Kreislaufwirtschaft im Bausektor: Einsatz und zukünftige Substitution von industriellen Nebenprodukten aus anderen Branchen

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Agenda

- **Circular stream #1 CDW waste & Recycled aggregates**
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  - Modelling
  - Results
- **Circular stream #2 CCU/Carbonation**
  - Background
  - Modelling
  - Results
- **Circular stream #3 Intersectoral secondary flows**
  - Background
  - Modelling
  - Results
- **Conclusions & Outlook**

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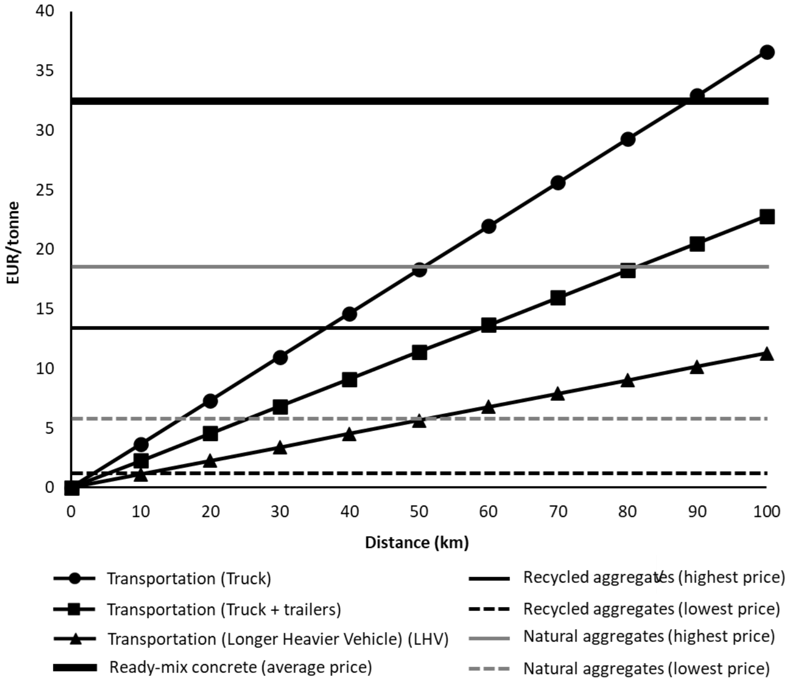
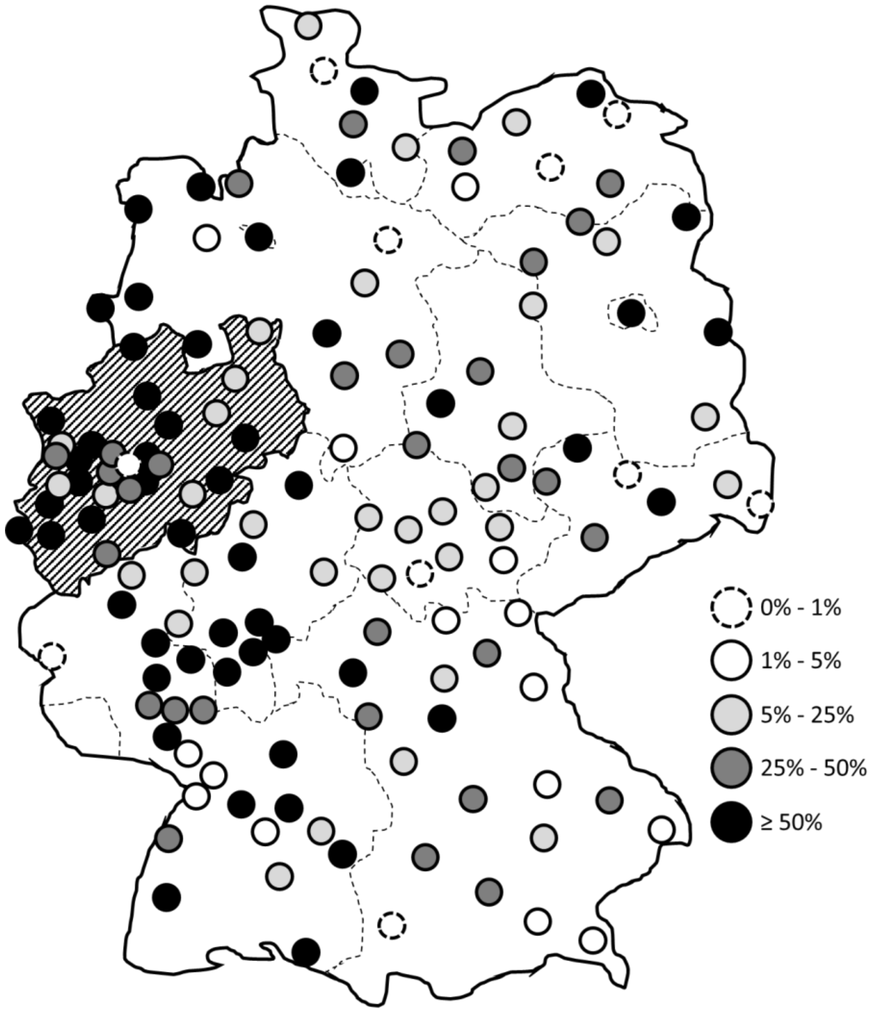
- **Conclusions & Outlook**

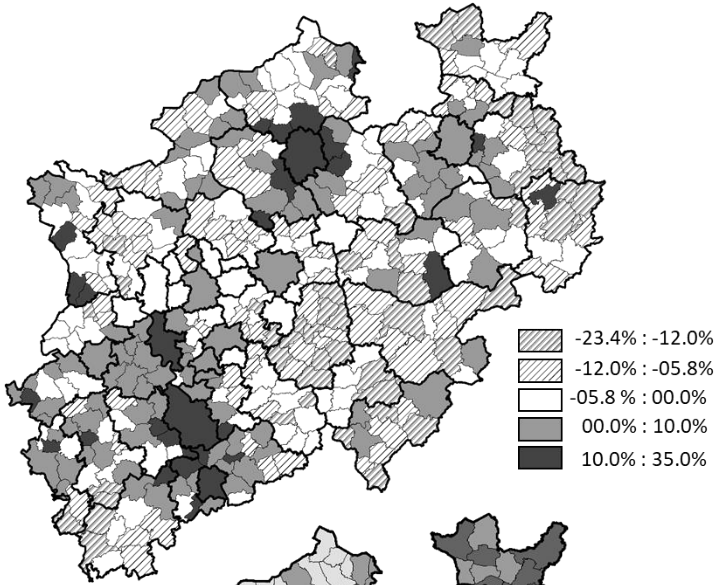
Background (Modelling dimensions)

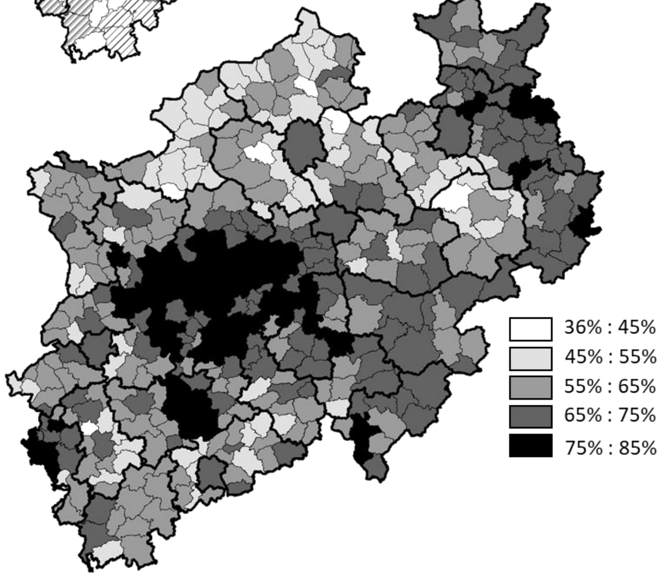


Destruction due to WWII



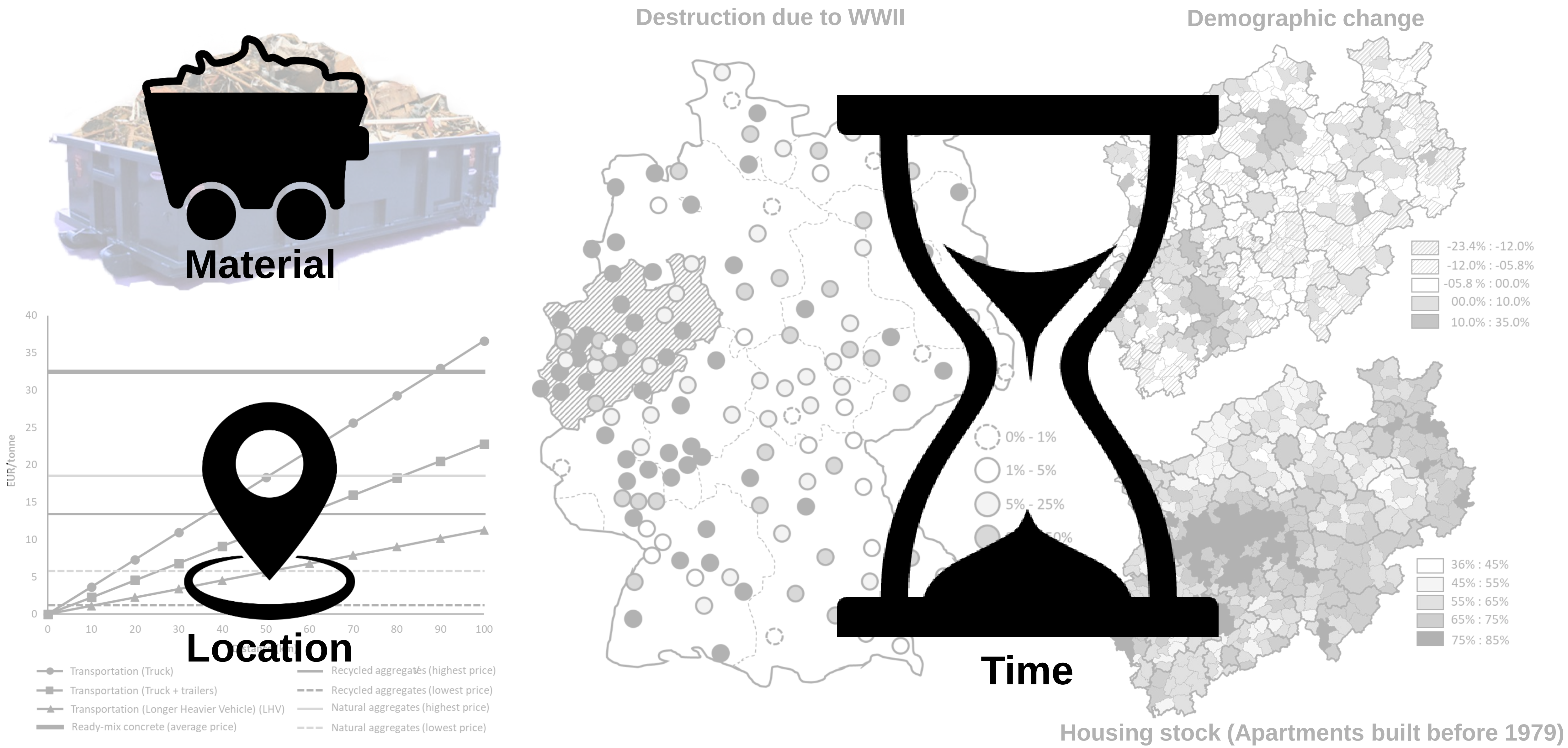
Demographic change





Housing stock (Apartments built before 1979)

Background (Modelling dimensions)



Dynamic-locational MFA

- Production and recycling activities normally take place domestically.
- Circularity cannot be realized in the construction industry without considering the locational aspects.
- Besides location, time is also an indispensable dimension in order to address the dynamics of the construction sector and urban stock.
- The stock dynamics refers to the population's behavior in terms of consumption, lifestyle, demolition, etc., which change over time.
- We have to make sure that the supply and demand of recycled aggregates are within the same vicinity and time.
- Omitting any of the three modelling capabilities mentioned above can be regarded as a shortcoming.
- No study succeeded to integrate the three aspects in one model

Study	Region	Methodology
(Fatta et al., 2004; Huang et al., 2011)	Greece, Taiwan	Statistical approach
(Islam et al., 2019)	Dhaka city, Bangladesh	Regression, statistical approach
(Bergsdal, Brattebø, et al., 2007; Fishman et al., 2014; Kapur et al., 2008; Luciano et al., 2018; Mah et al., 2016; Mercader-Moyano & Ramírez-de-Arellano-Agudo, 2013; Miatto et al., 2017; Müller, 2006; Ortlepp et al., 2015; Ram & Kalidindi, 2017; Schiller et al., 2010; Schiller et al., 2020; Shi et al., 2012; Surahman et al., 2017; Tangtinthai et al., 2019; Weil et al., 2006; Yost & Halstead, 1996)	Norway, Japan, USA, Italy, Spain, Malaysia, Globe, India, Germany, Netherlands, Vietnam, UK, Thailand, Indonesia, China	Material Flow Analysis
(Villoria Sáez et al., 2012)	Spain	Empirical approach
(Han et al., 2018; Roy et al., 2015)	China, Ireland	Locational Material Flow Analysis
(Lockrey et al., 2016)	Vietnam	Empirical approach & interviews
(Cheng et al., 2018; Haberl et al., 2021; Lanau & Liu, 2020; Mesta et al., 2019; Oezdemir et al., 2017; Tanikawa et al., 2015)	Japan, Taiwan, Denmark, Peru, Austria, Germany	Material Flow Analysis & GIS
(Bergsdal, Bohne, & Brattebø, 2007; Coelho & Brito, 2011; Hsiao et al., 2002; M. Hu et al., 2010; Paz & Lafayette, 2016; Schiller et al., 2017; Seo & Hwang, 1999)	Norway, Portugal, Taiwan, Beijing, Brazil, Germany, Korea	Dynamic Material Flow Analysis
(Heeren & Hellweg, 2018)	Switzerland	Locational and dynamic material flow analysis
(Dahlbo et al., 2015)	Finland	Material Flow Analysis, Life Cycle Assessment, Environmental Life Cycle Costing

