

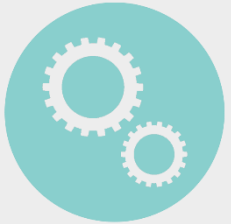


# URBAN MINING

## IN DESIGN AND CONSTRUCTION PROCESSES

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A study on implementing urban mining of existing building elements in the local housing for improving the construction industry towards a circular economy



# Content

Introduction

Research setup

Supply side

Demand side

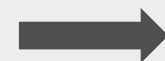
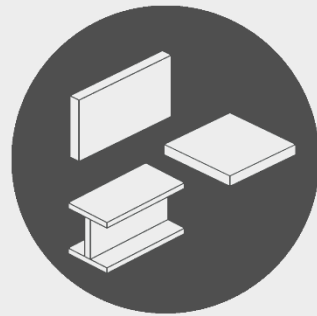
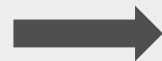
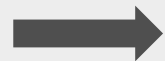
Operational model

Results & discussion

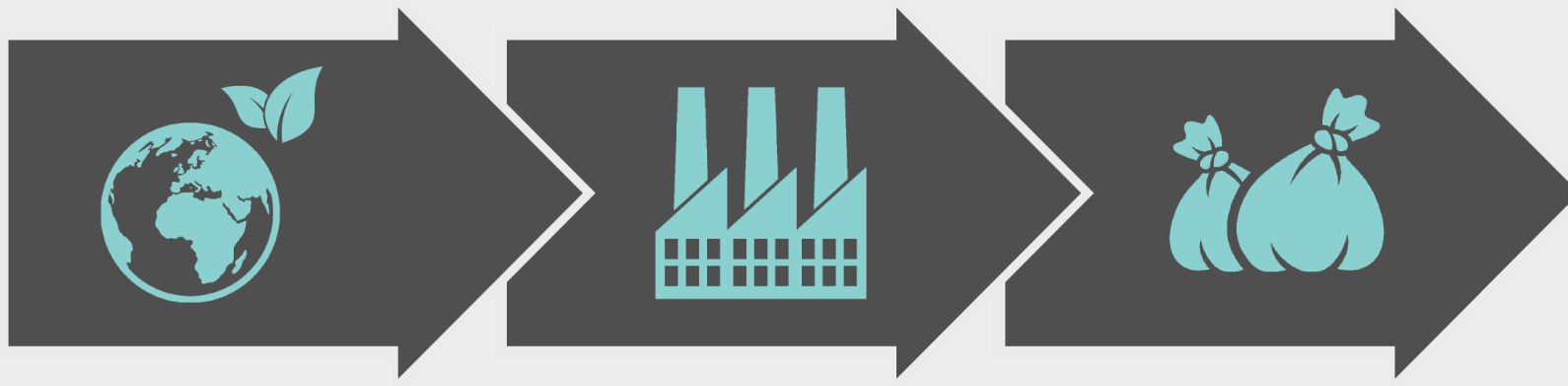
Conclusion

Recommendations





(most of the) **Construction sector**  
is a linear economy



**Take**

**Make**

**Dispose**



# Current trends



**Renewable  
energy**



**Digital  
innovation**



**Recycling**



**Zero waste**



**CO2-UITSTOOT 1990  
10,79 TON  
PER NEDERLANDER**

**TAAT  
HET  
MAAT**

**49% MINDER IN 2030  
100% MINDER IN 2050**



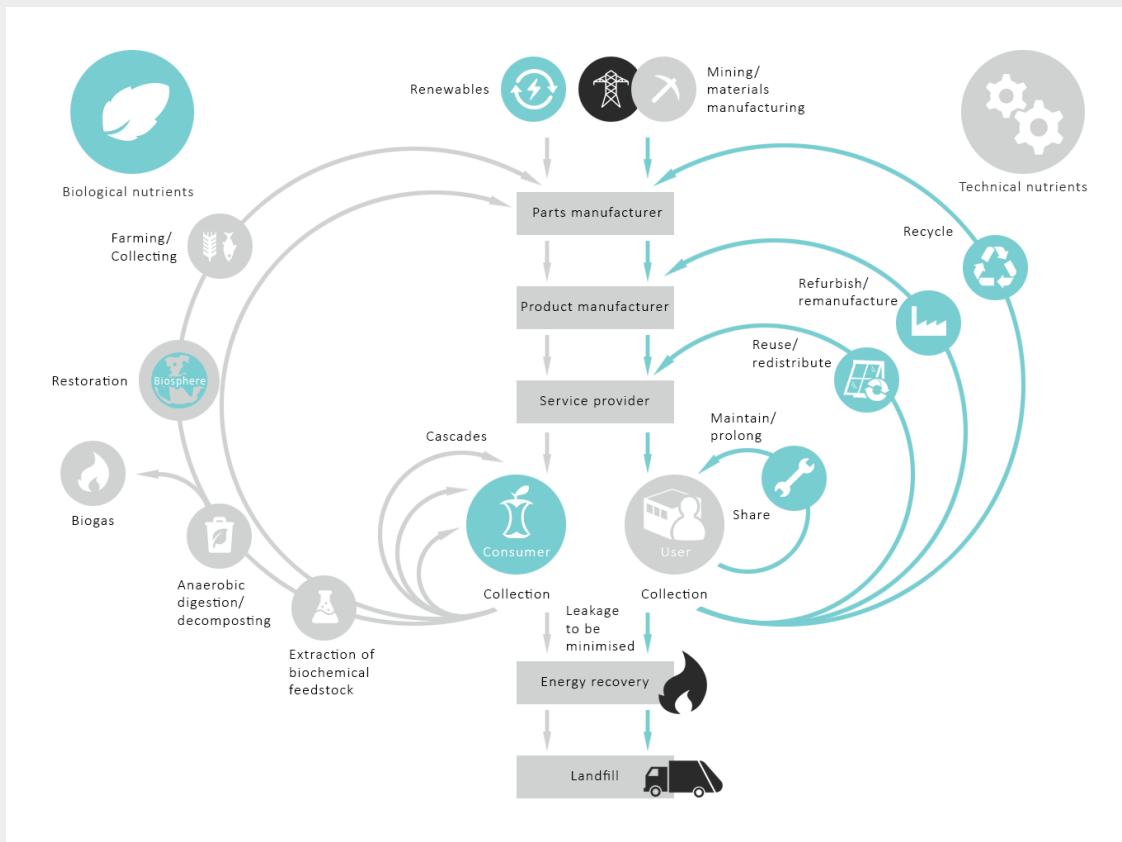




# SUSTAINABLE DEVELOPMENT GOALS



Source: United Nations (2018)



(EMF, 2017)



Home Nieuws Columns/Interviews  
Mijn DuOn

## Miljoenennota 2020: eenmalig € 88 miljoen voor circulaire economie beschikbaar

Geplaatst op 17 september 2019

Vandaag is op Prinsjesdag 2019 de Miljoenennota gepresenteerd. In deze begroting voor 2020 wordt maar liefst eenmalig € 88 miljoen beschikbaar gesteld voor de circulaire economie. Een opsomming van de voor het bedrijfsleven interessante zaken op het gebied van duurzaamheid.

Ministerie van Infrastructuur en Waterstaat

Source: <https://www.duurzaam-ondernemen.nl/miljoenennota-2020-eenmalig-e-88-miljoen-voor-circulaire-economie-beschikbaar/>



# Construction sector

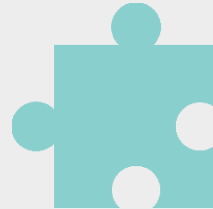
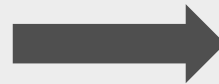
Linear economy



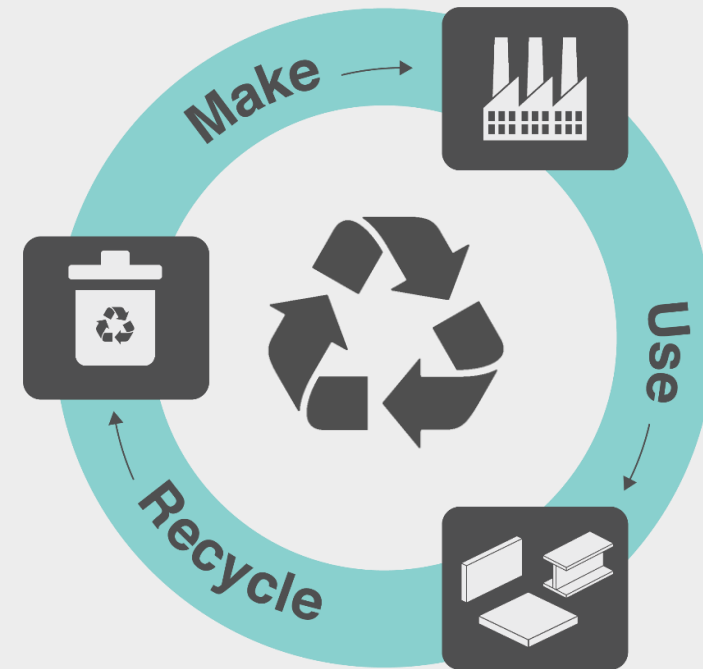
Take

Make

Dispose



Circular economy







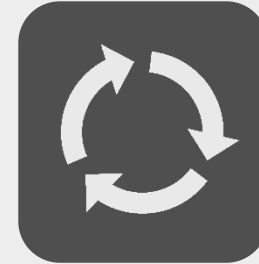
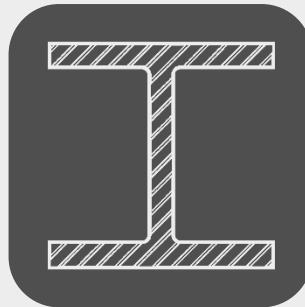
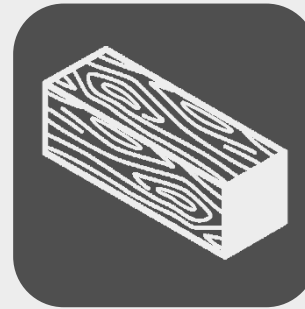
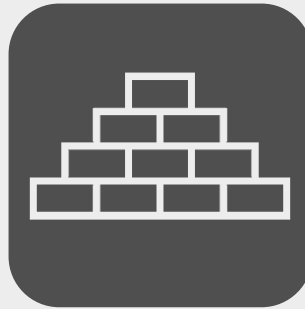




## Processing factories

- Processing waste
- Pollution
- Overproducing of materials
- Not cost efficient

## Virgin building materials



## Shorter lifespan

- Less reuse of materials
- No circular process
- Leftover of materials
- No sustainable certificate or subsidies



A photograph of a two-story brick house with a steep gabled roof. A complex wooden structural frame, consisting of numerous vertical and diagonal beams, is being added to the exterior of the house, particularly around the windows and along the roofline. The house is situated on a green lawn with several trees and bushes. A man in a brown jacket and khaki pants stands in the foreground on the right, looking towards the house. In the upper right corner, there is a white circular logo containing the letters "JIP".

JIP

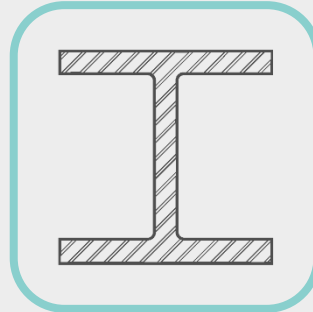
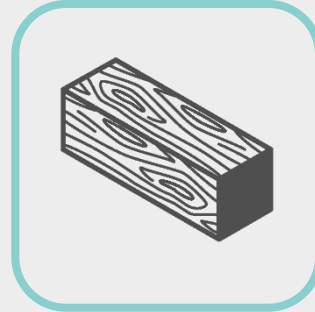
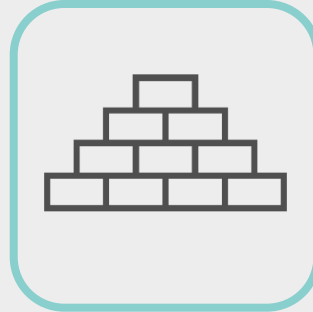


# Reusable materials



## Datasets

- Information on building materials
- Multiple companies possess datasets
- CE proposes collaboration and transparency



## Artifacts

- Urban mining methods
- Neglected dwellings
- Leftover materials of valuable quality
- No costs for processing new materials

## DREIGEND TEKORT AAN BOUWMATERIALEN IN NEDERLAND

Bastiaan Kleinjan / maandag 8 mei 2017, 8:05



Foto: HH/Erik-Jan Ouwerkerk



['Op het moment dat er meer nieuwbouw nodig is, krijg je een probleem'](#)

Er dreigt een tekort aan bouwmaterialen in Nederland. Tijdens de crisis was er zo weinig vraag, dat de productiecapaciteit van Nederlandse bedrijven flink naar beneden ging. Nu er weer meer gebouwd wordt, kan er niet genoeg worden geproduceerd om aan die vraag te voldoen.

Dat zegt de vereniging Koninklijke Nederlandse Bouwkeramiek tegen BNR. 'Je ziet een aantal producten uit de toelevering van de bouw uit Nederland verdwijnen', constateert Dick Tommel van die vereniging. 'Die productie is in de loop der jaren naar het buitenland verplaatst, omdat de productieomstandigheden in de landen om ons heen aanzienlijk prettiger zijn dan in Nederland. Dat is echt een probleem aan het worden', vervolgt hij.

Source: <https://www.bnr.nl/nieuws/economie/10322255/dreigend-tekort-aan-bouwmaterialen-in-nederland>

WOENSDAG 29 NOVEMBER 2017, 06:13

DEEL DIT ARTIKEL:



## Bouwbedrijven komen om in het werk, maar hebben tekort aan materiaal

Heipalen, vloeren, kalkzandsteen en prefab-kappen. Het duurt weken voordat bepaalde bouwmaterialen kunnen worden geleverd. De lijst met materialen waar een wachttijd voor geldt, wordt steeds langer. De Zeeuwse bouwbedrijven profiteren van de populariteit van nieuwbouw, maar hebben er tegelijkertijd ook last van. Doordat materialen niet op tijd geleverd kunnen worden, ligt de bouw soms enkele weken stil.

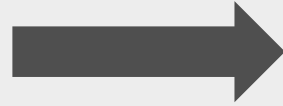


Bouwbedrijven plannen zich een ongeluk om alle projecten draaiende te houden

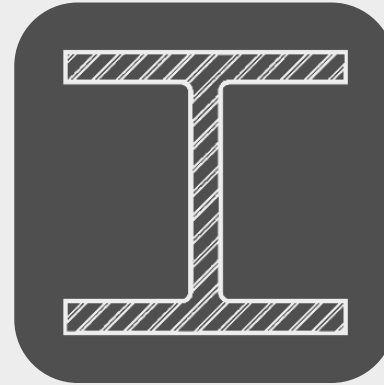
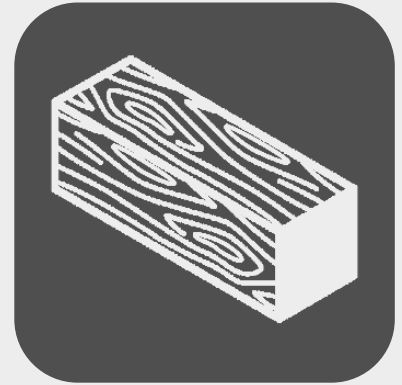
Dat de bouw enkele weken stilligt is vervelend, maar dat betekent niet dat het personeel van de bouwbedrijven thuis zit. Er is namelijk genoeg werk om de bouwvakkers tussen projecten heen en weer te sturen. "Dat doe je liever niet, maar als het niet anders kan, zoals nu, dan doe je het. Het fijnste is natuurlijk als onze mensen op een project beginnen en die achter elkaar door kunnen afmaken", legt directeur Hans Boogert van bouwbedrijf Boogert uit.

