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Social housing as a source for urban mining in The Hague by 2050.

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Sincerely,

Lia Montserrat Alvarez Mendez

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Acronyms

C&D	=	Construction and demolition
MFA	=	Mass Flow Analysis
GIS	=	Geographic information system
EPCs	=	Energy Performance Certificates
sqm	=	Square meters
Kg	=	Kilograms
Mt	=	Mega tonnes

SOCIAL HOUSING AS A SOURCE FOR URBAN MINING IN THE HAGUE.

Lia M. Alvarez-Mendez

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Keywords*: Resilient city, Urban mining, social housing The Hague, and The Netherlands.*

SUMMARY

Background: The municipality of The Hague and the Social housing associations are researching on how to cope with the population growth in The Hague. Every year approximately 5,000 new persons arrive at The Hague, meaning that in 10 years The Hague will increase their population by 8%. The main problem is that currently, the city has a shortage of social housing, which is the most vulnerable sector in the city. The municipality has a variety of new governmental strategies that provide answers for these upcoming changes.

Aim: The main challenge is that the municipality of The Hague's strategies in the construction sector will result in significant volumes of waste. These waste streams need to be quantified to find opportunities for urban mining.

Typically, the materials extracted from the construction and demolition (C&D) sector are downcycled into less valuable materials, incinerated or sent to the landfill, backfiring in economic loss and increase in CO_2 emissions.

Nowadays, there are companies that recover the material form the C&D site and recycle it into new construction material. However, even if it has been proved that circular demolition is between 10-15% cheaper and decreases emissions up to 44%, it is not a common practice. This develops the questions about 'why urban mining is not a common practice?', and 'how can it be encouraged?'

The purpose of this research is to explore the topic of urban mining by assessing the possibilities of implementing urban mining in the social housing sector in the upcoming years.

Methodology: For this research, three methodologies have been selected; A) Interviews, B) Stakeholder analysis and C) Mass Flow Analysis (MFA).

A) Interviews: Ten interviews were conducted with the main stakeholders related to urban mining of social housing in

The Hague. These include the municipality of The Hague, Social housing associations and C&D companies.

B) Stakeholder Analysis: The stakeholder analysis was performed to analyse the relation and communication between the various parties involved. The goal of this analysis was to understand the communications barriers that stand in the way of urban mining becoming a common practice.

C) Mass Flow Analysis: Using four different criteria (construction year, land use, energy label and the 20-80 rule) two estimations were created to quantify the projected number of social housing buildings that might be demolished by 2050. The result of the two estimations was the monetizing of the material – brick and glass- that can be extracted from the social housing buildings.

Results: Two main findings were established from the methodologies. On the one hand, the interviews and stakeholder analysis led to the finding that there is a lack of proper communication between social housing associations, municipalities, and C&D companies. The various parties are interested in collaborating in the area of urban mining. However, the lack of direct communication channels resulted in the slowing down of the process of upscaling to larger urban mining projects.

On the other hand, after doing the MFA, the results showed that urban mining practices could be between 15-20% more profitable than standard practices. Construction companies can save up to 20% by buying recycled material from a C&D site. The results also showed that urban mining of materials, such as brick and glass, can reduce the CO_2 emissions by 44%.

Conclusion: Urban mining in The Hague is an environmentally friendly and profitable option if the different parties agree to collaborate. After the municipality of The Hague creates a framework on how to apply urban mining techniques for the buildings owned by the municipality itself, the process can be more easily replicated by other companies.

Scientific relevance: This research quantifies the competitiveness of urban mining of social housing in The Hague, opening the path for new research about urban mining implementation and development.

1.INTRODUCTION

1.INTRODUCTION

There is a limit to the number of resources the earth has; each day, natural reservoirs are on a trend towards depletion. A way to stop this process is by extracting valuable materials from existing constructions; this process is called Urban mining (Park, Clark, Krueger & Mahoney, 2017).

This research is going to explore the opportunity of doing urban mining of social housing in The Hague. In the Netherlands, three-quarters of the population live in the cities of Amsterdam, Rotterdam, The Hague, and Utrecht (Nabielek, Hamers & Evers, 2016). The municipality of The Hague is developing a resilient city plan on how to cope with climate change, demographic change, and economic uncertainty by 2030 (Hitipeuw, 2018). One of the strategies is to increase housing by 8% in The Hague, resulting in 19,000 new houses by 2030 (Hekwolter, Nijskens, & Heeringa, 2017). However, most of the newcomers have an average income of 33,300 EUR, which complies with the income needed to be eligible for social housing in The Netherlands (Municipality of The Hague, 2019a; Dutch Government, n.d.b).

The Hague has a proportion of 90% of residential and 10% of non-residential buildings, making residential buildings central to reduce future emissions (CBS, 2019). From that, 90 % of residential buildings, 31% is owned by social housing associations (Hekwolter et al., 2017). The reason why social housing is a significant sector in the Netherlands is that in 1945, during the second world war, some neighbourhoods were destroyed, leading to a shortage of housing. From 1945 to 1990, there was an increase in social housing demand, and nowadays, the need for social housing is increasing rapidly again (Elsinga and Wessenberg, 2014; Hekwolter et al., 2017). Most of the buildings built post-war do not comply with the current housing needs, due to their condition or their year of construction, having a high probability of being demolished or refurbished (Elsinga and Wessenberg, 2014). The possible materials that will become available from these constructions are mostly concrete, brick, plastics, wood and metals, materials that can be urban mined by other industries if they are correctly extracted (Koutamanis, Reijn, & van Bueren, 2018).

The following section, '1.1 Background knowledge' is explained what resilient cities, urban mining and social housing are. Then, in '1.2 Objective and research question', is specified the knowledge gap, aim of the research and research question can be found.

1.1 Background Knowledge

The Literature review is divided into sections: urban mining in the Netherlands, The Hague as a Resilience City, and social housing associations in The Hague.

1.1.1 Resilient cities

There are different general definitions of what a resilient city is, such as the definition written by MacKinnon in 2015 as part of the 'International Encyclopedia of the Social & Behavioral Sciences: Second Edition': A Resilient City is a city with the capacity to deal with external sources of stress (such as natural phenomena) and recover normal functions in terms of economy, society, and urban infrastructure. However, there are different ways to deal with external sources of stress to become a resilient city.

On one hand, Wang, Shen, Xiang, & Wang (2018),considers that there are eight characteristics that define a resilient city: multi-functionality of space, the flexibility of spatial processes, interactivity of facilities, diversity of components, the intelligence of public services, the humanity of public services, prediction based on management concepts and the collaboration of management institutions. On the other hand, Renald et al. (2016) describe four factors that affect the city models directly: spatial arrangement, technology innovation, disaster mitigations, and disaster adaptation. In the case of The Hague as a Resilient City, the municipality made a list of the seven qualities that define a resilient city: Inclusive, integrated, flexible, robust, resourceful, regenerative, and reflective (Municipality of The Hague, 2019a). The three authors express in their text that the primary triggers of change in each Estimation are defined by the stakeholders of the system.

Table 1 Characteristics of a resilient city according to three authors: Wang and Collaborators (2018), Renald and collaborators (2016), and Municipality of The Hague (2019a).

Want et al. 2018	Renald et al. 2016	Municipality of The Hague 2019a
Multifunctional	Spatial arrangement	Inclusive
Flexibility	Technology innovation	Integrated
Interactivity	Disaster mitigation	Flexible
Diversity	Disaster adaptation	Robust
Intelligence		Resourceful
Humanity		Regenerative
Prediction based		Reflective
Collaboration		

The theories from the three authors, as can be seen in Table 1, can be subdivided into multiple categories. The characteristics that are highlighted can be assigned to the category of the built environment, giving an opportunity to create a guideline of the criteria the construction sector should follow in the upcoming years to build resilient buildings, such as social housing. The municipality of The Hague pinpointed two characteristics, Resourceful and regenerative, that opens the conversation to explore topics, such as urban mining and material passport.

1.1.2 Urban Mining in The Netherlands

The national Climate Agreement (pg. 35, 2019a) by the Dutch Government states:

"A colossal construction challenge lies ahead in the years to come, which provides opportunities for circular economy thinking to be embedded in the construction sector and requires smart coordination of interventions, whether for new construction or renovation projects."

The Dutch government wants to become fully circular by 2050, and, as is shown in the quote, they expect changes in the construction sector. It must be explained that the construction sector in the Netherlands accounts for an estimated consumption of 50% of the total raw materials, 30% of the total water, and 40% of the total energy produced (en Milieu & van Economische Zaken, 2016). Only, in 2010 the construction sector in the Netherlands produced 24 Mega tonnes of waste, from which 70% was construction and demolition (C&D) waste (Rijkswaterstaat Leefomgeving, 2013). The 95% of this C&D waste is recycled and used as the foundation for roads, and it is considered that only 3% of the recovered material re-enters to the construction sector, resulting in a significant loss of materials (Schut, Crielaard & Mesman, 2016). Nowadays, the government has initiatives to reuse materials and has a founding up to 100 million euros per year for innovations (Dutch Government, 2019a). The C&D waste can be used as an opportunity for urban mining, especially demolition waste. However, there are no policies in place about the urban mining of materials in the construction sector.

In the past years, there has been research on the quantification of the materials that can be found in the urban areas, such as copper and steel (van der Voet, van der Huele, Koutamanis, van Reijn, van Bueren, Spierings, & Blok, 2017; Gelferman et al., 2017). The central city that is used as a case of study for urban mining is Amsterdam. However, in more recent years, other cities have been assessed, such as Amersfoort and Utrecht (Blok, 2018). These researches have spiked the interest of different parties, which could gain

environmental and economic benefits if they practice urban mining. As an example, in 2015 the urban mining collective (UMC) was founded, the leading member of the collective is 'New Horizon: Material Balance', as the company that controls the raw material flows and brings innovations to the market. In 2017, the collective delivered their first project, called 'Circl' a pavilion that was built entirely based on circular principles. They reused and recycled materials from the former building and other demolition sites, such as the windows from the Philips office building and created a wooden floor with a variety of woods that were collected from different sites. Currently, the building is a restaurant and works in collaboration with different start-ups that work with circular mindsets (Circl,2019; Edwin Baars, 2019). Nevertheless, this example is not unique in the Netherlands, some other projects are the NDSM Wharf, Café de Cauvel and Buiksloterham, in Amsterdam, and the Binckhorst neighbourhood in The Hague.

The urban mining collective is integrated into multiple companies in the different areas of the construction sector. Therefore, they have developed materials that use as a primary source the demolition waste or previous constructions. Some examples of these materials are recycled bricks made with brick and glass (Appendix 4), circular wood made with retrieved wood that can be used for replacement of small wood pieces (Stiho, n.d), and circular concrete (New Horizon, 2019b), a concrete that is made by grinding concrete and sand into pieces of gravel.

As is previously mentioned, the main materials that constitute housing in The Netherlands are concrete, brick, plastics, wood and metals. However, from these materials, there are two materials that have the highest percentage of availability in Dutch constructions: concrete and brick (Koutamanis et al. 2018). Nowadays, there is a significant number of researches about concrete; Therefore, this research will focus on productions of recycled brick. Nevertheless, to be able to assess the possibility of urban mining brick, it is necessary to first understand the methodologies used in the most well-known urban projects.

Methodologies used in Urban Mining Projects

There is a variety of projects that research the possibility of doing urban mining of C&D waste. However, for this research the methodologies from two emblematic urban mining projects in Amsterdam are used as reference: 'Resource management in peri-urban areas' project (REPAiR; Gelferman et al., 2017) and 'Prospecting the Urban Mine of Amsterdam' project (PUMA; van der Voet et al., 2017). These projects explore a set of diverse methodologies resulting in the quantification of material sources in the city of Amsterdam and analyze the possibility of urban mining. The methodologies applied in total are e four: 1) Stakeholder Analysis, 2) Scenario Modelling, 3) Spatial Analysis, and 4) Material Flow Analysis.

1) **Stakeholder Analysis:** The PUMA and REPAiR projects, have different stakeholders interact to explore the possibility of urban mining in Amsterdam. The PUMA project (van der Voet et al., 2017) mentions that it is necessary to have actors involved in the processes of collection, repair, renovation, and refurbishment. However, other procedures, such as recycling and secondary material productions, might not be possible to manage locally. The main stakeholders are demolition companies, waste to energy companies, scrap dealers, Amsterdam municipality, housing corporations, and private companies that can facilitate the process of creating a material passport for metals.