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(Heeren & Hellweg, 2018)	Switzerland	Locational and dynamic material flow analysis
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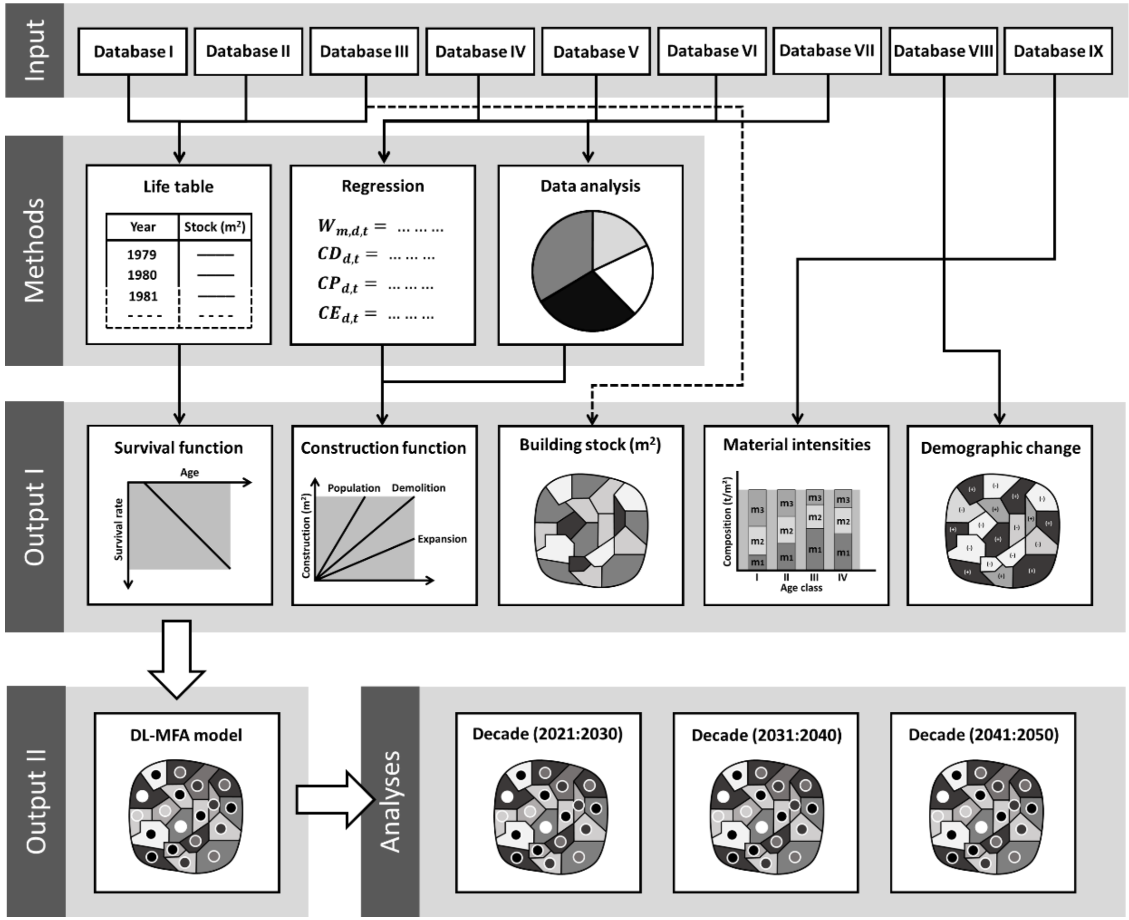
Study	Modelling capabilities		
	Spatial	Dynamic	Circular
(Schiller et al., 2010; Schiller et al., 2017)	○	○	●
(Haberl et al., 2021; Han et al., 2018; Lanau & Liu, 2020)	●		
(Tanikawa et al., 2015)	●	○	
(Bergsdal, Bohne, & Brattebø, 2007; Bergsdal, Brattebø, et al., 2007; M. Hu et al., 2010; Mingming Hu et al., 2010; Müller, 2006)		●	○
(Heinrich, 2016; D. Hu et al., 2010)		○	○
(Heeren & Hellweg, 2018; Roy et al., 2015)	●	○	○

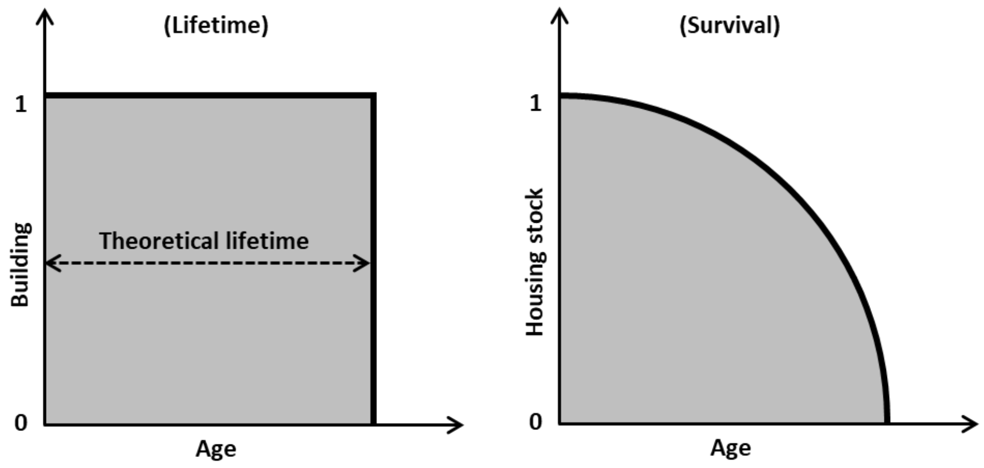
Dynamic-locational MFA (Framework)

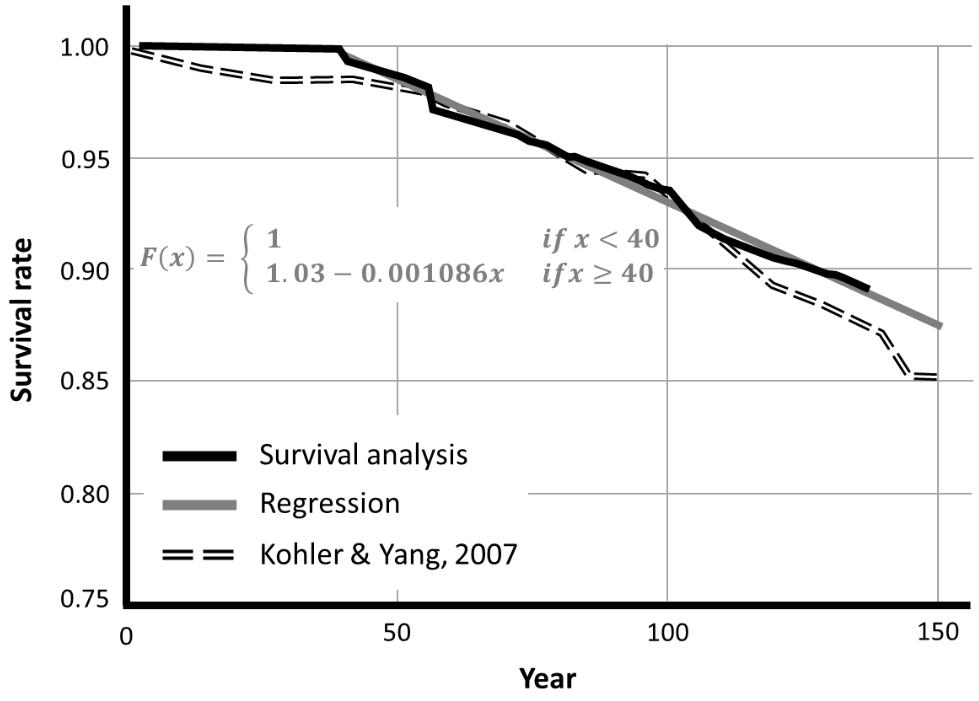


Database/information	Reference
Database I: Demolition statistics of NRW (1979:2020): number of annual demolished buildings, apartments and area classified by age class	(DESTATIS, 2001; IT NRW, 2021a)
Database II: Housing stock (1987): Number of buildings in each district and district-free city classified by age class	(SÄBL, 1987)
Database III: Housing stock (2011): Number of buildings and apartments in each district and district-free city classified by age class	(SÄBL, 2011)
Database IV: Demolition statistics (2000:2020): number of annual demolished units in each district and district-free city	(IT NRW, 2021a)
Database V: CDW recycling activities in NRW (1999:2019): amounts of different CDW types annually generated in NRW in tons	(IT NRW, 2021b)
Database VI: Construction statistics (1987:2020): number of annual construction activities (new apartments) in each district and district-free city	(IT NRW, 2020)
Database VII: Population (1962: 2020): number of residents in each district and district-free city	(IT NRW, 2020)
Database VIII: Population (prognosis): number of residents in each district and district-free city	(IT NRW, 2018)
Database IX: composition of the sample houses of different age classes in Germany	(IOER, 2021)

- The framework addresses the identified gaps via modelling both demolition and construction activities simultaneously along four dimensions (quantity, quality, location and time).
- Several databases have been used as inputs in order to implement the empirical analyses.

- The dynamics of housing stock are relatively unique as it survives longer than many other products (e.g. for centuries).
- The main shortcoming is assuming an average building lifetime over buildings of all age classes and types.
- Assuming an average lifetime of 100 years: the demolition activities in 2020 should contain only the buildings of 1920.
- Demolition and construction are complex phenomena and affected by several drivers.
- “average lifetime” is unrealistic and omits the economic, environmental, legislative, social and cultural factors behind it.
- Different types of obsolescence (e.g. structure, economic, utility, and social).
- Therefore, using survival functions to deal with the whole housing stock can be more accurate and precise.





- eq. 1 – eq. 3 to quantify the amount of each CDW type (i.e. concrete, bricks and minerals) in each locational/temporal unit.
- The formula $F(Y1 - Y0_g) - F(Y2 - Y0_g)$ in eq. 1 calculates the difference between the survival rate of each age class in the beginning and end of the investigation period (eq. 3).
- Multiplying this difference by $S_{g,d}$ (housing stock of each age class in each locational unit) yields the demolished area of each age class in each locational unit during the investigation period.
- Multiplying this value by $C_{m,g}$ (specific material content per unit area of each CDW type and each age class) results in the total amount of each CDW type in each locational unit during the investigation period.
- The total amount of CDW in each locational unit during the investigation period is calculated via summing the amounts of all CDW types ($\sum_{m\in M} W_{m,d,t}$) in eq. 2.

$$W_{m,d,t} = \sum_{g\in G} H_{g.d.t} * C_{m,g} = \sum_{g\in G} S_{g,d} * \left(F(Y1 - Y0_g) - F(Y2 - Y0_g)\right) * C_{m,g} \quad (1)$$

$$W_{d,t} = \sum_{m\in M} W_{m,d,t} \quad (2)$$

$$F(x) = \begin{cases} 1 & if\ x < 40 \\ 1.03 - 0.001086x & if\ x \geq 40 \end{cases} \quad (3)$$

$\boldsymbol{D}$ Set of districts and district-free cities in NRW ($d \in D = \{Düsseldorf, \dots, Unna\}$)

$\boldsymbol{G}$ set of age classes ($g \in G = \{I, \dots, VIII\}$)

$\boldsymbol{M}$ set of CDW types ($m \in M = \{waste\ concrete, waste\ bricks, waste\ minerals\}$)

$\boldsymbol{T}$ set of investigation periods ($t \in T = \{2021{:}2030, 2031{:}2040, 2041{:}2050\}$)

$\boldsymbol{F(x)}$ survival function

$\boldsymbol{x}$ age of the housing stock

$\boldsymbol{S_{g,d}}$ housing stock of age class $g \in G$ in district $d \in D$

$\boldsymbol{W_{m,d,t}}$ total amount of CDW type $m \in M$ in district $d \in D$ during the investigation period

$\boldsymbol{W_{d,t}}$ total amount of CDW in district $d \in D$ during the investigation period

$\boldsymbol{H_{g,d,t}}$ Demolished area (m^2) of age class $g \in G$ in district $d \in D$ during the investigation period

$\boldsymbol{C_{m,g}}$ specific material content per unit area $\left(\frac{tonne}{m^2}\right)$ of CDW type $m \in M$ of age class $g \in G$

$\boldsymbol{Y2}$ end year of the investigation period

$\boldsymbol{Y1}$ start year of the investigation period

$\boldsymbol{Y0_g}$ construction year of housing stock year of ofage class $g \in G$

Survival analysis & CDW inflows

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- eq. 1 – eq. 3 to quantify the amount of each CDW type (i.e. concrete, bricks and minerals) in each locational/temporal unit.
- The formula $F(Y1 - Y0_g) - F(Y2 - Y0_g)$ in eq. 1 calculates the difference between the survival rate of each age class in the beginning and end of the investigation period (eq. 3).
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D Set of districts and district-free cities in NRW ($d \in D = \{Düsseldorf, \dots, Unna\}$)

