eceee 2022

Decarbonising the building value chain of the European Union

A systematic overview of Circular Economy measures and their potential impact on basic materials

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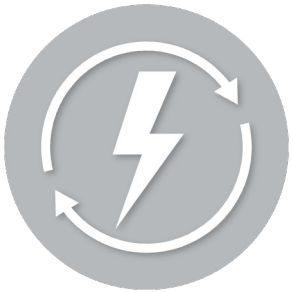
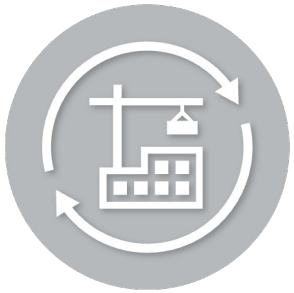
newTRENDs (H2020 project)

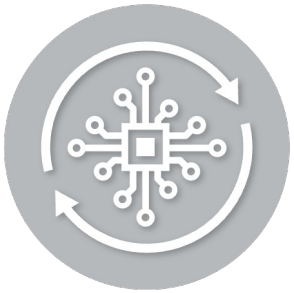
New Trends in Energy Demand Modelling



Prosumaging
Focus study on prosumagers and big data related to the built environment



Circular Economy
Focus study on the circular low-carbon economy related to the industry sector



Digitalisation
Focus study on digitalisation related to the tertiary sector

Sharing Economy
Focus study on sharing economy in the transport and the tertiary sector

Content

Content

Introduction

Relevance

- Industry decarbonisation challenging with available technologies
- Reducing material demand by implementing Circular Economy (CE) gains momentum
- Focus on the building sector
  - Large quantities of energy- and emission intensive basic materials, steel and concrete
  - EU Circular Economy Action Plan

(European Commission 2018; European Commission 2020; Rehfeldt et al 2020)

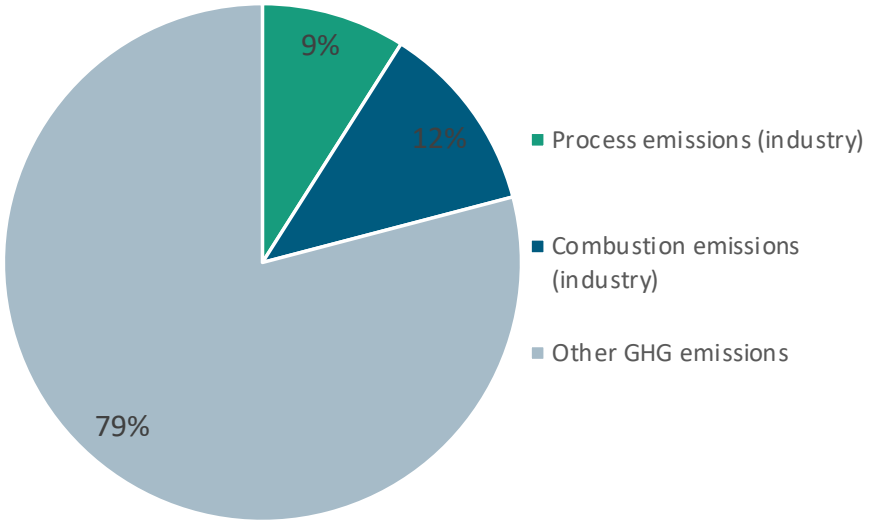


Figure 1

Industry emissions, EU 2019

(European Environment Agency 2020)

Introduction
Background

Circular Economy - an umbrella concept

"[...] *the various resource strategies grouped under the CE's banner are not new individually, the concept offers a new framing of these strategies [...]"*

(Blomsma et al. 2017)

Circular Strategies

"[...] *an economic system that replaces the 'end-of-life' concept with **R**educing, alternatively **R**eusing, **R**ecycling and recovering materials in production/distribution and consumption processes*."

(Kirchherr et al. 2017)

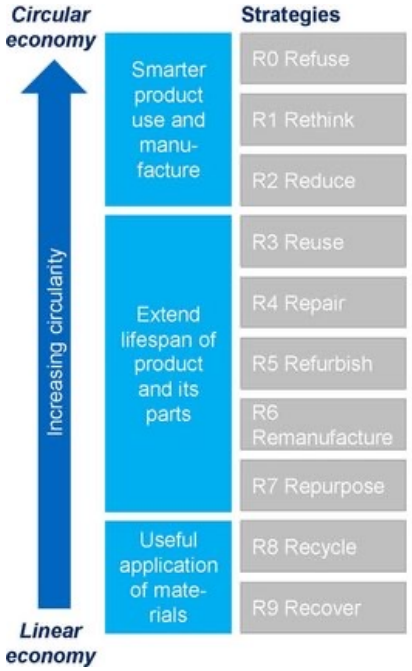


Figure 2

The 9R framework for circular strategies

(Kirchherr et al. 2017)