   The stakeholder analysis helps the research to locate who owns which data and how this information relates to the knowledge that the other parties have. When the main stakeholders are selected, the next step is to start an exploration of possible storylines (van der Voet et al., 2017).

2) **Scenario modelling:** The scenario modelling in the REPAiR project is based on two axes: Scale level (local or global) and driving force (markets or governments), with four scenarios; local governments, global governments, local markets, and global markets. The scenarios were explored with stakeholders and academia to brainstorm about the requirements and characteristics of what is successful urban mining. According to Gelferman (2017), the baseline scenario for urban mining, on the REPAiR project, was developed by calculating it based on business as usual. In both projects, the scenarios provide valuable insight, which can be used to stir the project in a more feasible path. When the scenario modelling is complete, the next step is to quantify the amount of material that is available. That is necessary to implement the geo-design framework and the material flow analysis.

3) **Spatial Analysis:** The primary purpose of spatial analysis is to explain and predict the possible scenarios based on knowledge of their current or future situation (Pumain, 2005). There are tools such as 'Geographic Information System' (GIS) that can help storage, retrieve and display geographic data, leading to the quantification of materials, with a visual approach (Steward and Rogerson, 1993). In the PUMA project, GIS was used as the platform where to combine the information collected by Leiden University, TU Delft, Metabolic, and Waag Society. In this case, the Waag society created the maps representing the copper and steel density on a very detailed level in Amsterdam (van der Voet et al. 2017).

4) **Material Flow Analysis (MFA):** is used to calculate the material inflows, outflows, and stocks within a system defined in time and space. The material is calculated based on the law of the conservation

of matter; the logic behind is that there must be a balance between inputs, stocks, and outputs of a process (Song, Yan, Cao, Song, Ding, & Sun, 2019). In the REPAiR project, the MFA of food and construction waste aims to be used to connect the spatial, material, and social analysis by illustrating the potential synergies between the different parties. The use as an example, through MFA and spatial analysis they can track how much-unsold bread is thrown away from bakeries, and then with the stakeholder analysis, they can map which breweries could use the leftover bread to make beer.

REPAiR and PUMA project approach the topic of urban mining in the city of Amsterdam. Inside the Netherlands, some companies are advocating the reuse of secondary raw materials and promote the practices of urban mining in big cities. However, there are no urban mining projects of construction waste in The Hague.

Based on the stakeholder analysis from the REPAiR and PUMA projects, the actors that can be involved in the process of urban mining in social housing areas in The Hague are; municipality; through the resilient city plans, demolition and construction companies; through implementation of secondary materials and social housing associations; through construction, refurbishment and demotion of housing.

1.1.3 The Hague as a Resilient City

The Hague is part of the '100 resilient cities', initiative created by the Rockefeller Foundation, that takes into consideration stresses that weaken the city fabric daily; degree of unemployment, inefficient public transport, endemic violence, food/water shortage and demographic changes (Hitipeuw, 2018; 100 resilient cities, n.d.). Currently, the municipality of The Hague released their resilient city plans, which are the 'Agenda-setting Workshop,' 'The Hague 100 resilient cities: preliminary resilience assessment', 'City of The Hague,' 'Sustainable Development Goals in the Netherlands' and 'The Hague, Resilience Strategy 2019'. These documents explain how the city of The Hague is growing and how the demography is changing. The resilient city chief office of The Hague explains how resilient strategies start with people living comfortably and safely in liveable neighbourhoods. However, they are threatened by segregation, population growth, poverty & debt, and underground crime. Creating resilient neighbourhoods as part of the resilient city plans is an iterative process, which challenges the city (The Hague, 2019) and includes the collaboration of many stakeholders, such as C&D companies, municipalities, and, in this case, social housing associations. As is mentioned, resilient city plans are iterative; therefore, constant changes in the built environment, such as construction, refurbishment and demolition, can be made, creating an opportunity for the exchange of materials.

Demographic Change

The municipality of The Hague has developed different strategies to deal with the demographic change, such as the 'housing agenda 2019-2023', 'Neighbourhood programs 2016-2019', 'Housing vision The Hague 2017-2030', and 'Policy brief on neighbourhood projects.' The Hague is home to more than 300 international organizations and NGO's, providing more than 38,500 jobs. The city has an estimated increase of 4,000 to 5,000 persons per year, from which 37.1% are between 20 and 44 years, meaning that 19,000 more houses will be needed by 2030 to cover the housing demand (Municipality of The Hague, n.d; Hekwolter et al., 2017; Nijskens and Lohuis, 2019). Furthermore, the rent prices of privately own properties keep rising every year, making it less approachable for young professionals and students, which increases the demand for social housing. However, even if the social housing sector covers 31% of the city of The Hague, only 67% is affordable, whit a waiting list of 2.8 years (Rijksoverheid, 2016b; Rijksoverheid, 2019).

1.1.4 Social Housing Associations

According to the resilience strategy of The Hague (2019a), 75% of the 27,000 dwellings that should be constructed by 2050 are still in the planning phase. Therefore, the Municipality of the Hague can build the upcoming residence in accordance with the resilient city characteristics that they defined (Table 1). Three of the seven characteristics to create a resilient design are: Regenerative, flexible and resourceful. These characteristics can be implemented by thinking of buildings as Lego boxes, where the materials can be exchanged and transformed based on the needs of the user (Gentile, 2013), giving an opportunity to combine urban mining and resilient design.

Currently, the social housing sector has 31.7% of the Dutch housing stock and is considered the most vulnerable segment of the population (Aedes, 2016; Mesquita and Kos, 2017). As can be seen in figure 1, the social housing sector is located in the neighbourhoods with a lower climate score and higher heating score. The climate score is based on three impact maps: possible damage, vulnerable in buildings and vulnerable roads. The score is calculated by the average impact per square meter of the neighbourhood. The Heating score is calculated based on the amount of radiation of heat in the area, this is calculated based on the material of roof and roads, and how dense and narrow the roads are. The combination of the climate score, heat score and the location of the social housing buildings, show how these neighbourhoods are one of the most vulnerable to climate change, which could result in heatwaves or floods (Municipality of The Hague, 2019a).

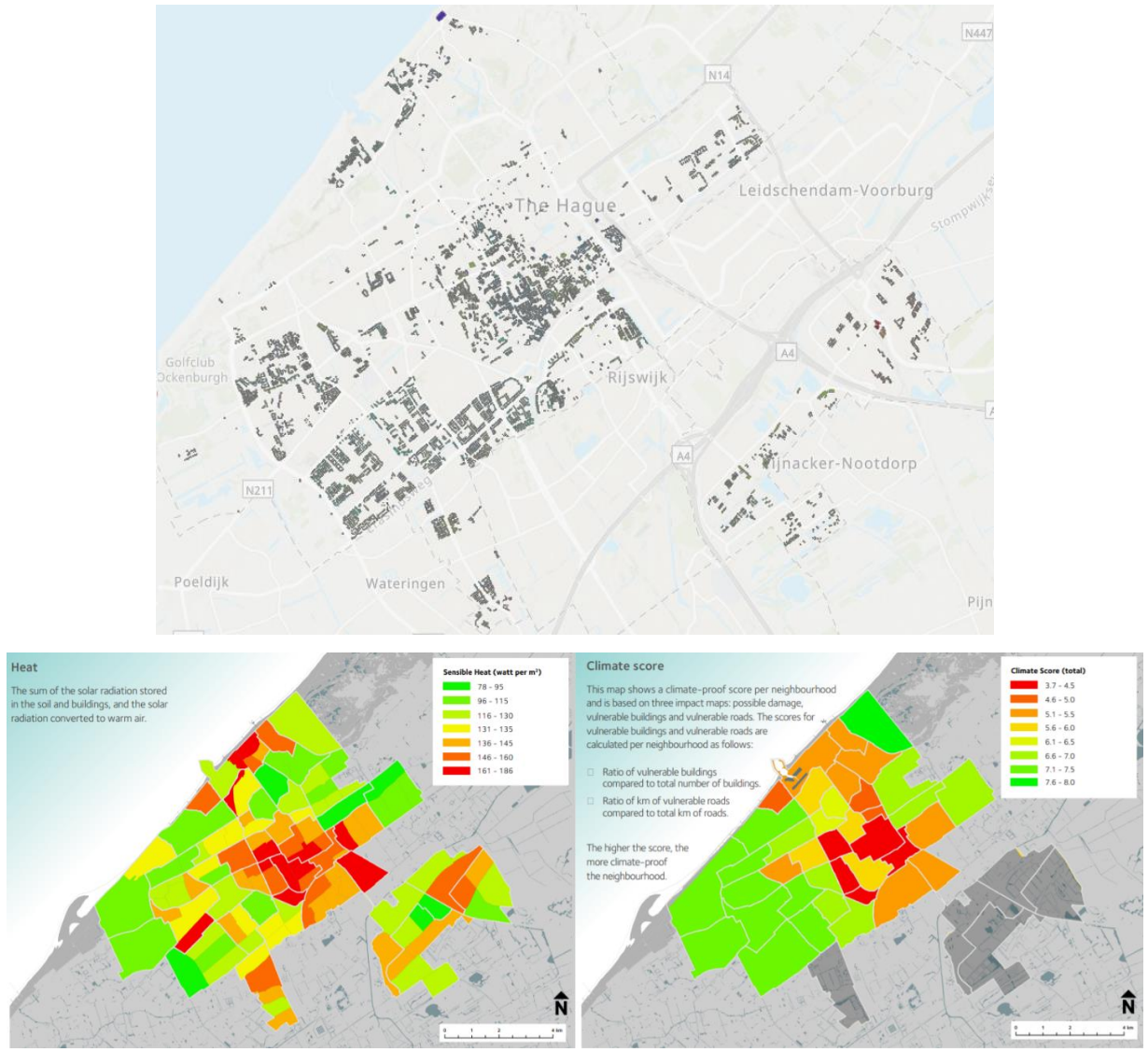

Figure 1. This figure shows the vulnerably of social housing areas demonstrated in images 1,2 and 3 (top, left, right). Image 1 shows the location of social housing buildings in The Hague ('Corporatiebezit panden in Den Haag, n.d.'). Image 2 shows Heatwaves. The red areas show the areas that are warmer. Image 3 shows the Climate Score per neighbourhood (Municipality of The Hague, 2019a).

There are eight significant social housing associations in the city of the Hague: Haag Wonen, Vestia, Vidomes, Staedion, DUWO, Arcade Wonen, Mooiland, and Woonlnvest (Municipality of The Hague, 2019b). Each one of these companies is partly responsible for the quality of life in the neighbourhood where their buildings are located and have roadmaps with the dwellings they plan to refurbish or demolish before 2050 (Aedes, 2016; Dutch Government, n.d.a). However, these roadmaps might or might not be aligned with the Resilient city strategy done by the municipality of The Hague.

The goal of the social housing sector in The Netherlands is to ensure enough affordable housing. However, in the past years, hefty taxes have been applied to new constructions and demolitions (1.5 billion Euros in 2015), reducing the amount of new social housing constructions and renovations by 50% between 2009-2014, resulting in a shortage of social housing (Aedes, 2016; Capital value, 2019; Municipality of the Hague, n.d.). During the next few years, a significant amount of material is needed to refurbish and build new constructions. The demolition and refurbishment sites will create a large amount of construction waste, creating an opportunity for implementing urban mining in the process, incentivizing the exchange of materials.

1.2 Objective and research question

Based on the literature review, a knowledge gap was found that resulted in a research question and a series of sub-questions. This section explores the following in three parts. The first part is an explanation of the knowledge gap found, then the second part describes the aim of the research, and the third part delves into the research question and sub-questions.

1.2.1 Knowledge gap

The demand for social housing in The Hague is increasing exponentially, by 8% per year (Hekwolter et al., 2017). However, The Hague is a dense city with a limited amount of land, meaning that buildings need to be demolished to make space for new constructions (Pg.55, Municipality of The Hague, 2018). The demolition of the current buildings is projected to produce a considerable amount of material which can be urban mined. Nevertheless, the state-of-the-art of the construction sector in The Netherlands does not take full advantage of the possibility of recycling or reusing materials in new constructions; currently, most of the material retrieved from the demolition site is downcycled and used for building new roads (Schut et al. 2016).