G set of age classes ($g \in G = \{I, \dots, VIII\}$)

Age class	Concrete (t/m²)	Bricks (t/m²)	Minerals (t/m²)
(I) Till 1918	0.095	0.74	0.74
(II) 1919 – 1949	0.23	0.71	0.58
(III) 1950 – 1959 (IV) 1960 – 1969 (V) 1970 – 1979	0.83	0.21	0.42
(VI) 1980 – 1989	0.88	0.1	0.56
(VII) 1990 – 1999 (VIII) 2000 – 2010	0.65	0.11	0.65

$W_{d,t}$ total amount of CDW in district $d \in D$ during the investigation period

$H_{g,d,t}$ Demolished area (m^2) of age class $g \in G$ in district $d \in D$ during the investigation period

$C_{m,g}$ specific material content per unit area $\left(\frac{tonne}{m^2}\right)$ of CDW type $m \in M$ of age class $g \in G$

$Y2$ end year of the investigation period

$Y1$ start year of the investigation period

$Y0_g$ construction year of housing stock year of of age class $g \in G$

Construction activities & Material demand

- The study also derived functions that can model the construction activities (new built stock) in each temporal and locational unit.
- Although the total population in NRW and Germany is almost constant, the construction demand is increasing as the housing sector in Germany is highly affected by the demographic change.
- Hence, besides substituting the demolished units, the urban growth has been considered as the second major motive.
- However, limiting the construction activities to these two drivers would imply that construction is predominantly active in the urban centers.
- In reality, building activities in the regions with shrinking population also surpass the number of demolished houses.
  - ➢ Vacancy rates ≠ zero because of market imperfections.
  - ➢ Houses are seen as an investment and safe deposit. Such attitude is augmented in Germany by favorable conditions (e.g. low mortgage rates and booming economy) as well as incentives.

$$CD_{d,t} = \sum_{g \in G} S_{g,d} * \left(F(Y1 - Y0_g) - F(Y2 - Y0_g)\right) \quad (4)$$

$$CP_{d,t} = \begin{cases} (P_d(Y2) - P_d(Y1)) * A_d & \text{if } P_d(Y2) > P_d(Y1) \\ 0 & \text{if } P_d(Y2) \le P_d(Y1) \end{cases} \quad (5)$$

$$CT_{d,t}\,(LB) = CD_{d,t} + CP_{d,t} \quad (6)$$

$$CE_{d,t} = P_d(Y1) * E_d * (Y2 - Y1) \quad (7)$$

$$CT_{d,t}(UB) = CD_{d,t} + CP_{d,t} + CE_{d,t} \quad (8)$$

$$K_{d,t} = CT_{d,t} * R \quad (9)$$

$\boldsymbol{R}$ specific aggregates demand per unit area $\left(\frac{tonne}{m^2}\right)$

$\boldsymbol{A_d}$ average living area per capita $\left(\frac{m^2}{capita}\right)$ in district $d \in D$

$\boldsymbol{P_d}$ residents (population) in district $d \in D$

$\boldsymbol{E_d}$ annual housing stock expansion factor $\left(\frac{\frac{m^2}{capita}}{year}\right)$ in district $d \in D$

$\boldsymbol{CT_{d,t}\,(LB)}$ lower bound of total construction activity (m^2) in district $d \in D$ during the investigation period

$\boldsymbol{CT_{d,t}\,(UB)}$ upper bound of total construction activity (m^2) in district $d \in D$ during the investigation period

$\boldsymbol{CD_{d,t}}$ construction activity (m^2) to compensate demolished units in district $d \in D$ during the investigation period

$\boldsymbol{CP_{d,t}}$ construction activity (m^2) due to population increase in district $d \in D$ during the investigation period

$\boldsymbol{CE_{d,t}}$ construction activity (m^2) due to the housing stock expansion in district $d \in D$ during the investigation period

$\boldsymbol{K_{d,t}}$ total aggregates demand in district $d \in D$ during the investigation period

Construction activities & Material demand

- Eq. 4 calculates the construction activity needed to compensate the demolished units in each district during each investigation period.

- The second driver for construction demand (i.e. the population increase) is calculated in each district via eq. 5.

- Only if the number of residents at the end of investigation period is higher than the number at the beginning, the difference is multiplied by the average living area per capita.

- Eq. 6 is the summation of eq.4 & 5, which yields the lower bound of the total construction activity in each district during the investigation period.

- In order to determine the construction activity due to the housing stock expansion, the annual housing stock expansion factor (E_d) is multiplied by the number of residents (P_d) in each locational unit (eq. 7).

- The total demand of aggregates in each district ($K_{d,t}$) is calculated by multiplying the specific aggregates demand per unit area (R) by the total construction activity ($CT_{d,t}$), as shown in eq. 9

$$CD_{d,t} = \sum_{g \in G} S_{g,d} * \left(F(Y1 - Y0_g) - F(Y2 - Y0_g)\right) \qquad (4)$$

$$CP_{d,t} = \begin{cases} (P_d(Y2) - P_d(Y1)) * A_d & if\ P_d(Y2) > P_d(Y1) \\ 0 & if\ P_d(Y2) \leq P_d(Y1) \end{cases} \qquad (5)$$

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$$CT_{d,t}(UB) = CD_{d,t} + CP_{d,t} + CE_{d,t} \qquad (8)$$

$$K_{d,t} = CT_{d,t} * R \qquad (9)$$

$\boldsymbol{R}$ *specific aggregates demand per unit area* $\left(\frac{tonne}{m^2}\right)$

$\boldsymbol{A_d}$ *average living area per capita* $\left(\frac{m^2}{capita}\right)$ *in district* $d \in D$

$\boldsymbol{P_d}$ *residents (population) in district* $d \in D$

$\boldsymbol{E_d}$ *annual housing stock expansion factor* $\left(\frac{\frac{m^2}{capita}}{year}\right)$ *in district* $d \in D$

$\boldsymbol{CT_{d,t}\,(LB)}$ *lower bound of total construction activity* (m^2) *in district* $d \in D$ *during the investigation period*

$\boldsymbol{CT_{d,t}\,(UB)}$ *upper bound of total construction activity* (m^2) *in district* $d \in D$ *during the investigation period*

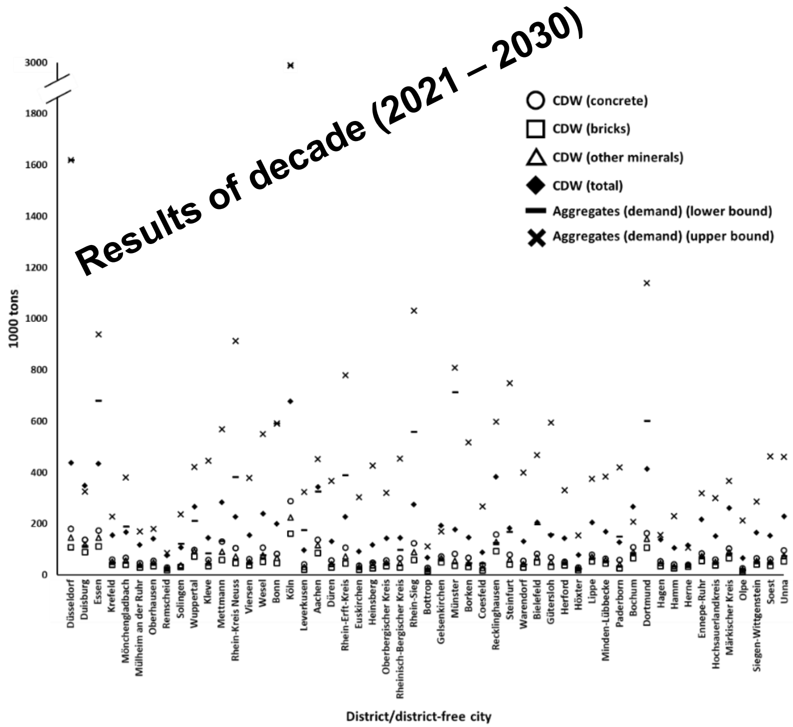
$\boldsymbol{CD_{d,t}}$ *construction activity* (m^2) *to compensate demolished units in district* $d \in D$ *during the investigation period*

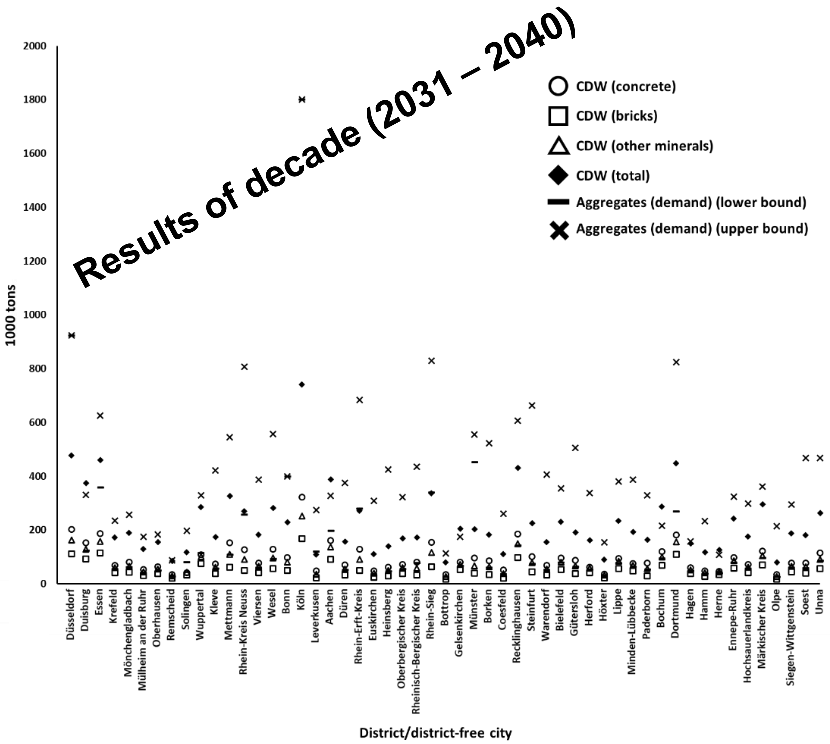
$\boldsymbol{CP_{d,t}}$ *construction activity* (m^2) *due to population increase in district* $d \in D$ *during the investigation period*

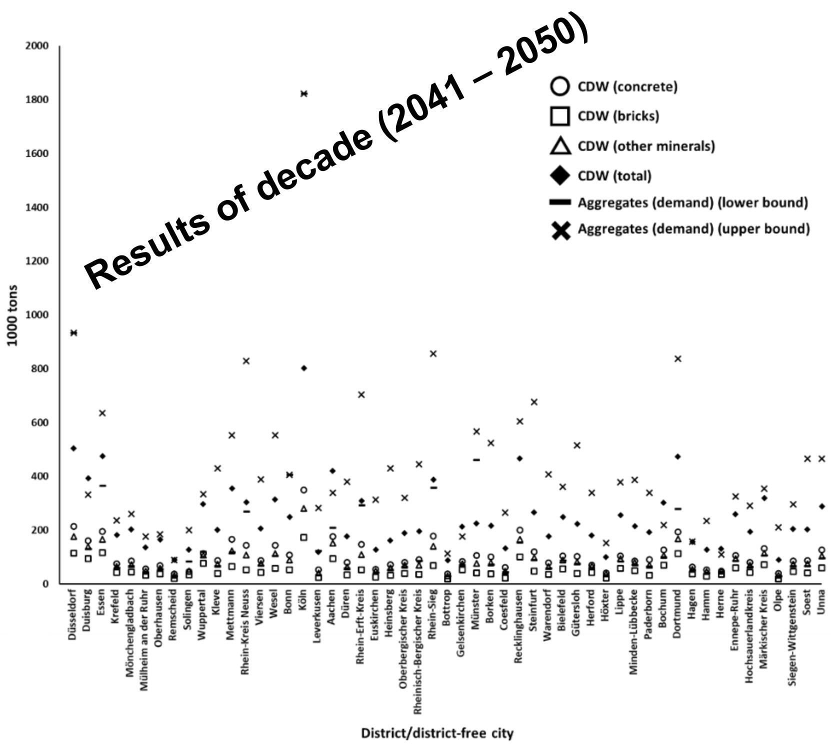
$\boldsymbol{CE_{d,t}}$ *construction activity* (m^2) *due to the housing stock expansion in district* $d \in D$ *during the investigation period*

$\boldsymbol{K_{d,t}}$ *total aggregates demand in district* $d \in D$ *during the investigation period*