Introduction

Background

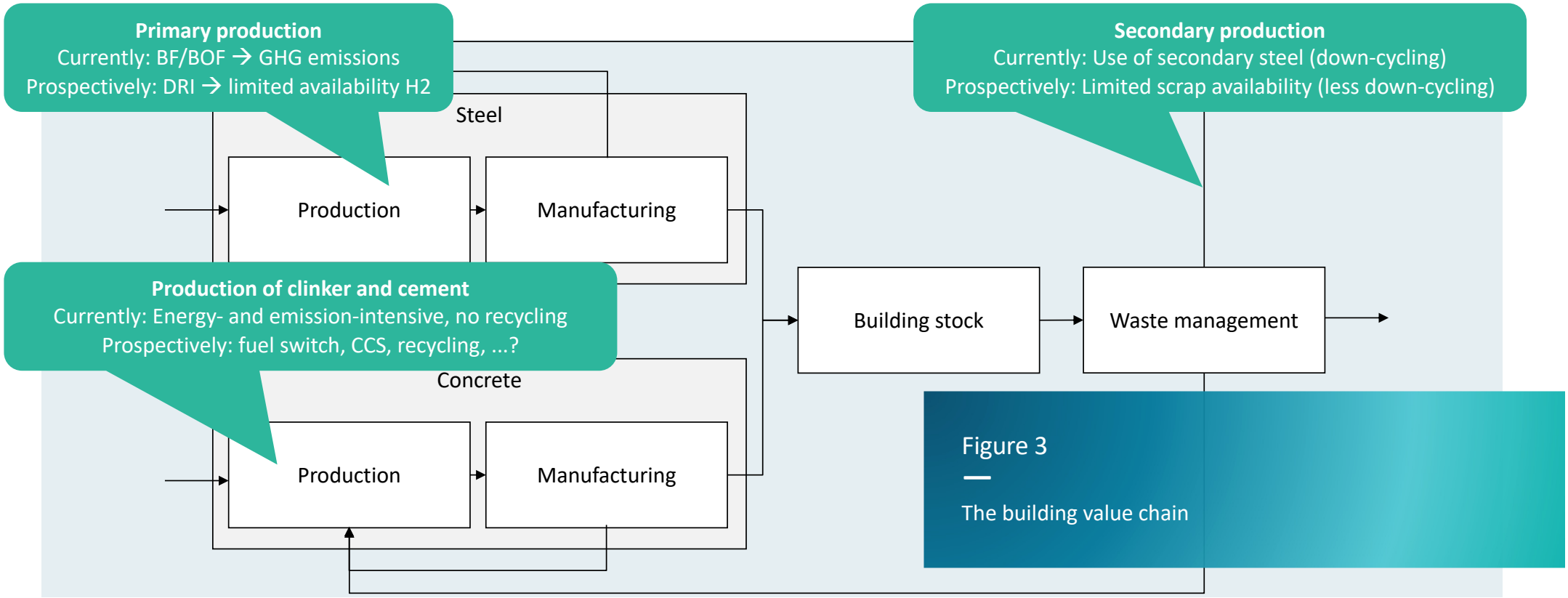


Figure 3

The building value chain

Introduction

Objective

Research objective

The identification of promising measures and supporting policy instruments in context of a Cirular Economy for the decarbonisation of the building value chain.

Objective **of this contribution**

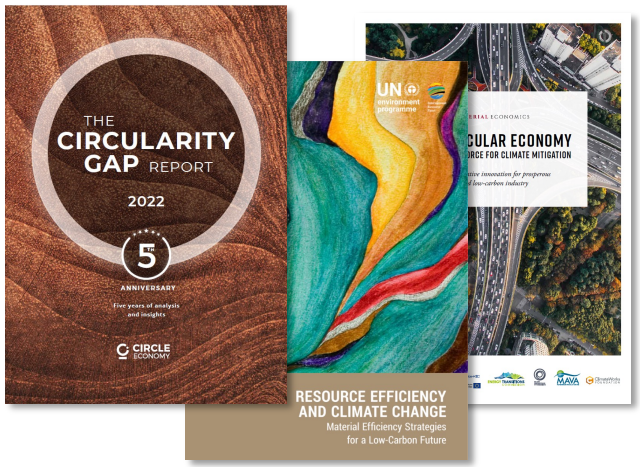
1. Identify promising Circular Economy measures for buildings and related basic materials.
2. Developing a database for the consideration of these measures in further research.