Source: <https://www.omroepzeeland.nl/nieuws/102347/Bouwbedrijven-komen-om-in-het-werk-maar-hebben-tekort-aan-materiaal>

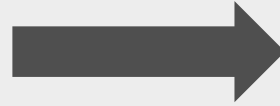
## Construction sector



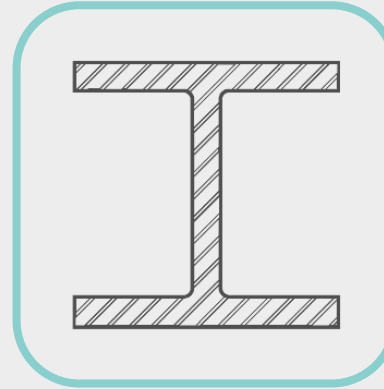
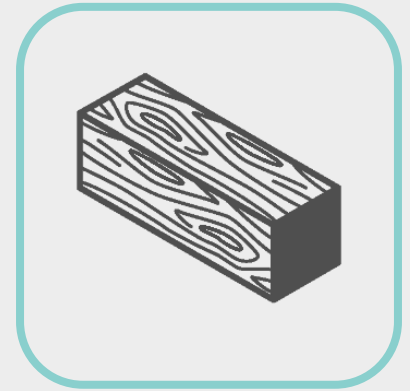
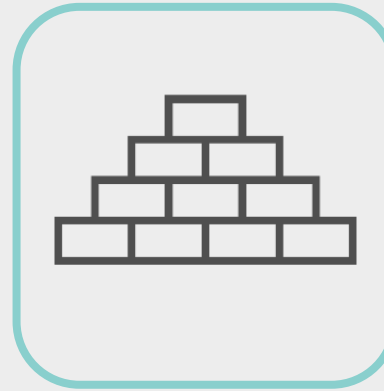
## Virgin materials



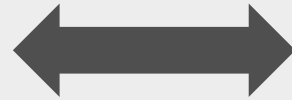
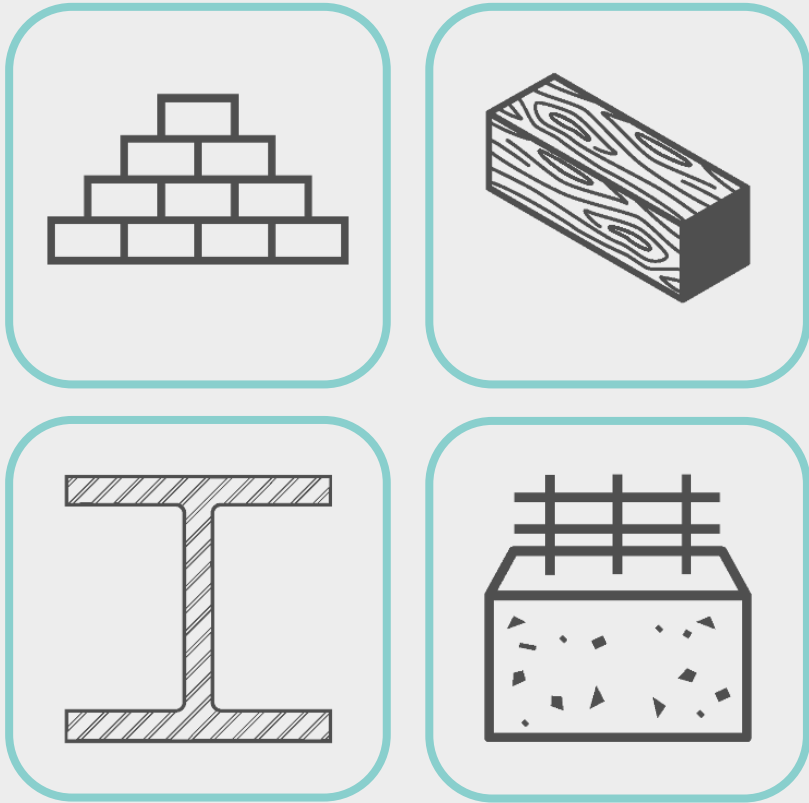
## Groningen Case



## Reusable materials



## Reusable materials



## Construction sector



**CONNECTION IS MISSING**

# Research question

*How can an operational model link the supply of existing building materials with the demand for new construction projects in order to reduce the use of virgin materials and thereby improve circularity in the construction industry?*

*What specifications are necessary for a case study to be implemented as input for the operational model?*

*What is the current demand in the construction industry for new housing projects?*

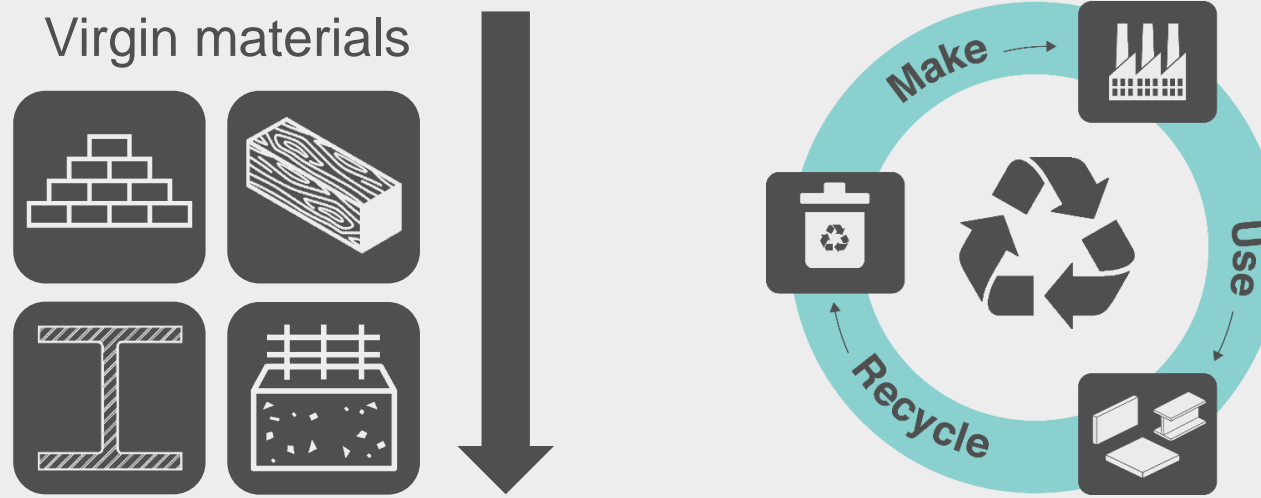
*How can a comparison between the overview of the costs of virgin and existing building elements for new dwellings provide a feasible business opportunity?*

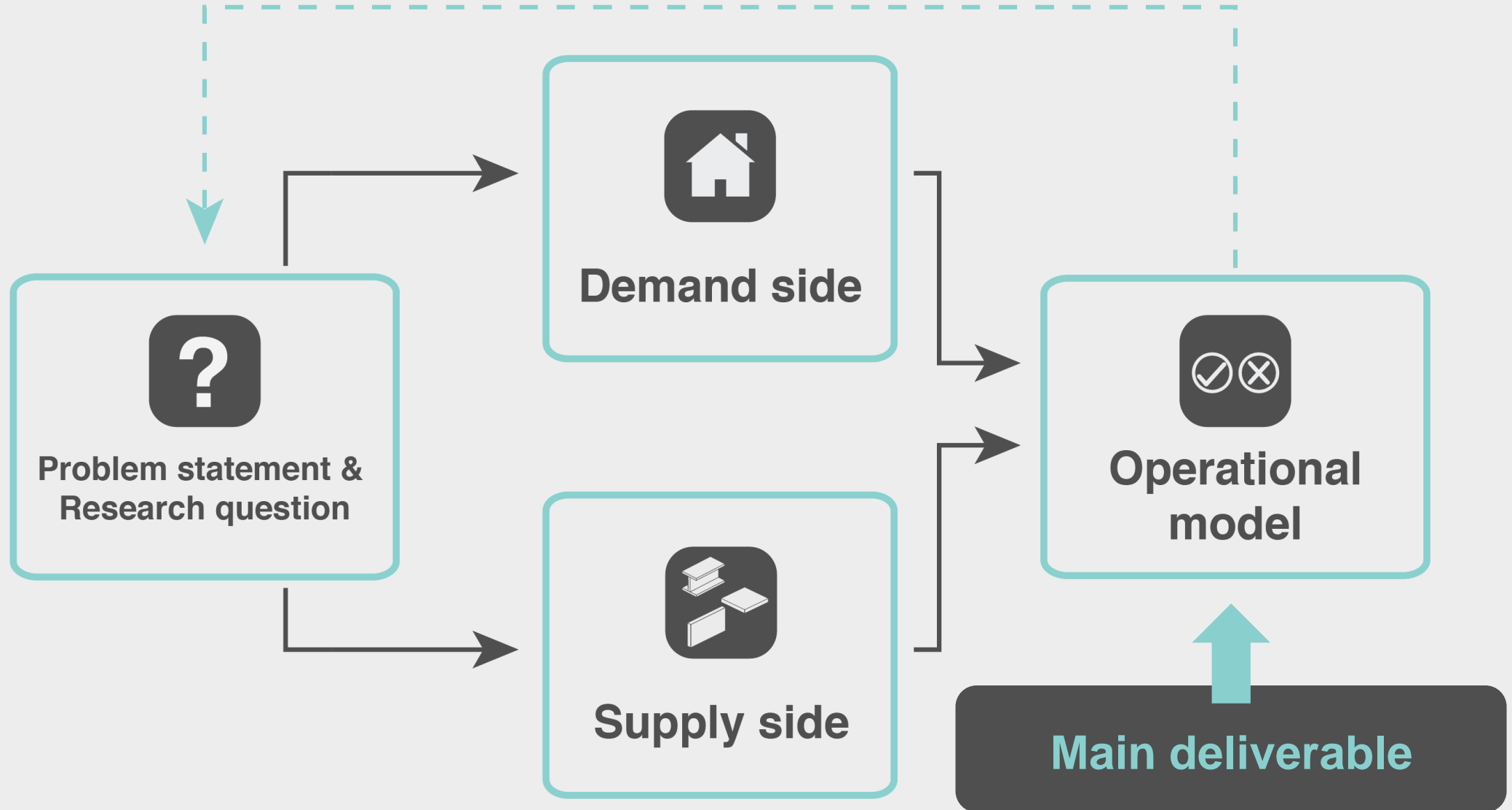




# Research goal

*The goal of this research is to minimize the usage of virgin building materials in starting construction projects to support the transition towards a circular economy.*





# Supply side



Case studies



## Context

Location  
Stakeholders  
Amount



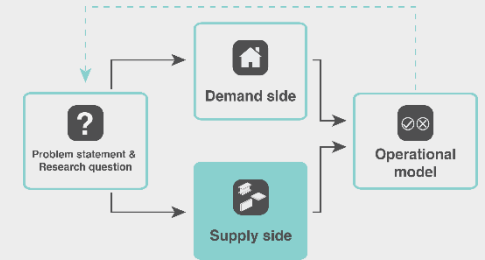
## Building information

Neglected housing  
Materials  
Building elements



## Energy transition

Demand for  
sustainable projects  
Circular economy  
Climate agreement Paris



# Levels of scale



## Project-based

Focus on one or few projects  
Small setup  
Short timespan  
Few stakeholders  
Different materials and building elements



## Region-based

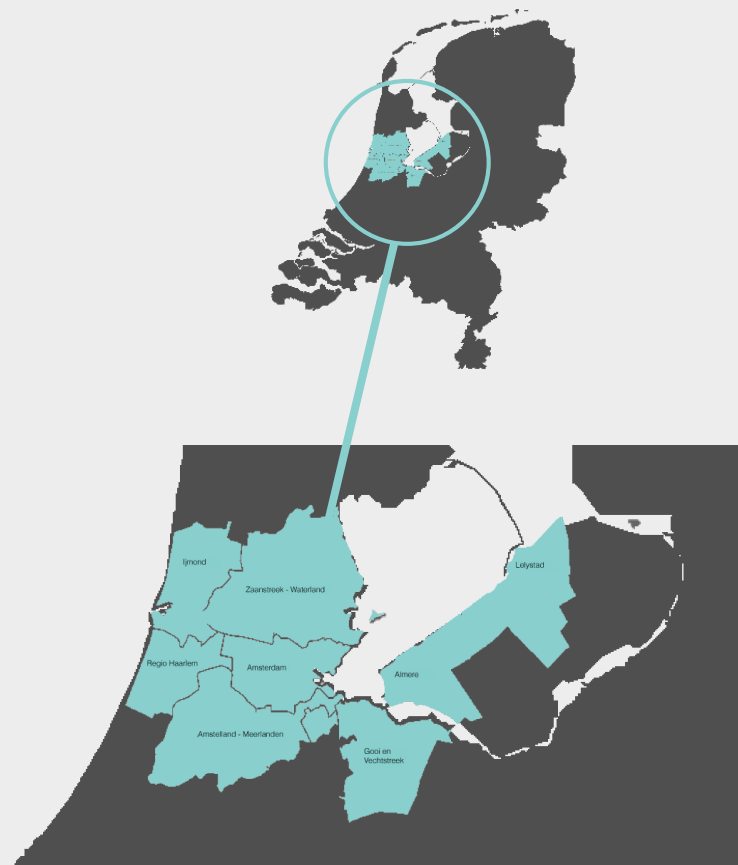
Focus on specific area  
Multiple stakeholders  
Municipality involved  
Data from multiple projects



## Enterprise-based

Focus on system  
Choice of specific material  
Perspective from company  
National / international orientated





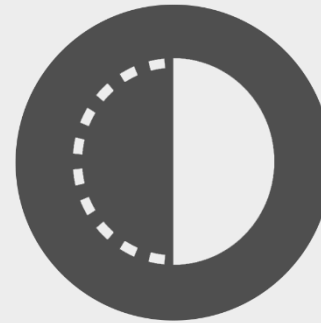


# **General Data Protection Regulation**

# Privacy regulations



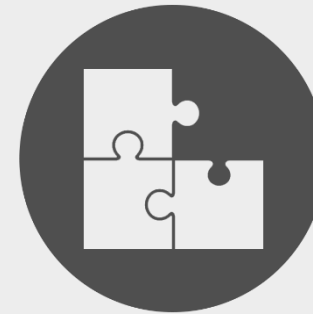
**Competition** instead of **collaboration** between 'middle man' companies.



Lack of **transparency** in building information.



Companies with datasets **not willing to share** the information.