Results

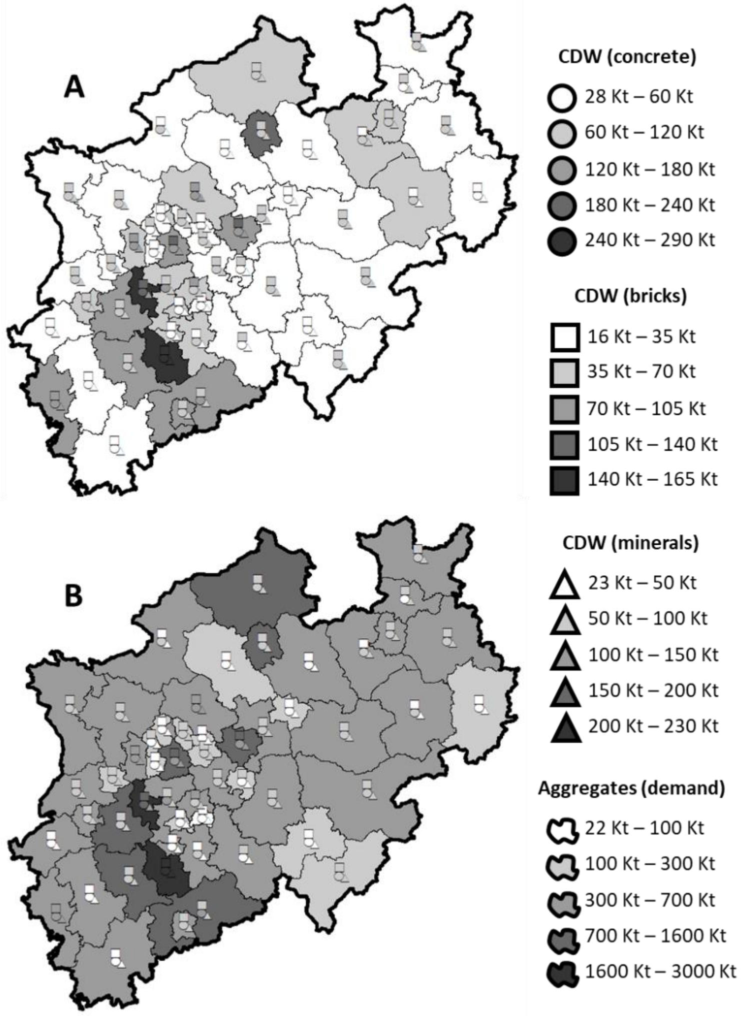


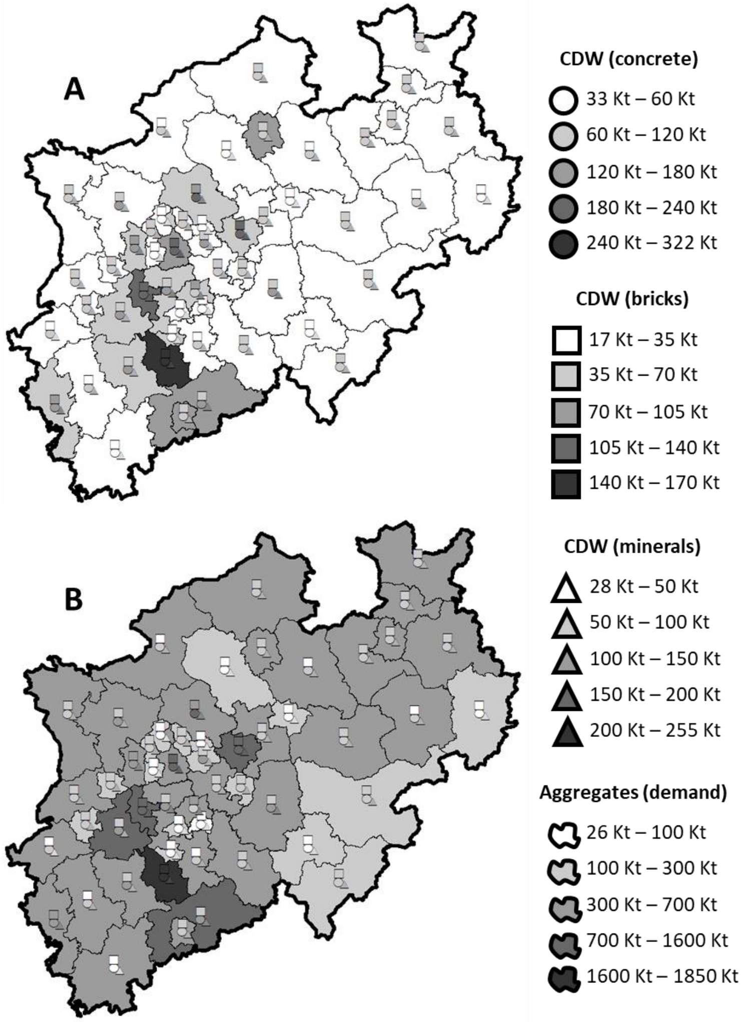


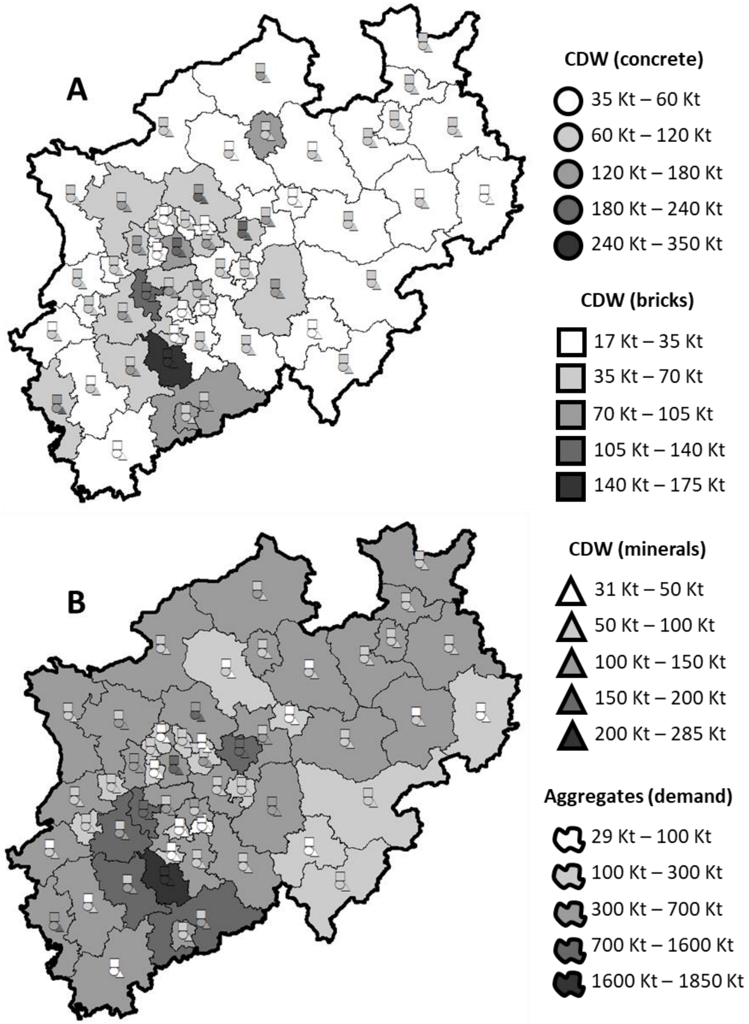


- The total demand of aggregates in the first three decades are and 26.1 Mt, 22 Mt, 22.2 Mt respectively (UB).
- Regions with a net increase in the number of residents have the highest demand in both scenarios, and urban centers attract the majority of aggregates consumption.
- One city (i.e. Cologne) consumes roughly one quarter of total consumption and three other cities (Düsseldorf, Münster and Essen) consume another quarter in the first decade.

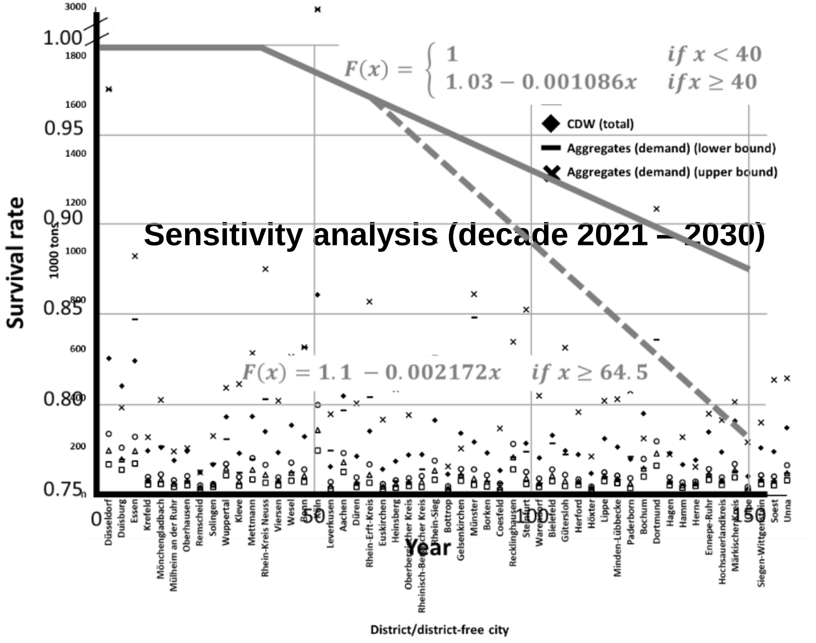
Results

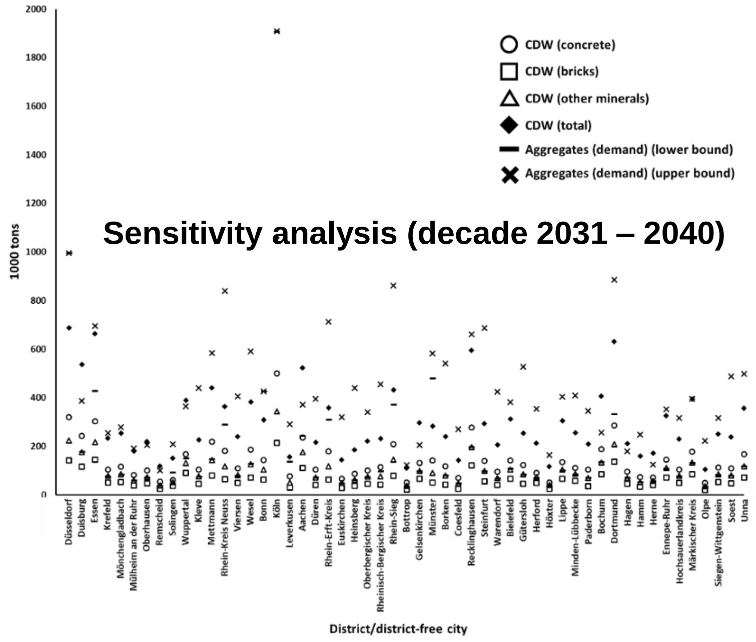

A
B
CDW (concrete)
28 Kt – 60 Kt
60 Kt – 120 Kt
120 Kt – 180 Kt
180 Kt – 240 Kt
240 Kt – 290 Kt
CDW (bricks)
16 Kt – 35 Kt
35 Kt – 70 Kt
70 Kt – 105 Kt
105 Kt – 140 Kt
140 Kt – 165 Kt
CDW (minerals)
23 Kt – 50 Kt
50 Kt – 100 Kt
100 Kt – 150 Kt
150 Kt – 200 Kt
200 Kt – 230 Kt
Aggregates (demand)
22 Kt – 100 Kt
100 Kt – 300 Kt
300 Kt – 700 Kt
700 Kt – 1600 Kt
1600 Kt – 3000 Kt

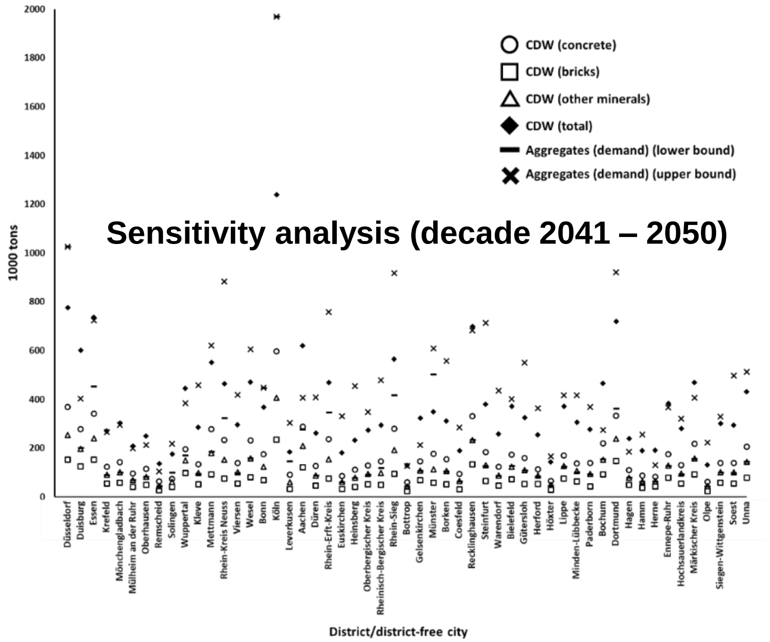

A
B
CDW (concrete)
33 Kt – 60 Kt
60 Kt – 120 Kt
120 Kt – 180 Kt
180 Kt – 240 Kt
240 Kt – 322 Kt
CDW (bricks)
17 Kt – 35 Kt
35 Kt – 70 Kt
70 Kt – 105 Kt
105 Kt – 140 Kt
140 Kt – 170 Kt
CDW (minerals)
28 Kt – 50 Kt
50 Kt – 100 Kt
100 Kt – 150 Kt
150 Kt – 200 Kt
200 Kt – 255 Kt
Aggregates (demand)
26 Kt – 100 Kt
100 Kt – 300 Kt
300 Kt – 700 Kt
700 Kt – 1600 Kt
1600 Kt – 1850 Kt


A
B
CDW (concrete)
35 Kt – 60 Kt
60 Kt – 120 Kt
120 Kt – 180 Kt
180 Kt – 240 Kt
240 Kt – 350 Kt
CDW (bricks)
17 Kt – 35 Kt
35 Kt – 70 Kt
70 Kt – 105 Kt
105 Kt – 140 Kt
140 Kt – 175 Kt
CDW (minerals)
31 Kt – 50 Kt
50 Kt – 100 Kt
100 Kt – 150 Kt
150 Kt – 200 Kt
200 Kt – 285 Kt
Aggregates (demand)
29 Kt – 100 Kt
100 Kt – 300 Kt
300 Kt – 700 Kt
700 Kt – 1600 Kt
1600 Kt – 1850 Kt

