Mapping the anthropogenic stock of Germany

Top-down, bottom-up and combination of approaches

Cost Action MINEA Workshop

"Characterizing the built environment stocks: methods and case studies"

Odense, August 11-12, 2016

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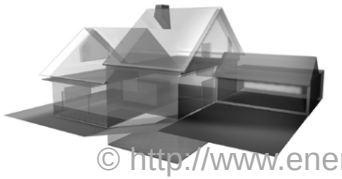
Objects of investigation

Durable goods > 1 year of lifespan

- Buildings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- Building services


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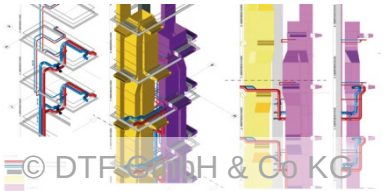
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- Infra-structure


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- Durable con-sumer goods


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Methods and data sources

Top down

overall economic data (flows)
- economic environmental accounts, external trade, trade associations' data, waste statistics, …
- metric, monetary, mass

differentiation
- flow characteristics (in-, output, flow-through)
- groups of goods / sectors / materials

conversion
- conversion from metric dimensions into mass

deduction

material amount
- flows, accumulated flows

+ complete
- mainly flows
- limits of differentiation

+ high degree of differentiation
+ stocks and flows
- incomplete

material amount
- stocks, flows

induction

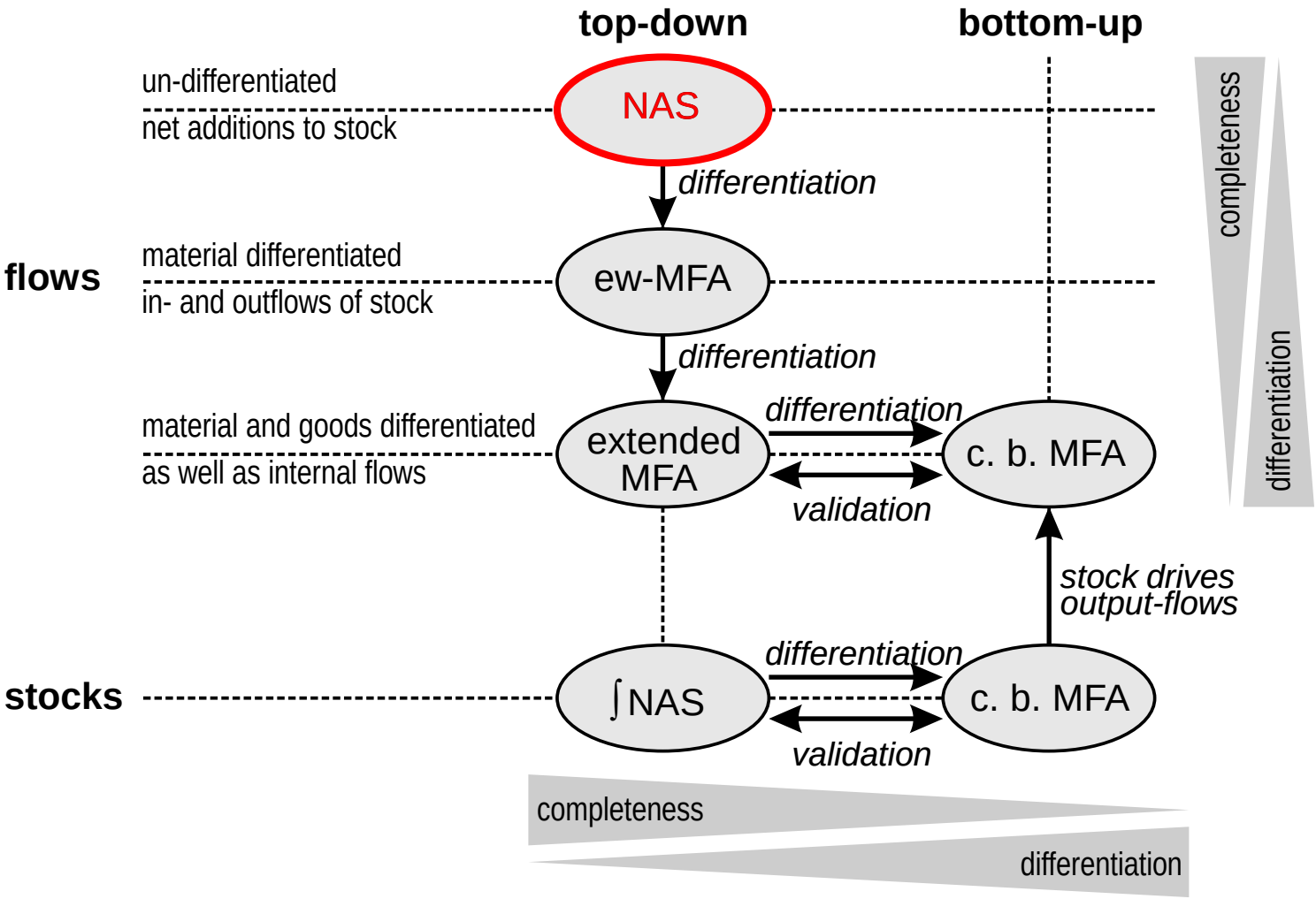
coefficients
- material compositions single goods / good's representatives

quantity parameters
- functional unit (area, length, pieces, inhabitants)

basket of goods (stocks / flows)
- from official statistics (e.g. DB's, indirect NDB)
- from geodata (streets, local roads)
- further sources / assumptions / estimatable models

Bottom up

Methodological structure



Top-down methods and data sources

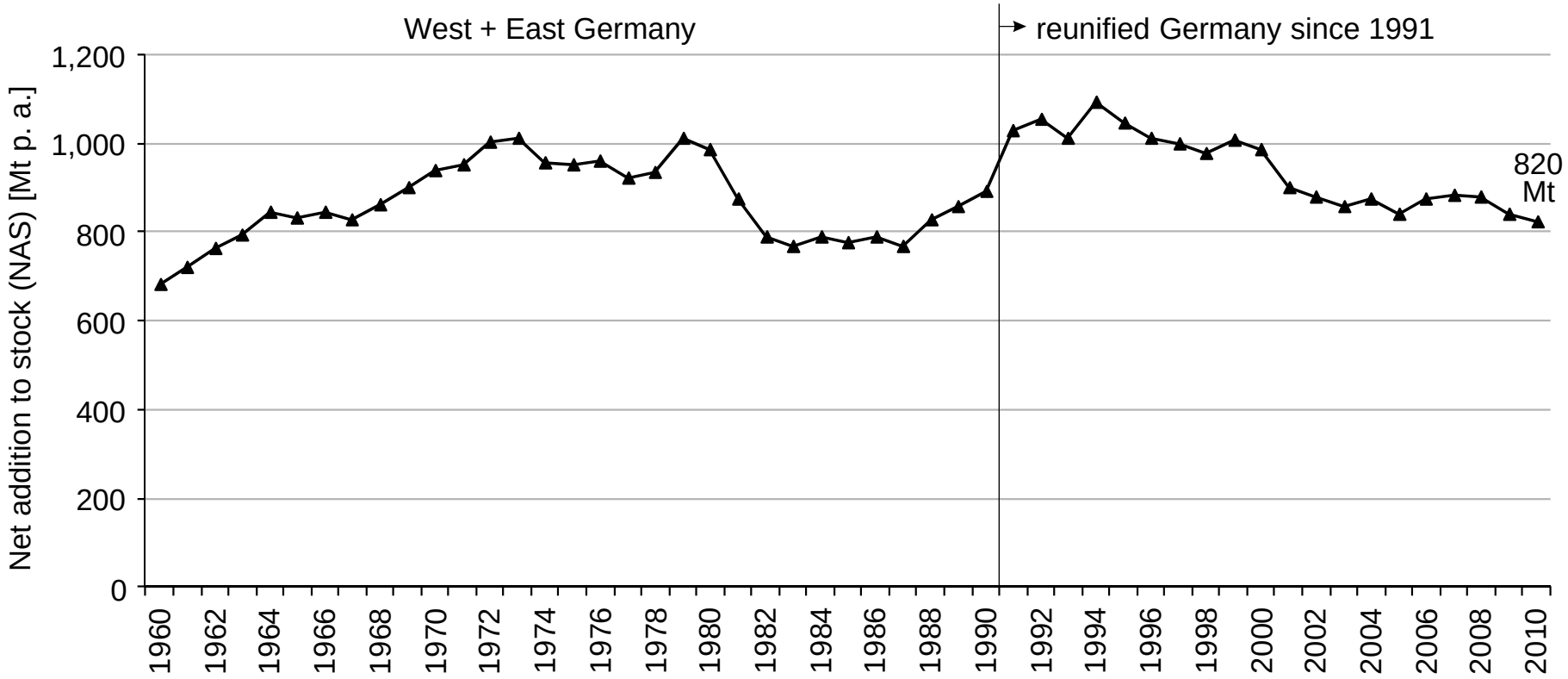
Net additions to stock (NAS)