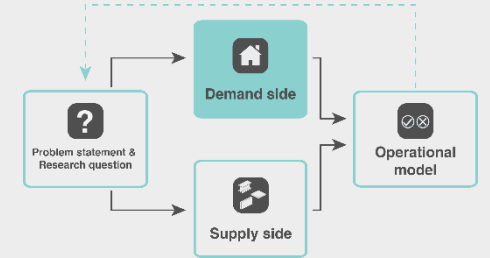


**Gaps of information** between suppliers, due to many different systems.





# Demand side



Literature study



Dwelling prototypes



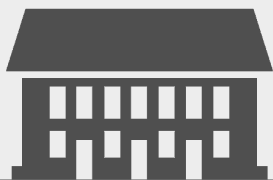
Construction costs





Dwelling prototypes

Based on:  
*Referentiewoningen*  
*Rijksoverheid*



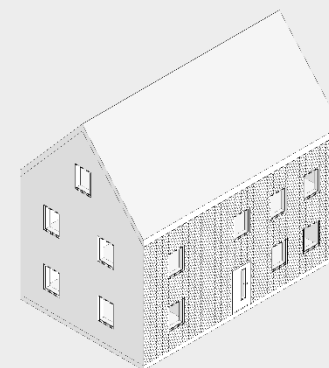
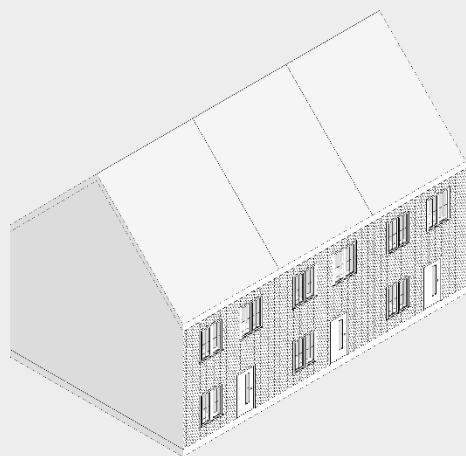
Type A:  
*Standard row-house*



Type B:  
*Semi-detached dwelling*



Type C:  
*Detached dwelling*



# Dwelling prototypes

**General dwelling information**

**Dimensions [m2]**

NVO

BVO

**Volume [m3]**

NVO

BVO

Foundation

Floors

Exterior walls

Roof

Interior walls

**Building elements**  
Per facade or level

**Building material**  
Dimensions / products  
[m2] / #

**Reusability scale**

**Building material information**

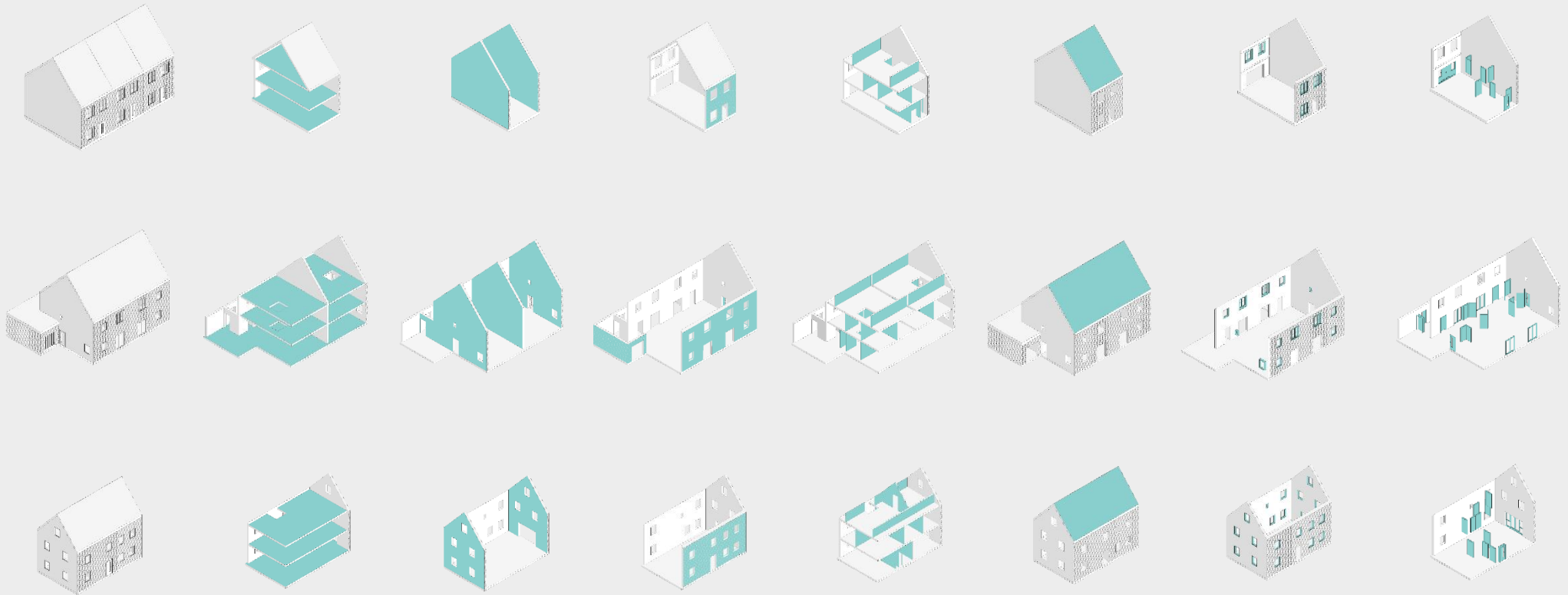
**Material costs**  
€

**Specific weight**  
[kg/m3]

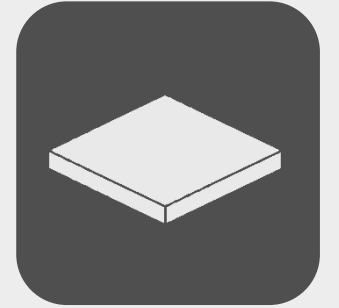
**Total material weight  
in reference dwelling**  
[kg]



# Reusable building materials



# Floors

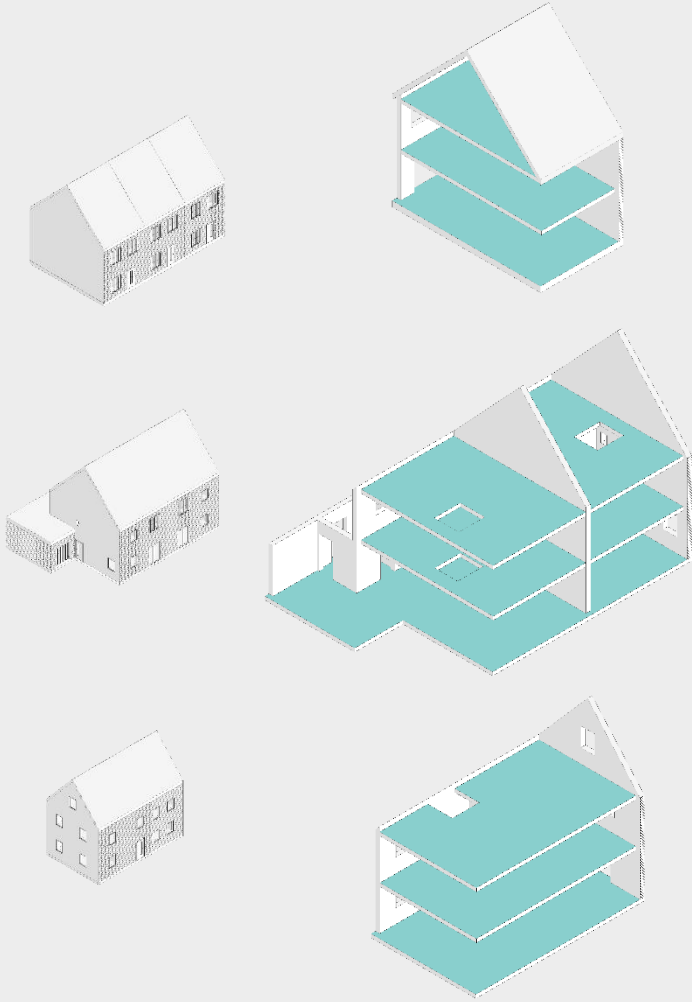


## Channel plate floors

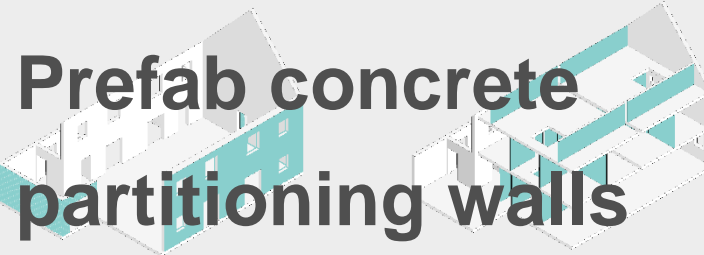
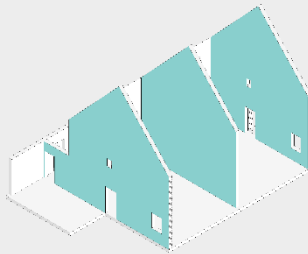
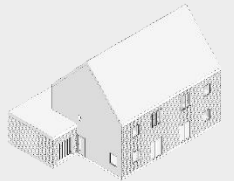
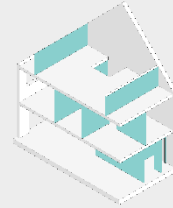
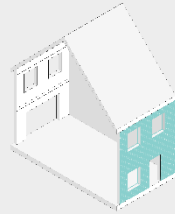
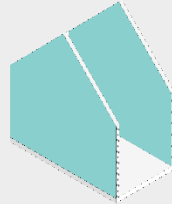
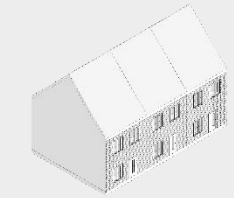
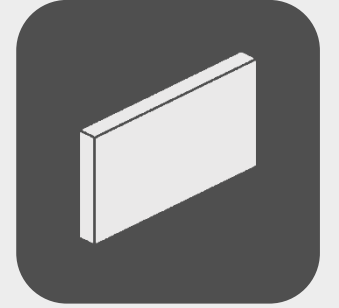
- Ground floor 150mm thickness
- 1<sup>st</sup> / 2<sup>nd</sup> floor 200mm thickness

Source:

[http://www.bouwkosten.nl/Materiaalprijzen/Bouw,\\_installatie,\\_terrein/Systeemvloer,\\_kanaalplaatvloer/kostengegevens-Prijzen,\\_Normen\\_en\\_Tarieven/2355278.htm](http://www.bouwkosten.nl/Materiaalprijzen/Bouw,_installatie,_terrein/Systeemvloer,_kanaalplaatvloer/kostengegevens-Prijzen,_Normen_en_Tarieven/2355278.htm)



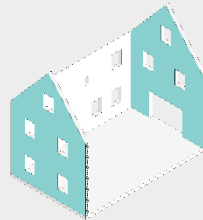
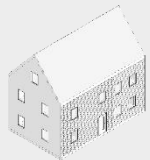
# Walls



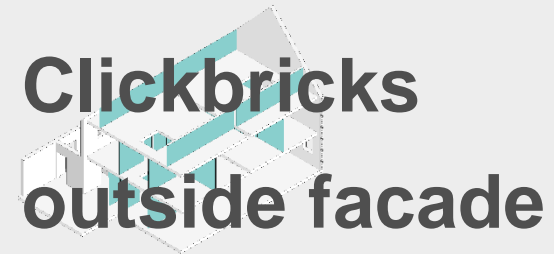
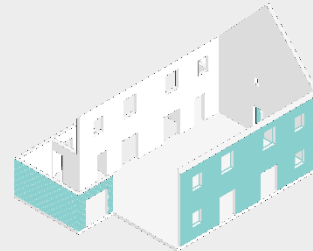
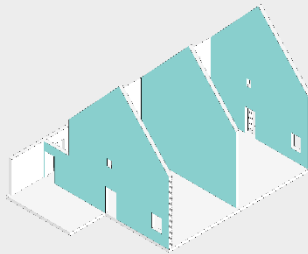
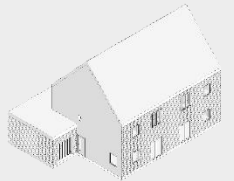
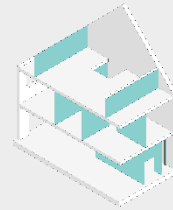
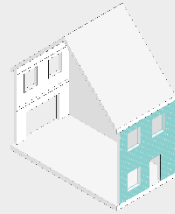
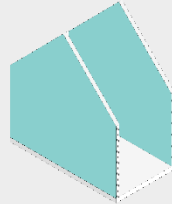
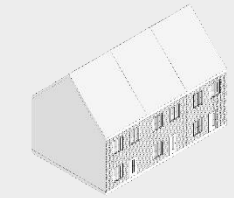
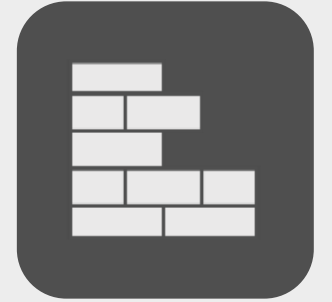
## Prefab concrete partitioning walls

Source:

[http://www.bouwkosten.nl/Proefabonnement\\_Ramen/Utiliteitsbouw/Kostenkengetallen\\_21\\_Buitenwanden,\\_steen/kostengegevens-Kostenkengetallen/3966000.htm](http://www.bouwkosten.nl/Proefabonnement_Ramen/Utiliteitsbouw/Kostenkengetallen_21_Buitenwanden,_steen/kostengegevens-Kostenkengetallen/3966000.htm)



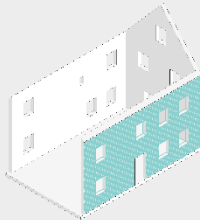
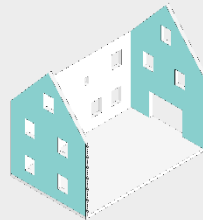
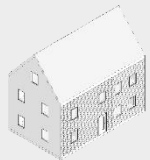
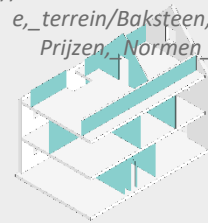
# Walls



**Clickbricks  
outside facade**

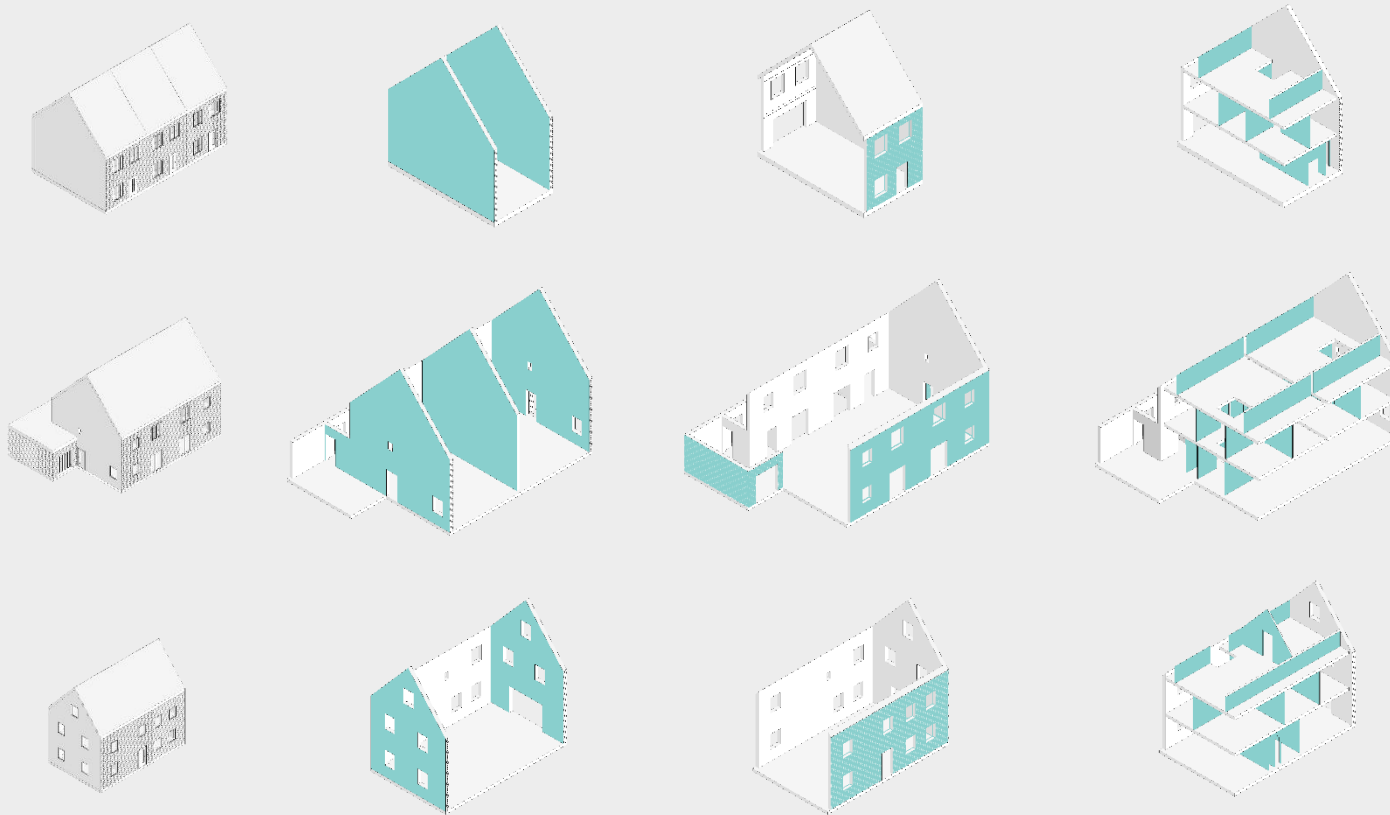
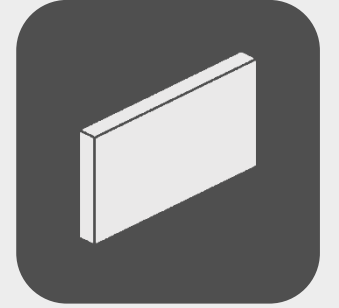
Source:

[http://www.bouwkosten.nl/Materiaalprijsen/Bouw\\_installatie\\_terrein/Baksteen\\_Click\\_Brick/kostengegevens-Prijzen\\_Normen\\_en\\_Tarieven/2355256.htm](http://www.bouwkosten.nl/Materiaalprijsen/Bouw_installatie_terrein/Baksteen_Click_Brick/kostengegevens-Prijzen_Normen_en_Tarieven/2355256.htm)





# Walls

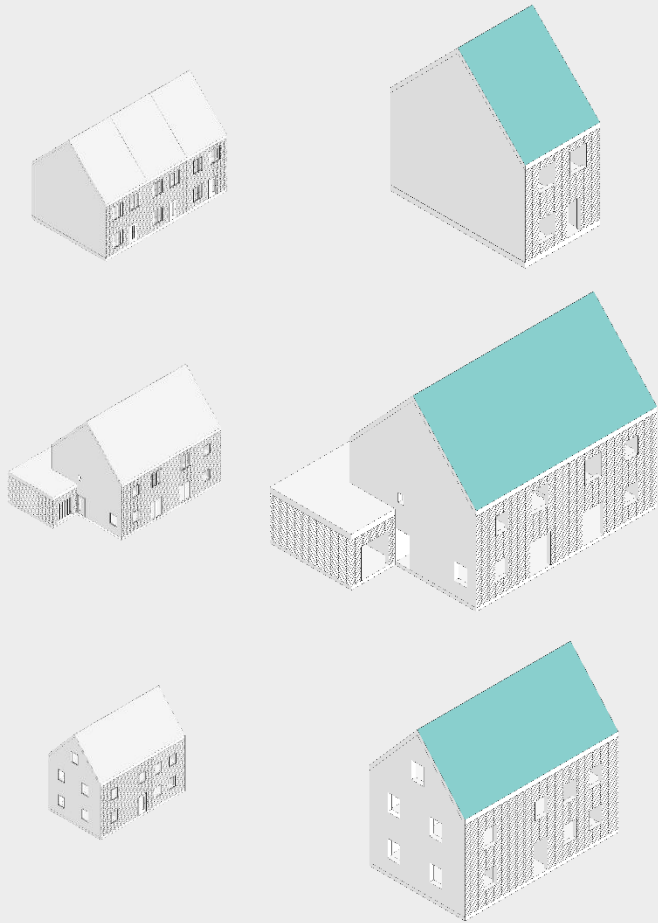


## Faay panels interior walls

Source: [https://www.sleiderink.nl/faay-vp54?child\\_id=11598&quantity=1&gclid=CjwKCAjwkenqBRBgEiwA-bZVtq1eTogQ9yJ1YJU77mHXRPN6O8grl0fgx6EH7rolb8ioTvdONkxWlxCNB0QAvD\\_BwE](https://www.sleiderink.nl/faay-vp54?child_id=11598&quantity=1&gclid=CjwKCAjwkenqBRBgEiwA-bZVtq1eTogQ9yJ1YJU77mHXRPN6O8grl0fgx6EH7rolb8ioTvdONkxWlxCNB0QAvD_BwE)



# Roof tiles



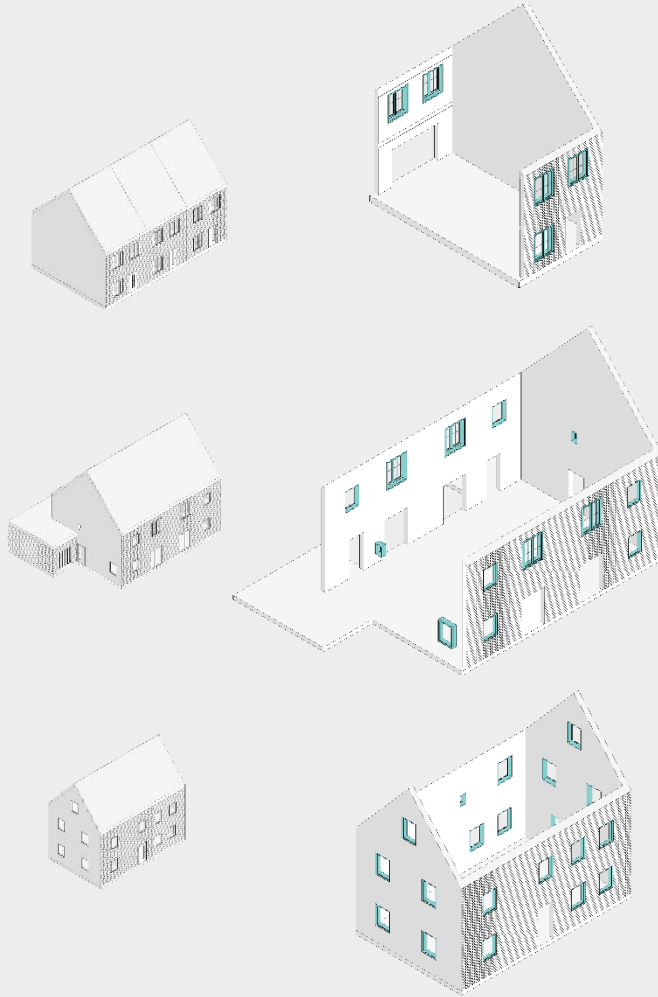
## Ceramic roof tiles

Source:

[http://www.bouwkosten.nl/Proefabonnement\\_Ramen/Utiliteitsbouw/Kostenkengetallen\\_47\\_Dakafwerkingen/kostengegevens-Kostenkengetallen/3966003.htm](http://www.bouwkosten.nl/Proefabonnement_Ramen/Utiliteitsbouw/Kostenkengetallen_47_Dakafwerkingen/kostengegevens-Kostenkengetallen/3966003.htm)



# Windows



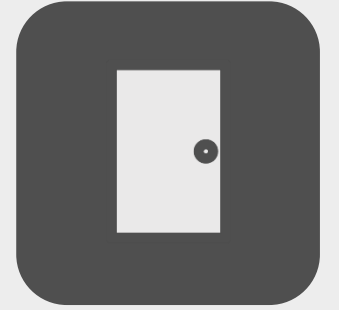
## Meranti window frame

Source:

[http://www.bouwkosten.nl/Proefabonnement\\_Ramen/Utiliteitsbouw/Kostenkengetallen\\_31\\_Buitenwandopeningen,\\_gevelkozijn/kostengegevens-Kostenkengetallen/3966001.htm](http://www.bouwkosten.nl/Proefabonnement_Ramen/Utiliteitsbouw/Kostenkengetallen_31_Buitenwandopeningen,_gevelkozijn/kostengegevens-Kostenkengetallen/3966001.htm)



# Doors

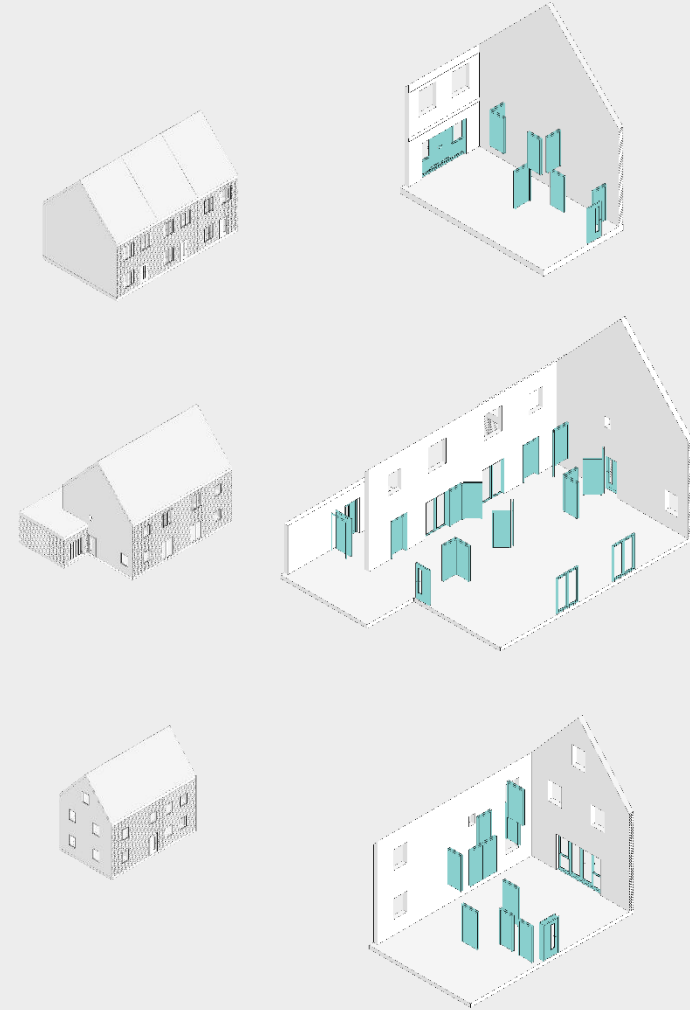


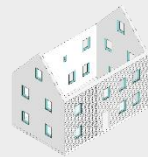
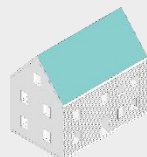
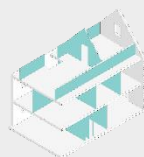
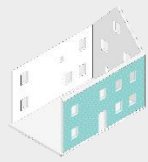
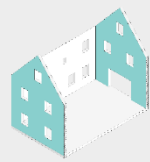
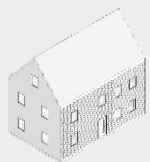
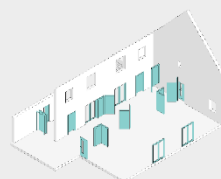
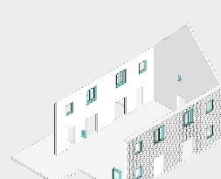
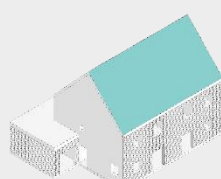
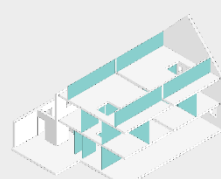
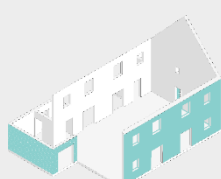
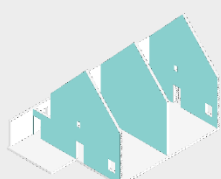
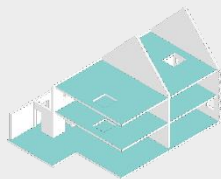
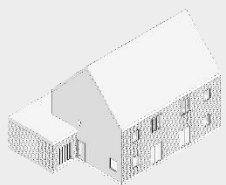
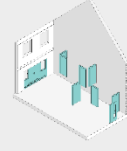
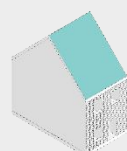
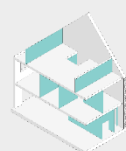
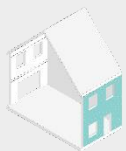
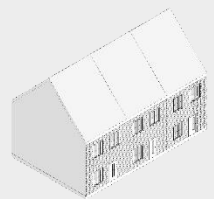
## 3 types of doors

- Front door
- French (garden) doors
- Corridor doors

Source:

[http://www.bouwkosten.nl/Materiaalprijzen/Bouw,\\_installatie,\\_terrein/Buitendeur,\\_merbau/kostengegevens-Prijzen,\\_Normen\\_en\\_Tarieven/4423242.htm](http://www.bouwkosten.nl/Materiaalprijzen/Bouw,_installatie,_terrein/Buitendeur,_merbau/kostengegevens-Prijzen,_Normen_en_Tarieven/4423242.htm)







**Supply  
side**



**Constraints**

**Demand  
side**



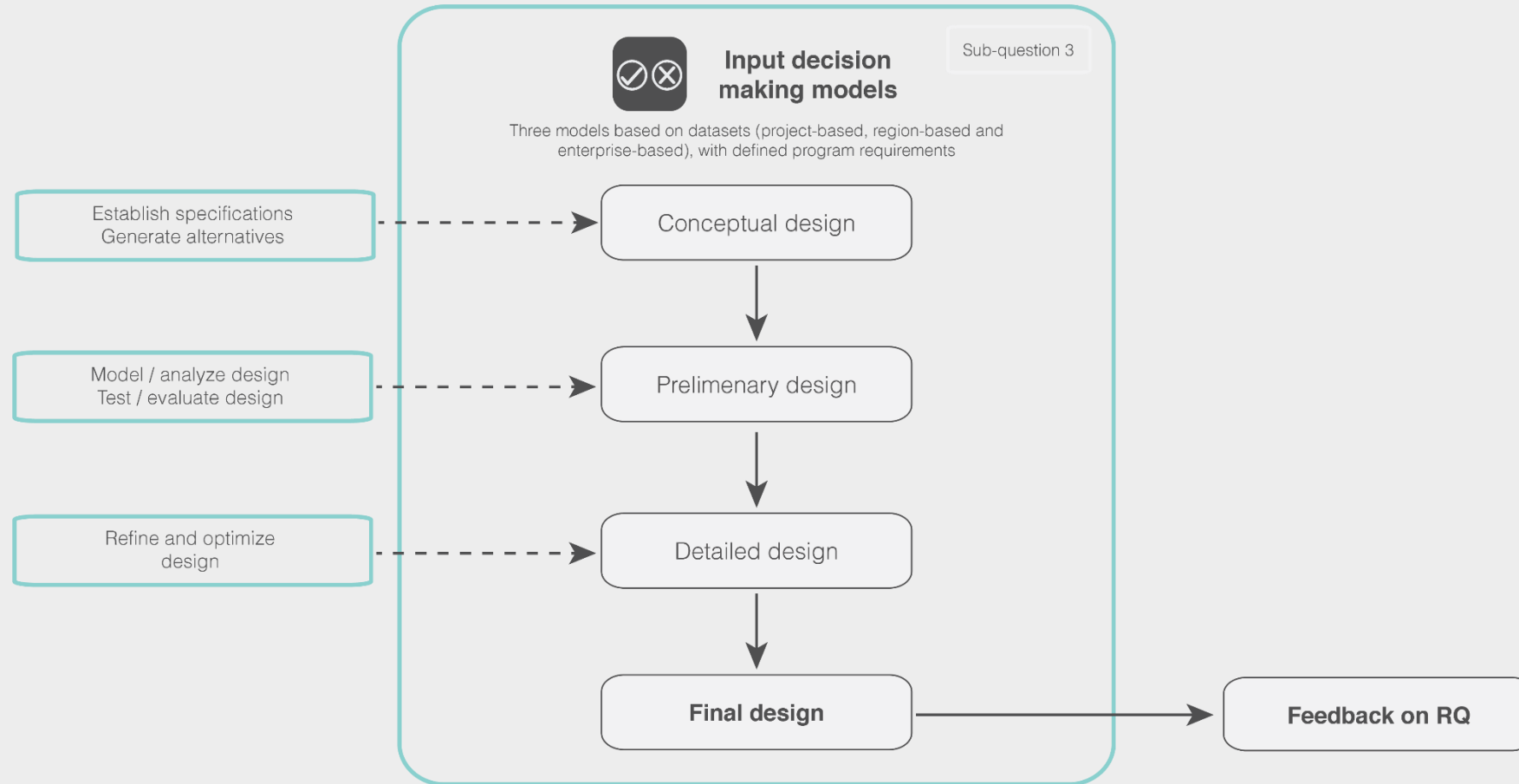
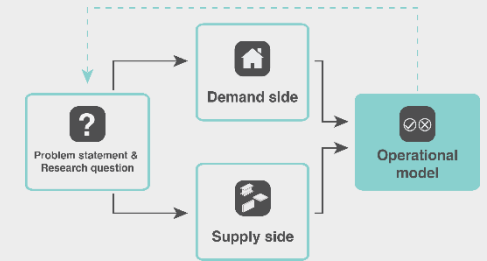
**Variables**