Sensitivity analysis

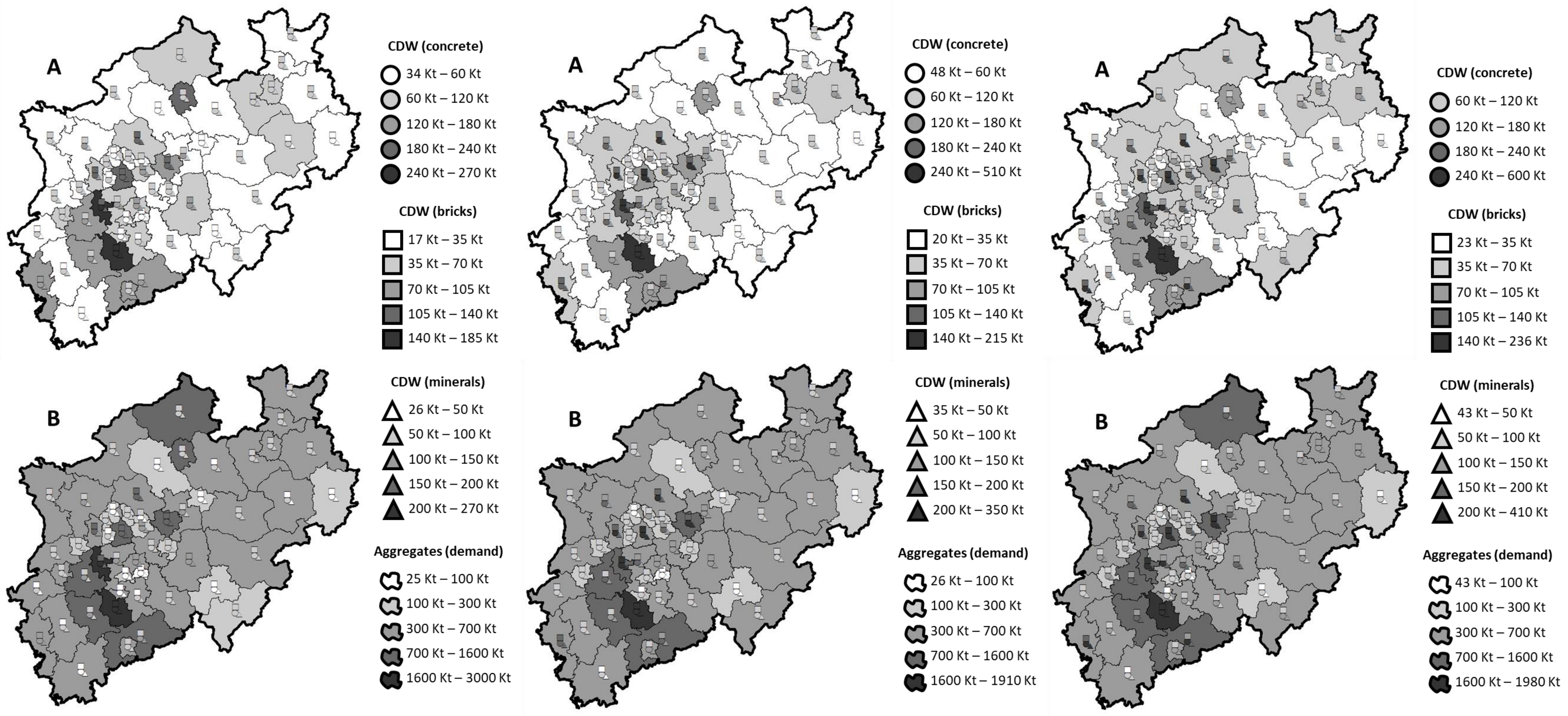






- A sensitivity analysis has been conducted in order to investigate the impact of higher demolition rates.
- The deterioration rate of age classes III, IV and V is assumed double in the coming three decades
- Not all CDW types witnessed the same relative increase. While waste bricks and waste minerals have mildly increased, waste concrete significantly increased.
- Similarly, this increase is not evenly distributed geographically. the inflows of waste concrete increased by 46% and 64% in the first two decades in Gelsenkirchen and more than three quarters in the third decade in Duisburg.

Sensitivity analysis



Agenda

- **Circular stream #1 CDW waste & Recycled aggregates**
  - Background
  - Modelling
  - Results
- **Circular stream #2 CCU/Carbonation**
  - Background
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- **Conclusions & Outlook**

Concrete products

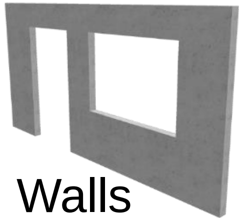
- There are several types of concrete products
- Different products/plants have different scales, TRLs, requirements and sequestration capacities.

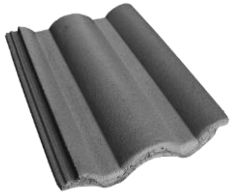

RMC

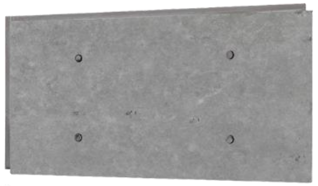

Blocks & Bricks


Slabs & Paving stones

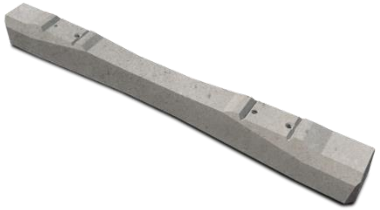

Pipes


Walls


Roof tiles


Ceiling panels


Beams & Lintels


Fittings & Railway sleepers


Precast elements

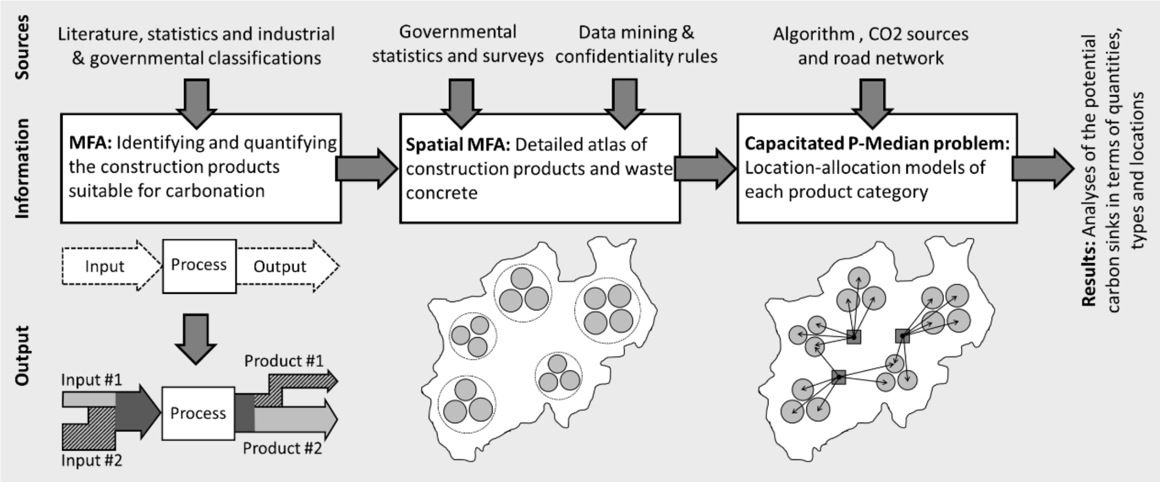

Buildings & Garages

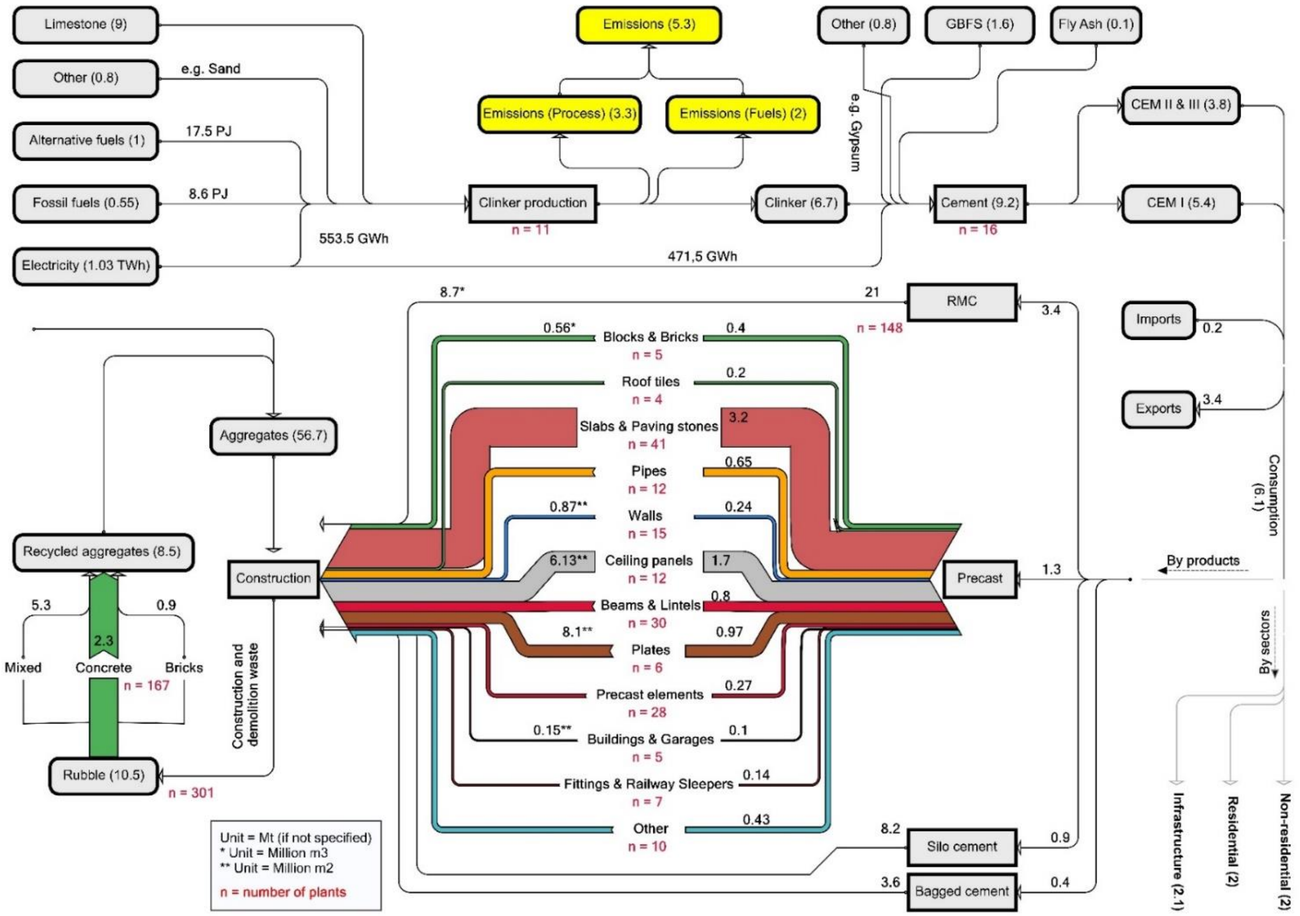

Plates


Other precast products


Waste concrete

(Classified) locational MFA model





- MFA model: The study adopted the governmental classification systems in assorting the construction products and waste streams.

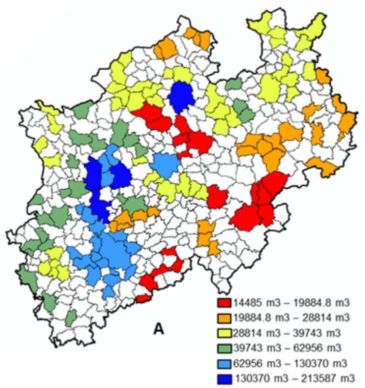
- Atlas/choropleth maps of concrete products & waste

- Location-allocation model of each product category

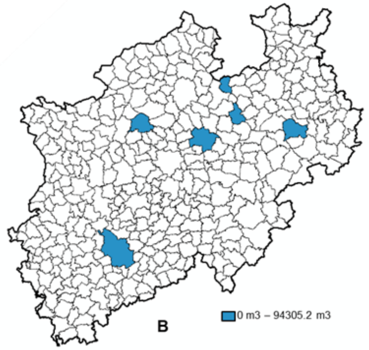
(Classified) locational MFA model

Based on extensive data mining and statistical analyses, the **locations**, **outputs** and **types** (e.g. stationary & mobile) of the concrete and recycling plants have been determined.