The primary materials that compose the housing sector in the Netherlands are concrete and brick (Koutamanis et al. 2018)). However, there are numerous ongoing researches on concrete. Therefore, for this research, the focus is on Brick, an advantageous material since it can be easily recycled into new bricks. The recycling process is done by crushing and combining the brick and glass. Then the mix is heated on high temperatures. The reason behind this is that glass is a material that stores energy. Consequently, when the glass is combined with brick, the glass radiates heat during the cooking process, shortening the production process by 25% and consequently saving 25% of the emissions in comparison to traditional brick manufacture. (Edwin Baars, 2019; Appendix 1).

1.2.2 Aim of the research

Due to upcoming changes in the city of The Hague, a significant amount of materials will become available from demolition waste. Currently, there is no estimation of the construction waste that will come out from the social housing sector, and according to the circular accord, The Hague states that they want to become climate neutral for 2050 (Ministries of infrastructure, environment and economic affairs, 2016). This research aims to map the buildings that will be demolished by 2050 and quantify the amount of brick and glass that will come out from the demolition process, opening the opportunity for new collaborations and material exchange.

1.2.3 Research Question

How can urban mining of social housing help to achieve the transformation of The Hague into a resilient city by 2050?

1.How are construction companies, demolition companies, and the municipality involved in the demolition process in The Hague?

2.Which social housing buildings might be demolished in The Hague by 2050?

3.How many kilograms of brick and glass can be extracted from the social housing demolition waste by 2050, and what is their value in euros?

2.METHODOLOGY

2. METHODOLOGY

The social housing buildings in The Hague can be seen as a significant source of material stock. These materials can become available through demolition or refurbishment to build social housing in the future to keep up with demographic changes. Different methodologies were selected to find the key elements to transforming urban mining from the pioneering stage to a common practice in the future.

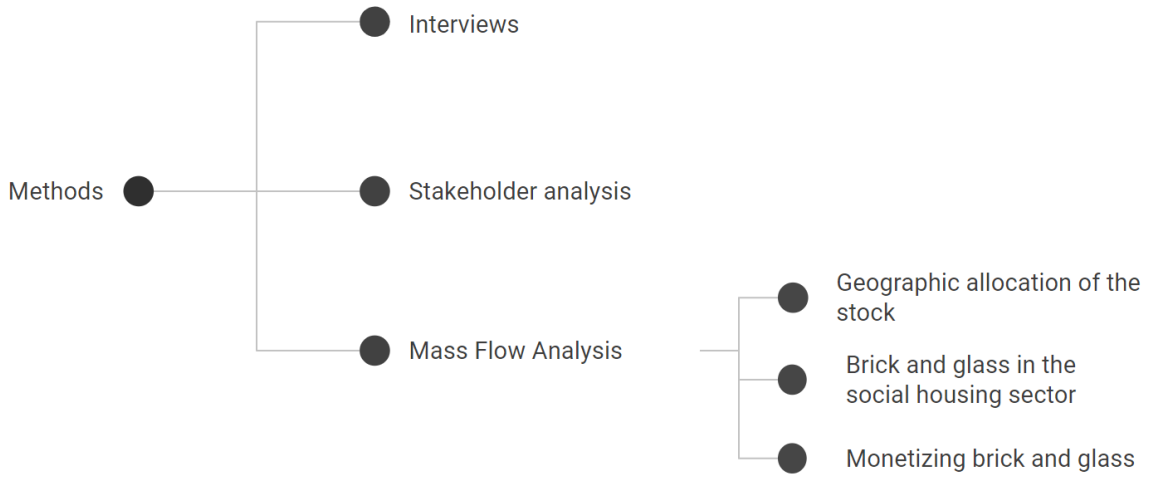

Figure 2. Flow diagram of how the approach and methodology are composed.

The three methodologies selected are interviews, stakeholder analysis and material flow analysis. Each of the methodologies is used to address a specific sub-question, as explained in the following overview:

Sub-question 1: How are construction companies, demolition companies, and the municipality currently involved in the demolition process in The Hague?

Methodology selected: Interviews and stakeholder analysis, based on the framework of Enserink et al. (2010). In section '2.2.1 Stakeholder Analysis' there is a more detailed explanation of the process.

Sub-question 2: Which social housing constructions might be demolished in The Hague to by 2050?

Methodology selected: Geographical allocation through GIS in combination with the demolition criteria found in the interviews. This methodology is further explained in section '2.2.2 Material Flow Analysis', '1) Geographical allocation of the stock'.

Sub-question 3: How many kilograms of brick and glass can be extracted from the social housing demolition waste by 2050, and what is their value in euros?

> *Methodology selected: Material Flow Analysis. The quantification of the material that can be extracted from the demolition site of social housing associations was calculated; based on different criteria. For further explanation, the methodology is explained in section '2.2.2 Material Flow Analysis', '2) Brick and glass in the social housing sector', and '3) Monetizing brick and glass'.*

2.1 Methods and Data Sources

The social housing sector in the Netherlands is a complex system that intertwines with other topics such as resilience and urban mining. This section has explained the approach used to understand the current-state-of-the-art and how the different parties collaborate with each other. The methodology is composed of three sections: Interviews, Stakeholder Analysis, and Material flow analysis. Furthermore, in the following text, a more elaborate explanation of how each methodology was used to answer each sub-question is done.

2.1.1 Interviews

The limited amount of information contained from the literature and technical reports was an encouragement to have an alternative way to obtain information which can be used in the analyses. Under those circumstances, interviews with the key actor were done. For this section, four key informants were interviewed. The informants were selected based on the companies and institutions more relevant for this research. Each one of the informants is from a different institution that collaborates closely with the others to pursue the topics of resilience city, social housing, and urban mining in the Netherlands and The Hague. The informants are 1) Demolition company (New Horizon), 2) Construction company (Van Wijnen Noord), 3) Social housing association (Vestia and Sociale Verhuurders Haaglanden), and 4) Government (Municipality of The Hague).

The interviews are done with the intent to understand the gaps in the literature review were and to understand the relationship between the different parties. Information that is highly relevant for this research when assessing the Possible Estimations of urban mining of the social housing sector in The Hague. The interviews can be found in Appendix 1.

2.1.2 Stakeholder analysis

A stakeholder analysis is performed -between the social housing associations, demolition companies, and the municipality of The Hague - to have a holistic view of the relation and perception of urban mining in The

Hague, and how to facilitate the transition to urban mining as a common practice. The information used for the analysis is technical reports, interviews and the previous accords between the municipality, social housing associations, and the company New Horizon.

The methodology used for the stakeholder analysis is based on the framework of Enserink et al. (2010). The framework is composed of six steps. Each step is designed to understand the power-interest of the actors, their network structure, and their perception of the problem.

Step 1: Formulation of a problem as a point of departure

There are two approaches that can be taken to solve this step. The first is to formulate the problem from the point of view of the problem owner (in this case, one of the Institutions) and mapped by the analyst. The second, formulate the problem from the point of view of the analyst, based on the previous exploration. This research is made as a third party observing the problem between the different institutions. Therefore, the second option was chosen

Step 2: Inventory of the actors involved

Find the main actors that are involved in the system. There are six different techniques to identify them:

1) The actors have an imperative approach or strong feelings about the cause.

2) Formal actors that are already involved with existing policies.

3) Key informants that are related to the policy problem.

4) Actors that participate in activities related to policy issues, such as citizens.

5) The actors who are the leaders and tend to shape public opinion.

6) Identify actors via specific characteristics, such as age, sex, and education.

The technique listed in number three was the one addressed in this research. Since urban mining in The Hague has a large pool of actors in different disciplines, the most convenient approach was to map the main sectors on the process and how they interact.

Step 3: Exhibiting the formal chart, the formal task, authorities, and relations of actors and the current legislation

Drawing of the formal chart of the relationship within the actors, giving context information about the formal and informal relationship within the different parties. The graph can also highlight the dependencies between actors in a network. There are three ways to approach the chart:

1) The formal position of the actors, with their tasks and responsibilities.

2) Relationship within the actors with an organization chart.

3) Most important laws, legislation, procedures, and/or authorities that play a role.

The third option was chosen, since one of the key points that were needed to be explored were the constrains and the hierarchy difference between the actors.

Step 4: Determine the interest, objectives and problem perceptions of actors

The problem formulation, as is currently presented, is only one of the ways to approach the issue. However, depending on how the problem is formulated, there can be different ways to solve it. The topics that were pinpointed from each actor were their interest, their objectives, their perception of the problem, the cause, and the problem solution. The result was a table of actors with their interests, objectives and problem perception. Then, each actor was compared, finding the similarities, differences, and shared interests.

Step 5: Mapping out the interdependencies between actors by making inventories of resources and the subjective involvement of actors with the problem

Ones the actors were mapped, and their interest was shown, there was space for collaboration and partnerships. In most cases, the pain of one of the actors can be solved with the gains of another, creating a win-win situation. In this step, the crucial resources of each actor were highlighted, opening the opportunity for collaborations.

Step 6: Determine the consequences of these findings regarding the problem formulation.

The last step consisted of confronting the original problem formulation with the results from the previous steps. There are three sub-steps to approach the comparison. The first one “consequences that relate to the content of the problem analysis of the analyst,” refers to the reason the reformulating of how the problem was analyzed. The second sub-step, “Consequences that relate to the dealing with other actors,” points which actors are open for a fruitful collaboration and from which actors’ opposition is expected. The last

sub-step was "consequences regarding research activities," this sub-step highlights the knowledge gaps and the research questions that should be answered in the future.

2.1.3 Material Flow Analysis

This section explains the methodology used to extract the different data databases to create the maps that show the material stock in the social housing sector in The Hague. This section explains in detail the handling of data. The approach used is divided into three parts: 1) Geo-graphic allocation of material stock, 2) Brick and glass in the social housing sector, and 3) Monetizing brick and glass.

1) GEOGRAPHIC ALLOCATION OF THE STOCK

Specific criteria were needed to quantify the number of materials in the social housing sector, such as location, shape area, year of construction, and energy label. The data has been extracted from three databases to create the maps: "Corporatiebezit pandan in Den Haag" (Municipality of The Hague, n.d.), the "Datalab Energietransitie" (Municipality of The Hague, n.d.) and the BAG 3D (Land Registry, 2019). The first database is an open-source map generated by the municipality of The Hague; it shows the location of all the buildings own by social housing associations in The Hague and the name of the companies who own the building. The second database, also created by the municipality of The Hague, shows the energy label of all the buildings in The Hague. The third database (BAG 3D) is a joined dataset of BAG (Basisregistratie Adressen en Gebouwen) and AHN (Algemeen Hoogtebestand Nederland) database, is done by ESRI, the producer of ArcGIS software. The BAG is a database published by the Netherlands land registry and Mapping Agency. This database has specific information about each building in the Netherlands, such as the year of construction, height, and area. The three databases were handled on ArcGIS 10.6.1. Ones all the databases were extracted, they were merged, locating all the social housing buildings in The Hague and their properties.

2) BRICK AND GLASS IN THE SOCIAL HOUSING SECTOR

The quantification of the materials in the social housing sector is done based on information retrieved from New Horizon, a circular demolition company. New Horizon is part of the urban mining collective in the Netherlands and collects information about every building they demolish. For this research, they provided the average amount of kilograms (Kg) per square meter (sqm) of brick that will come out from the demolition of a household. They also provided the average amount of glass in Kilograms per square meters (kg/sqm) in the housing sector.

3) MONETIZING BRICK AND GLASS

In the previous section, the amount of brick and glass that can be extracted from social housing by 2050 is quantified. These numbers were multiplied by the price (in Euros) of the materials per Kilogram, giving the total amount of euros that can be calculated by recycling and/or disposal. The price was calculated by scattering market prices and calculating the average.

3.RESULTS

3.RESULTS

Based on the applied methodologies over three databases and ten interviews, different types of results were obtained: '3.1 Stakeholder analysis', '3.2 Assumptions for future demolitions', '3.3 Material flow analysis and monetizing of brick and glass extracted'. These results aim to create a holistic basis for implementing urban mining in the Hague.

The first result, '3.1 Stakeholder analysis', approaches the interaction between the parties that are involved in implementing urban mining in The Hague as standard practice; C&D companies, municipality, and social housing associations as owners of a significant amount of properties. The results of the stakeholder analysis visualize the interaction between the different parties and their lack of direct communication channels.

The second result, '3.2 Assumptions for future demolitions', analyses the number of buildings that might be demolished by 2050. The number of buildings is calculated through two different approaches which are based on four criteria. This creates two estimates of the number of constructions that could be demolished by 2050, and how it is translated into a material stock of brick and glass.