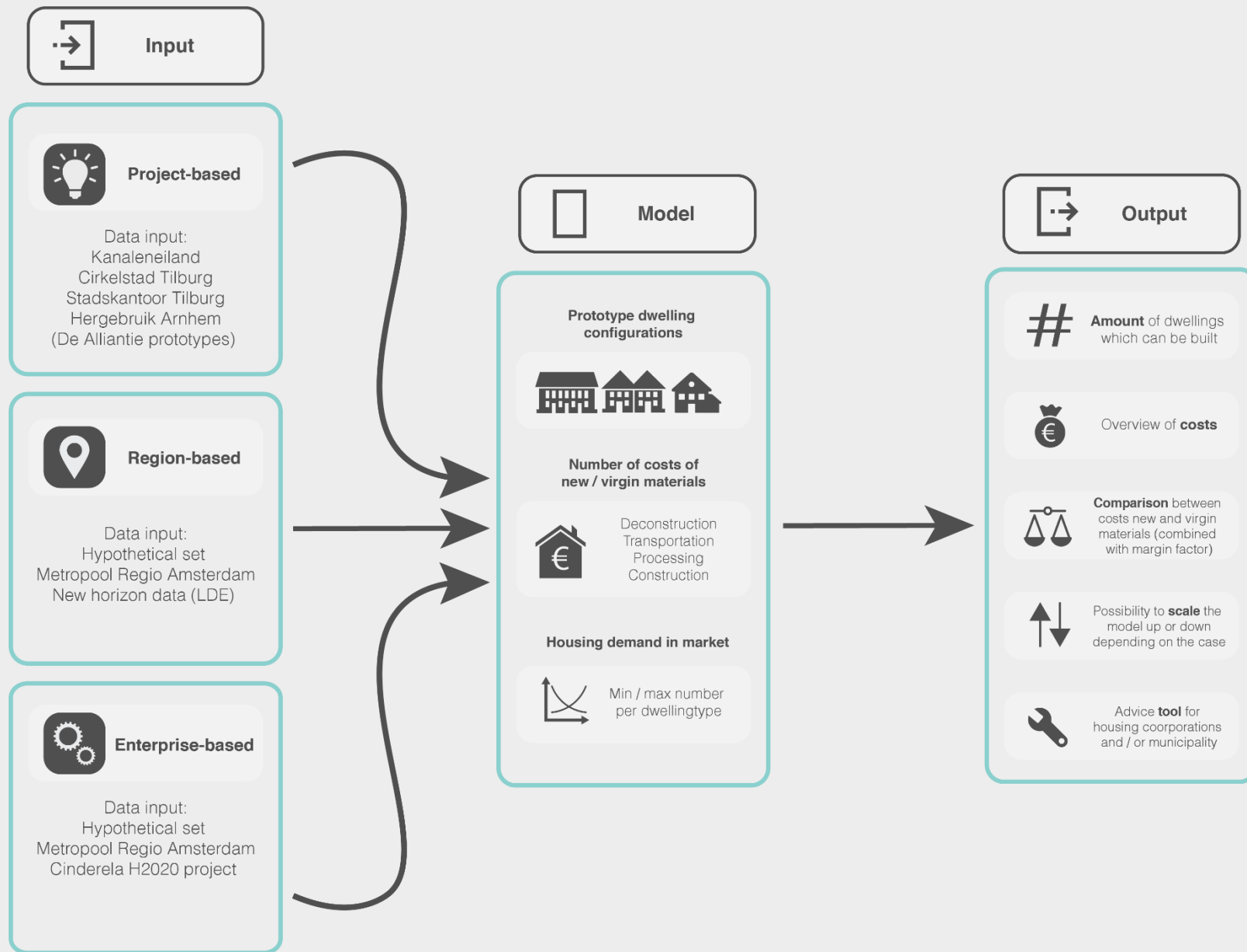
**+**

**=**



# Operational model





# Virgin materials reduction case



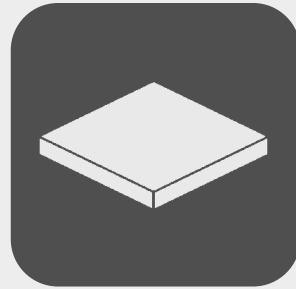
Project-based level



3 dwelling types







Channel plate floor  
200mm [m2]



Distance  
[km]



Lifespan  
[years]



O

8.000

20

1989

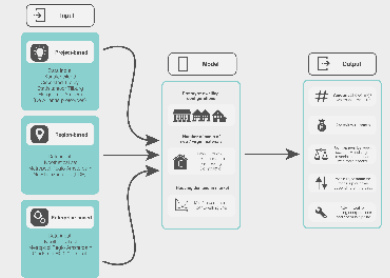


P

5.000

15

1997





Model



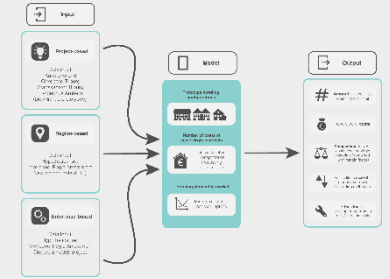
Dwelling types



Housing demand



Construction costs & budget





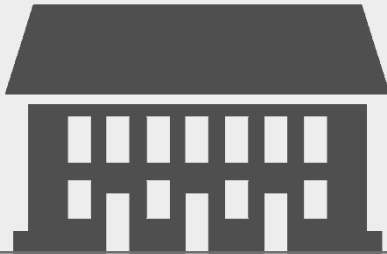
Dwelling  
types



Housing  
demand



Construction  
costs &  
budget



Type A:  
*Standard row-house*



Type B:  
*Semi-detached dwelling*



Type C:  
*Detached dwelling*





Dwelling  
types



Housing  
demand



Construction  
costs &  
budget



Type A



Type B



Type C

**MIN**  
**MAX**

10

20

12

40

50

60

Depends on client







Dwelling  
types

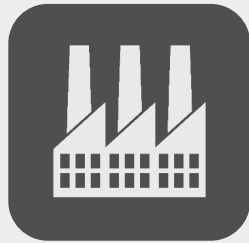


Housing  
demand

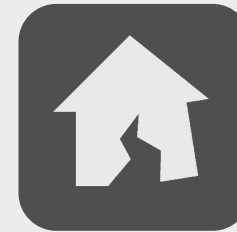


Construction  
costs & budget

### Costs comparison



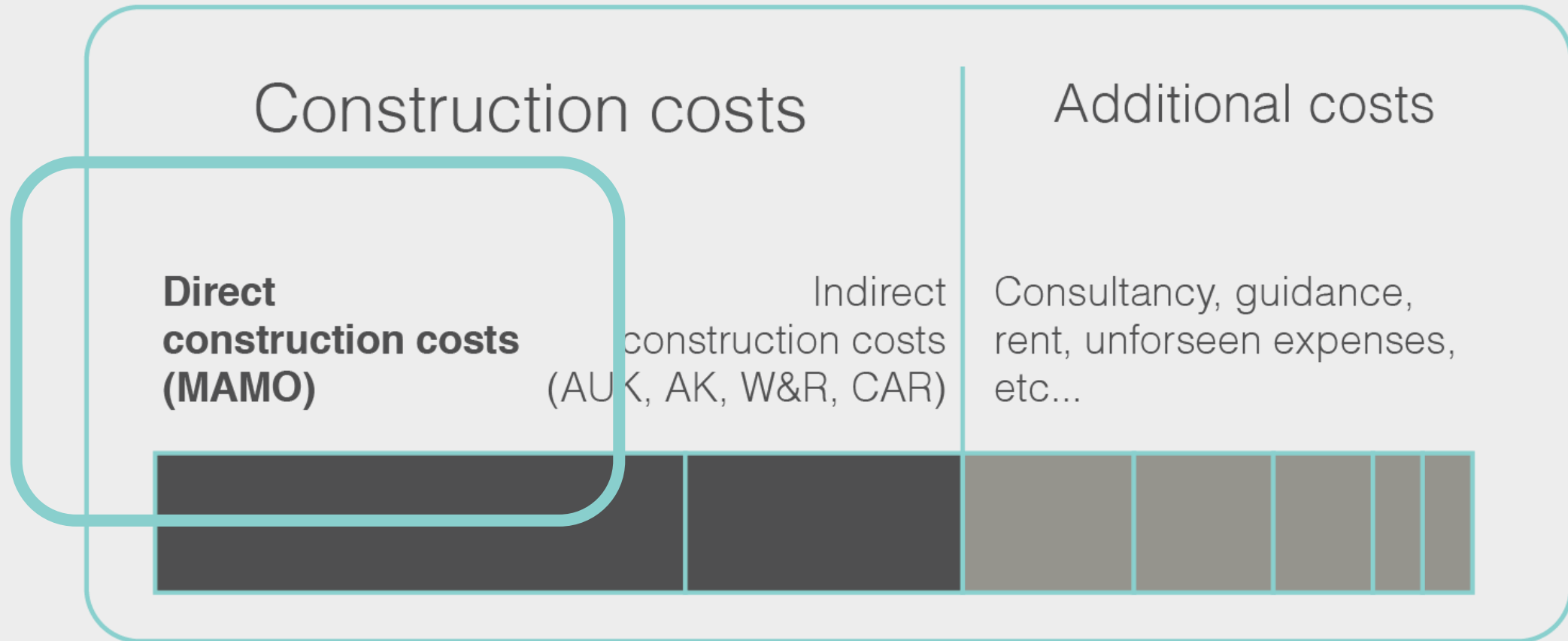
Virgin building  
materials



Reusable building  
materials



# Investment costs



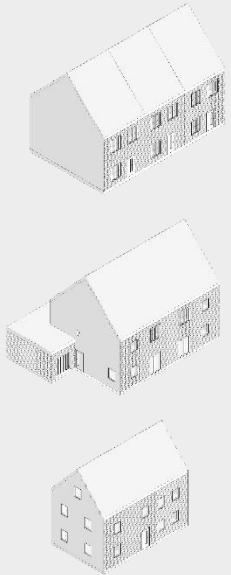
(Gemeente Amsterdam, Concepts, & Copper8, 2017)





## Costs Virgin building materials

Dwelling types



Reusability potential  
of building materials



*Reusable*

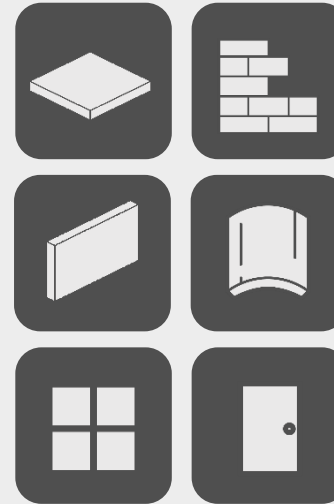


*Possible reusable*



*Not reusable*

Total square meters of  
building material per  
dwelling



€/m<sup>2</sup> material

- Based on practice
- Pure material costs
- No labor costs
- No construction costs





alba

## URBAN MINING

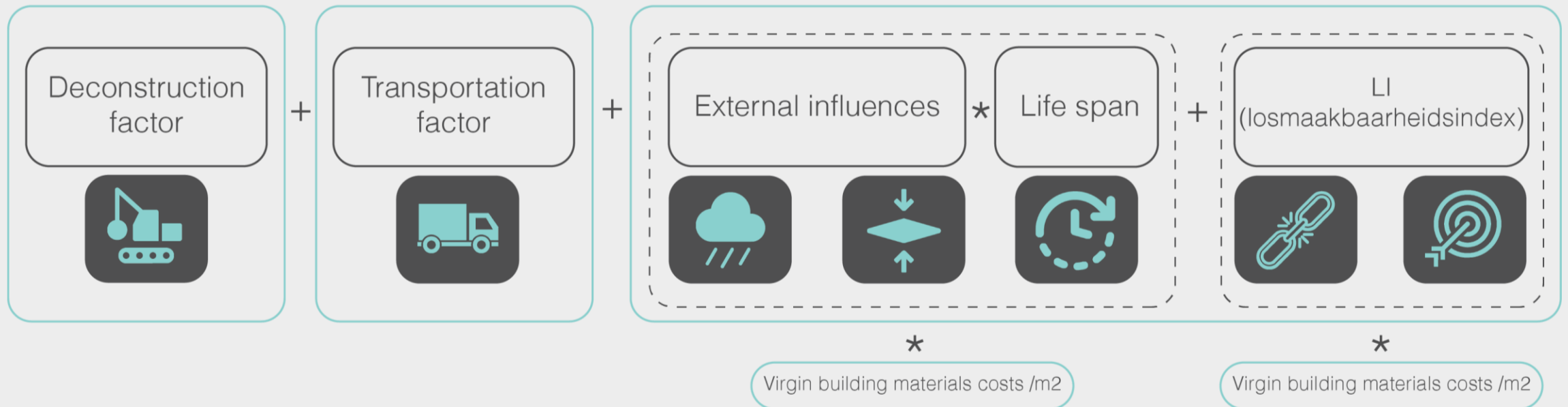
IN DESIGN AND CONSTRUCTION FOR A RESILIENT FUTURE

- A study on implementing urban mining in housing for improving resource efficiency





## Costs Reusable building materials / m2





Costs

Reusable building materials / m<sup>2</sup>

Based on '*Rekenregel  
grondstofwaardering*' TNO  
/ Madaster

Deconstruction  
factor



$$fk.1.1 = ((TSDK_{gebouw} / M_{gebouw}) * Mk1) * (1 + Llk.1)$$

- $fk$  = sloop & demontagekosten uit referentiewoning 1 [€]
- $TSDK$  = totale sloopkosten referentiewoning [€]
- $M_{gebouw}$  = massa referentiewoning [kg]
- $MK1$  = massa bouw materiaal in referentiewoning [kg]
- $Llk.1$  = Losmaakbaarheidsindex bouw materiaal (LI)





