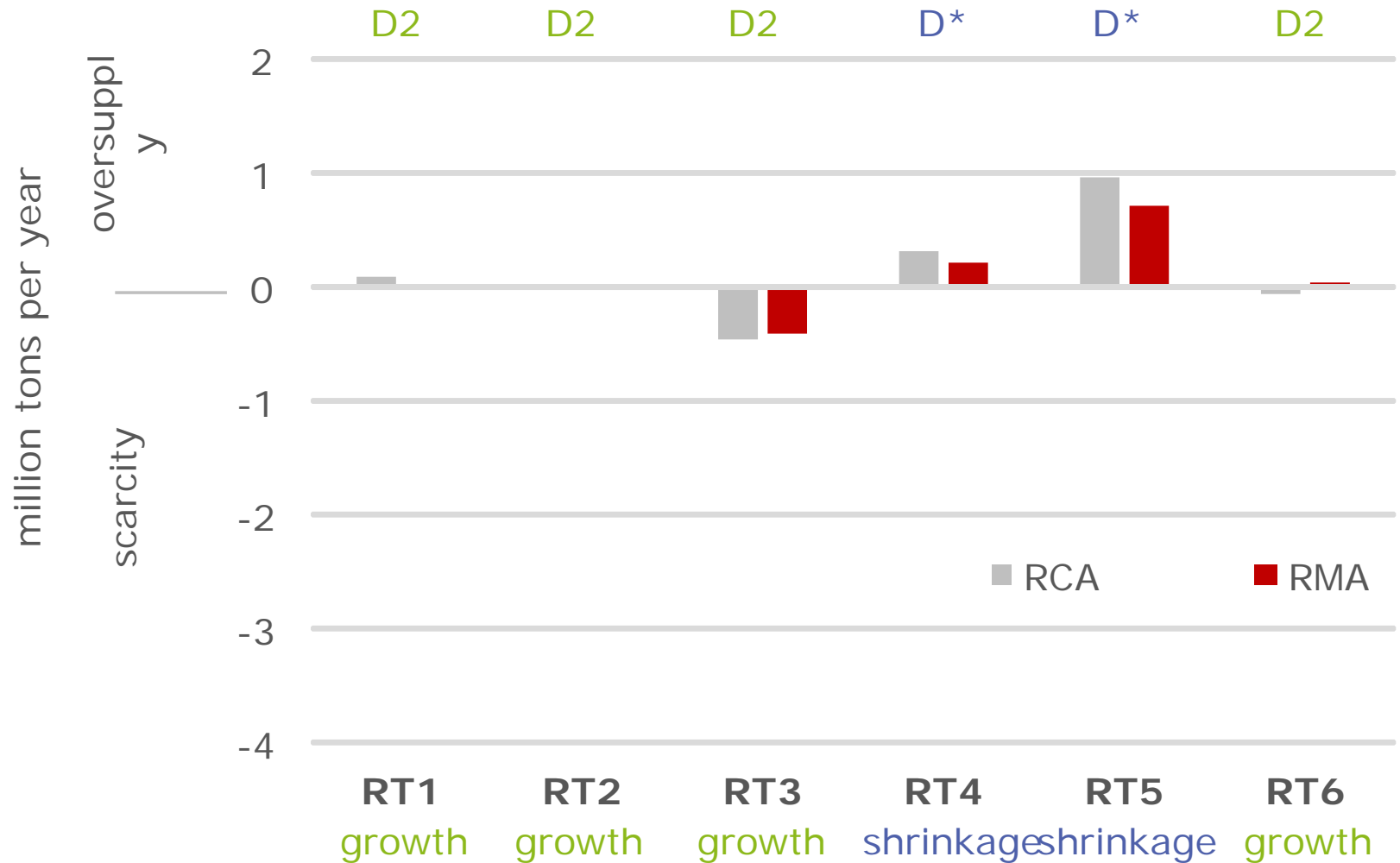


Regional supply and demand (D^*)

100% RCA



Regional supply and demand (D^{opt})



Conclusion

Material flow is dominated by demographic change. After 2030 the input until 2050 will decrease by 45 % (= -55 Mio. t), Output + 150 % (= + 60 Mio. t) in comparison with today's flows.

Rawmaterial-Savings by use of Secondary Rawmaterials (RC) in building construction might increase from 7 % to – under optimistic framework conditions – 21 % 2050 .

More resource conscious construction, design and building-types can save 6 % -11 % (- 6,5 Mio. t). Avoided construction waste might theoretically reach: 5-3 Mio. t

Trading of mineral aggregates is difficult, because it is bound to short transport radiuses. Therefore Recycling strategies for mineral products need to be regionalized.

Built environment continuous MFA-model = important tool to test and illustrate RC-strategies and effects.

Acknowledgement



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Jörg Wagner

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Industry, Research, BBSR and UBA

Researchfindings are based on several projects:

- **Ressourceneffizienzpotenziale in der Abfall- und Kreislaufwirtschaft, BBSR**
- **Kartierung des anthropogenen Stofflagers in Deutschland, UBA**
- **Datenanalyse Nichtwohngebäude, BBSR**
- **Gebäudebestandsentwicklung Deutschland 2050, IOER**
- **Wohngebäude- und Nichtwohngebäudetypologien, IOER**