Data source:

- System of Integrated Environmental and Economic Accounting (SEEA)
  - balancing items → NAS evaluation
  - suitable for dynamic MFA
- datasets available from as far back as 1960, but changes in the data-gathering methods
  - differentiation to material groups impossible
  - NAS = aggregate value, un-differentiated

Results of top-down calculations – flows

Un-differentiated NAS over time



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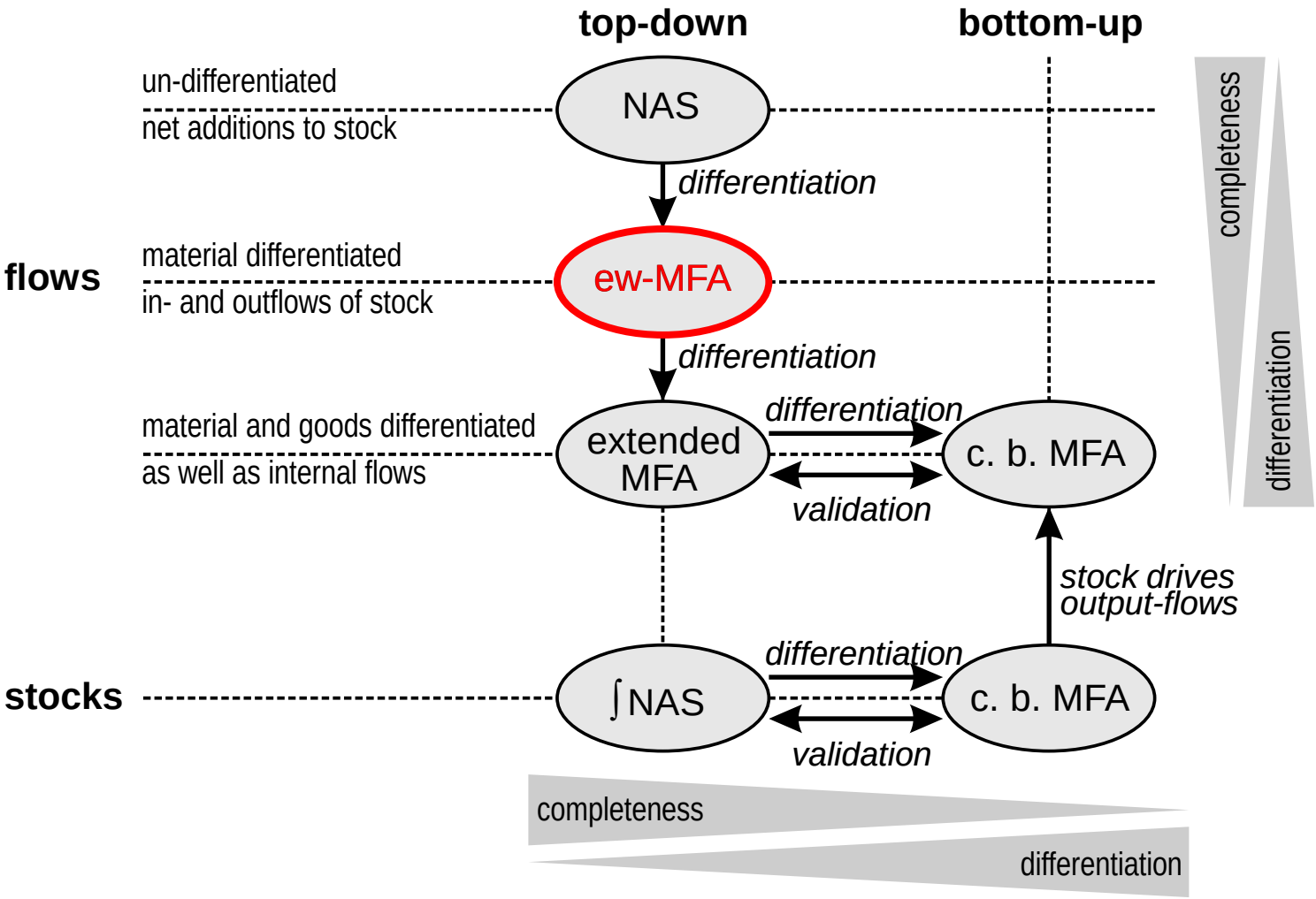
Top-down methods and data sources



Top-down methods and data sources

Material differentiated inflows and outflows

Data sources:

- economy-wide data + waste statistics:
  - SEEA economy-wide data
  - FAOSTAT (Food and Agriculture Organisation)
  - Federal Environment Agency (UBA):
    Office of the Basel Convention to Control the Transboundary Movement of Hazardous Waste
  - Statistics on the waste economy
- classification acc. to main material groups
- static MFA (reference year 2010)