The third and final result, '3.3 Material flow analysis and monetizing of brick and glass extracted', looks into the material stock that could be obtained from the buildings that might be demolished by 2050. Then, the material stock is monetized, based on their market price: new-price from the store, sold as demolition waste, or, the price of material when recycled into new bricks or glass.

3.1 Stakeholder analysis

In this section, it would explain the results of each one of the six steps of a Stakeholder analysis based on the framework of Enserink et al. (2010). Each step is designed to understand the power-interest of the actors, their network structure, and their perception of the problem, in this case: 'why urban mining is not a common practice?'.

Step 1: Formulation of a problem as a point of departure

The municipality of The Hague has a catalogue of strategies that want to follow to turn the city into a more resilient and circular city. They stated that only by 2050, they want to have 19,000 new homes since the population of The Hague is exponentially increasing by 5,000 people every year (Hekwolter et al., 2017). However, at the same time, there is a social housing shortage in The Hague. Only in 2019, the housing prices in soared 11.82%, each quarter, the prices increase 0.47%, and about 50% of the housing in The Hague is own by social housing associations (Delmendo, 2019). Therefore, there is a high probability that the most affected sector will be the social housing sector.

Then it is assumed that some constructions must be demolished to make space for new high-rise constructions that can host the new residents. Considering that the city wants to become more circular the construction and demolition waste becomes a fascinating subject, mainly since the municipality of The Hague works in a municipality level, and the construction, demolition, and social housing associations work in a National or regional level, making a complex system even more complicated.

Point of departure: *understand how the cooperation between social housing associations, municipality, construction companies, and demolition companies works.*

Problem: *finding where the construction and demolition waste will be allocated and asses the possibility of urban mining of the social housing sector in The Hague.*

Step 2: Inventory of the actors involved

The main actors involved in the system are the construction companies, social housing associations, demolition companies, and the municipality of The Hague. Inside of each one of the actor's categories, some main actors were needed to understand their cooperation. On the following list, all the actors that were interviewed as part of this research are listed, to show the diversity within the content extracted from the interviews:

Municipality of The Hague:

1. Ger Kwakkel: Circular Economy Advisor.
2. Jack Amesz: Tender Board.
3. Wilco Verkade: Coordinator Expert and Bureau of Engineers.
4. Thimo de Nijs: Corporate Advisor Sustainability.
5. Anne-Marie Hitipeuw: Resilient city chief Office.

Social Housing

1. Martin Roeders: Senior Policy Advisor of Sustainability at Vestia.
2. Koen van der Most: Data Analyst at Sociale Verhuurders Haaglanden.
3. Guido van de Wijgert: Sustainability program Manager at Staedion

Construction and Demolition

1. Marije Kamphuijs: manager of Circularity at Van Wijnen Noord.
2. Edwin Baars: Director of Urban mining and Material Balance at New Horizon.

For more detailed information about the interviews is in Appendix 1. Based on the information gathered from the different interviews, a diagram was drawn:

On figure 3, it can be seen how the stakeholders relate to each other. The National Dutch Government has a significant amount of power, and they can influence directly on all the parties involved. In the case of the Municipality, they cannot influence social housing associations, at least not directly. They can influence construction and demolition companies by not releasing construction permits and streamline projects that are more in line with their strategies.

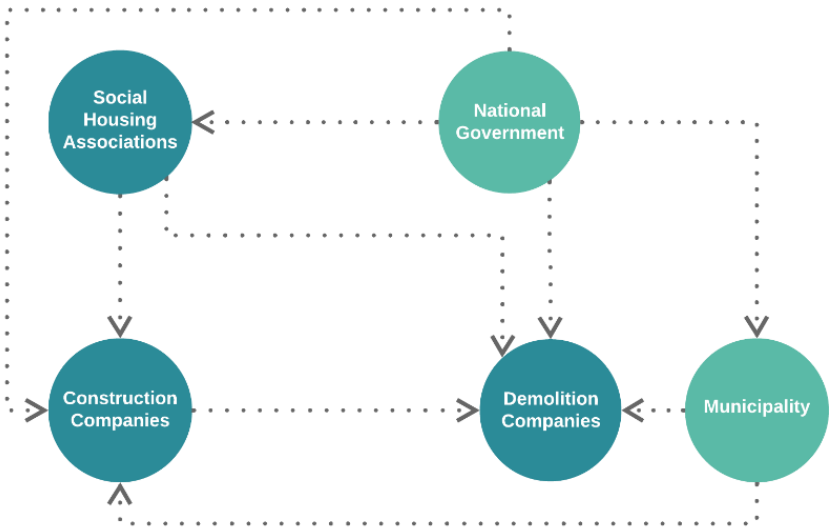

Figure 3. State-of-the-art o the network between National government, municipality, social housing associations, demolition and construction companies, in The Hague. Based on interviews conducted in 2019 (Appendix 1).

Step 3: Exhibiting the formal chart the formal task, authorities, and relations of actors and the current legislation

The actors explained how their relationship with the other parties was. However, in most of the cases, it appeared that the social housing associations, demolition companies, and construction companies were detached from the new municipal strategies. Nevertheless, even if their line of work and the level (regional, municipal, national) where they work was different, most of the actors try to cooperate with the municipality to achieve their goals. They take this decision based on the viability and profit they can obtain by following the strategy. Then again, in some cases is not possible, such as the goal of the municipality of being 100% circular by 2030 or the circular construction accord for 2024 for social housing associations to be ready to be circular. The years 2024 and 2030, might sound far away, however on construction terms 4 and 10 years is a short amount of time to change the operations of such a high conservative sector. The municipality of The Hague on their strategies has the horizon of 2030, and the social housing sector has stated their horizon on 2050, this means a considerable conflict of interest (Martin Roders, 2019; Ger Kwakkel, 2019; Appendix 1).

On the other hand, the construction companies respond to the necessities of the social housing associations. The primary driver of these associations is money, they are not profit-driven, but they have a fixed capital that they can invest, and, currently, there is a shortage of social housing. They want to build the

highest amount of residences with the lowest investment, creating constraints in the investment of new techniques or materials for the construction sector. Some of the construction companies are open to the idea of working with new techniques, such as circular demolition, where they might be able to reuse materials or components on their new constructions. Nevertheless, in one of the interviews was explained that these changes considerably the way they demolish and construct, making the process more time consuming and difficult for them. Still, they are open to keep working with this new technique even if it might take some time to grasp the new method. Figure 5 can be seen the informal and formal relations (Koen van der Most, 2019; Marije Kamphuijs, 2019; Martin Roeders, 2019; Appendix 1).

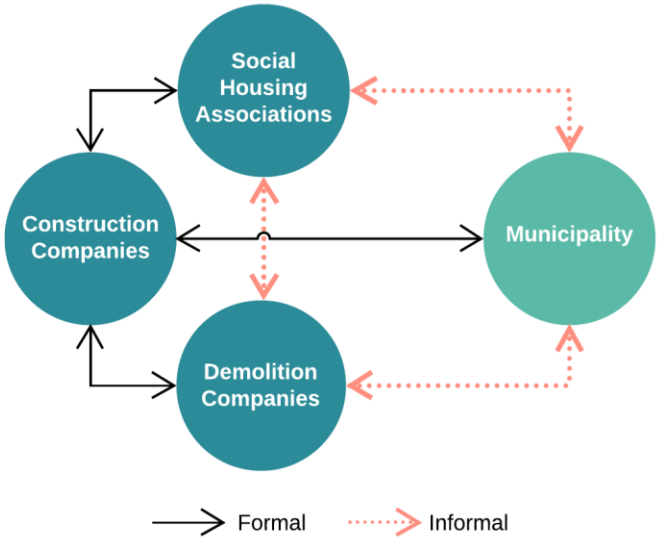

Figure 4. State-of-the-art of stakeholder analysis in The Hague, showing the formal and informal connections between the four main actors: social housing associations, the municipality, construction and demolition companies. Based on interviews conducted in 2019 (Appendix 1)

Step 4: Determine the interest, objectives and problem perceptions of actors

This step is described as the main interests, objectives and problem perceptions of each one of the stakeholders. Then the stakeholders are compared, finding the similarities, differences and share interests.

Social Housing Association

Their primary interest is to cover the demand for social housing in The Hague. Meanwhile, they create a safe investment. Their objective is to do a significant amount of construction based on demographic needs. Therefore, the problem of construction waste and urban mining is not relevant. They find other issues more

pressing. Urban mining is assessed as a 'buzzword' for pioneers, where it is unclear if there is any gain for social housing associations. However, currently, some members are trying to explore the topic. Nevertheless, the interest is limited to the prove that urban mining is a profitable and low-risk investment in the Netherlands (Koen van der Most, 2019; Martin Roeders, 2019; Appendix 1).

Construction Company

The main interest of the construction company is to do the major amount of construction on a lower amount of time. Their objective is to comply with the client's needs and national laws. In some cases, they try to reuse materials, but they try to do what is more efficient for them. Their problem perception with urban mining is addressed by three factors: cost, time and logistics. Some construction companies such as Van Wijnen Noord have tried to do circular demolition to do urban mining. However, the logistics get more complicated, and this increases their amount of work, creating constraints on time and money (Marije Kamphuijs, 2019; Appendix 1).

Demolition Company

The main interest of the demolition companies is to extract a higher amount of materials as possible and give it a purpose. In the case of traditional demolition companies, this material is used on the construction of roads. In the case of circular demolition companies, such as New Horizon the demolition waste is urban mined for a construction project. The objective of the demolition companies is to finish their tasks within three weeks, a period that is given by the construction company. Their problem perception lies in the architectural design of the building that is going to be built on the demolition site. If the architect does not design for a circular construction, the materials are not extracted correctly during the demolition process. To increase the urban mining sector, the architects, need to design thinking on the materials that can be extracted from the previous construction (Edwin Baars, 2019; Appendix 1).

Municipality

The main interest of the municipality of The Hague is to turn the city into a more resilient and circular city, with the objective of becoming a wholly resilient and circular city by 2050. Their problem perception lies in the fact that there is much theory about resilient cities and circular economy. However, the amount of knowledge that is applied is limited; therefore, as a municipality, the creation of new policies for circularity is a novel subject. The municipality has the plan of quantifying the amount of material that will come out of each building, to be able to match a demolition with a construction. Their first step will be through their

constructions. Then they will implement some policies to incentivise urban mining (Ger Kwakkel, 2019; Gert-Jan van der Panne; 2019, Jack Amesz,2019; Appendix 1).

Step 5: Mapping out the interdependencies between actors by making inventories of resources and the subjective involvement of actors with the problem

On Figure 6, there is an overlap between the different parties. On the left corner, there is the social housing association and the construction companies. This first group has an overlap on their way of framing the problem and their drivers. Both social housing associations and construction companies are money and time driven. Social housing associations need to follow a set of strict rules formulated by the national government, resulting in a limited budget for new constructions, making them avoid risks. On the other hand, construction companies respond to what is asked by the social housing associations, and when the construction starts running, they need to follow the schedule tightly. Consequently, construction companies are not keen on unconventional investments, and those investments include urban mining of materials.

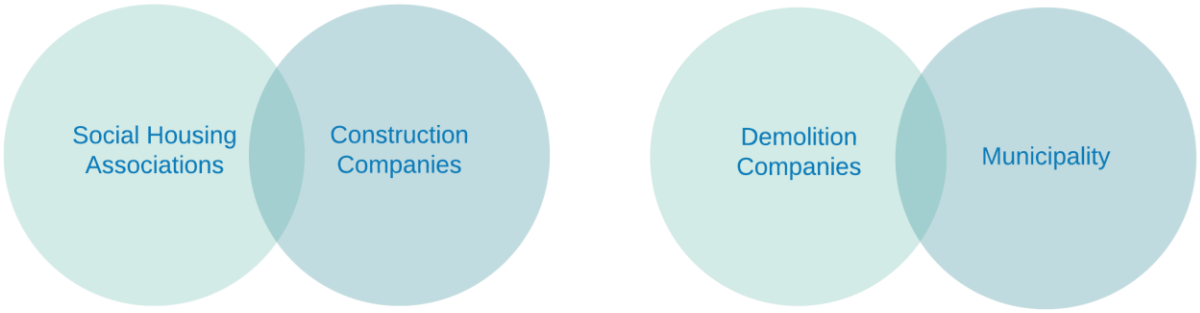

Figure 5. Interest overlaps between the actors. Based on the interviews with social housing associations, municipality of The Hague, Construction company and Demolition company. Based on the interviews conducted in 2019 (Appendix 1).