Research question

How can relevant Circular Economy measures in the building sector be compared and prioritised?

Content

Method



1. Long list of CE measures

CE measures applying to the the building value chain identified from three major publications

(Circle Economy 2022; Hertwich et al. 2020; Material Economics 2018)

2. Fact sheets

Fact sheets for five measures with high impact on GHG emissions including

- Description
- Materials and value chain stage
- 9R category
- Limitations and potentials

3. Multi-criteria decision analysis

- Weighted sum method
- Criteria (Calzolari et al. 2022)
  - Reduction of material demand
  - Reduction of energy demand
  - Reduction of GHG emissions
  - (Reduction of costs)
- Rating
  - From 1 to 4
  - Based on 1st quartile, average and 3rd quartile of the relative reduction
- Weighting
  - Focus on GHG emissions (40%)
  - Equal distribution for other criteria
- Reference: EU-28, 2020 (Lotz et al. 2021)

Fraunhofer ISI

Content

Results

Fact sheets

Seven measures considered in MCDA

Table 1 Overview of fact sheets

Fact sheet	CE measure	Consideradtion im MCDA
1	Reducing floor space demand	Yes
2	Material efficiency during construction of buildings	Yes, as two measures (adapted design and reduced over-specification)
3	Reuse of buildings and building components	Yes
4	Recycling of construction materials	Yes
5	Substituting construction materials	Yes, as two measures (subtitution with timber or innovative concrete)

Results

Multi-criteria decision analysis

Table 2 Results of the multi-criteria decision analysis

	Cost	*GHG emissions*	*Material demand*	*Energy demand*	*Total*	
Reducing floor space demand	0,6	0,8	0,6	0,2	2,2	
Adapted design	0,8	1,2	0,8	0,4	3,2	←
Reduced over-specification	0,6	0,8	0,6	0,8	2,8	←
Reuse of building components	0,6	0,4	0,6	0,4	2	
Recycling of cement from concrete	0,2	1,6	0,2	0,8	2,8	←
Substituting concrete with timber	0,8	1,6	0,8	0,6	3,8	←
Substituting concrete with innovative pre-cast concrete	0,2	0,4	0,2	0,2	1	

Results

Fact sheets

Table 3 Fact sheet: Substituting construction materials (Karlsson et al. 2020; Hertwich et al. 2020; Le Den et al. 2020)

Aspect	Content
Description	Substituting high-impact materials (e.g. timber or innovative concrete)
Material	Concrete
Value chain stage	Use phase
9R category	Refuse (R0)
Applicability	All building types
Limitation	Depending on substitute, e.g. timber (sustained availability, heating)
Potential	45% reduction of concrete demand in residential buildings when using timber 70% reduction of GHG emissions during production of pre-cast concrete

Use of timber and innovative concrete are considered separately in the MCDA

Results

Fact sheets

Table 4 Fact sheet: Material efficiency during construction of buildings (Hertwich et al. 2020; Circle Economy 2022; Allwood 2017; Le Den et al. 2020)

Aspect	Content
Description	Reducing material demand by adapting design or reducing over-specification
Material	Steel, concrete
Value chain stage	Use phase
9R category	Reduce (R2)
Applicability	All buildings
Limitation	Adaption of building standards (e.g. Eurocodes)
Potential	15% steel and 20% concrete demand reduction by adapted design 41% steel and 12 concrete demand reduction by reduced over-specification

Adapted design and reduced over-specification are considered separately in the MCDA

Results

Fact sheets

Table 5 Fact sheet: Recycling of construction materials (Circle Economy 2022; Hertwich et al. 2020; Material Economics 2018; Le Den et al. 2020)

Aspect	Content
Description	Increased recycling of construction materials decreasing the primary material use
Material	Concrete
Value chain stage	Waste management
9R category	Recycle (R8)
Applicability	All building types
Limitation	Limited availability of secondary material
Potential	25% primary cement demand reduction

Content

Conclusion

Results

- Comparison of CE measures
  - Different types: material substitution, material efficiency and recycling
  - High impact of measures addressing use phase (high R prio)
  - High impact of recycling (lower R prio)
- Prioritisation of CE measures
  - R framework as indicator
  - Relevant measures considered by existing policy frameworks
  - „New“ measures have to be added to the discussion
- Impact depends on actual implementation and policy framework

Conclusion

Data and method

- Established a database structure for CE measures
- Limited data availability, especially for costs
- Results depend strongly on parametrisation, further validation needed
- Improve analysis by adding further criteria and CE measures