Costs

Reusable building materials / m<sup>2</sup>

Based on '*Rekenregel  
grondstofwaardering*' TNO  
/ Madaster

Transportation  
factor



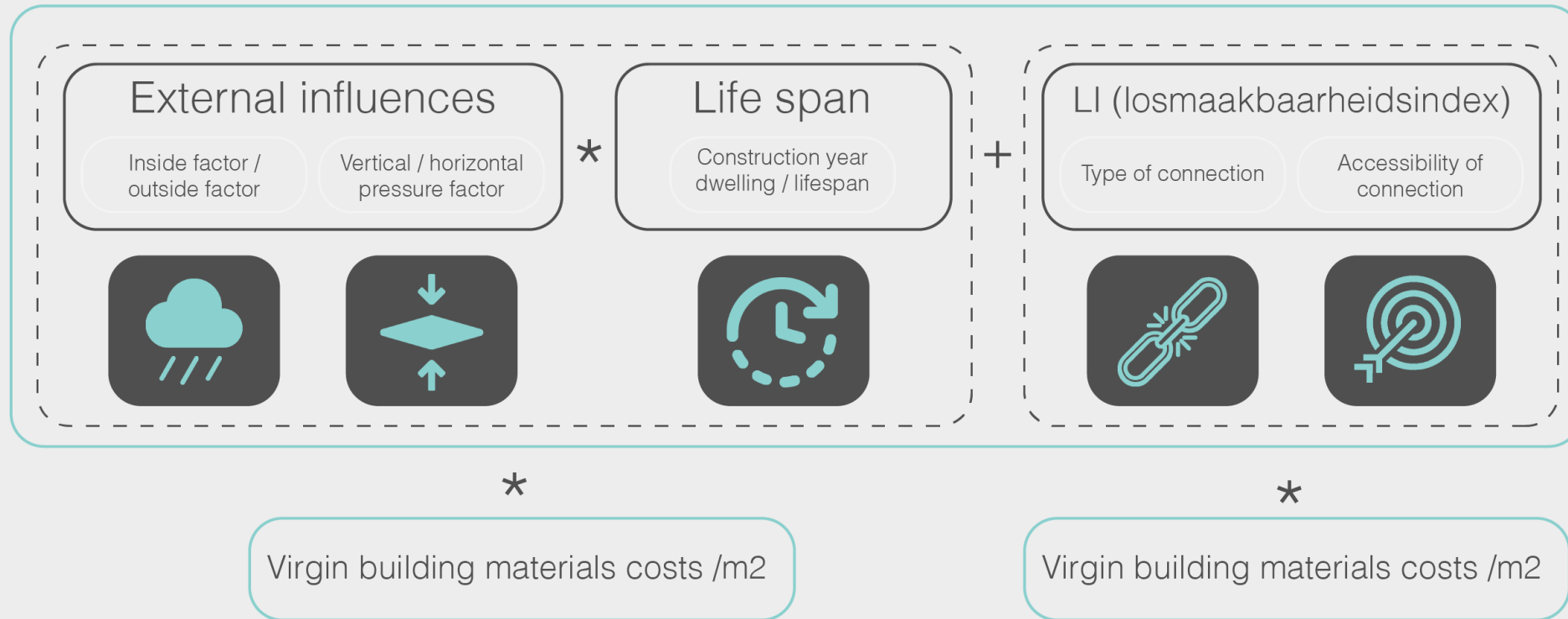
$$fk.1.2 = Abouwplaats * \text{€/km}$$

- $fk$  = additionele vervoerskosten [€]
- $Abouwplaats$  = afstand bron tot nieuwe bouwplaats [km]
- €/km = bedrag / kilometer



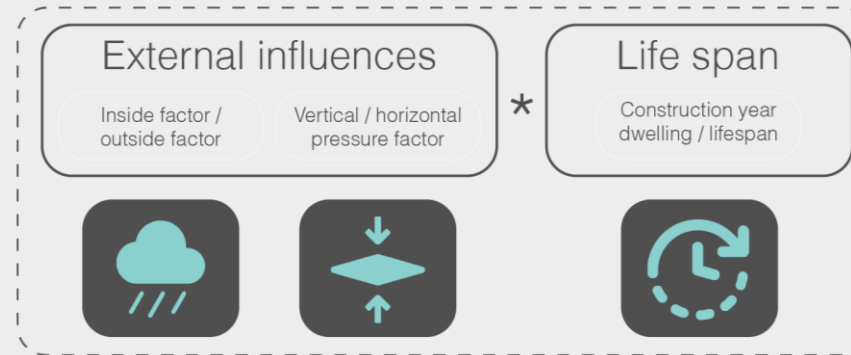


Costs  
Reusable building materials  
Material validation factor



Vertical / horizontal pressure	Factor
No pressure	1
Horizontal BG	0,7
Horizontal first floor	0,8
Horizontal 2 <sup>nd</sup> floor	0,9
Vertical 1 floor	0,8
Vertical 2 floors	0,9

## Material validation influences



Inside / outside	Factor
Inside	0,8
Outside	0,6

Life span
Construction year dwelling / Life span material

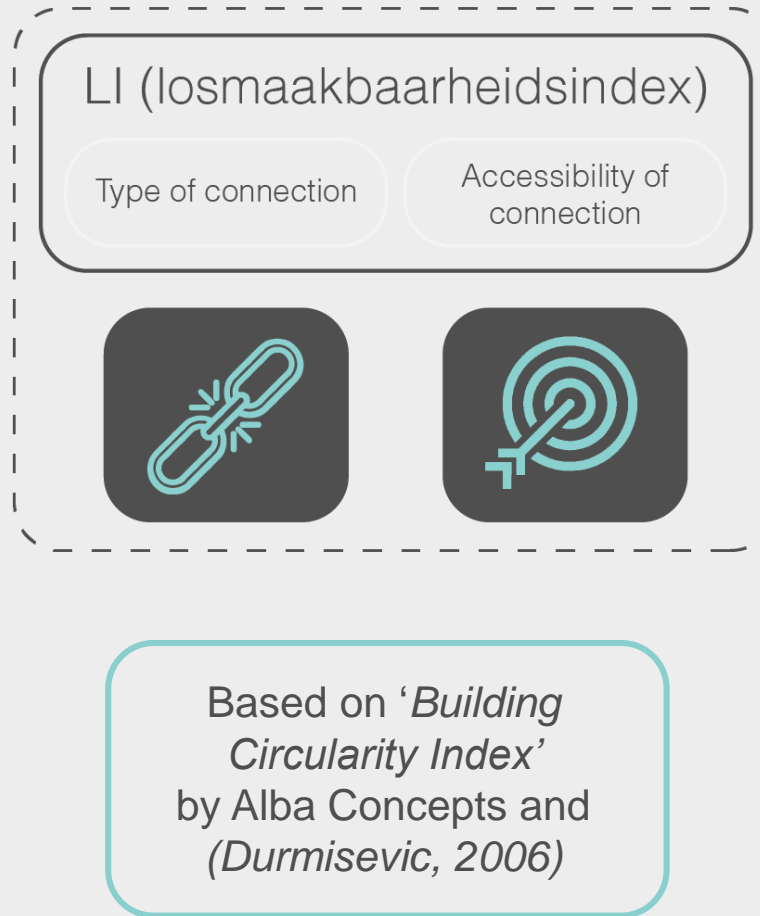
Based on discussions with experts from Alba Concepts





Type of connection	Factor
Dry connections	1
Direct connection with additional fixing devices	0,8
Direct integral connection	0,6
Filled soft chemical connection	0,2
Filled hard chemical connection	0,1

## Material validation influences

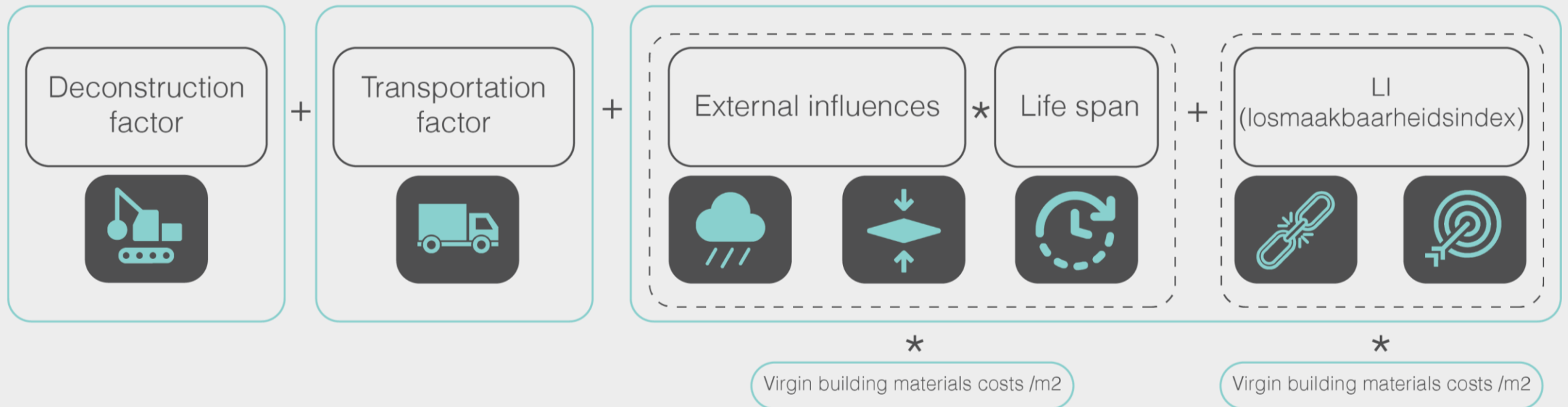


Accessibility of connection	Factor
Accessible	1
Accessible with additional operation: no damage	0,8
Accessible with additional operation: reparable damage	0,6
Accessible with additional operation with damage	0,4
Not accessible	0,1