On the right part of Figure 5 is group two, composed by the municipality and the demolition companies. In this case, I am talking specifically of New Horizon, as a circular demolition company, and the Municipality of The Hague. These two parties have in common that they want to change the mindset of the construction environment. For one-part, New Horizon already has the technology for collecting and separating nearly 90% of all the materials found in the demolition site. However, this material is wasted if the construction company does not take it into account on the design of the new construction. For the other, the municipality does not regularly collaborate with the social housing associations, only with the construction company or

the demolition companies when the construction permits are issued. Regardless, the municipality of The Hague wants to become circular for 2050, meaning that incentivising urban mining is the key.

Step 6: Determine the consequences of these findings with regard to the problem formulation

Based on the interview with Edwin Baars (2019), the main issue on the system is the lack of knowledge about urban mining by the architect. In most of the cases, the social housing association wants to decrease their cost and emissions, and some of the social housing associations are open to exploring the topic of urban mining. However, they believe that this topic is under the realisation of the architect and the construction company. Currently, the construction sector prefers to use traditional techniques for the design of new buildings (new materials, no circular/resilient criteria). Nevertheless, if the architects and the built environment are willing to change, such as the case of Van Wijnen Noord, the Scenario of making urban mining mainstream is not unrealistic. As some of the interviewees point out, we are running out of materials, and we need to decrease our emissions (Ger Kwakkel, 219; Edwin Baars, 2019; Marije Kamphuijs, 2019; Appendix 1).

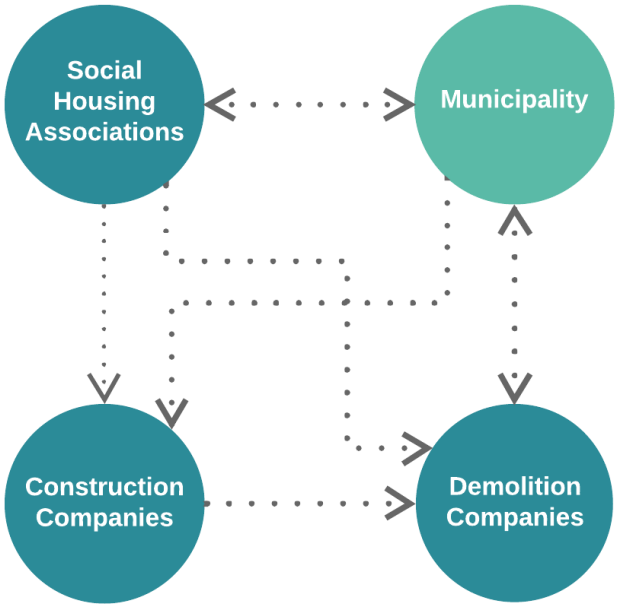

Figure 6. Ideal stakeholder network between the main actors in the topic of urban mining of social housing in the Hague: Social housing associations, the municipality, construction and demolition companies. Based on the interviews conducted in 2019 (Appendix 1).

3.2 Social Housing buildings that are projected to be demolished by 2050

Based on the interviews made, the demolition criteria for the social housing associations are guided by the financial aspect of the operation. On the moment a building exceeds the number of resources they can invest in continuing its use, is demolished. Different criteria can be applied to know if a building will be demolished or not. It was found that two techniques can be applied to know the ultimate amount of materials that will be extracted from the demolition site of all buildings by 2050. Therefore, two Estimations were developed.

The first Estimation was quantified by filtering all the buildings according to three criteria: year of construction, energy label, and land use. The second Estimation also considers three criteria: land use, year of construction, and a parameter that was presented by one of the social housing associations: the 20-80 rule. This rule states that 20% of the buildings stock of social housing associations will be demolished and 80% will be refurbished by 2050 (Martin Roeders, 2019; Appendix 1).

Both Estimations give a quantification of the number of square meters (sqm) that will be demolished before 2050, which can be multiplied by the amount of brick and glass shown in Table 2. This information was retrieved from New Horizon, and each category is an average based on six data points. Based on the interview made to Vestia is assumed that it is more economically preferable for social housing associations to demolish whole apartment buildings than single/row housing. Consequently, the numbers for row houses, high rise, and single houses are not used. The results were compared to create a range of the amount of brick and glass that will become available before 2050. The extra information that was given by the BAG 3D (2019) database was deleted. Then a base map was added to create a spatial reference as it can be seen in Figure 7. The complete data set ended with 18,727 buildings. However, after the merge of the database, it was pointed out that the first map had slightly different polygons than the second, creating a margin error of approximately 7%.

Table 2. Kilograms per square meter (Kg/sqm) of brick and glass in the Housing sector. Data obtained from New Horizon (2019; Appendix 2), based on six residential areas, with 213 buildings. The year of construction of the residences was between 1931 and 1974, with an average of 155 sqm per residence.

Typology	Floor area (sqm)	Bricks Kg/sqm	Glass Kg/sqm
Building apartment	1	522.2	19.6

Figure 7. Social Housing and Energy labels in The Hague, Netherlands. Map made in ArcGIS with the databases of 'Corporatiebezit pandan in Den Haag' (Municipality of The Hague, n.d.), 'Datalab Energietransitie' (Municipality of The Hague, n.d.) 'and GIS base map' (ESRI, 2019).

3.2.1 ASSUMPTIONS FOR FUTURE DEMOLITION

Two different Estimations were modelled. The Estimations are based on the information retrieved from the literature review and interviews. Each Estimation is based on three factors, from which two factors are shared: Land use and year of construction. The first Estimation is based on the selection of buildings with a high probability of being demolished due to their energy label. The second Estimation is based on the ratio of demolish-refurbished buildings in The Hague in the past four years; 18% of buildings are demolished, and 82% are refurbished (CBS, 2020).

For these Estimations, the two main criteria are land use and year of construction. In this section, each one of the aspects is explained:

Land use is typical, one of the main criteria's that are considered to demolish a building is their land use, a topic that is expressed by Marije Kamphuijs (2019) in her interview. In some cases, when a city is continuously growing, the outskirts becomes the inside of the city, creating situations such as having industry or storage units inside the city. These properties increase their value, are sold, and the building is demolished to construct housing or retail.

The year of construction in The Netherlands has different building categories depending on their year of construction. Any building built before the 18th century is considered a monument; therefore, it cannot be demolished or highly refurbished. Building from the 18th century till 1940 is considered youth monuments, and consequently, they cannot be demolished. In the case of buildings between 1940 to 1965, post-war, some of them are under the revision of being considered monument since that time is called the era of reconstruction. However, most of the buildings in this period are not considered a monument and ergo can be demolished. In some cases, buildings over 50 years old can be appealed as a monument (Cossons, 2014).

The filtering of these elements reduced the number of buildings significantly. The first filter, land use: Social Housing Buildings, gave a result of 20,500 buildings, as can be seen in Figure 8. The second filter, year of construction: after 1940, decreased the constructions from 20,500 to 15,900, as can be seen in Figure 9.

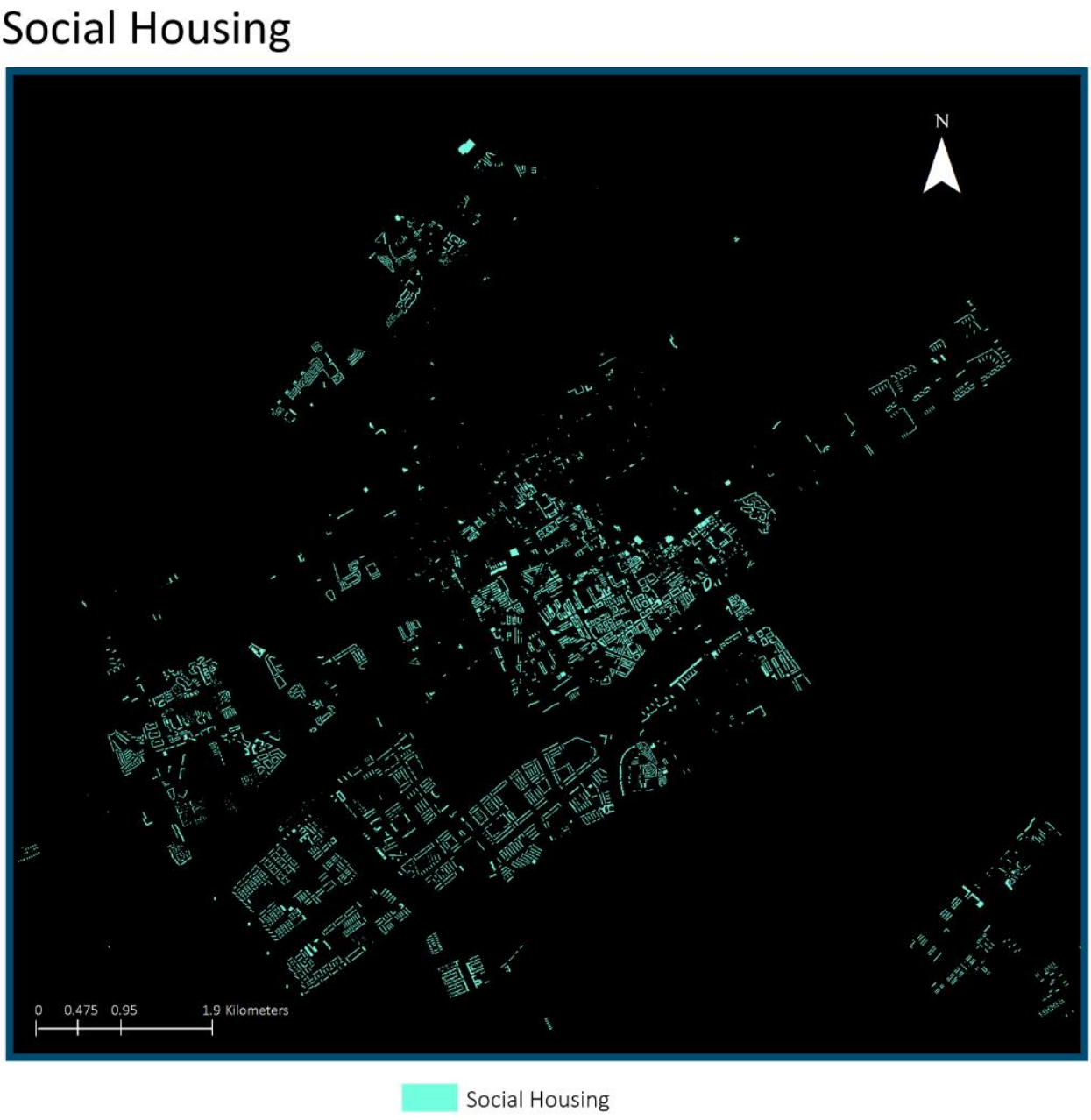

Figure 8. Social Housing buildings in the Hague. Map made on ArcGIS with the database: "Corporatiebezit panden in Den Haag" (Municipality of The Hague, n.d.)

Figure 9. Social Housing buildings in the Hague built after 1940. The letters represent the Energy Performance Certificates (EPCs) in relation to the energy-efficient from A (the highest) to G (the lowest). Map made on ArcGIS with the database: of "Corporatiebezit panden in Den Haag" (Municipality of The Hague, n.d.), "Datalab Energietransitie" (Municipality of The Hague, n.d.) and the BAG 3D (Land Registry, 2019).

Estimation 1

This Estimation takes in consideration three factors: land use (social housing), year of construction (after 1940), and energy label.

Energy label or the Energy Performance Certificates (EPCs) for buildings show how energy efficient the constructions are. Depending on the label, which can go from A (the highest) to G (the lowest). The suggestions on how the building needs to be modified to be more energy efficient. Nowadays, the label is one of the key characteristics that determine the quality and quantity of investment a building needs (Dutch Government, 2019b). Typically, the buildings that have an energy label from A to D are new construction or had a "recent" refurbishment. The European parliament (2016) stated that by 2020 the social housing buildings should have an average energy label of B on the Netherlands. Therefore, the investment needed on these properties to increase their energy label is substantially low in comparison with other labels, having a low probability of being demolished.

The different steps of Estimation 1 can be seen in the following diagram that was taken to filter the social housing buildings. Giving, as a result, the number of buildings that will be demolished by 2050 (Figure 10).