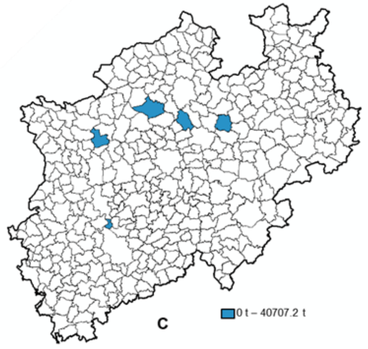
RMC



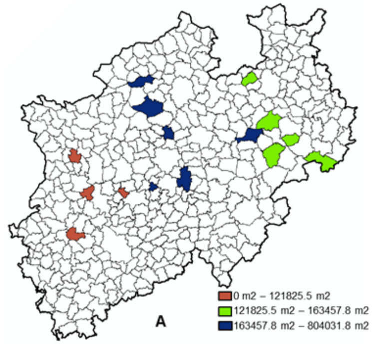
Blocks & bricks



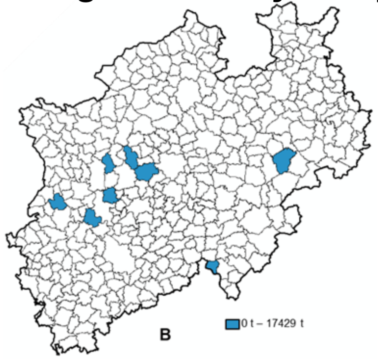
Roof tiles



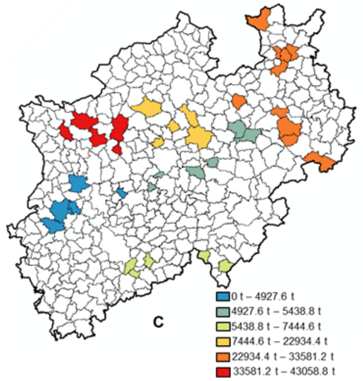
Ceiling panels

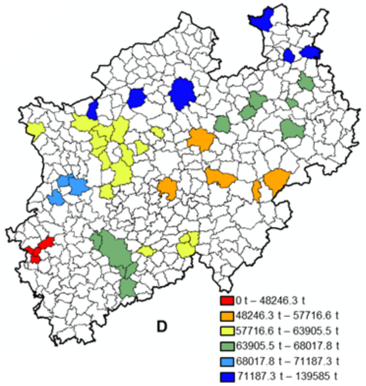


Fittings & railway sleepers

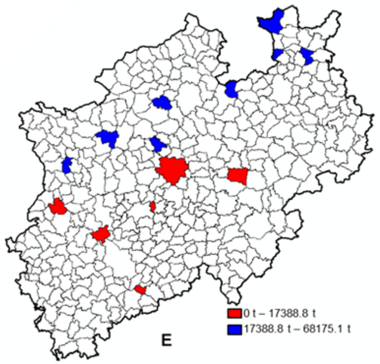


Beams & lintels

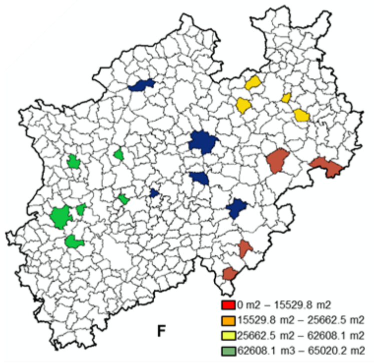




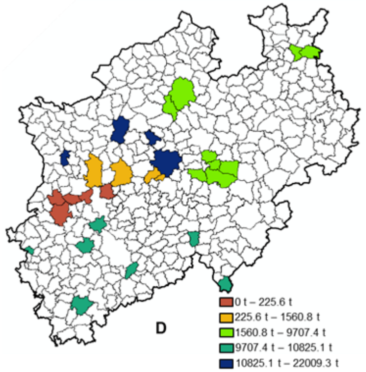
Slabs & paving stones



Pipes



Walls



Concrete elements

Buildings & garages

Plates

The effect of location on CCU supply chain

$$MIN\ f(x) = \sum_{i\in I}\sum_{j\in J} w_i \cdot d_{ij} \cdot X_{ij} \quad (1)$$

Subject to:

$$\sum_{j\in J} X_{ij} = 1 \quad \forall i \in I \quad (2)$$

$$\sum_{j\in J} Y_j = P \quad (3)$$

$$\sum_{i\in I} w_i \cdot X_{ij} \le b_j \cdot Y_j \quad \forall j \in J \quad (4)$$

$$Y_j \in \{0,1\} \quad \forall j \in J \quad (5)$$

$$X_{ij} \in \{0,1\} \quad \forall i \in I, j \in J \quad (6)$$

$\boldsymbol{I}$ *set of lime and cement plants* $(i \in I = \{1, \dots, n\})$

$\boldsymbol{J}$ *set of potential carbon sinks* $(j \in J = \{1, \dots, m\})$

$\boldsymbol{d_{ij}}$ *the distance between plant* $i \in I$ *and sink* $j \in J$

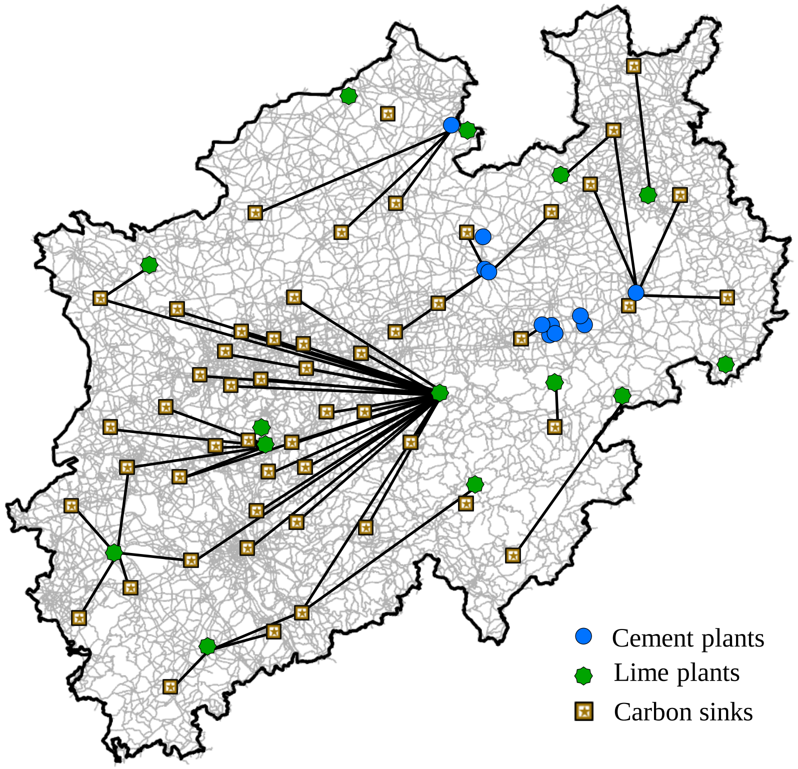
$\boldsymbol{w_i}$ *the amount of process emissions at* $i \in I$

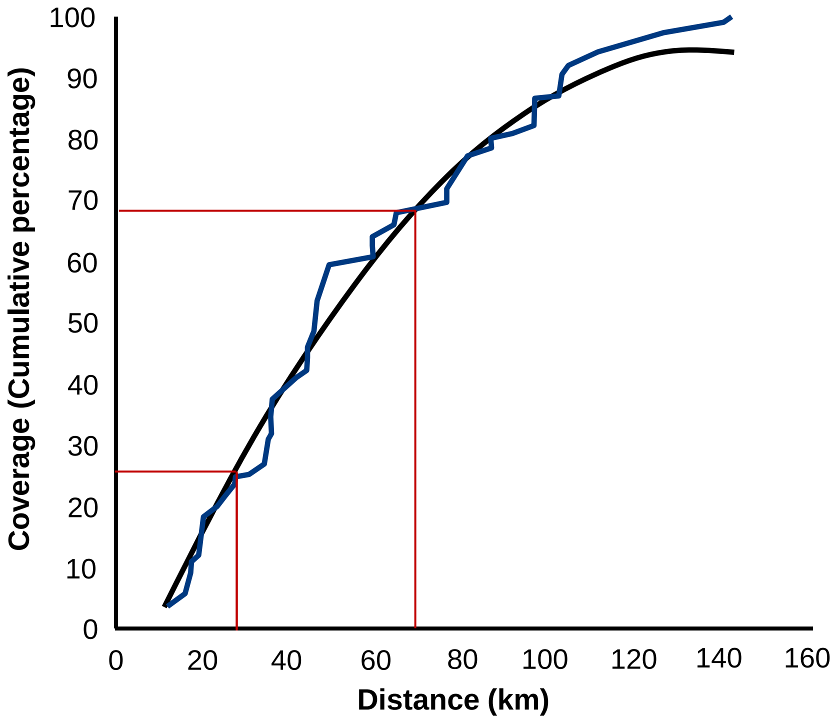
$\boldsymbol{P}$ *the number of carbon sinks*

$\boldsymbol{b_j}$ *the capacity of a carbon sink located at* $j \in J$

$$\boldsymbol{Y_j} = \begin{cases} 1, & \text{if a carbon sink is located at site } j \in J \\ 0, & \text{otherwise} \end{cases}$$

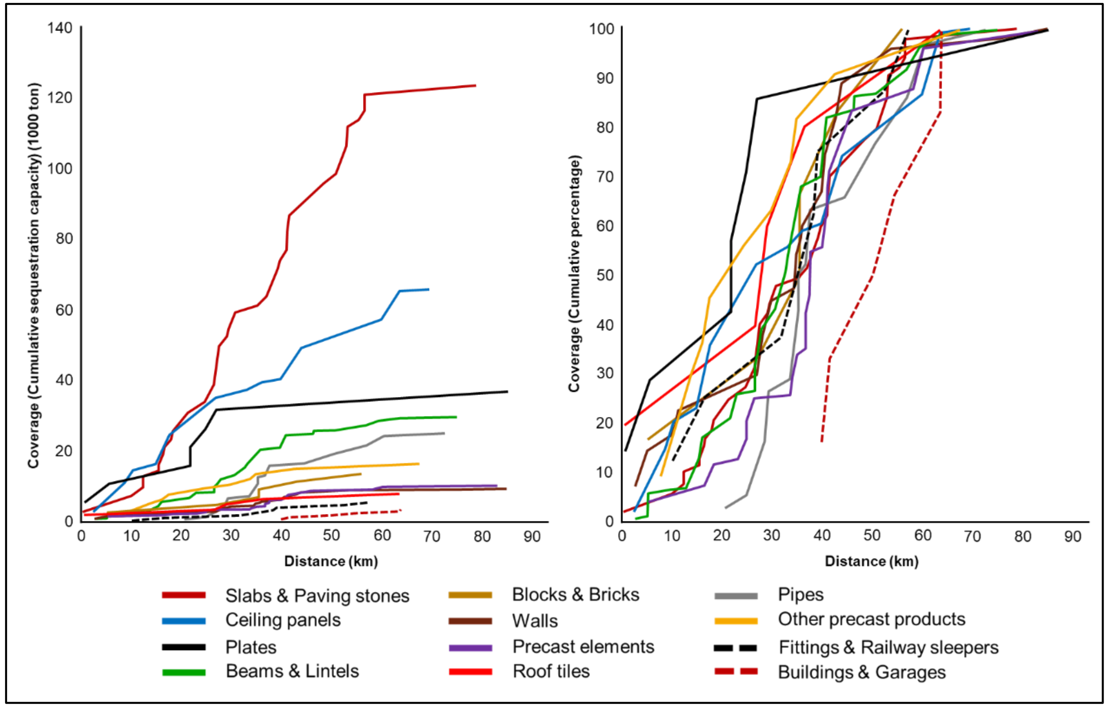
$$\boldsymbol{X_{ij}} = \begin{cases} 1, & \text{if a plant } i \in I \text{ is assigned to a sink } j \in J \\ 0, & \text{otherwise} \end{cases}$$

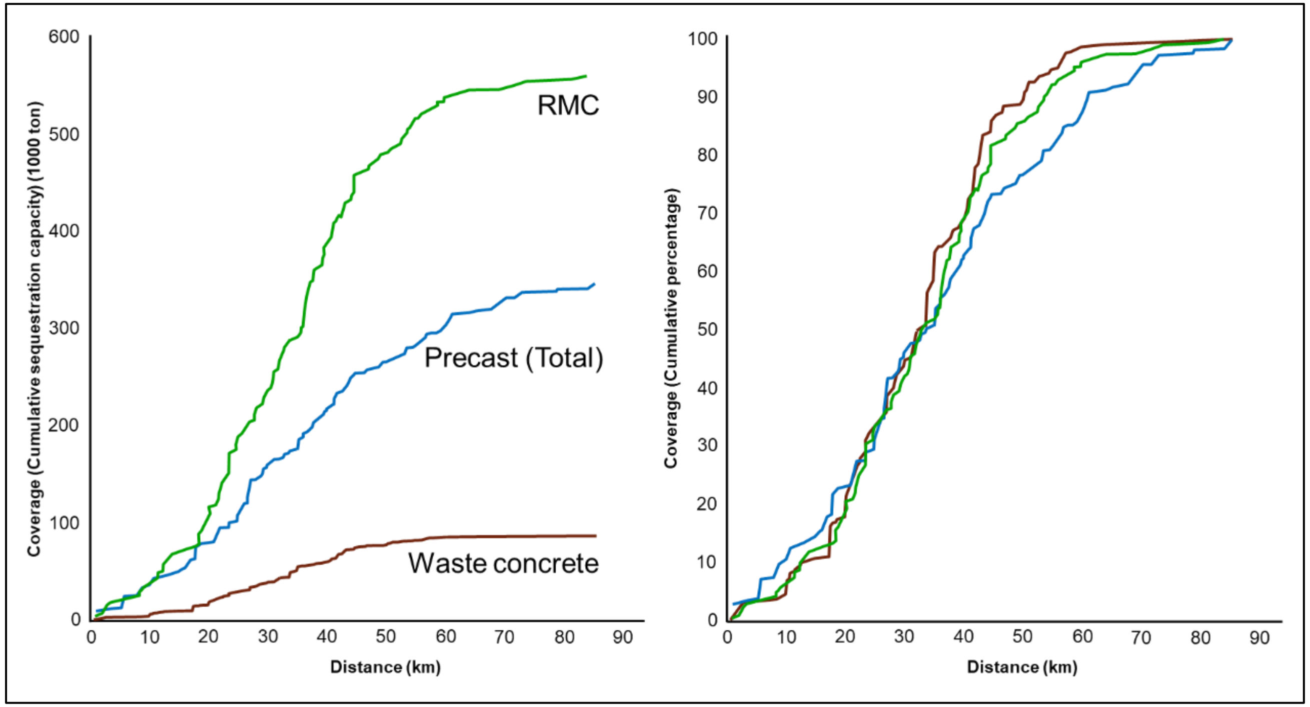




- A location-allocation model has been designed for each product.
- The output curve of each model shows the relationship between transportation distance (costs) and cumulative carbonation capacity.
- Accordingly, the feasible/economic sequestration capacities can be investigated.