Top-down methods and data sources

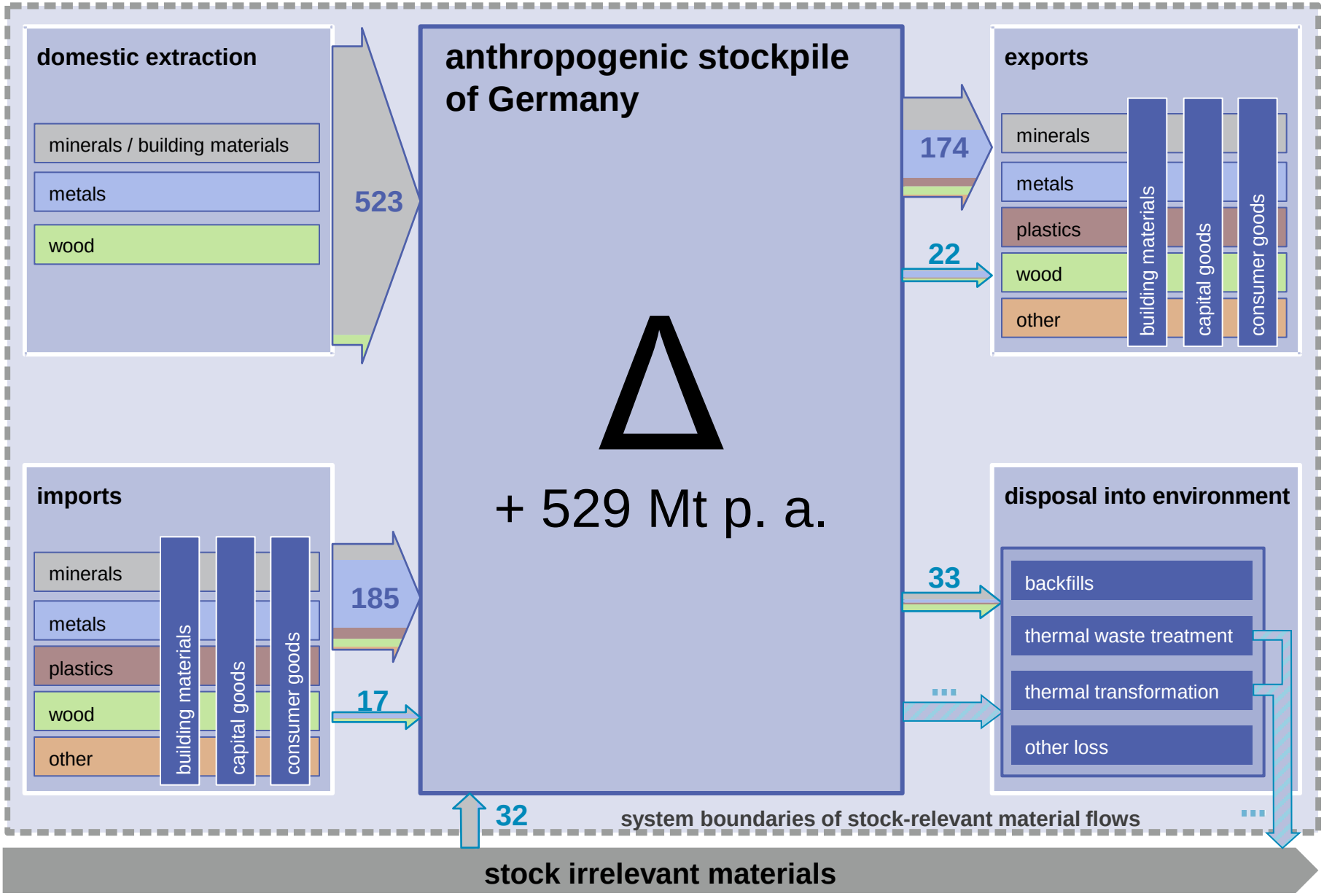
Material differentiated inflows and outflows

Input flows:

- domestic extraction
- imports incl. waste
- recycled material backflow from stock irrelevant materials
  (e.g. fly ashes, FGD gypsum from energy industry)

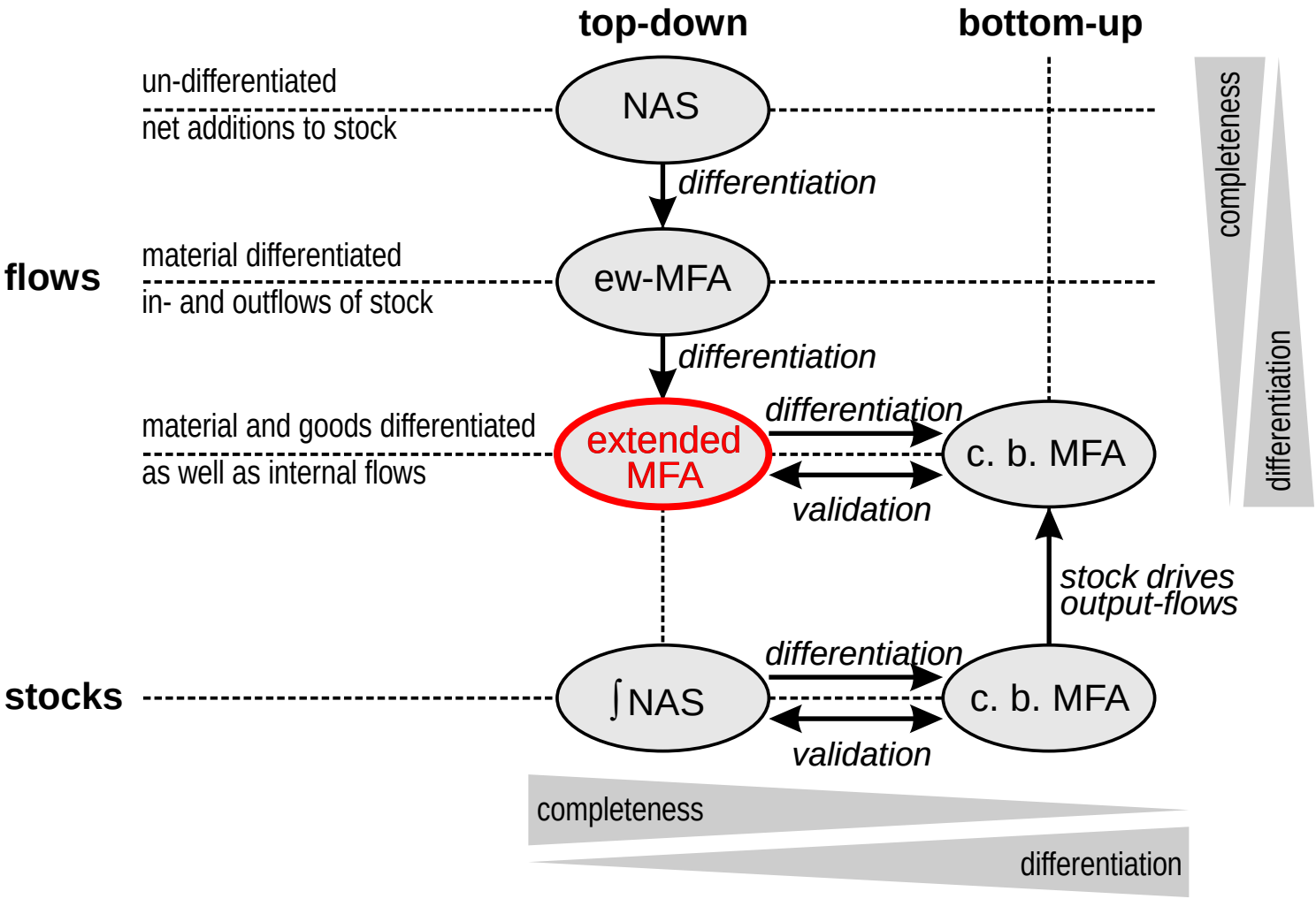
- Output flows:
- exports incl. waste and
- domestic disposals to environment (e.g. backfills)

Results of top-down calculations – in-/outflows



material flows 2010 (all materials / *mineral only*) [million tonnes]: MFA waste management