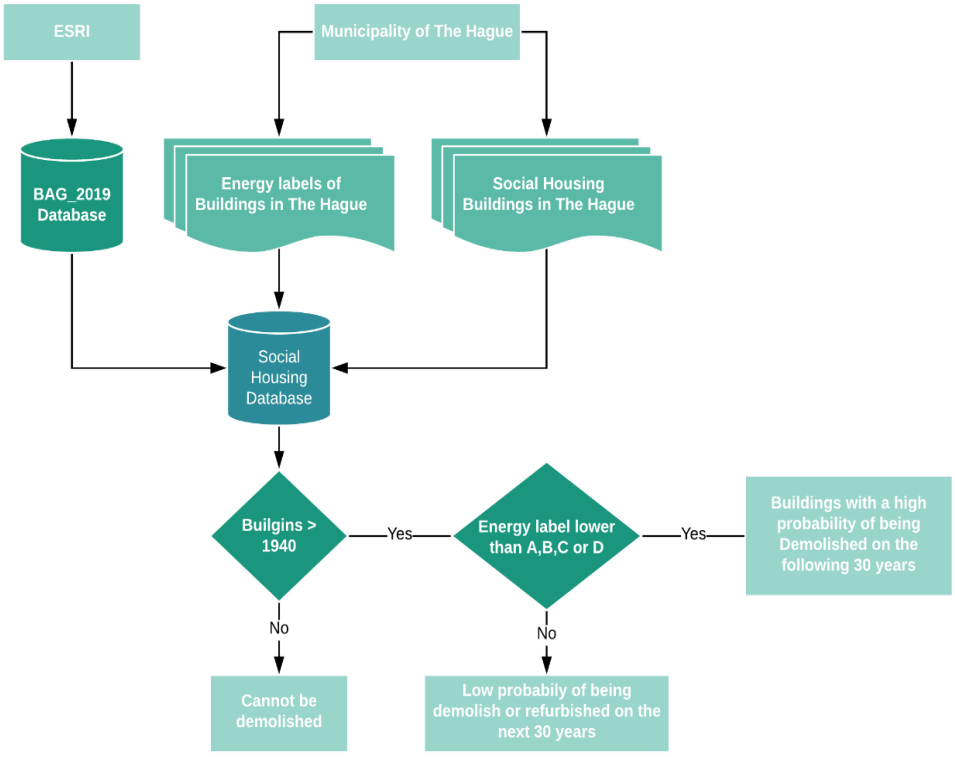

Figure 10. Estimation 1: Data selection for building demolition, based on three factors: land use (social housing), year of construction (after 1940) and the energy label (E, F and G).

After applying the first two filters (year of construction and land use), the third filter is applied: energy label from E to G, the number of buildings decreased from 15,900 to 5,400 buildings (Figure 11).

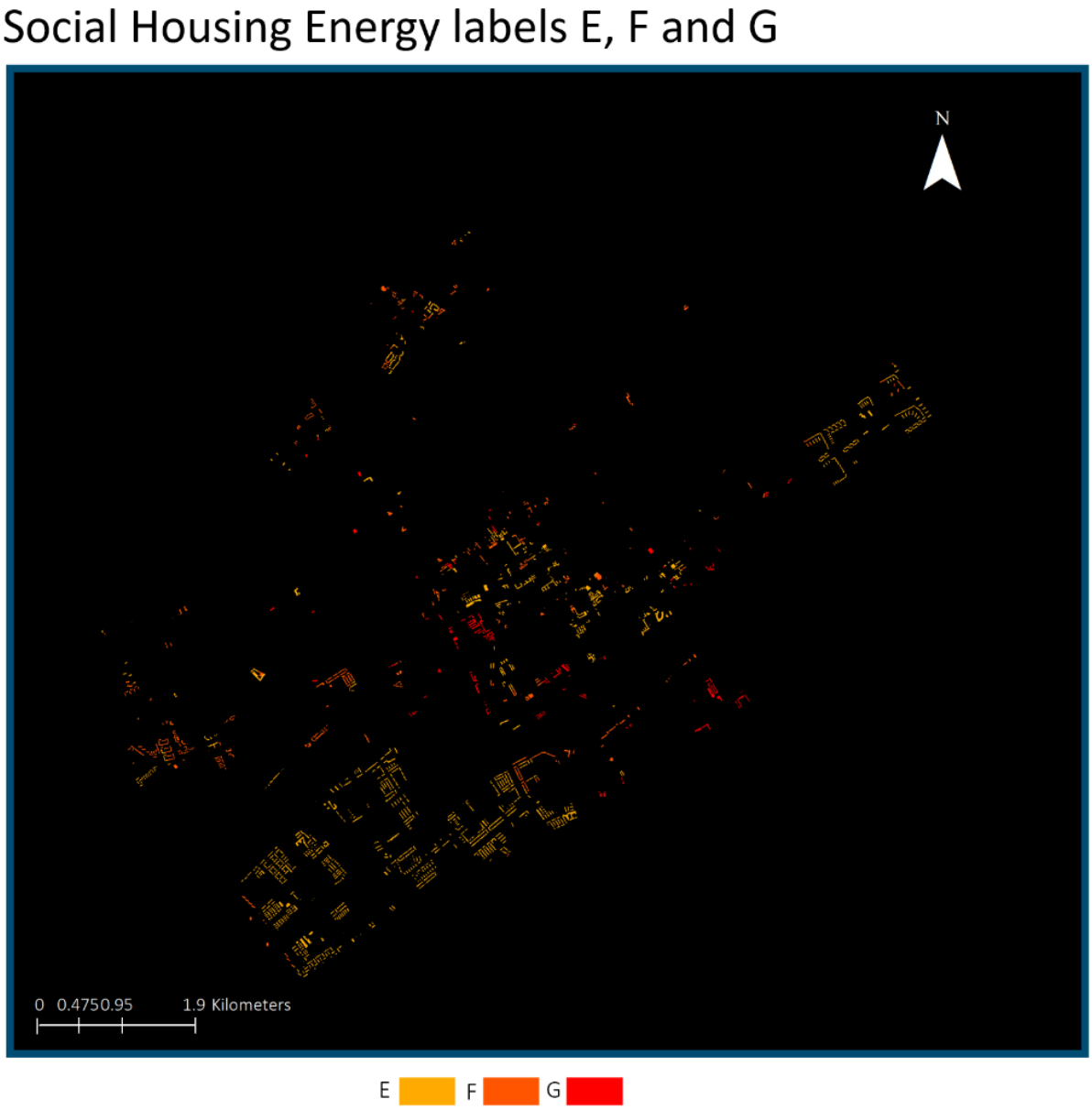

Figure 11. Social Housing buildings in The Hague, built after 1940 and with Energy Performance Certificates (EPCs) in relation to the energy-efficient from E, F, or G. Map made on ArcGIS with the database: of "Corporatiebezit pandan in Den Haag" (Municipality of The Hague, n.d.), "Datalab Energietransitie" (Municipality of The Hague, n.d.) and the BAG 3D (Land Registry, 2019).

Demolition and refurbishment

Based on the results obtain by filtering all the buildings from 20,500 to 5,400, an analysis of the different strategies for demolition and refurbishment is needed. The 5,400 buildings are equivalent to 860,000 sqm of construction, from which according to New Horizon (2019; Appendix 2) there are 522 Kg of brick per sqm and 20 Kg of glass per sqm. Giving an approximate of 450 Mega tonnes of brick and, 17 Mega tonnes of glass.

Table 3. Material quantification based on baseline and results from estimation one. The results are shown in kilograms (kg) and megatonnes (Mt) of brick and glass, according to the square meters (sqm) of the buildings.

1 Mt = 1,000,000 Kg

	Floor area (sqm)	Brick	Glass
Baseline	1	552 Kg	20 Kg
Estimation 1	860,000	450 Mt	17 Mt

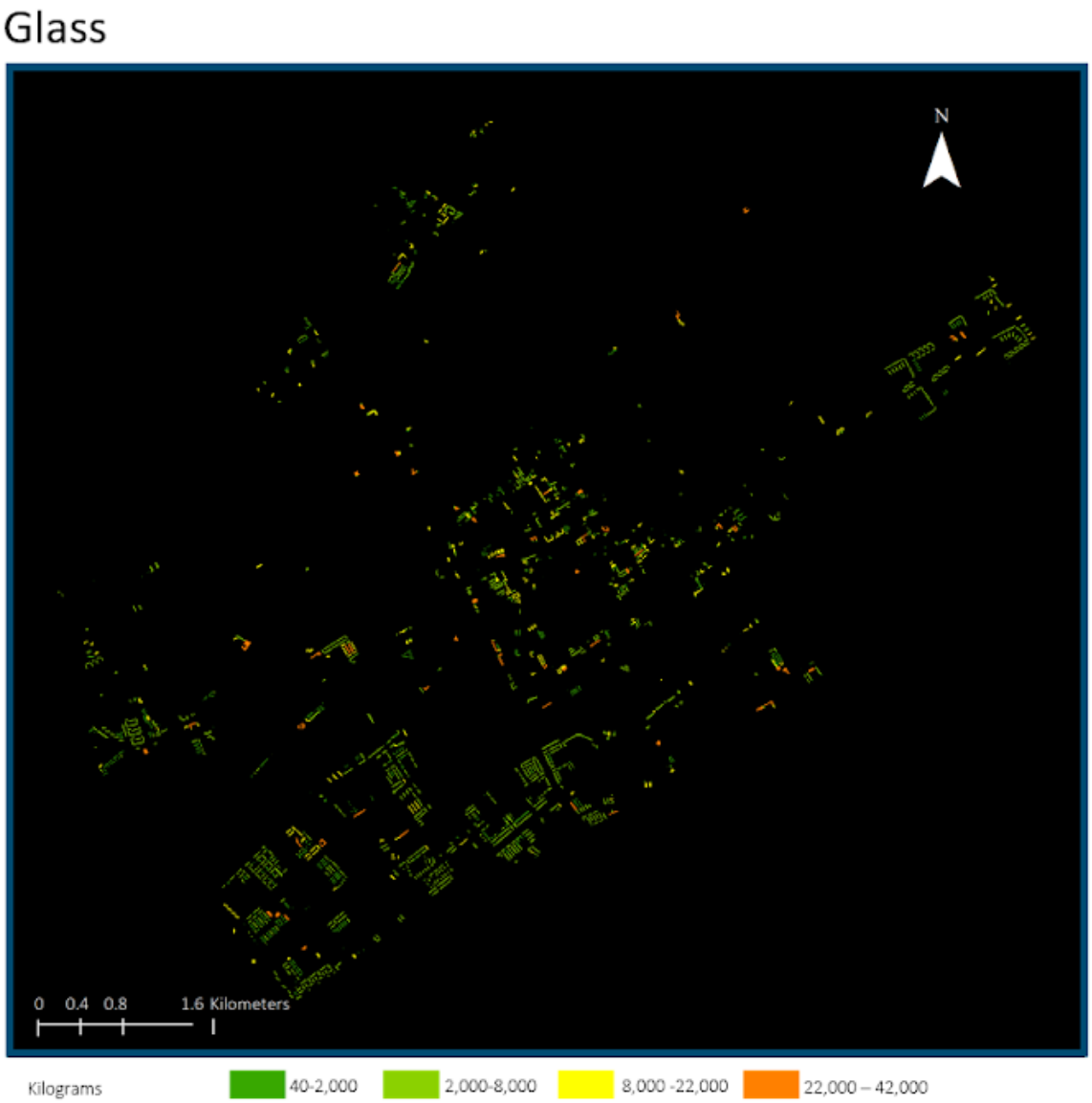

Figure 12. Glass quantification in social housing buildings in The Hague. Each colour shows the number of kilograms (Kg) of glass that can be found in each building. The darker the colour, the more substantial the amount of glass the building has. The maps were made on ArcGIS with the databases of: "Corporatiebezit pandan in Den Haag" (Municipality of The Hague, n.d.), "Datalab Energietransitie" (Municipality of The Hague, n.d.) and the BAG 3D (Land Registry, 2019).