The effect of location on CCU supply chain





- Each product category has a different profile and the sequestration capacities of the product categories also vary substantially
- The range of transportation costs vary significantly with a minimum distance of 0.7 km (0.2 EUR/ton) and a maximum distance of 99.7 km (22.1 EUR/ton).
- The distance/transportation influences the economic performance significantly

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Secondary resources & applications

Secondary resources as **alternative raw materials**

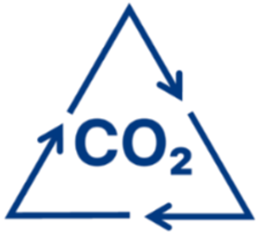
- Blast furnace slag
- Fly ash
- FGD gypsum
- Rubble/waste concrete

Secondary resources as **alternative fuels**

- Plastic waste
- RDF (Refuse-derived fuels)
- Process gases

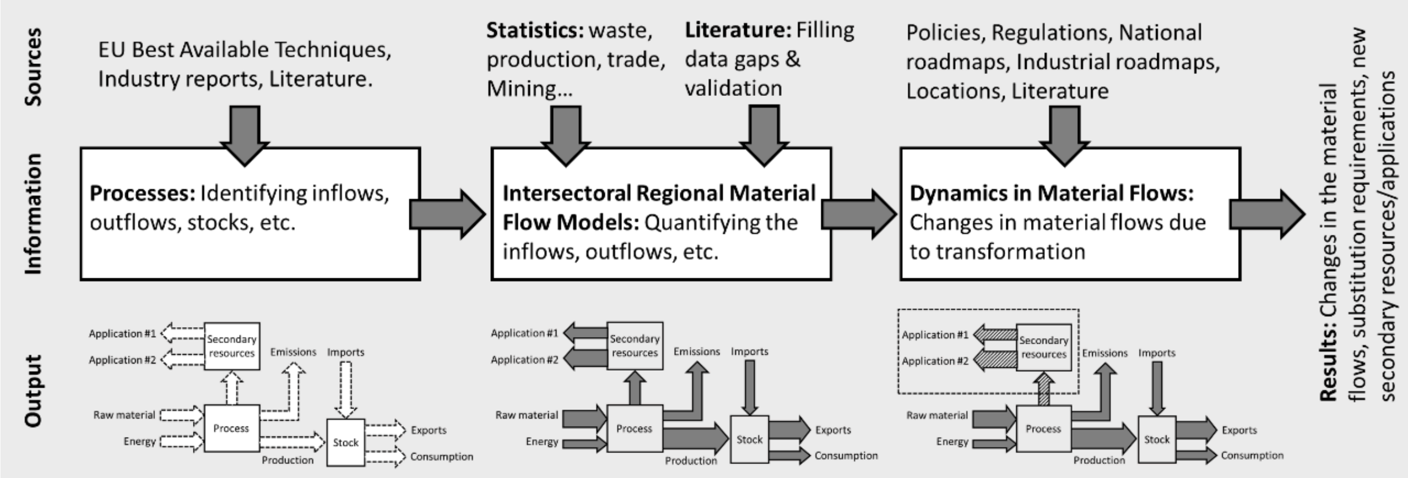
Secondary resources as **carbon sinks**

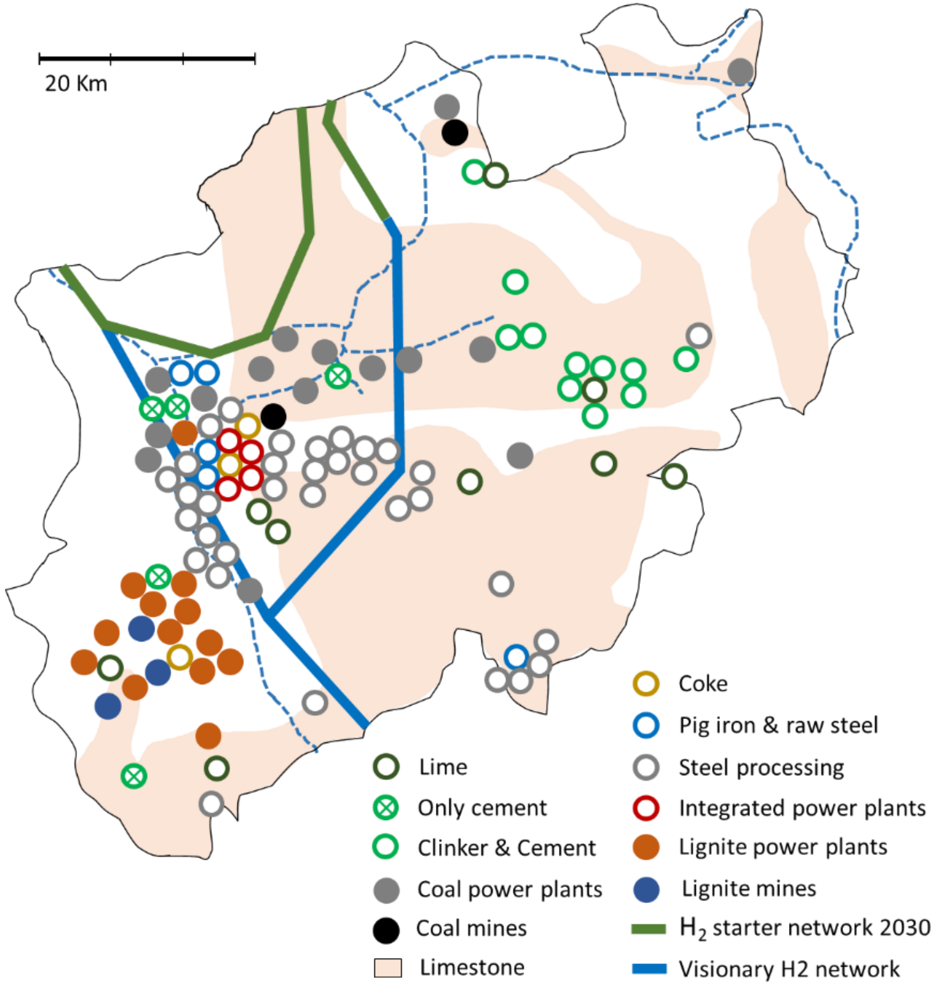
- Waste concrete
- Concrete products
- Blast furnace slag
- Steel slag (BOF, EAF)



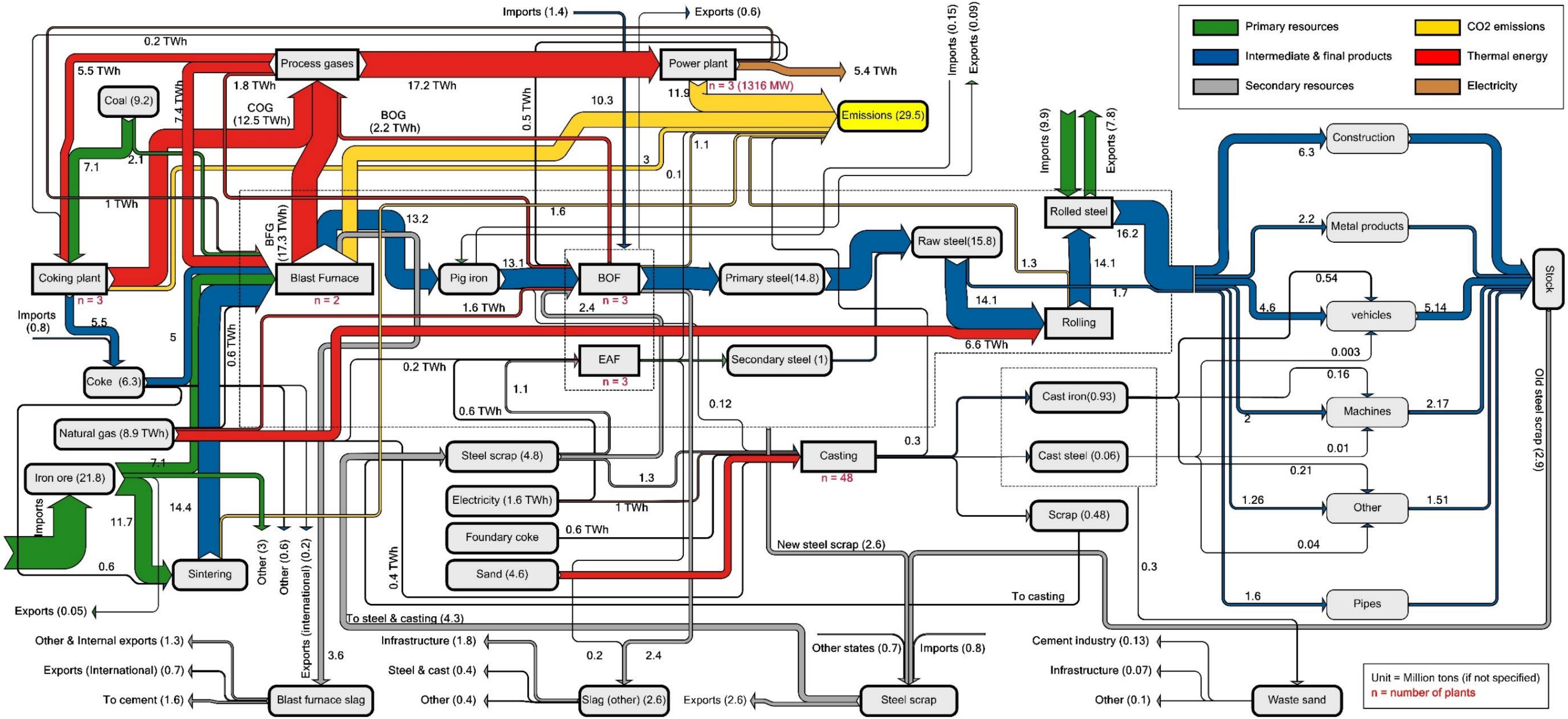
Intersectorial dynamic MFA models

- **Models:** detailed enough to account for specific plants and materials, but broad enough to account for entire industries.
- We explicitly decided against purely scaling down all values from the macro-level (i.e. Germany).
- A combination of bottom-up process analyses and extensive regional statistics data and policy analyses.
- Three industries are investigated simultaneously