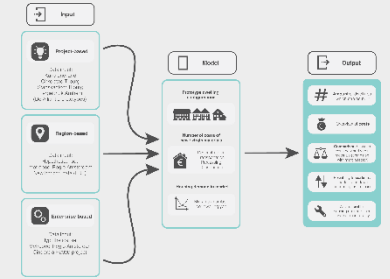


## Costs Reusable building materials / m2

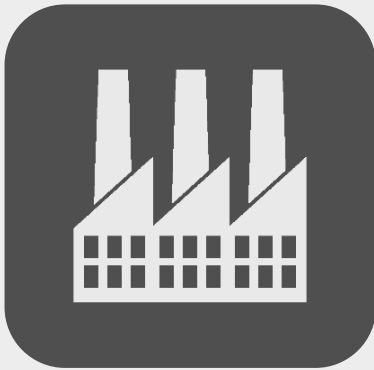




Model output



## Costs comparison



Virgin building  
materials

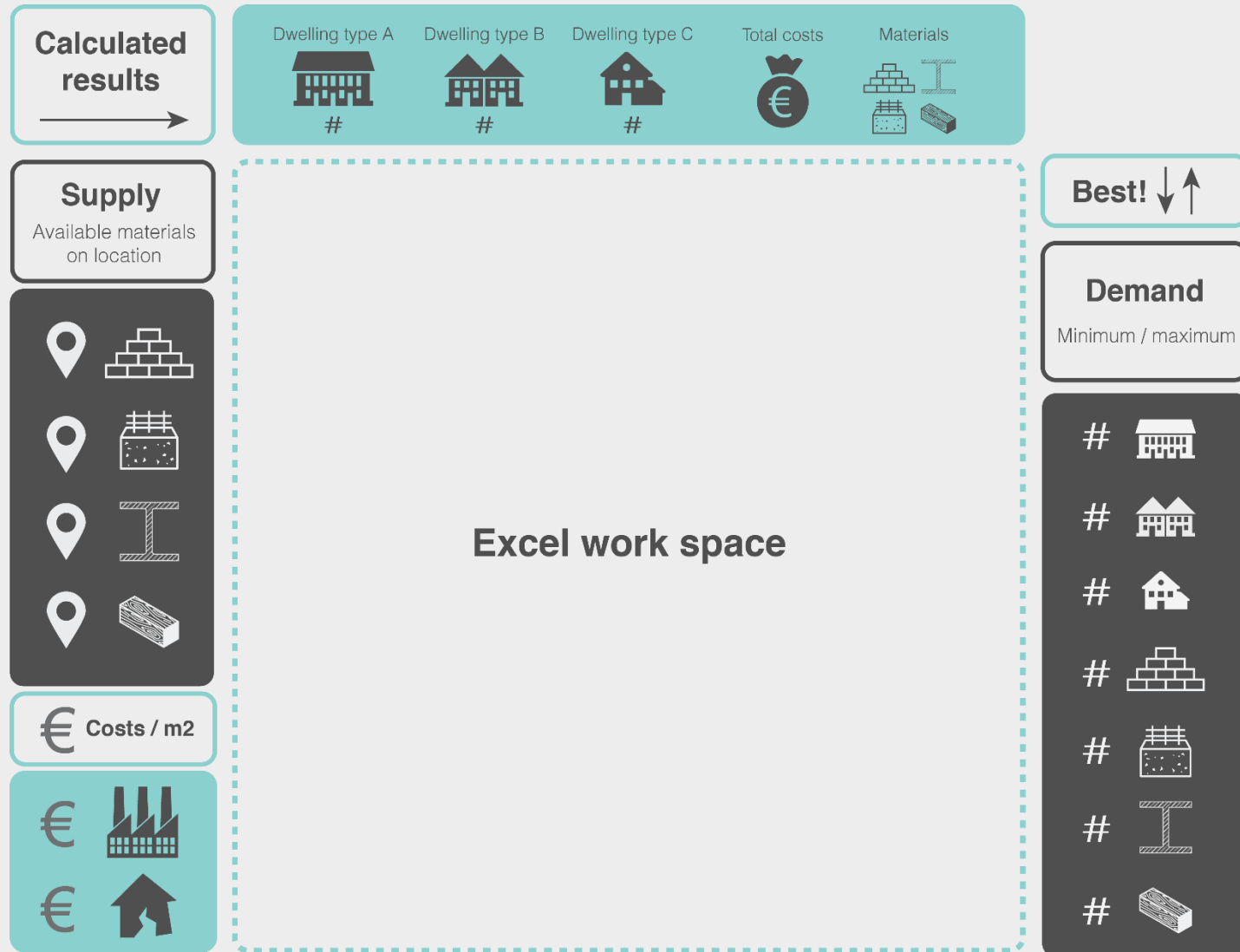


Reusable building  
materials





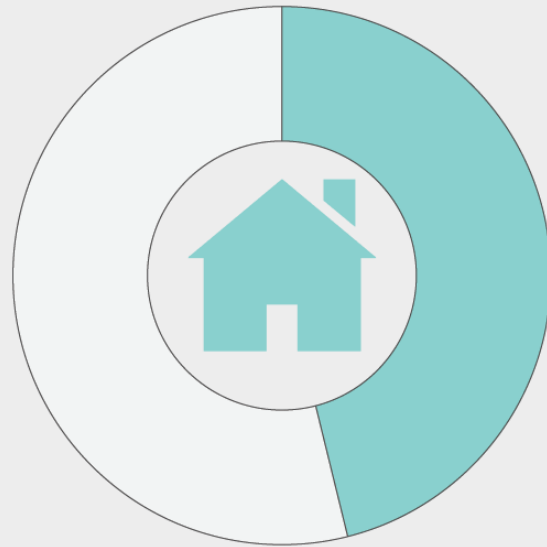
Case studies



Literature study



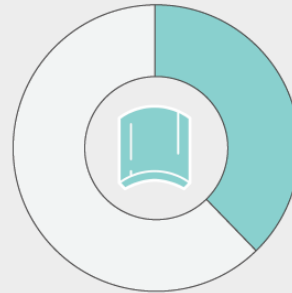
## Dwellings



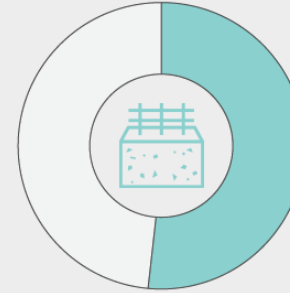
# Virgin materials reduction case



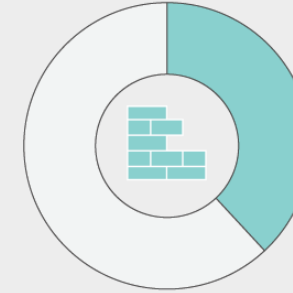
Roof  
*Roof tiles*



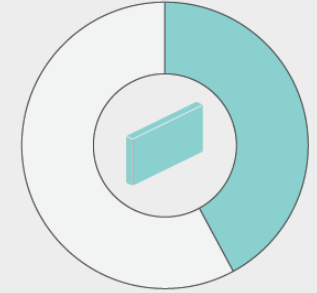
Exterior wall  
*Prefab concrete*



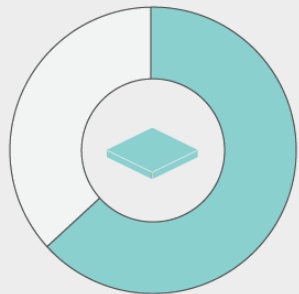
Exterior wall  
*Clickbrick*



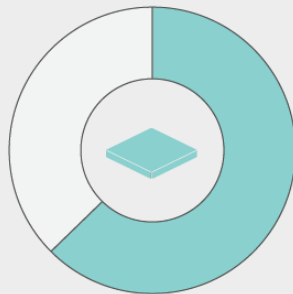
Interior wall  
*Panels*



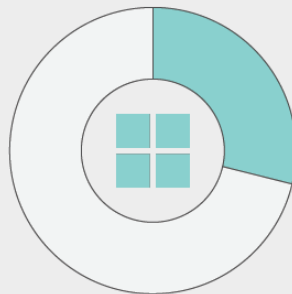
Channel plate floor  
*Ground floor*



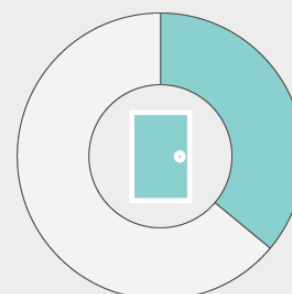
Channel plate floor  
*1st & 2nd floor*



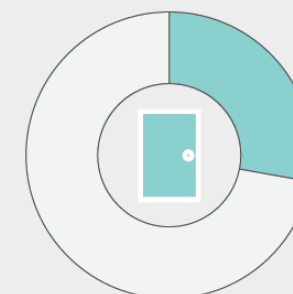
Windows  
*Glass & frame*



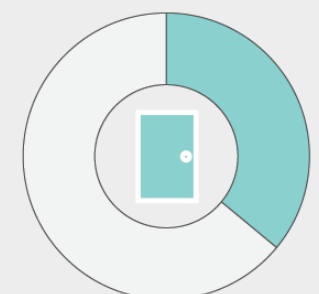
Doors  
*Front door*



Doors  
*Corridor door*



Doors  
*French doors*



Costs virgin materials

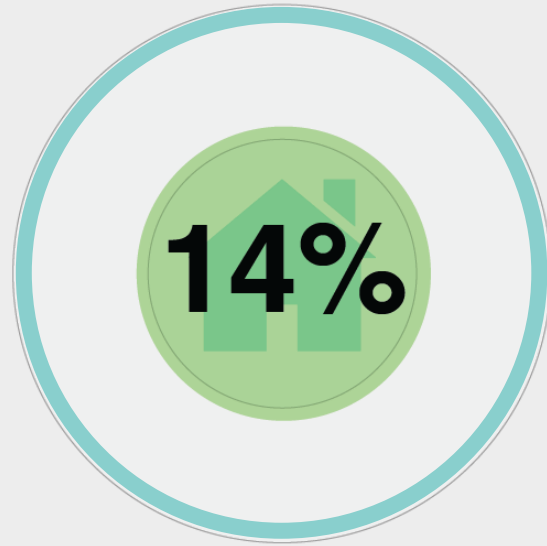


Costs reusable materials





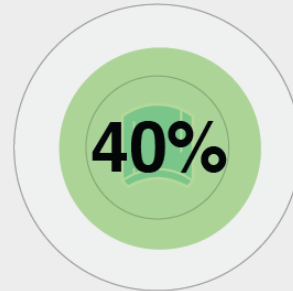
## Dwellings



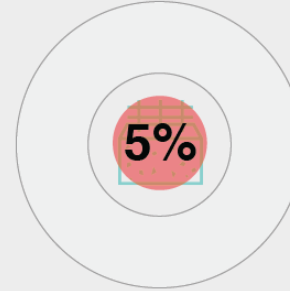
## Virgin materials reduction case



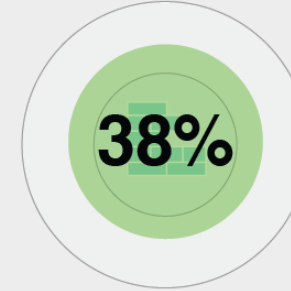
Roof  
*Roof tiles*



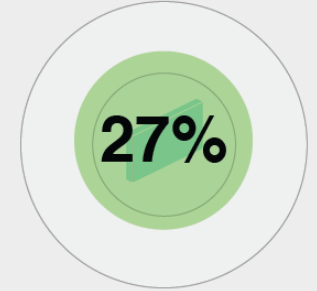
Exterior wall  
*Prefab concrete*



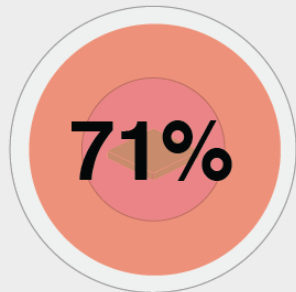
Exterior wall  
*Clickbrick*



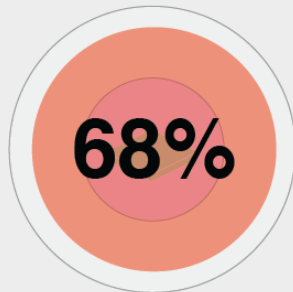
Interior wall  
*Panels*



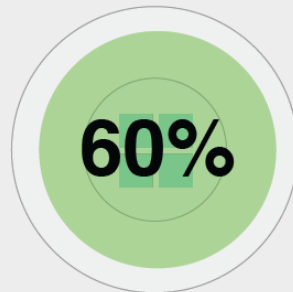
Channel plate floor  
*Ground floor*



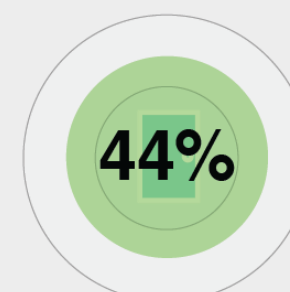
Channel plate floor  
*1st & 2nd floor*



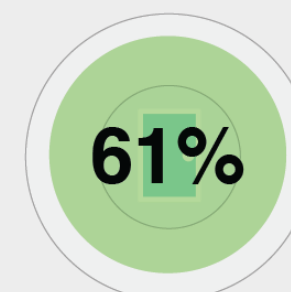
Windows  
*Glass & frame*



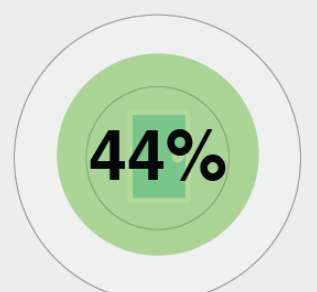
Doors  
*Front door*





Doors  
*Corridor door*



Doors  
*French doors*



 Percentual difference in costs  
(*Virgin materials more expensive*)

 Percentual difference in costs  
(*Reusable materials more expensive*)



# Results & discussion

The total costs of reused building materials for standard dwellings are **14%** cheaper compared to dwellings built with virgin building materials, taking the following topics into account:



Transparency  
of datasets



Reusability of  
building materials



Validation of  
feasibility



Involvement of  
stakeholders





**Competition** should be replaced  
with **collaboration**



Lack of **trust**



Transparency  
of datasets



**Hypothetical datasets** used for  
the project-based model



**Cinderella project** potential  
collaboration for follow-up





**Select amount** of different  
type of materials are used



New dwellings should be **detachable** or  
**reusable** designed



Reusability of  
building materials



Various **sources** for  
obtaining material info



Future project could implement **more**  
**materials** for reuse, further  
research





Reusable formulas are  
**hypothetical**



Based on **expert panels and discussions** with colleagues of Alba  
Concepts



Validation of  
feasibility



Focus on **MAMO**, not additional and  
indirect construction costs



Factors and formulas should be  
**validated**







Getting stakeholders **early in the project involved**



Collaboration is necessary for obtaining **datasets**



Involvement of stakeholders



Model gives advice to invest, **more stakeholders** are necessary to check the feasibility of a project



# Conclusion

*How can an operational model link the supply of existing building materials with the demand for new construction projects in order to reduce the use of virgin materials and thereby improve circularity in the construction industry?*

By developing a model which calculates the **difference in costs** between the reused and virgin building materials, showing that the reusable materials are **cheaper** compared to the virgin materials, based on the given **framework**.



# Recommendations



## **Tool**

Creation of interface for practice, such as an app or website.



## **Cinderela**

Collaboration with Cinderela for test of an enterprise-based model and future implementation of model in real-life cases.



## **Design to deconstruct**

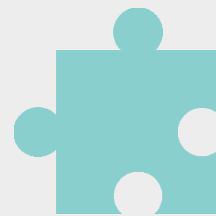
Improvement of design techniques which makes future dwellings detachable.



## **Costs strategies**

Adapting the model to different strategies to generate a positive outcome for the client.







# URBAN MINING

## IN DESIGN AND CONSTRUCTION PROCESSES

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A study on implementing urban mining of existing building elements in the local housing for improving the construction industry towards a circular economy





### Sloop- en demontagekosten k.1 uit gebouw

$$f_{k.1.1} = ((TSDK_{\text{gebouw}} / m_{\text{gebouw}}) * m_{k1}) * (1 - LI_{k.1}) * i_{\text{funct./techn.lid}} \Rightarrow \text{uitkomst in €}$$

Waarbij:

$f_{k.1.1}$  Sloop- en demontagekosten k.1 uit gebouw

$TSDK_{\text{gebouw}}$  Totale sloop- en demontagekosten gebouw in één bouwstroom (nominaal)

$m_{\text{gebouw}}$  Totale massa gebouw (=  $\sum m_{\text{structure;skin;services;spaceplan}}$ )

$m_{k1}$  Totale massa k.1 (=  $\sum m_{\text{structure;skin;services;spaceplan}}$ )

$LI_{k.1}$  Losmaakbaarheidsindex in % (zie circulaire tab, default 1)

$i_{\text{funct./techn.lid}}$  BDB-index op einde functionele of technische levensduur product

### Totale sloop- en demontagekosten gebouw in één bouwstroom (nominaal)

$$TSDK_{\text{gebouw}} = m^2_{\text{bvo}} * \text{gem. €/m}^2_{\text{bvo}} * f_{\text{functie}} * f_{\text{hoogte gebouw}} \Rightarrow \text{uitkomst in €}$$

Waarbij:

$TSDK_{\text{gebouw}}$  Totale sloop- en demontagekosten gebouw in één bouwstroom (nominaal)

$m^2_{\text{bvo}}$  Aantal  $m^2$  bruto vloeroppervlakte gebouw

gem. €/m<sup>2</sup> Gemiddelde sloop- en demontagekosten per m<sup>2</sup> bvo gewogen naar Layers of Brand

$f_{\text{functie}}$  Factor voor functie van het gebouw

$f_{\text{hoogte}}$  Factor voor de hoogte van het gebouw

### Additionele vervoerskosten naar verwerker

$$f_{k.1.2} = A_{\text{verwerker}} * \text{€/km} * f_{\text{bgv}} * i_{\text{cor;funct./techn.ld}} \Rightarrow \text{uitkomst in €}$$

Waarbij:

$f_{k.1.2}$  Additionele vervoerskosten naar verwerker

$A_{\text{verwerker}}$  Afstand naar verwerker (in km)

€/km Prijs per kilometer

$f_{\text{bgv}}$  Factor voor beschikbaarheid goedkoop vervoer

$i_{\text{CPI,funct./tec}}$  Inflatiecorrectie op einde functionele of technische levensduur product

Specifications	
Sloop / demontage kosten $f_{k,1,1}$	Additionele vervoerskosten naar nieuwe locatie

Material	Source O m <sup>2</sup> k <sub>1</sub> [kg]	€ total	€/ m <sup>2</sup>	Source P m <sup>2</sup> k <sub>1</sub> [kg]	€ total	€/ m <sup>2</sup>	Source O	/ m <sup>2</sup>	Source P	/ m <sup>2</sup>
Floors										
Channel plate floor 150mm	14329,98 €		722,10 €	15,87	22607,50 €	1.228,28 €	17,11	€	26.528,91 €	15.159,38 €
Channel plate floor 200mm	28407,54 €		1.431,49 €	21,16	23493,96 €	1.276,45 €	17,11	€	42.446,25 €	22.739,06 €
Exterior walls										
Prefab Beton	23303,28 €		1.268,22 €	11,43	31075,90 €	1.823,45 €	12,32	€	33.603,28 €	22.739,06 €
Clickbricks	5626,58 €		430,97 €	12,41	14018,93 €	1.157,72 €	13,38	€	27.286,88 €	15.592,50 €
Interior walls										
Prefab Panels	2919,14 €		200,05 €	3,79	3350,97 €	247,60 €	4,09	€	7.450,33 €	4.656,45 €
Roof										
Roof tiles	4513,60 €		327,52 €	5,08	5312,44 €	415,63 €	5,48	€	5.895,31 €	3.368,75 €
Windows										
Glass	294 €		23,70 €	1,21	204 €	17,73 €	1,30	€	1.364,34 €	812,11 €
Frame	281,75 €		20,44 €	4,17	195,5 €	15,30 €	4,50	€	581,11 €	345,90 €
Doors										
Corridor door	168 €		12,19 €	0,73	168 €	13,14 €	0,78	€	84,22 €	48,13 €
Facade door	24 €		1,74 €	0,73	24 €	1,88 €	0,78	€	842,19 €	481,25 €

TDSK Referentiewoning 3 (source ?)		
M2 bvo		225,72
Gem €/m2	€	28,04
f <sub>functie</sub>		0,8
f <sub>hoogte</sub>		1
TDSK	€	5.063,35

TDSK Referentiewoning 3	
m <sub>gebouw</sub>	99206,23 kg
L <sub>k,1</sub>	Laatste tabel <i>Uitleg financieel hfd</i>
f <sub>funct./techn.Id</sub>	n.v.t. <i>Uitleg financieel hfd</i>