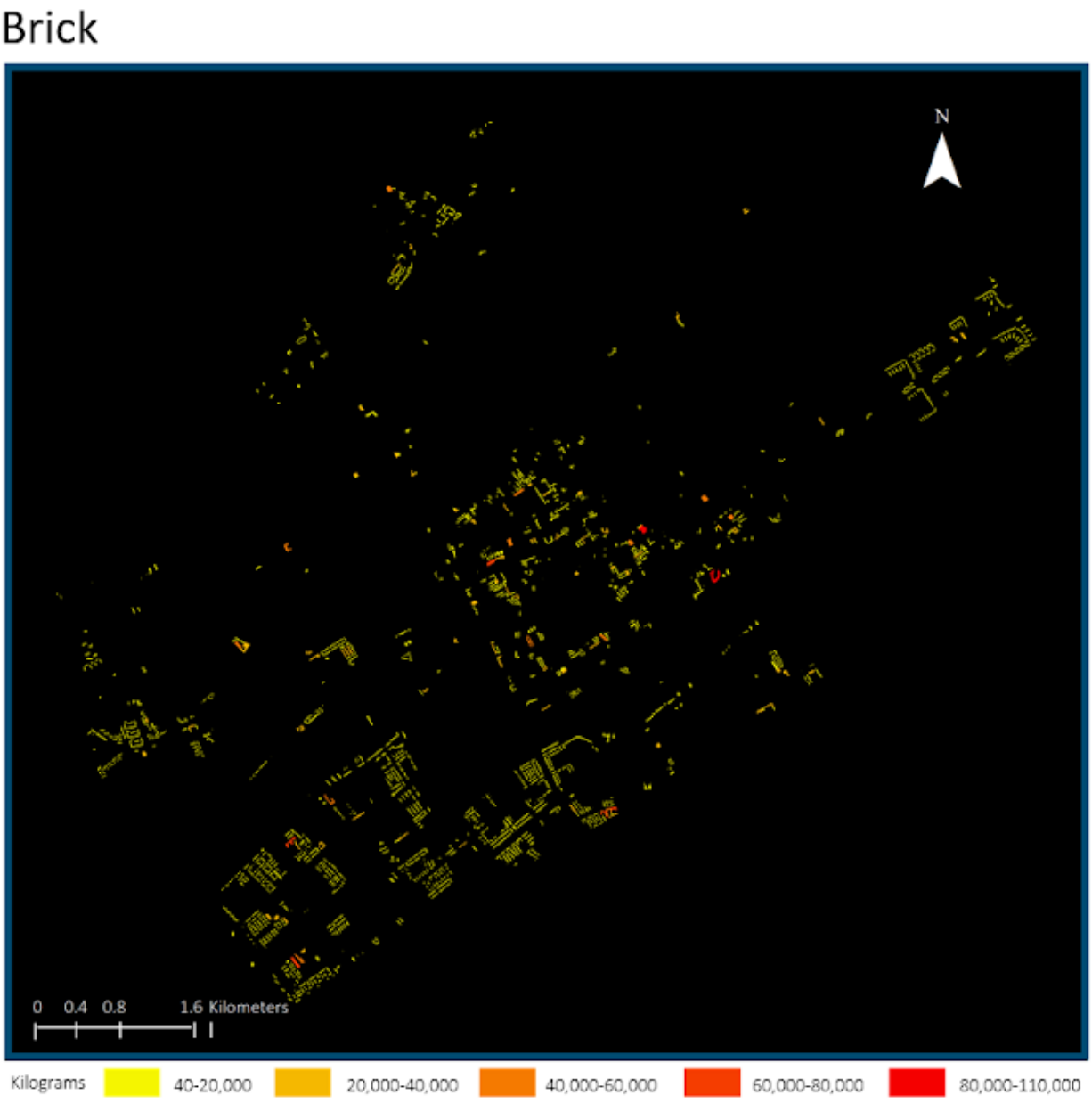

Figure 13. Brick quantification in social housing buildings in The Hague. Each colour shows the range of kilograms (Kg) of brick that can be found in each building. The darker the colour, the more significant the amount of brick the building has. The maps were made on ArcGIS with the databases of "Corporatiebezit pandan in Den Haag" (Municipality of The Hague, n.d.), "Datalab Energietransitie" (Municipality of The Hague, n.d.) and the BAG 3D (Land Registry, 2019).

Estimation 2

Estimation 2 takes into consideration three factors, from where two factors are the same as in Estimation 1; land use: social housing, and year of construction: after 1940. Then, according to the interview made to the social housing association "Vestia," when they get construction permits in The Netherlands, around 80% of their constructions are refurbishments, and 20% are demolitions (Appendix 1). Furthermore, based on the database of CBS (2020), the ratio demolition-refurbishment in The Hague between 2015 and 2018, has an average of 18% demolition and 82% refurbishment. Therefore, the third factor will be known as the 20-80 rule. On the following figure, it can be seen the process for filtering the results.

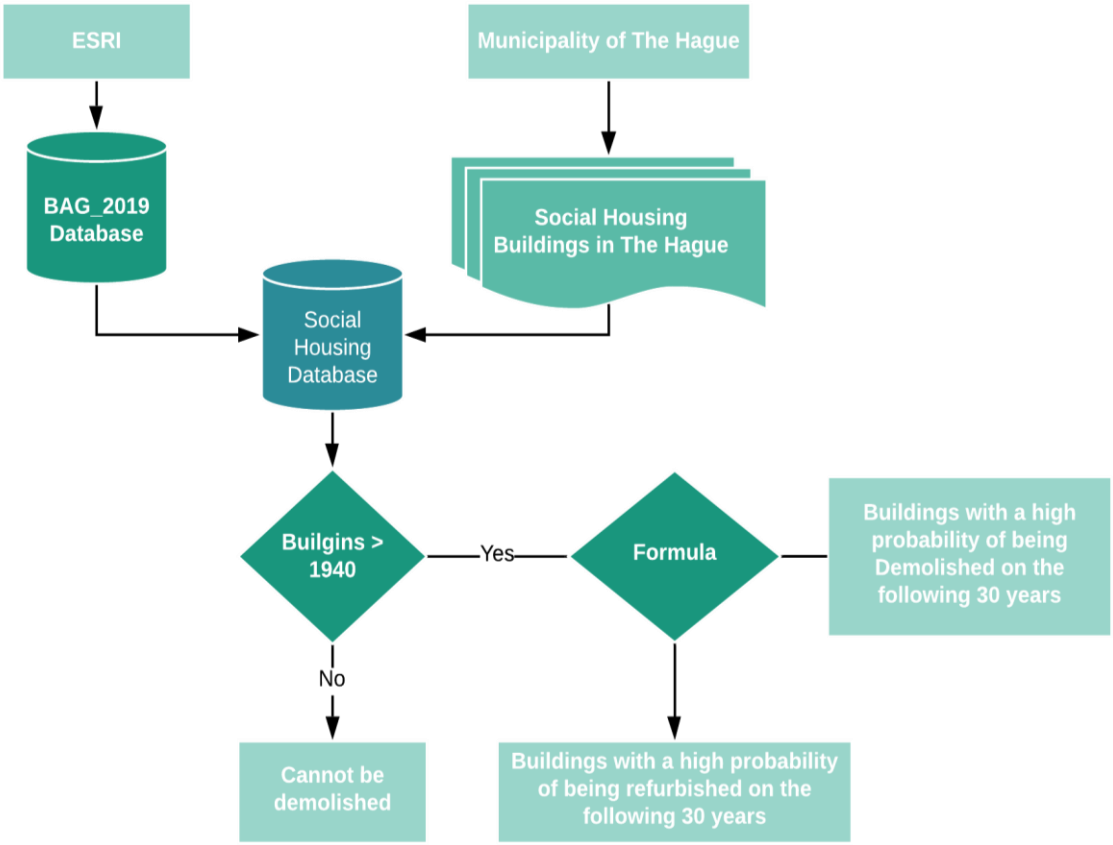

Figure 14. Estimation 2: Data selection for building demolition, based on three factors: land use (social housing), year of construction (after 1940) and the 20-80 rule that indicates that 20% of the buildings will be demolished by 2050.

The first step was to filter all the buildings based on their land use, selecting only the buildings that are social housing. Then the second step was to filter the buildings based on their year of construction; the buildings that were built before 1940 were filtered out since they are considered a monument and cannot be demolished (Cossons, 2014). Therefore, in this Estimation, we start with the same amount of buildings as Estimation 1, after filtering the land use and year of construction, the number of buildings left are 15,900. These buildings range from energy label A to G, with a total amount of 860,000 sqm. According to the 20-80 rule presented by the social housing association Vestia and the CBS statistics, 3,200 buildings will be demolished, and 12,700 buildings will be refurbished. The total sqm that will be demolished are 429,000 sqm and considering that New Horizon (2019; Appendix 2) stated that 522 Kg of brick and 20 Kg of glass could be extracted per sqm, the results are 224 Mega tonnes of brick per sqm and 8.4 Mega tonnes of glass per sqm.

Table 4. Material quantification based on baseline and the results of estimation 1. The results show the amount of brick and glass expressed in kilograms (kg) and megatonnes (Mt), according to the number of square meters (sqm) of the buildings.

1 Mt = 1,000,000 Kg

	Floor area (sqm)	Brick	Glass
Baseline	1	552 Kg	20 Kg
Estimation 2	429,000	224 Mt	8.4 Mt

3.2.2 Estimation 1 and Estimation 2 comparison

After concluding the Estimations (Figure 15), the result was a range of the amount of material that will become available before 2050. According to the first Estimation, the 860,000 square meters (sqm) will become available, and according to Estimation 2, it will be 429,000 sqm. Estimation 2 is nearly half of Estimation 1. These estimations calculated the demolishment of 5,370 to 3,200 buildings, which results in a middle point of 4,274 buildings, with 644,500 sqm of floor area, that is equal to 337 Mt of brick and 12.7 Mt of glass (Table 5).

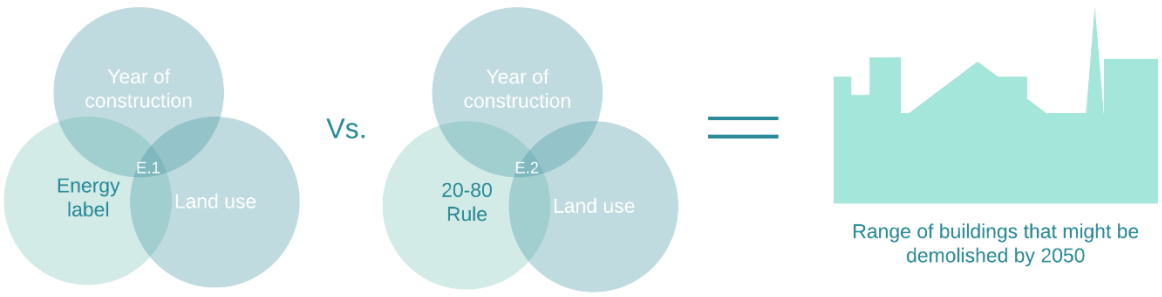

Figure 15. Estimation 1 (left) takes into consideration three factors: Year of construction, land use and energy label (EPCs). Meanwhile, Estimation 2 (right) takes into consideration, also three factors: year of construction, land use and the 20-80 rule. The comparison of the estimations gives, as a result, an assumption of the number of buildings that might be demolished by 2050.

Table 5. Quantification of the amount of brick and glass in kilograms (Kg) or megatonnes (Mt), depending on the number of square meters (sqm) of floor area.

1 Mt = 1,000,000 Kg

	Floor area (sqm)	Brick	Glass
Baseline	1	552 Kg	20 Kg
Estimation 1 (E1)	860,000	450 Mt	17 Mt
Estimation 2 (E2)	429,000	224 Mt	8.4 Mt
The middle point	644,500	337 Mt	12.7 Mt

3.3 Monetizing of the brick and glass extracted

The result from the scenarios was the number of square meters of material that will be demolished by 2050. Both estimations were translated to euros per kilogram, to quantify the cost of the loss of the materials. The comparison of both scenarios results in a range of the amount of demolition waste that will be expected by 2050, and their price of they are bought from the store, sold as demolition waste or recycled into new materials.

3.3.1 The economic value of urban mining

The economic value per building was calculated by multiplying the price on euros of each kilogram of material (€/kg) by the total amount of brick or glass present per square meter of social housing demolition waste. The price was calculated based on three parameters; the first one is the price of the material when is bought directly from the store; the second price, is when the material is sold as C&D waste, and the third parameter is when the material is recycled into new bricks or flat glass.

The reason why these three parameters were chosen, is to make a comparison between the price the construction companies pay for the material when is new and the amount of money they lose when they label it as C&D waste, downcycling it. If construction companies can see the value of the material if they reuse or recycle them, they could save money and emissions. However, this research only focuses on the recycling of materials into new materials for the construction sector; further information about reuse of components can be found in the paper 'Reuse of building components: an economic analysis' (Bougrain & Laurenceau, 2017).