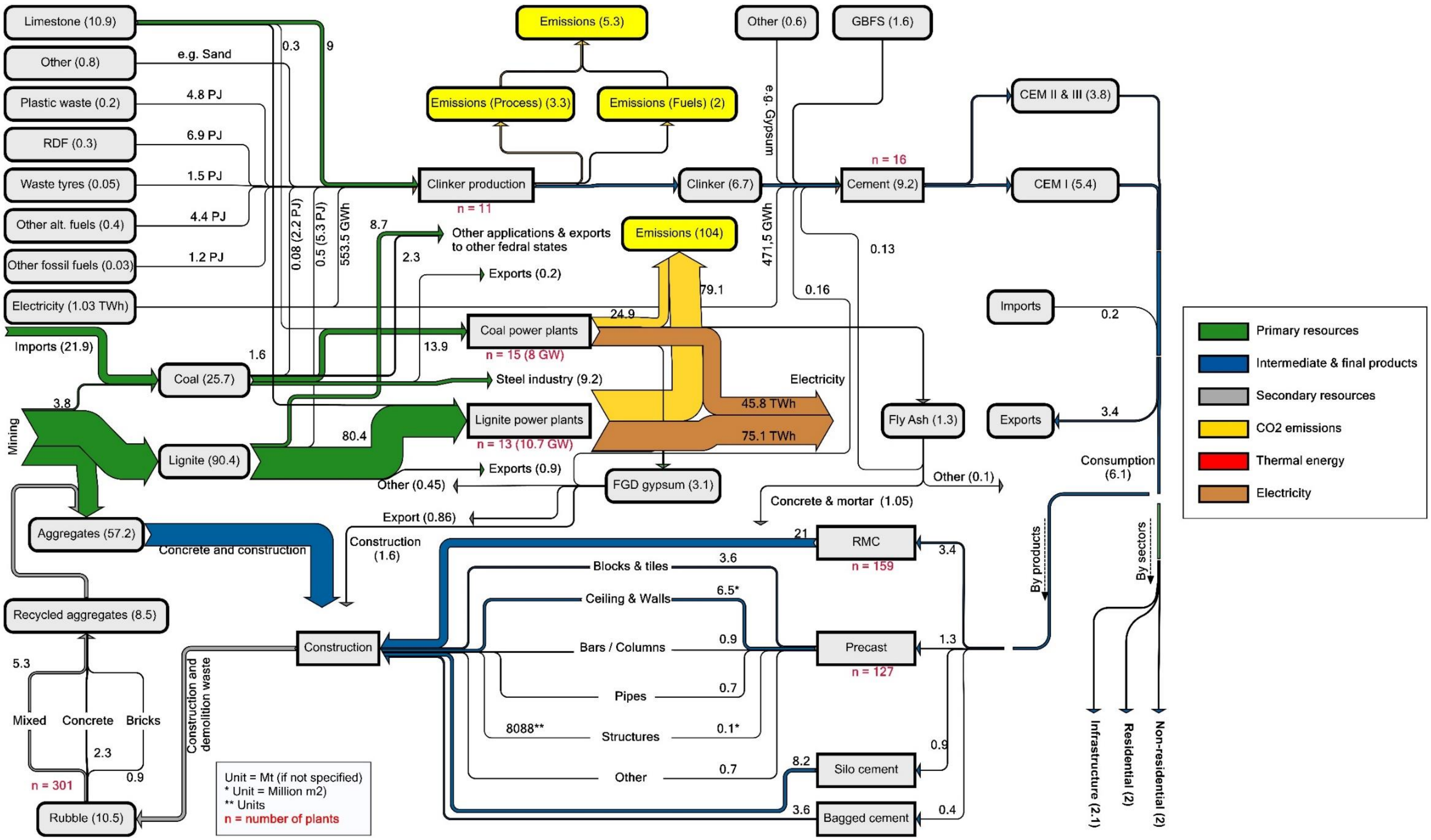




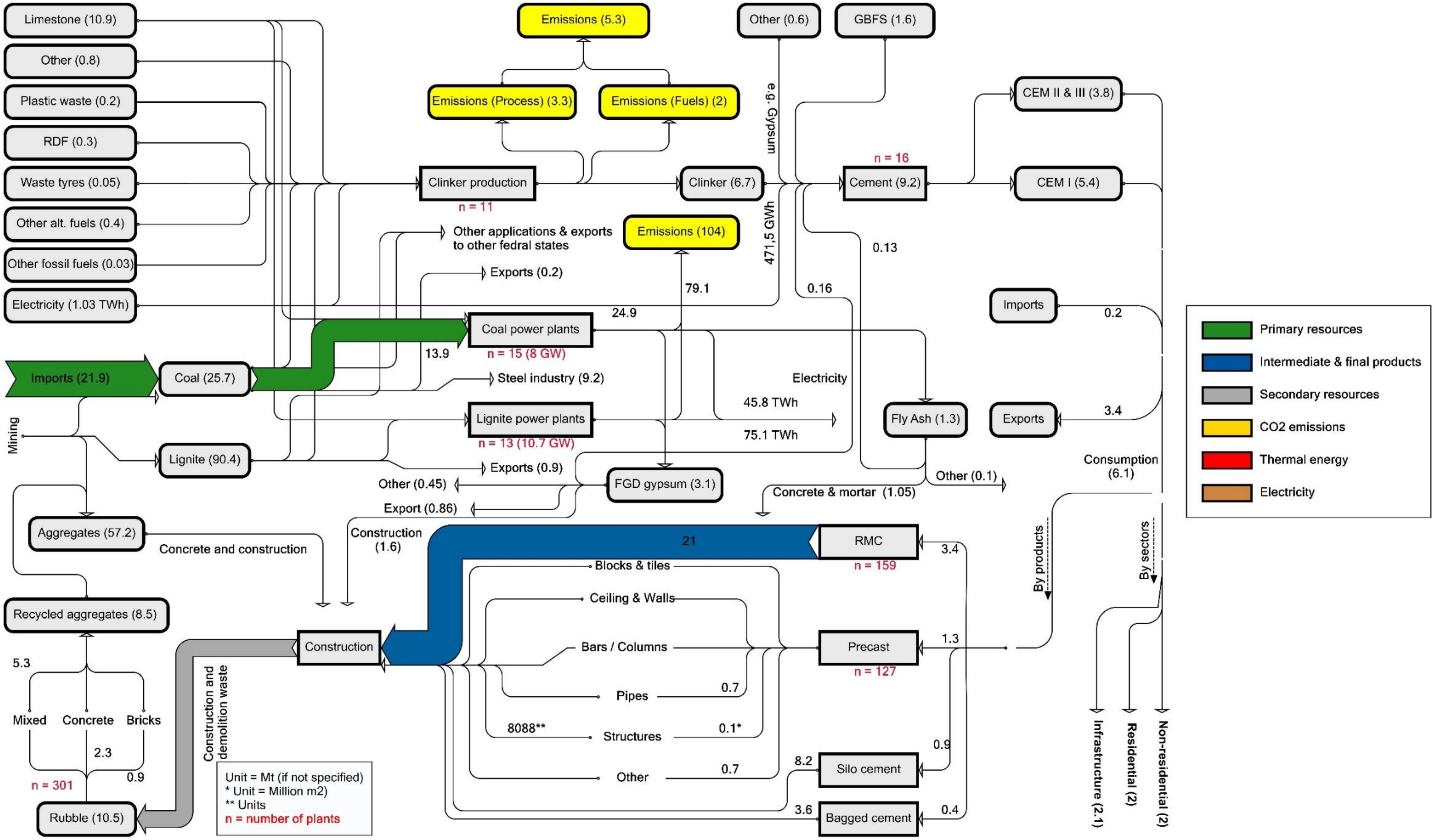
MFA Model (steel industry in NRW)



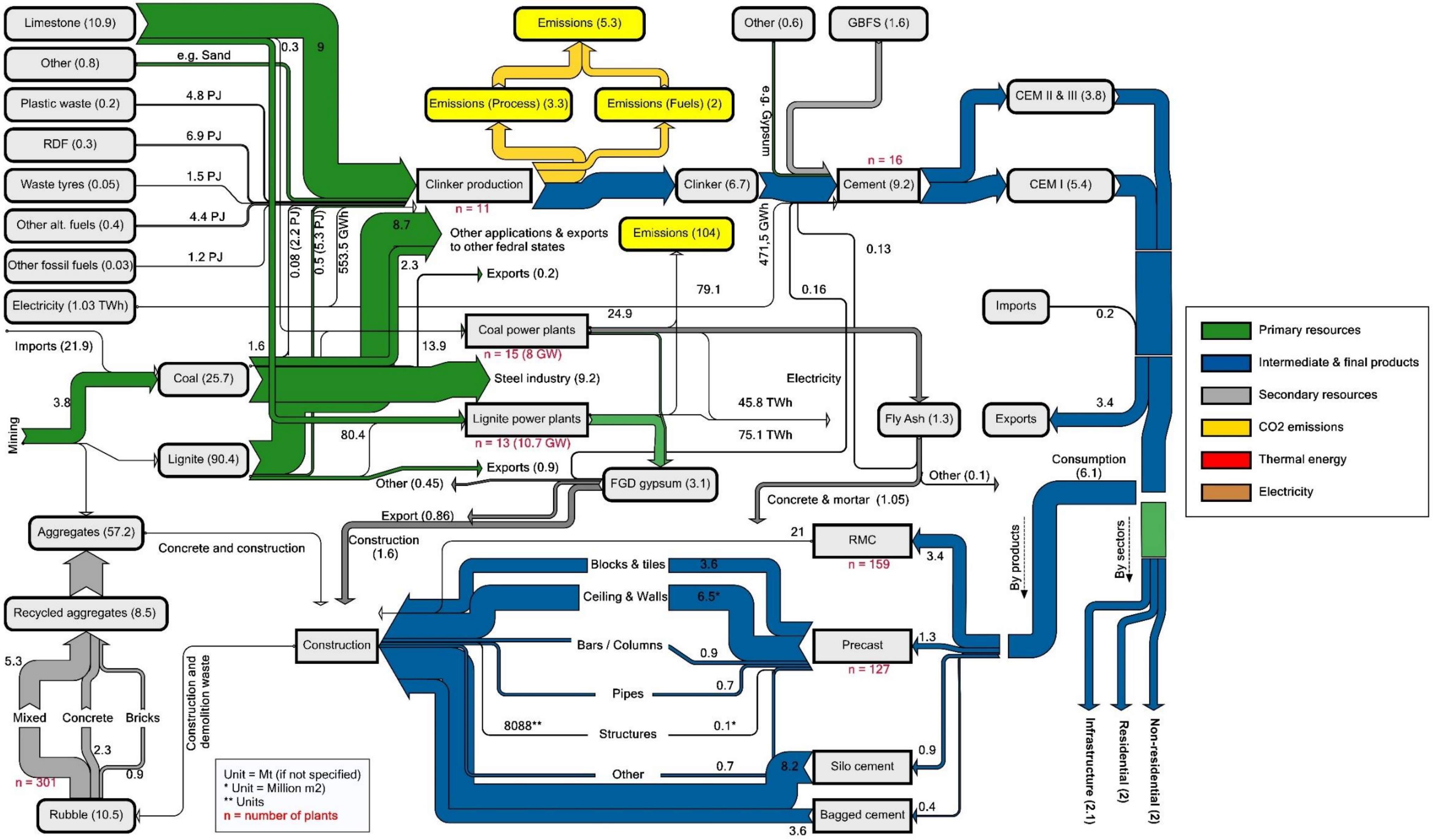
MFA Model (construction industry in NRW)



MFA Model (construction industry in NRW)



MFA Model (construction industry in NRW)



Secondary resources & applications

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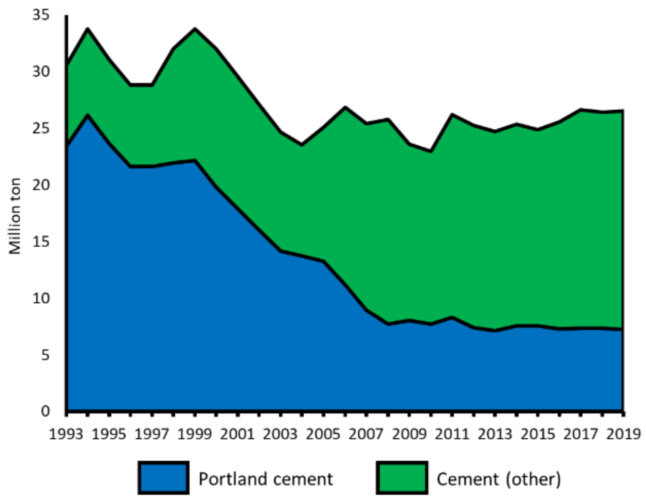

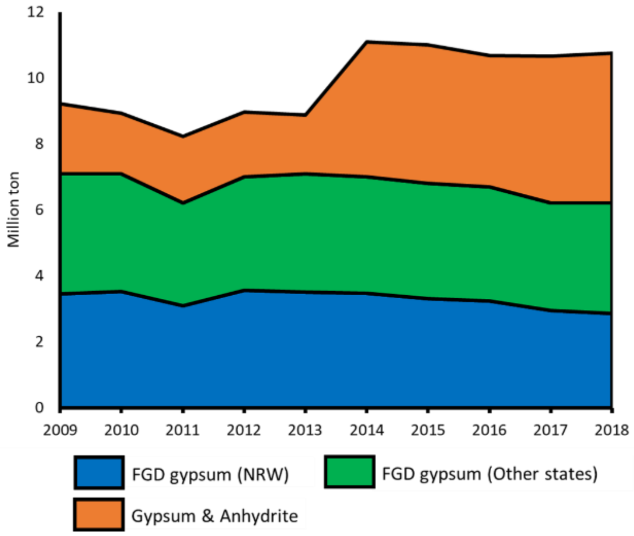

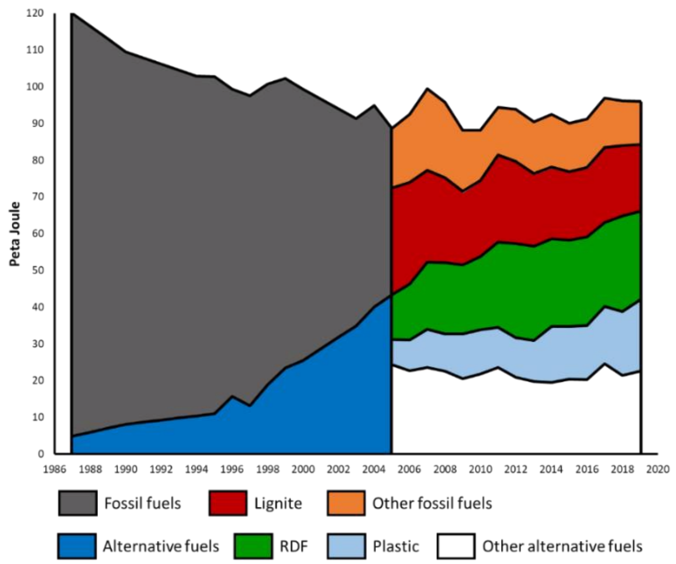

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Conclusions & Outlook

- The spatial and temporal aspects are very important for the construction sector and more specifically for promoting circularity within the industry..
- As more age classes of the housing stock are entering the deterioration phase, several changes are expected to occur in the CDW inflows in terms of quantities, composition and locations.
- The results are not only important in terms of resource efficiency, but will also help in anticipating and planning the future recycling potentials.
- The locational aspects and transportation can influence the potential CCU supply chains (carbonation) significantly.
- Besides the intended reduction of GHG emissions and increasing recycling quotas, energy transition and circularity concepts also have unintended effects on material flows (e.g. FGD gypsum).
- Changing material flows due to the GHG reduction measures might result elsewhere in an unintended increase in GHG emissions (e.g. blast furnace slag).
- Current recycling practices should be reviewed and improved (e.g. waste concrete & gypsum).

Acknowledgement

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Thanks for attention

Questions