Outlook

- Database for the modelling of circular economy
- Include data in material flow modelling approach
- Consider circular economy in transformation pathways of the industry sector

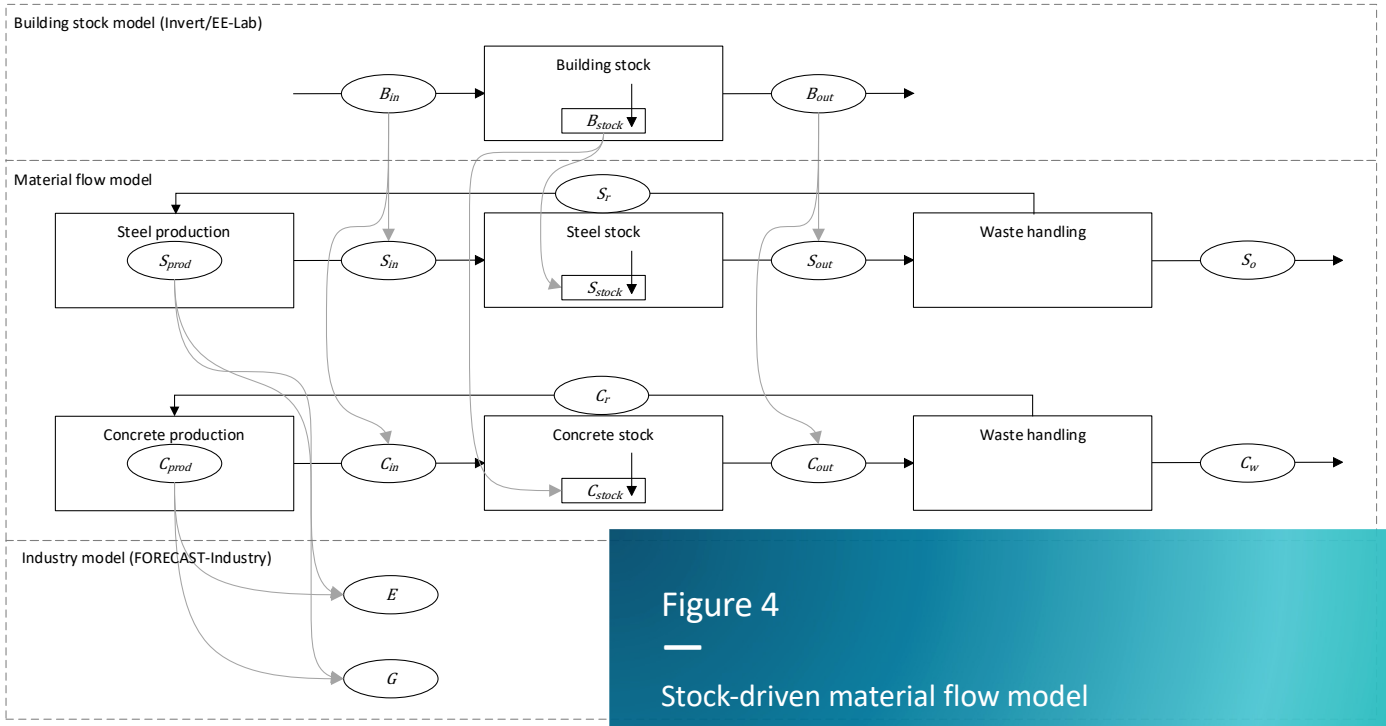


Figure 4

Stock-driven material flow model

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Results

Fact sheets

Table 6 Fact sheet: Reducing floor space demand (Circle Economy 2022; Hertwich et al. 2020; Le Den et al. 2020)

Aspect	Content
Description	Reducing floor space demand by sharing spaces or reducing building size
Material	Steel, concrete
Value chain stage	Use phase
9R category	Rethink (R1)
Applicability	Residential buildings, offices
Limitation	Contrary to current trend, requires substantial behavioural change
Potential	20% reduction of floor space demand in residential buildings 36% reduction of floor space demand in offices

Results

Fact sheets

Table 7 Fact sheet: Reuse of buildings and building components (Karlsson et al. 2020; Hertwich et al. 2020; Material Economics 2018; Le Den et al. 2020)

Aspect	Content
Description	Reuse of building structures and components for new purpose/at new location
Material	Steel, concrete
Value chain stage	Use phase
9R category	Remanufacture (R6), repurpose (R7)
Applicability	All buildings
Limitation	Standardization and modularization of building components required
Potential	65% steel and 50% pre-cast concrete demand reduction