Top-down methods and data sources



Top-down methods and data sources

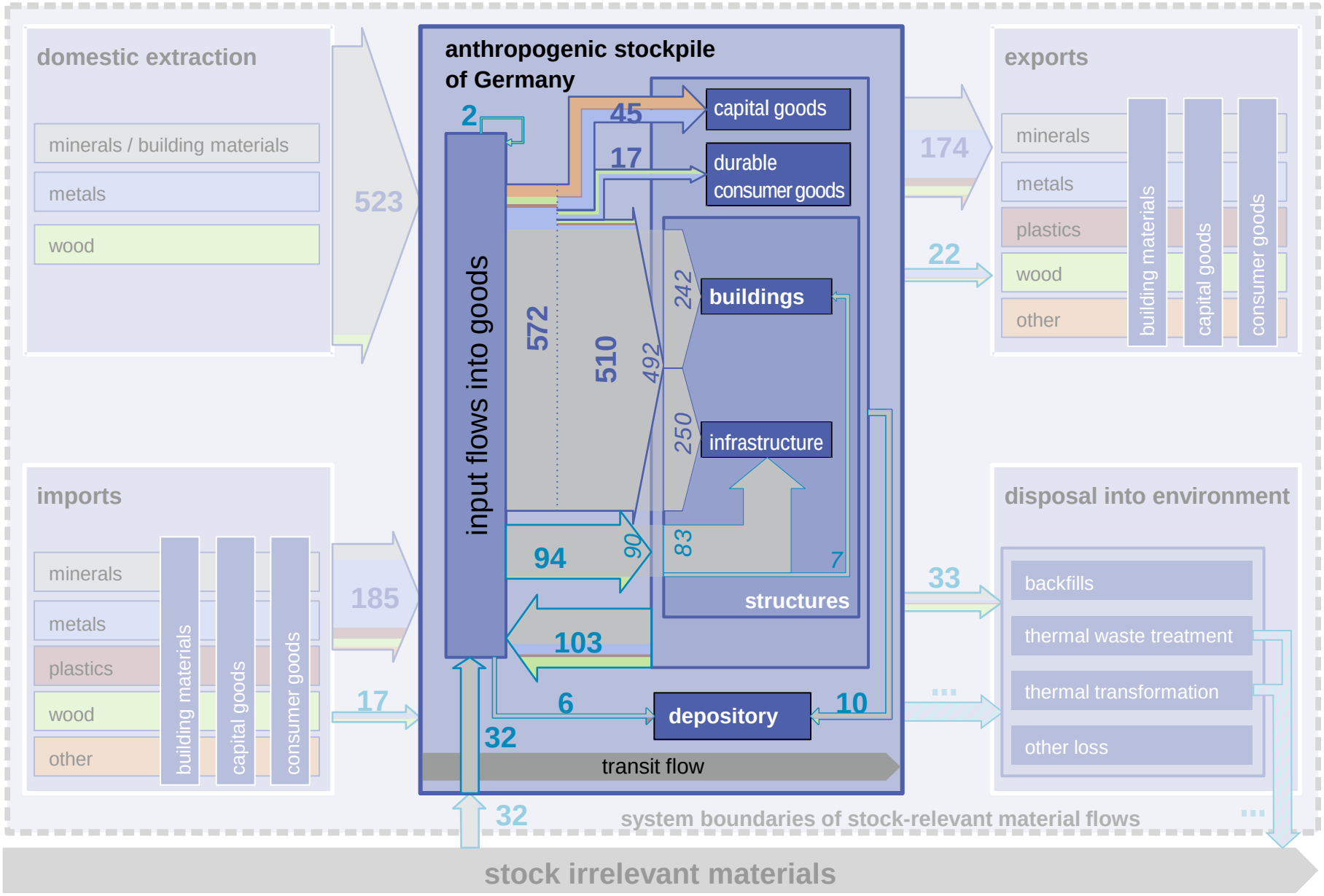
Expanded top-down approach:

Material + goods differentiated and stock internal flows

Data sources:

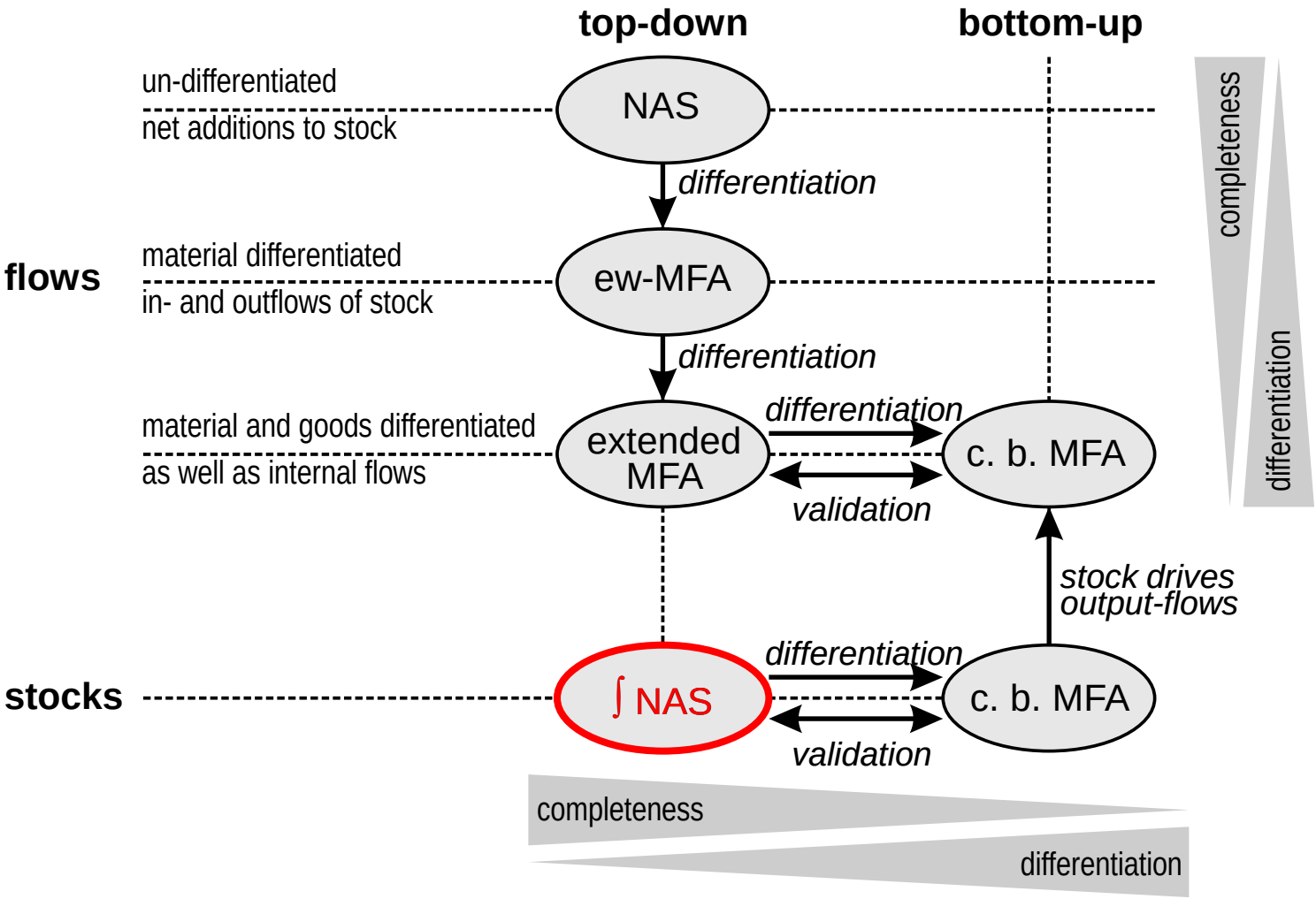
- Foreign trade
- SEEA
- Sectoral data sources:
  - Production statistics
  - Trade associations' data
  - Statistics from different industry associations (e.g. for non-metallic mineral materials, steel, copper, zinc, metals, process-related emissions)

Results of top-down calculations – internal flows



material flows 2010 (all materials / *mineral only*) [million tonnes]: MFA waste management

Top-down methods and data sources



Top-down methods and data sources

Stock estimation

Data sources:

- dynamic MFA data (NAS based on SEEA)

Method:

- initial stock plus
- changes in NAS over time

→ material accumulation: $S(t) = S(t_0) + \int_{t_0}^{t} NAS$

Results of top-down calculations – stocks

Stock estimation

Estimated initial stock in 1960:

- $S(t_0) \approx 9{,}900$ Mt

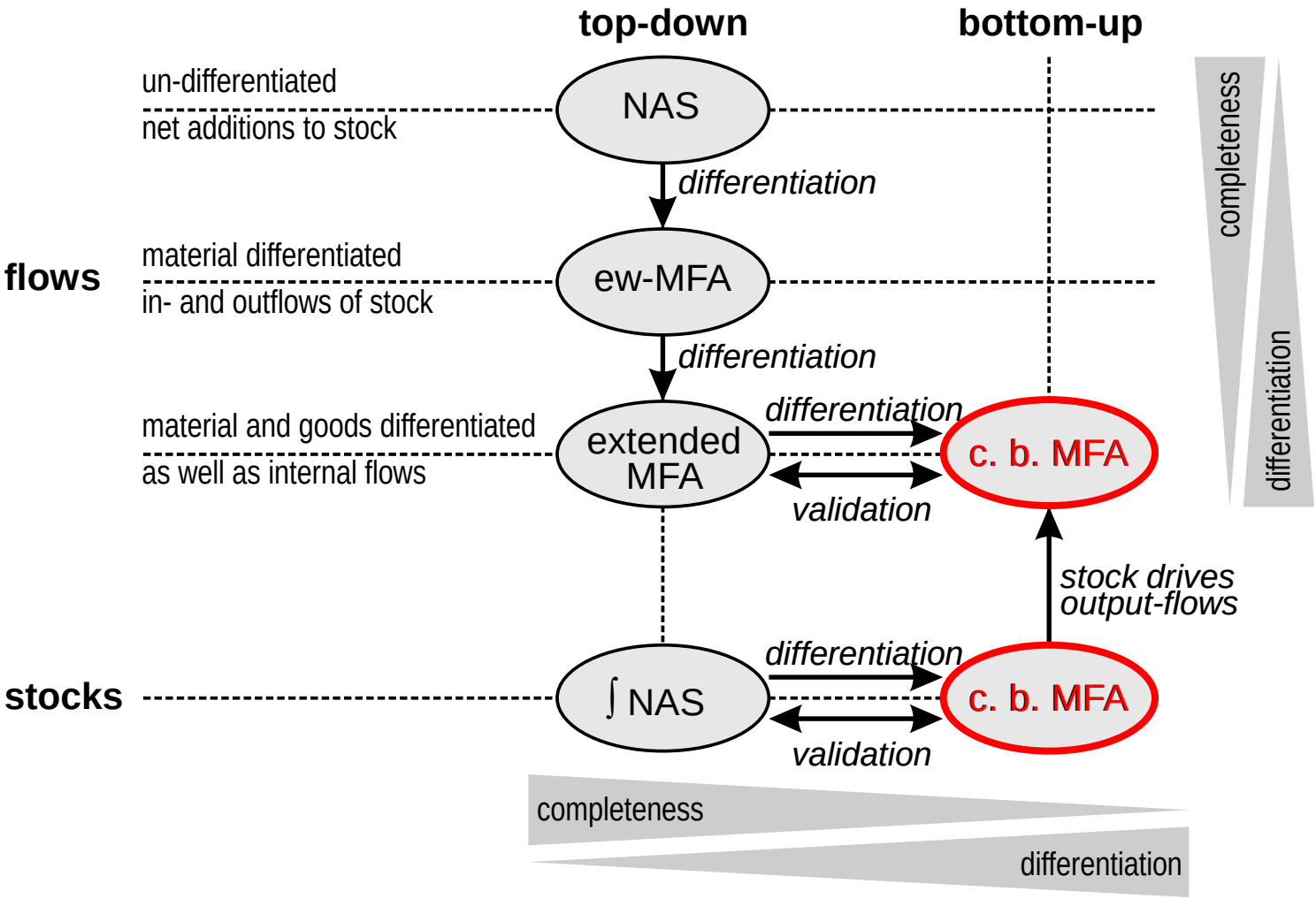
Stock accumulation 1960 – 2010:

- $\int_{t_0}^{t} NAS = 41{,}800$ Mt

Estimated stock in 2010:

- $S(t) \approx 51{,}700$ Mt

Bottom-up methods and data sources



Bottom-up methods and data sources

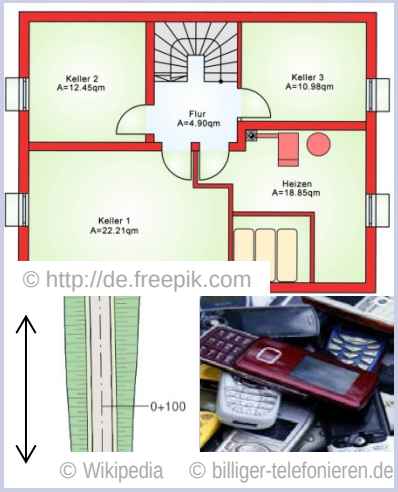
Calculation of flows and stocks

flow / stock

absolute mass
[million tons]

=

good's quantity



metric flow / stock
[m², m, piece, …]

x

material content

specific mass
[tons per m², m, piece,…]

Bottom-up methods and data sources

Calculation of flows and stocks

Method:

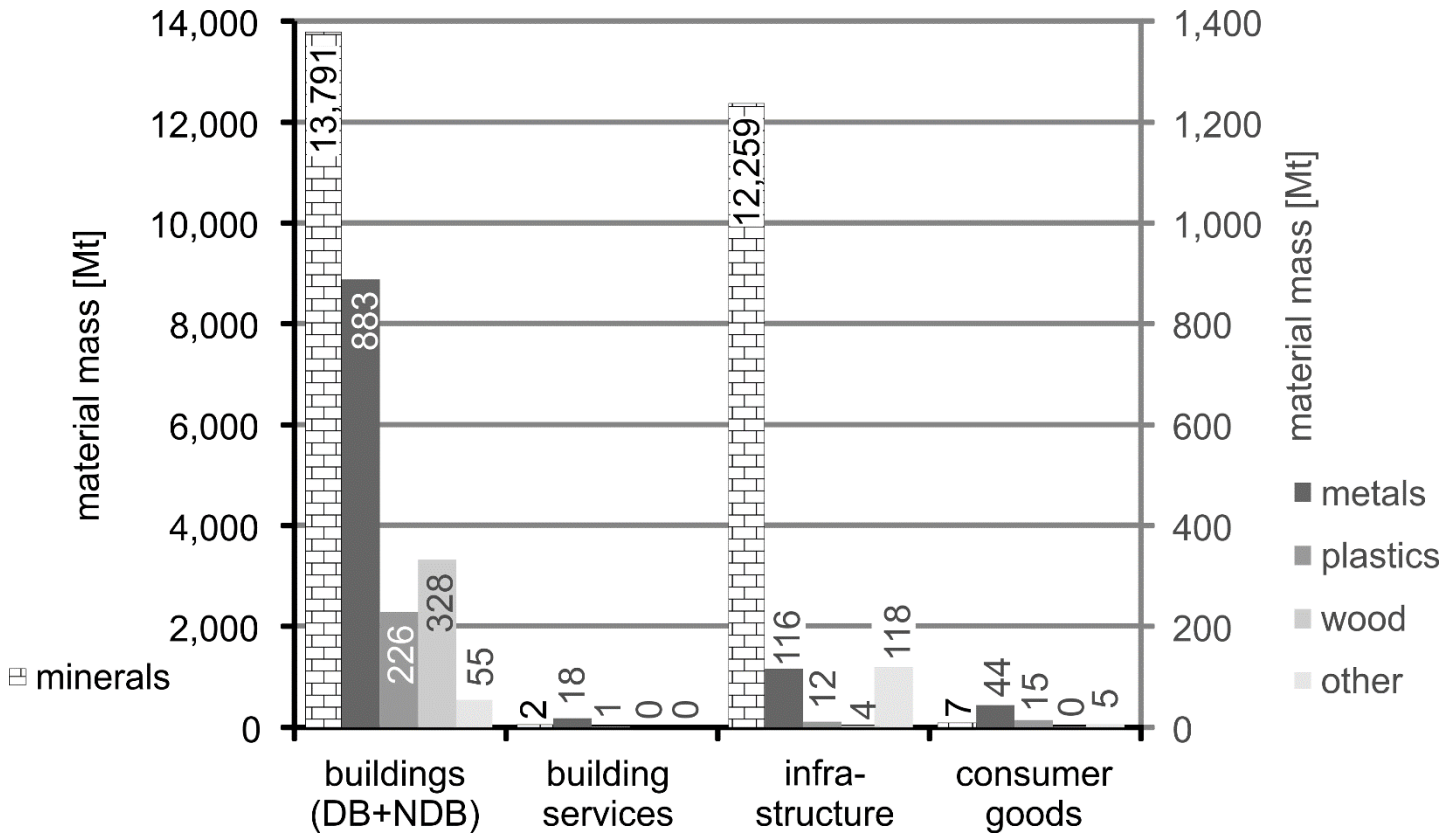
- $$F/S(t) = \sum_{i=1}^{M} \sum_{j=1}^{N} \left(g_i(t) \times m_{i,j}(t) \right)$$
- various partial analyses for (g_i and $m_{i,j}$)