Referentiewoning 1 (source O)		€ 20,09	Referentiewoning 2 (source P)		€ 14,35
Distance source [km]	35		Distance [km]	25	
Default distance Stone [km]	20		Default distance Stone [km]	20	
Default distance Wood [km]	50		Default distance Wood [km]	50	
Default distance Glass [km]	150		Default distance Glass [km]	150	
€/km	€ 1,10		€/km	€ 1,10	
Max gewicht [kg]	4000		Max gewicht [kg]	4000	
Gem. gewicht [kg]	3200		Gem. gewicht [kg]	3200	
Inhoud [m³]	55,2		Inhoud [m³]	55,2	
Gem. inhoud [m³]	44,16		Gem. inhoud [m³]	44,16	
Laden (20%)	20%		Laden (20%)	20%	
Lossen (20%)	20%		Lossen (20%)	20%	

Stone		Stone	
Subtotaal	€ 38,50	Subtotaal	€ 27,50
Laden & lossen	40%	Laden & lossen	40%
Totaal	€ 53,90	Totaal	€ 38,50
Prijs per kg	€ 0,017	Prijs per kg	€ 0,012
Prijs per m³	€ 1,22	Prijs per m³	€ 0,87

Materials dwelling 1 [m2]	400,61	Materials dwelling 1 [m2]	534,37
Costs all materials dwelling 1 [€/m2]	€ 20,09	Costs all materials dwelling 1 [€/m2]	€ 14,35
Total transport costs dw 1	€ 8.049,44	Total transport costs dw 1	€ 7.669,42
Weight dwelling 1 [kg]	79867,87	Weight dwelling 1 [kg]	100451,20
Average capacity truck	3200	Average capacity truck	3200
Total # of rides for 1 truck	25	Total # of rides for 1 truck	31
	€ 322,51		€ 244,32
1 ride price per M3	€ 67,38		
1 ride price per KG	€ 53,900		

Construction costs  
Reused building materials

Specifications																															
Waardering materialen factor																															
Virgin eur/m2	Inside / outside facade		Factor		Vertical / horizontal pressure		Factor		Lifespan material			Factor O		Factor P		Inside / outside		Pressure		Interfacing materials		Factor		Accessibility of connection		Factor		LI (Losmaakbaarheidindex)		Additional casts LI factor/m2	
€ 36,80	Inside		0,8	Horizontal BG		0,7			75,0		0,4	0,3	€ 4,42	€ 5,20			€ 6,62	€ 7,80		Filled hard chemical connection		0,1	Toegankelijkheid met extra ha		0,4			0,25	€		27,60
€ 38,05	Inside		0,8	Horizontal 1st floor		0,8			75,0		0,4	0,3	€ 4,57	€ 5,38			€ 4,57	€ 5,38		Filled hard chemical connection		0,1	Toegankelijkheid met extra ha		0,4			0,25	€		28,54
€ 109,80	Partially inside / outside		0,7	Vertical outside 2 floors		0,9			75,0		0,4	0,3	€ 19,76	€ 23,28			€ 6,59	€ 7,76		Filled hard chemical connection		0,1	Toegankelijkheid met extra ha		0,6			0,35	€		71,37
€ 110,42		Outside		0,6	Vertical outside 2 floors		0,8			75,0		0,4	0,3	€ 26,50	€ 31,21			€ 13,25	€ 15,61		Direct connection with additional fixing devices		0,8	Vrij toegankelijk		1,0			0,90	€	
€ 30,50	Inside		0,6	Vertical Inside 1 floor		0,9			60,0		0,5	0,4	€ 6,10	€ 7,73			€ 1,53	€ 1,93		Direct connection with additional fixing devices		0,8	Toegankelijkheid met extra ha		0,6			0,70	€		9,15
€ 48,07	Outside		0,6	No pressure		1,0			75,0		0,4	0,3	€ 11,54	€ 13,59			€ -	€ -		Direct connection with additional fixing devices		0,8	Toegankelijkheid met extra ha		0,8			0,80	€		9,61
€ 220,70	Outside		0,6	Vertical outside 2 floors		0,8			35,0		0,9	0,6	€ 12,61	€ 32,79			€ 6,31	€ 16,39		Dry connections (with or without accessory external		1,0	Vrij toegankelijk		1,0			1,00			
€ 220,70	Outside		0,6	Vertical outside 2 floors		0,8			35,0		0,9	0,6	€ 12,61	€ 32,79			€ 6,31	€ 16,39		Direct connection with additional fixing devices		0,8	Toegankelijkheid met extra ha		0,8			0,80	€		44,14
€ 100,00	Inside		0,8	Vertical Inside 1 floor		0,9			75,0		0,4	0,3	€ 12,00	€ 14,13			€ 6,00	€ 7,07		Direct connection with additional fixing devices		0,8	Toegankelijkheid met extra ha		0,8			0,80	€		20,00
€ 595,00	Outside		0,6	Vertical outside 2 floors		0,8			75,0		0,4	0,3	€ 142,80	€ 168,19			€ 71,40	€ 84,09		Direct connection with additional fixing devices		0,8	Toegankelijkheid met extra ha		0,8			0,80	€		119,00

(based on virgin material costs,  
correction factor for extra costs /  
materials)

Inside / outside facade	Factor	Vertical / horizontal pressure	Factor	Lifespan	Years	Years	Life span formula's	Type of connection	Factor	Accessibility of connection	Factor
Inside	0,8	Horizontal BG	0,7	Source construction year	1989	1994	€Reuse = (1-(t/LSm)) * €Virg * (1-factor in/out)	Dry connections (with or without accessory external connection)	1	Vrij toegankelijk	1,0
Outside	0,6	Horizontal 1st floor	0,8	t [years]	30	22	€Reuse = (1-(t/LSm)) * €Virg * (1-factor pressure)	Dry connection	1,0	Toegankelijkheid met extra handelingen die geen schade veroorzaken	0,8
		Horizontal 2nd floor	0,9					Click connection	1,0		
		Vertical outside 1 floor	0,9					Velcro connection	1,0	Toegankelijkheid met extra handelingen met herstelbare schade	0,6
		Vertical outside 2 floors	0,8					Magnetic connection	1,0		
		Vertical Inside 1 floor	0,9								
		Vertical Inside 2 floors	0,8					Direct connection with additional fixing devices	0,8	Toegankelijkheid met extra handelingen met herstelbare schade > 20% vd bouwkosten	0,4
		No pressure	1,0					Bolt and nut connection	0,8		
								Tongue and groove connection	0,8	Niet toegankelijk onherstelbare schade aan objecten	0,1
								L-profile connection	0,8		
								Screw connection	0,8		
								Connection with additional fixing devices	0,8		
								Direct integral connection	0,6		
								Pin connection	0,6		
								Nail connection	0,6		
								Filled soft chemical connection	0,2		
								Putty connection	0,2		
								Filled hard chemical connection	0,1		
								Glue connection	0,1		
								Poured connection	0,1		
								Weld connection	0,1		
								Cement based connection	0,1		
								Chemical anchors	0,1		
								Hard chemical connection	0,1		

## Dwelling information

General					
Dimensions (NVO)	[m] NVO	[m] BVO	Volume	[m3] NVO	[m3] BVO
Width	5,10	5,40	BG	118,28	149,81
Depth (BG / 1e)	8,92	9,70	1e	118,28	149,81
Depth (2e)	6,40	7,18	2e	84,86	110,89
			Total	321,42	410,50
Hight BG	2,60	2,86			
Hight 1e	2,60	2,86			
Hight 2e	4,64	4,90			
Hight total	9,84	10,62			

## Reusability scale

reusability
possible reusability
no reusability

Building elements		Building material / product		Reusability	
Element	Dimensions [m2]	Type	Dimensions [m2]	Product	Gradation Comment

Foundation					
Site	[m2]				
Foundation	52,38	Concrete piles	?		
		Wooden piles	?		Dmv trekken hergebruiken?

Floors					
Surface	[m2] NVO	[m2] BVO			
BG	45,49	52,38	Channel plate floor	45,49	Dekvloer verwijderen
1e	45,49	52,38	Channel plate floor	35,00	Dekvloer verwijderen
			Concreeet (landing)	10,50	In werk gestort met prefab scheidingswand
2e	32,64	38,77	Channel plate floor	32,64	
Total	123,62	143,53			

Exterior walls					
BG north	[m2]	#			
Window	2,60	1	Glass + frame	2,60	1
Window (door)	0,40	1	Glass + frame	0,40	1
Door	2,40	1	Front door	2,40	1
Cavity wall facade	8,50		Clickbrick	8,50	
			Sand-lime brick	8,50	
Total	15,44				
BG south	[m2]	#			
Window	9,70	1	Glass + frame	9,70	1
Cavity wall facade	5,74		Clickbrick	5,74	
			Sand-lime brick	5,74	
Total	15,44				
BG east/west	[m2]	#			
Party wall (scheidingswand)	55,48		Prefab Concrete	55,48	
					Prefab elements, otherwise downcycle
1e north	[m2]	#			
Window	5,2	2	Glass + frame	5,20	2
Cavity wall facade	10,24		Clickbrick	10,24	
			Sand-lime brick	10,24	
Total	15,44				
1e south	[m2]	#			
Window	5,2	2	Glass + frame	5,20	2
Cavity wall facade	10,24		Clickbrick	10,24	
			Sand-lime brick	10,24	
Total	15,44				
1e east/west	[m2]	#			
Party wall (scheidingswand)	55,48		Prefab Concrete	55,48	
					Prefab elements, otherwise downcycle

Roof					
2e north	[m2]	#			
Window	1,4	1	Glass + frame	1,4	1
Cavity wall facade	31,54		Roof tiles	31,54	
Total	32,94				
2e south	[m2]	#			
Cavity wall facade	32,94		Roof tiles	32,94	

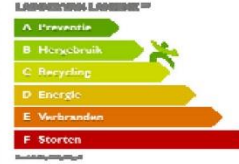
Interior walls					
BG	[m2]	#			
Wall (panels)	26,84		Prefab panels Ytong (cellenbeton) / Faay	19,64	
					Gedeeltelijk hergebruiken (uitzagen,



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 Titel Inventarisatie hergebruik SPW 30 Arnhem  
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 Auteur BJS  
 Versie 2.0



Opmerking: De maatvoering betreft een indicatie.



nr.	Onderdeel	Toelichting	Foto	Materiaal	Afalstrategie	Conditie	Demontage	Afzetmogelijkheid	Aantal (st)	Lengte (mm)	Breedte (mm)	Hoogte (mm)
<b>Bouwkundige werken</b>												
<b>Fundering</b>												
<b>Skelet</b>												
27	Daken (skelet)											
	Dakraam / lichtkoepel		86		Hergebruik	Gemiddeld	-	-	1			
	Glazenwas installatie		87		Hergebruik	Onbekend	-	-	3			
<b>Dakafbouw/dakafwerking</b>												
37	Dakopeningen											
	Zonwering lichtkoepel		88a	Metaal	Hergebruik	Goed	-	-	1			
<b>Gevelafbouw/gevelafwerking</b>												
31	Buitenwandopeningen											
	Kozijn vluchtdeur	Brandwerend	14	Hout	Hergebruik	Goed	0	0	1		1.263	2.500
	Vluchtduur	Brandwerend	15	Hout	Hergebruik	Goed	+	+	1		1.135	2.350
41	Buitenwandafwerkingen											
	Gevelpui	Ter plaatse van entree	104	Aluminium	Hergebruik	Goed	+	0	1		5.398	2.474
	Gevelpui	Ter plaatse van entree	105	Aluminium	Hergebruik	Goed	+	0	1		2.780	2.196
	Gevelkozijnen				Recyclen	Gemiddeld	0	-	n.t.b.		divers	divers
<b>Binnenwandafbouw/ binnenwandafwerking</b>												
42	Binnenwand afbouwconstructies											
	Kozijn pui		50	Staal en glas	Hergebruik	Goed	+	+	1		6.580	2.034
	Kozijn pui		58	Hout en glas	Hergebruik	Goed	+	+	4		640	2.537
	Kozijn pui		59	Hout en glas	Hergebruik	Goed	+	+	2		1.955	2.537
	Metal stud scheidingwand	1e t/m 6e verdieping			Recyclen	Gemiddeld	-	-	n.t.b.			
32	Binnenwandopeningen											
	Binnenkozijn wandraam		1	Hout en glas	Hergebruik	Gemiddeld	+	+	1		1.453	2.190
	Dubbele binnenkozijn deur		2	Hout	Hergebruik	Gemiddeld	+	+	1		1.770	2.162
	Deur		3	Hout	Hergebruik	Gemiddeld	+	+	1		850	2.110
	Deurdranger	Merik Dorma	16	Aluminium	Hergebruik	Goed	+	+	115			
	Deurklem	Positie wand	17		Hergebruik	Goed	+	0	2			
	Kozijn deur	Brandwerend	28	Hout	Hergebruik	Gemiddeld	0	0	1		1.015	2.055
	Deur	Brandwerend	29	Hout	Hergebruik	Goed	+	+	1		870	1.970
	Kozijn deur	Toiletdeur	115	Hout	Hergebruik	Gemiddeld	0	0	57		920	2.165
	Deur	Toiletdeur	115	Hout	Hergebruik	Goed	+	+	57		825	2.110
	Binnenkozijn wandraam	Veiligheidsglas	33	Hout en glas	Hergebruik	Gemiddeld	+	+	4		4.286	2.273
	Binnenkozijn wandraam	Veiligheidsglas	34	Hout en glas	Hergebruik	Gemiddeld	+	+	4		2.630	2.413
	Deurkozijn met zijlicht	Veiligheidsglas (14 per verdieping)	35	Hout en glas	Hergebruik	Goed	+	+	40		1.297	2.180
	Deur		36	Hout	Hergebruik	Goed	+	+	40		825	2.110
	Kozijn deur		41	Hout en glas	Hergebruik	Gemiddeld	+	+	6		1.000	2.160
	Deur vluchtroute	Maatvoering raam: b430 en h305	42	Hout	Hergebruik	Goed	+	+	6		920	2.011
	Deurkozijn met zijlichten		45	Hout	Hergebruik	Gemiddeld	+	+	20		1.773	2.266
	Deur		46	Hout	Hergebruik	Goed	+	+	20		920	2.216
	Deurklem	Positie vloer	47		Hergebruik	Goed	+	+	1			
	Kozijn deur		51	Hout	Hergebruik	Gemiddeld	+	+	16		1.773	2.160
	Deur		51	Hout	Hergebruik	Gemiddeld	+	+	16		910	2.110
	Kozijn deur	Beschadigd door constructieve balk	52	Hout	Hergebruik	Gemiddeld	+	+	4		2.359	2.551
	Schuifdeur kozijn	t.h.v. wenteltrap, veiligheidsglas (b=820, h=590)	54	Hout	Hergebruik	Gemiddeld	0	-	1		820	590
	Schuifdeur	t.h.v. wenteltrap	55	Hout	Hergebruik	Goed	+	+	1		1.015	2.085
	Deurdranger schuifdeur	Elektronisch	56		Hergebruik	Goed	+	+	2			
	Kozijn deur		65	Hout	Hergebruik	Gemiddeld	0	0	2		3.001	3.287
	Deur	Glas b=600 en h=985	66	Hout en glas	Hergebruik	Goed	+	+	6		930	2.012
	Kozijn deur		67	Hout	Hergebruik	Gemiddeld	0	0	7		2.050	3.287
	Kozijn deur		68	Hout	Hergebruik	Gemiddeld	0	0	7		2.500	3.287
	Schuifwand	Breedte panelen = 3830	69		Hergebruik	Gemiddeld	+	+	1		4.172	4.050
	Gevangenisdeur	Verzwaarde deur	70	Hout	Hergebruik	Goed	+	+	7		1.010	2.019
	Kozijn deur		71	Hout	Hergebruik	Goed	+	+	7		1.050	2.070