Data sources:

- good's quantities (g_i)
  - official statistics
  - geobasis data (street and roadway network)
  - other data estimates
- material contents ($m_{i,j}$)
  - databanks
  - relevant literature
  - producer specifications
  - model calculations
  - expert estimates

Results of bottom-up calculations – stocks

stock (2010)



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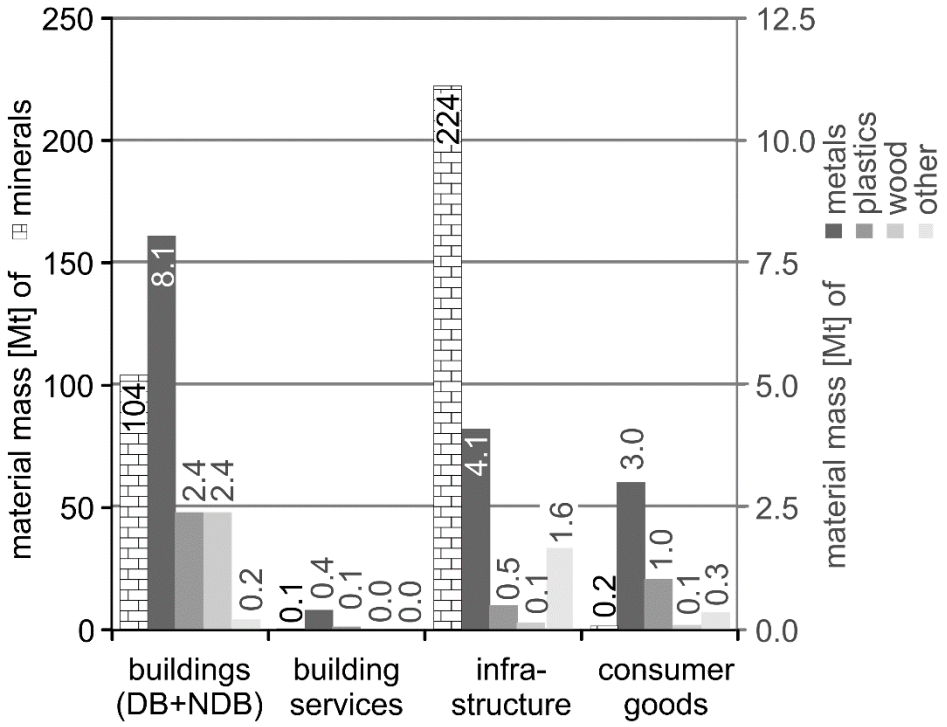
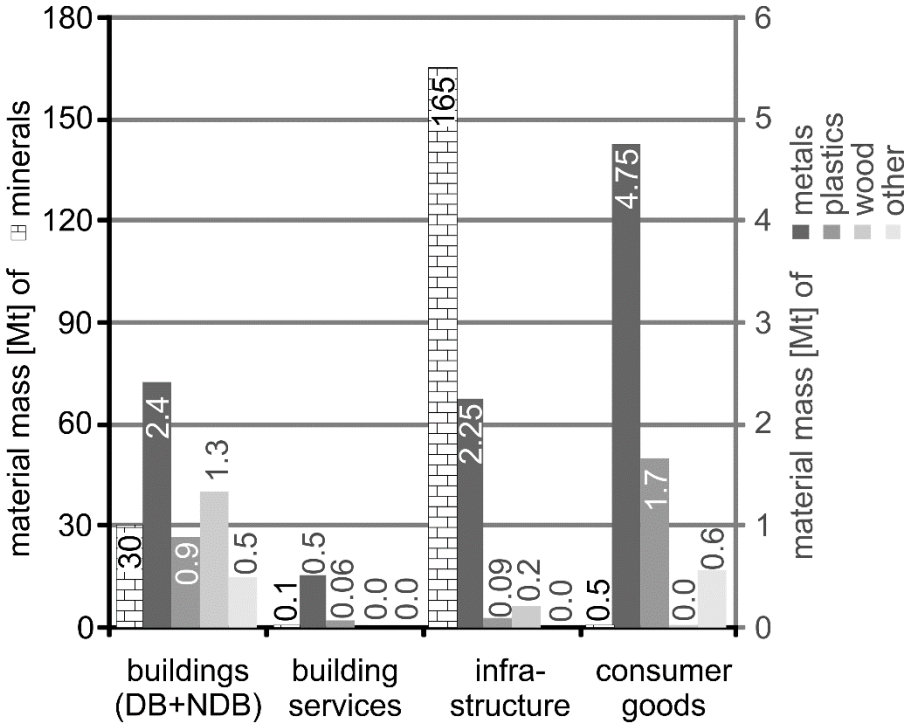
Results of bottom-up calculations – flows

inflows
(2010)



outflows
(2010)



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Methods to take account of uncertainties

- Data uncertainties
  - ➢ data quality, lacking data
- Model uncertainties
  - ➢ model accuracy, level of detail
- simple approaches
  - ➢ e.g. uncertainty intervals, averages + variations
- statistical approaches
  - ➢ e.g. sensitivity, probabilistic, fuzzy analysis
- Common method:
  - ➢ input variable's uncertainties
    → variability of outcome variables

Methods to take account of uncertainties

Problem in present study :

- quality of underlying data do not allow for uncertainties' quantification of input variables

  →common (statistical) approaches not applicable

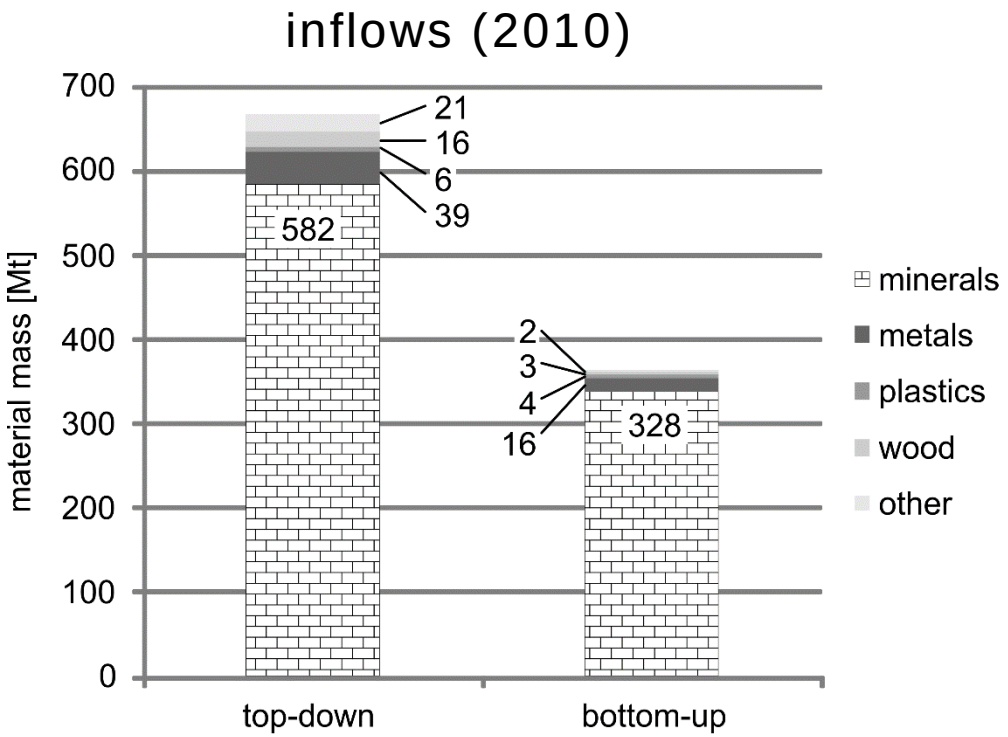
Used methods to deal with uncertainties:

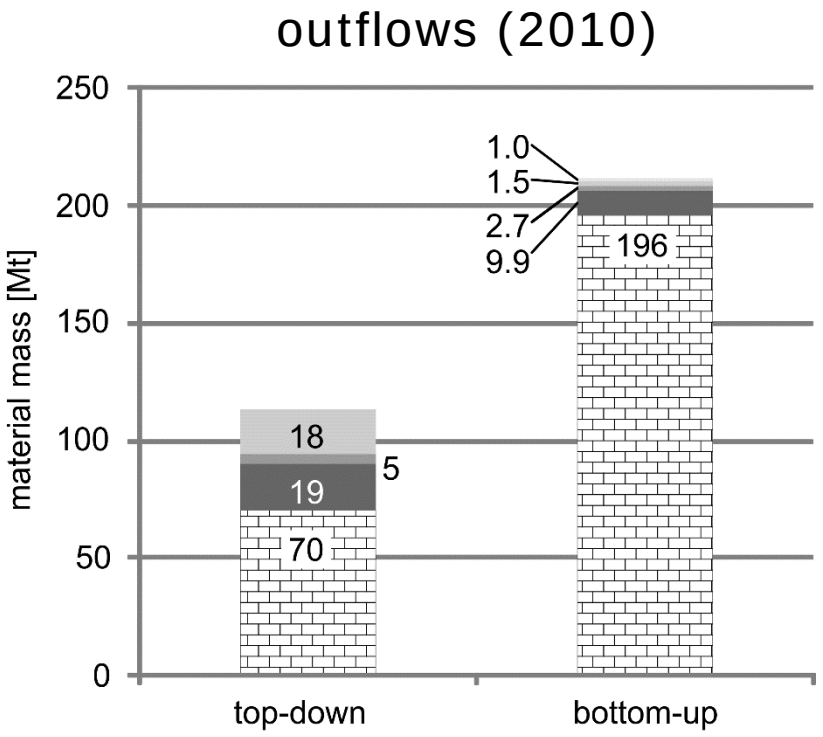
- pedigree matrix (descriptive method)
  - ➢ enables users to assess results' reliability and representativeness
- Combination of approaches (comparing top-down and bottom-up results)
  - methodologically independent
  - quantification
  - validation of the basic model → modeling of missing data

Combination of approaches

Main categories of materials

(flows)





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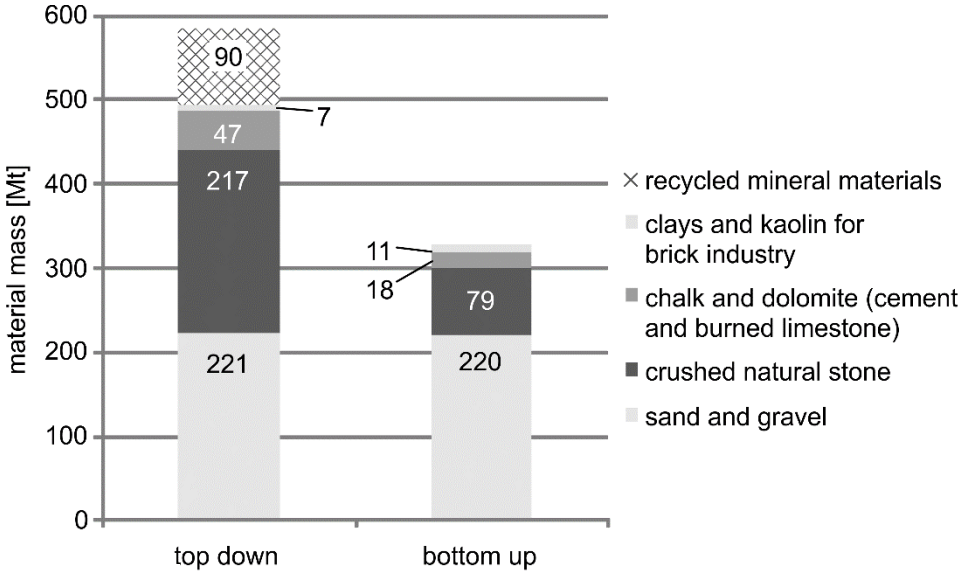
Combination of approaches

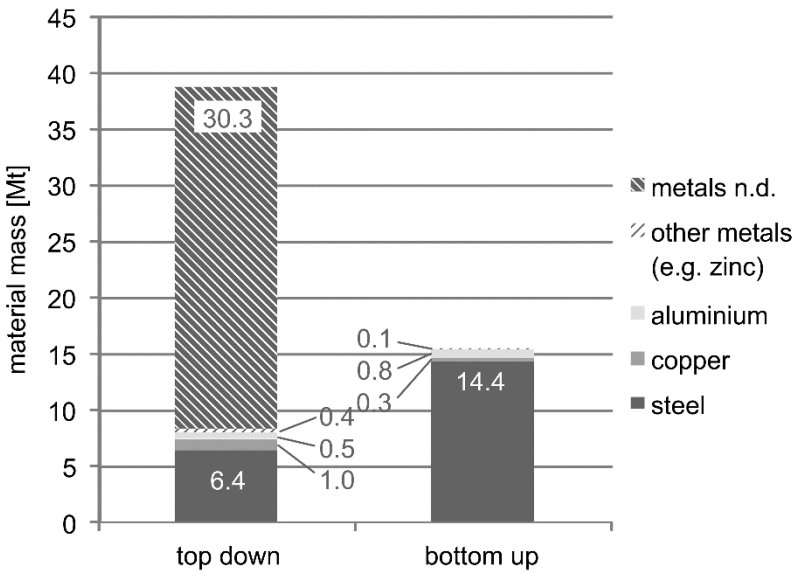
Materials differentiated

(flows)

minerals



metals



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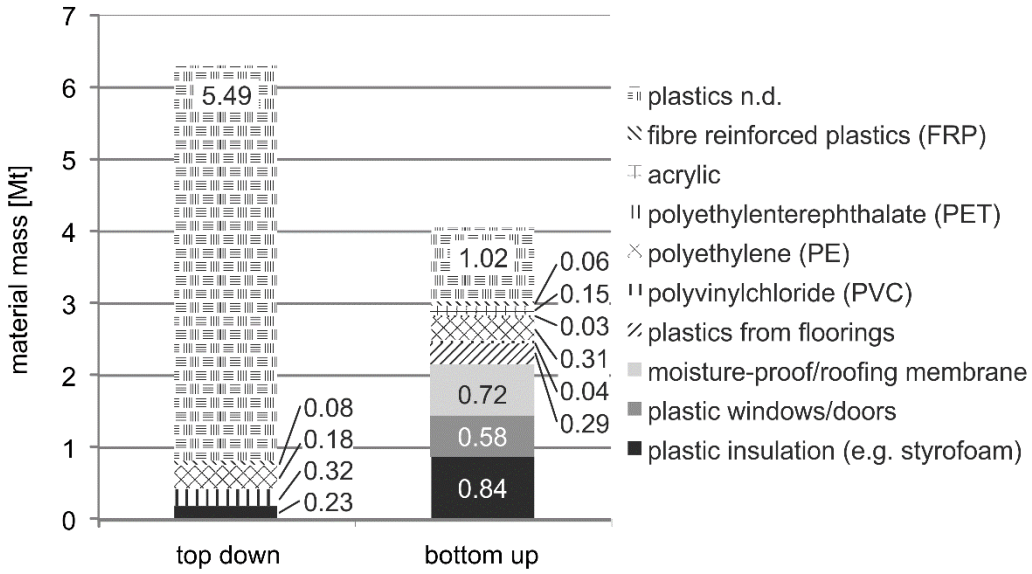
Combination of approaches

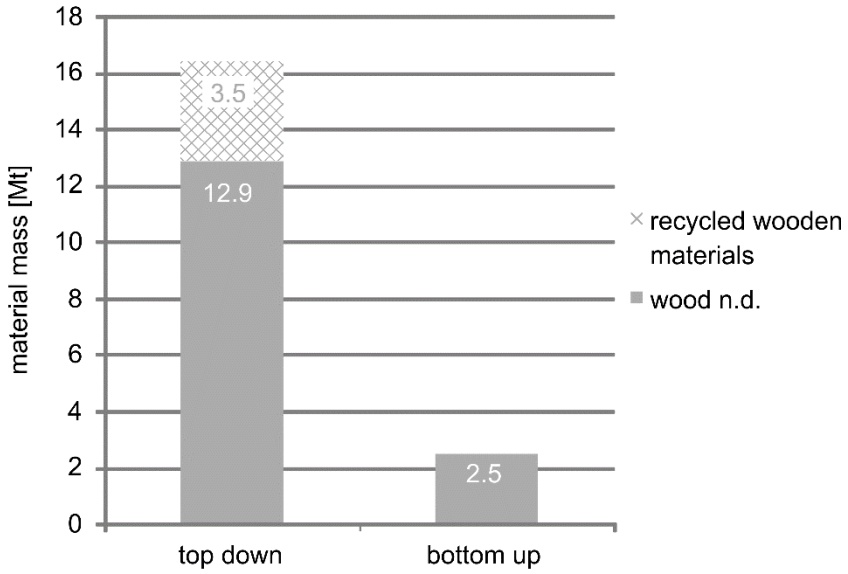
Materials differentiated

(flows)

plastics



wood



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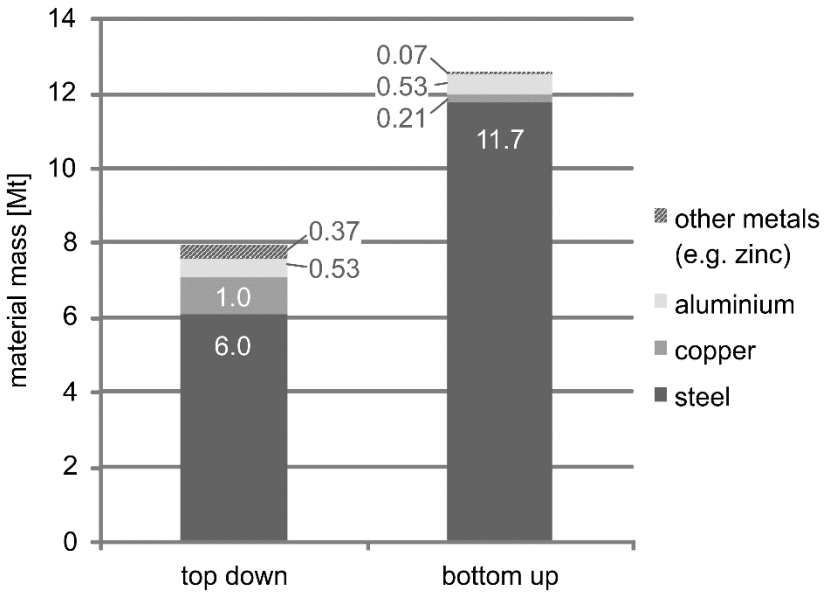
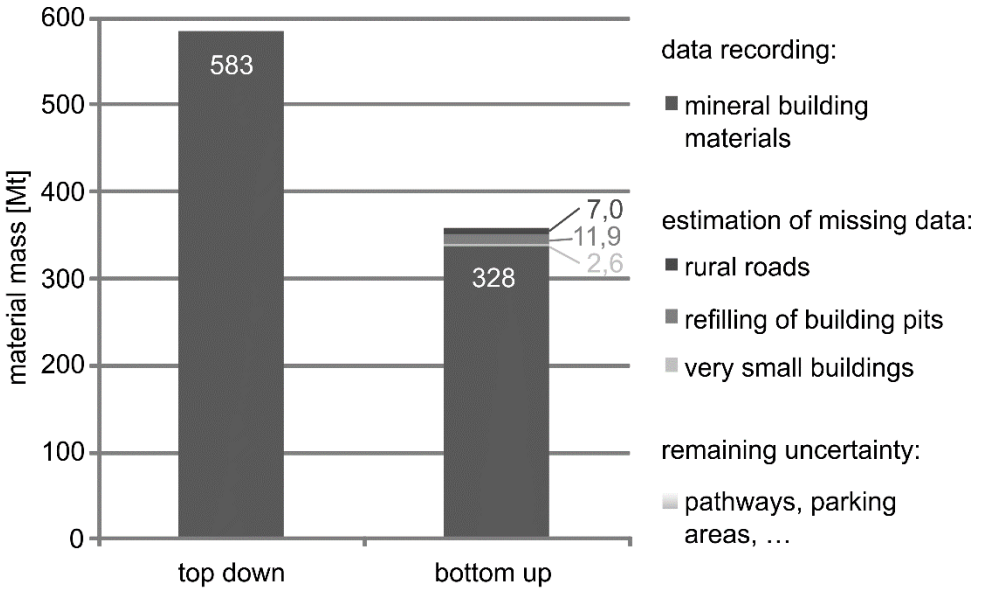
Combination of approaches

Goods differentiated (example built environment)
main categories materials (inflows)

metallic building materials



mineral building materials



Conclusions

- Detailed picture of material flows and stocks
- Results contain uncertainties, but:
  - accurate uncertainty models are of no advantage if source data do not permit parameter setting
  - method to deal with uncertainties must align on the characteristics of the source data
    - ➢ accurate models need accurate data
    - ➢ “rough data” requires “rough models”
- validation by comparing of methodologically independent results can help to overcome problems
- More information soon in ResourConservRecy
  - ➢ “Mapping the anthropogenic stock in Germany: Metabolic evidence for a circular economy”

Many Thanks for your attention!

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