Brick

The price of brick is dependent on its characteristics, for this research we will focus on traditional Dutch brick, which has a price between 0.0710 to 0.0825 €/kg for a new brick of 2010 x 105 mm (Brickworld, 2015). However, when the bricks are recovered from the demolition site, their price is equal to 0 (New Horizon, Appendix 1). Meanwhile, bricks made from wasted brick have a price of 120 euros per square meter (€/sqm) with a price of 0.0765 €/ kg (Stonecycling, 2019).

Table 6. Brick price when it is bought from the store (Brickworld, 2015), when it is retrieved from the demolition site and when it is recycled into new bricks (Stonecycling, 2019).

B R I C K	€/kg
New bricks from store	0.077
Retrieved from demolition waste	0
Recycled into new bricks	0.076

Glass

The price of the glass changes highly based on the retailer and the characteristics of the glass. For this research, the scope is on single glassing (regular clear glass) of 4 mm. Based on different market prices (Table 7), the average price is 4.49 €/sqm, and considering that the weight of the glass is 10 kg per sqm (Hollingsworth, 2016), the price of new glass is 0.449 €/kg. The price of second-hand glass depends in if it is still fixed as part of a window, or if it is crushed, for this research I will focus uniquely on crushed glass retrieved from the demolition site without any type of coating, which has an approximate value of 0.0146 €/kg, today 13th of November 2019 (letsrecycle, 2019). In the case of recycled glass, that has been transformed into a flat glass; there is no price difference since there is no apparent distinction in the market. More information about recycled and C&D glass waste can be found on the page of Glass for Europe.

Table 7 The glass price per square meter according to the companies AoHong and StarGlass (AoHong, n.d.; StarGlass, n.d.), with a currency conversion of 1.09 from US Dollar to Euro (Xe, 2020).

Company	Glass Type	Date	Min	Max	Average in US Dollars		Average in Euros	
AoHong	Tempered-Safety	12-02-20	4.060	4.400	4.230	US Dollar	4.611	Euro
AoHong	Clear float	12-02-20	2.990	5.300	4.145	US Dollar	4.518	Euro
AoHong	Tempered	12-02-20	3.990	4.600	4.295	US Dollar	4.682	Euro
StarGlass	Colored	12-02-20	2.040	5.630	3.835	US Dollar	4.180	Euro
AoHong	One-way mirror	12-02-20	2.900	5.280	4.090	US Dollar	4.458	Euro
							4.490	Euro

Table 8. Glass price when it is bought from the store (Table 6), when it is retrieved from the demolition site (letsrecycle, 2019) and when it is recycled into a new glass (market research).

G L A S S	€/kg
New glass from the store	4.490
Retrieved from demolition waste	0.015
Recycled into new glass	4.490

3.3.2 Monetizing of estimations

For brick, the first investment (without considering the fluctuations in the market price) was 7 million of euros then when the building was demolished the price of the brick would be close to 0 €, since most of the time is considered waste, and the payment is for the transportation to the waste facility (landfill, incineration, or other). However, if the brick is recycled, it can have a total value equal to the first-hand market price. Nevertheless, this value does not take into consideration the machinery and primary sources cost of the manufacturing company (Table 3, Figure 13).

Table 3. The economic value of brick per one square meter (sqm) and per 845,266 sqm. Based on different sources that show the market price of brick from the store, demolition waste and recycled into new bricks. The price of brick from the store, demolition waste and when it is recycled into new bricks, can be found in Table 6.

BRICK

	Floor area [sqm]	Amount of brick	From store (€)	Demolition waste (€)	Recycled into new bricks (€)
Baseline	1	522 Kg	234.5	0	234.5
Estimation 1	860,000	450 Mt	**198 M**	0	**198 M**
Estimation 2	420,000	224 Mt	**100.6 M**	0	**100.6 M**
The middle point	644,500	337 Mt	**151 M**	0	**151 M**

In the case of glass, the market price, on Euros per kilogram (€/Kg), of the total original investment was 7.5 million Euros. Then, when the glass is extracted from the construction site, the total value dropped to a quarter-million euros. However, if the case the glass is recycled, the value of the material remains the same as in the original investment (Table 2, Figure 12).

Table 2. The economic value of glass per one square meter (sqm) of floor area and per 860,000 sqm. Three measures were used: the price of glass from the store, demolition waste and recycled into a flat glass. The price of glass from the store based on the average price from AoHong (2020) and StarGlass(2020), found in Table 8 is 4.490 €/kg. The price of the glass when it is recovered from the demolition site is 0.0146 €/kg, (letsrecycle, 2019).

GLASS

	Floor area [sqm]	Amount of glass	From store (€)	Demolition waste (€)	Recycled into a flat glass (€)
Baseline	1	20 Kg	8.8	0.3	8.8
Estimation 1 (E1)	860,000	17 Mt	**7.5 M**	250,000	**7.5 M**
Estimation 2 (E2)	420,000	8.4 Mt	**3.7 M**	126,000	**3.7 M**
The middle point	644,500	12.7 Mt	5.6M	190,000	5.6 M

4.DISCUSSION

4.DISCUSSION

The purpose of this research was to explore and evaluate urban mining as a potential alternative to the traditional sourcing of material for construction and demolition companies. The case study used, the municipality of The Hague, developed a strategy called 'Resilient City, The Hague' (2018 & 2019a). In the strategy, the municipality stated that the need for new houses is increasing 8% per year, as most of the newcomers have an average income of 33,300 EUR, which complies with the requirements to be eligible for social housing in The Netherlands (Municipality of The Hague, 2019a; Dutch Government, n.d.b). Therefore, the growth of the city will affect the social housing sector directly, and new dwellings need to be built.

The space in the city of The Hague is becoming scarce, resulting in a shortage of land for new constructions; hence, it can be assumed that some buildings will be demolished by 2050 to make space for new constructions (Pg.55, Municipality of The Hague, 2018). The primary materials found in the construction sector in the Netherlands, are concrete, brick and asphalt, and, currently, there are companies around the city of The Hague, that recycle brick and glass (Koutamanis et al. 2018; Appendix 4). They combine both materials into new bricks, resulting in bricks with the same properties in the new one, but with a reduction in the price up to 20% and an emission reduction up to 44% (Appendix 4).

In the following section, the findings are discussed in five parts. The first part, '4.1 Result 1: Stakeholder analysis', shows how the interaction between the different parties could transform urban mining into common practice by 2050 in the social housing sector. The second part, '4.2 Result 2: Mass flow analysis', is an assessment of the number of buildings that might be demolished by 2050, based on two estimations. The third part, '4.3 Result 3: Monetizing of materials', is the monetizing of brick and glass that could come out from the demolition of the buildings estimated in '3.3 Monetizing of the brick and glass extracted'. The fourth part, '4.4 Future applications of urban mining', shows how urban mining can be used to decrease CO_2 emissions. The fifth and final part, '4.5 Limitations & recommendations', shows the constraints of the methodologies used and potential for future research.

4.1 Stakeholder Analysis

The stakeholder analysis shows the interaction between the different parties needed to transform urban mining into a common practice in the social housing sector; the municipality of the Hague, C&D companies and social housing associations, resulting in the diagram presented in Figure 6.

The Municipality of The Hague has the aim of becoming a resilient city by 2050, for that the city needs to comply with the 8 characteristics that they defined as a resilient city (Table 1). These characteristics are an opportunity of creating a guideline on how the new residences must be built. Furthermore, the Dutch government stated in the Climate Agreement (Dutch Government, 2019a) that by 2050 they want to become fully circular and want to decrease their CO_2 emissions by 95% in comparison to 1990. Meanwhile, the C&D companies are in a recession due to the heavy taxes in the construction sector, leading to a shortage of housing (Aedes, 2016). Every year the population of The Hague increases 8%, resulting in 19,000 new houses by 2030, especially in the social housing sector (Municipality of The Hague, 2019a; Dutch Government, n.d; Hekwolter et al., 2017). However, the land inside the city is becoming more scarce () To resolve this issue the C&D companies can partner with social housing associations to urban mine materials from existing buildings, decreasing the cost between 10-15% and saving up to 44% of the emissions, in the case of recycling the brick in a local factory (New Horizon, 2019a).

For the Stakeholder analysis, two of the largest social housing associations in The Hague were interviewed: Vestia and Staedion. Vestia is an association that went almost bankrupt eight years ago, making them more conscious about their investment in new techniques. Nevertheless, Vestia and Staedion agree that there is a future for urban mining. However, Vestia is more concerned about the material quality and how this could affect the space, they are open to urban mining techniques, but they need more information about their operation, pros and cons. In the case of Staedion, they are familiar with urban mining techniques, and they are in the process of doing their first pilots, they have worked in direct collaboration with New Horizon.

On the one hand New Horizon, in their interview, expressed their concern is mostly toward the architects since they are not designed for circular construction. Therefore, the materials are not correctly extracted. The architects need to be design based on the materials that are available on the building that will be demolished. On the other hand, the construction companies prefer traditional techniques over urban mining due to time, cost and logistics. Urban mining a construction can increase their amount of work, creating constraints of time and money, and if the customer is not asking for it, then there is no added value.

In step six, section '3.1 Stakeholder analysis', it was concluded that the different parties that circulate around the social housing sector in The Hague, agree that urban mining is in the pioneer stage, there is future on this technique, and they are open to implementing it. Nevertheless, the primary concern is the full transition of urban mining from the theoretical to the practical realm. During the interview made to Ger Kwakkel –circular economy advisor of the municipality of The Hague –-(2019; Appendix 1), he explains how they will apply the urban mining concepts primarily to the buildings owned by the Municipality of The Hague before making a policy stating the percentage of material that should be urban mined. On the past years, there have been companies, such as New Horizon, that have worked with urban mining, and they have achieved to reclaim more than 40% of the materials and components (e.g. windows, lamps) from the demolition site (New Horizon, 2020). This 40% could be a low number since currently, 95% of the materials in the C&D sector is recycled. Nevertheless, from that, 95% of material that is currently recycled only 3% re-enters the system, the rest is downcycled, and used for building roads (Schut et al. 2016). In the meantime, when the demolition company stated that they reclaim more than 40% of the materials and components they are referring that these materials/components re-enter to the construction sector, they are upcycled.

The results of the stakeholder analysis showed that the critical element to transform urban mining into common practice is through the collaboration of the different parties. This collaboration can be done by having integrative (or round table) meetings or by creating direct communication channels between the different parties on a municipal level; resulting in a conversation that takes into consideration national and municipal strategies. However, if the communication channels are not well established the communication cannot be effective, resulting in slowing the process of transforming urban mining into common practice.

In conclusion, to apply successfully urban mining and transform it into common practice, it is needed that all the parties communicate expressing their concerns, understanding the pros and cons of this technique. A large percentage of the resistance in the market to invest in urban mining is the unfamiliarity with the procedures and the gains they could obtain.

4.2 Social housing buildings projected to be demolished in The Hague by 2050

In section '3.1 Stakeholder analysis' it was assessed the relation between social housing associations, the municipality of The Hague and C&D companies. It was found out that one of the ways to develop a compelling argument to this parties to approach the urban mining practices as a common practice, was to quantify the number of buildings that might be demolished by 2050 and assess their opportunities.

In the section '3.2 Social Housing buildings that might be demolished by 2050' the quantification of the estimations 1 and 2, were done based on the interviews and three datasets: 'Corporatiebezit pandan in Den Haag" (Municipality of The Hague, n.d.), "Datalab Energietransitie" (Municipality of The Hague, n.d.b) and the BAG 3D (Land Registry, 2019). Each estimation was based on three of the four criteria selection: year of construction, land use and energy label and 20-80 rule. The first estimation was based on the year of construction, land use and energy label; meanwhile, the second estimation was based on the construction year, land use and the 20-80 rule. The 20-80 rule is the respective ratio in the city of The Hague of the buildings that are demolished and the ones that are refurbished on average.

Each Estimation gave a different number of buildings that might be demolished by 2050. The range is 3,180 to 5,370, having as a middle point 4,274 buildings, this would mean that each one of the seven social housing associations must demolish approximately 20 buildings per year, resulting in 140 buildings per year. According to CBS (2020), the average numbers of buildings demolished per year in The Hague are 222. Therefore, it is possible to assume that both results, 3,180 and 5,370 buildings, are possible, resulting in from 860,000 to 169,000 square meters of floor area being demolished toward 2050.

For every square meter of demolished floor area, based on the information retrieved from New Horizon (Appendix 2), is expected to extract 522 Kg of brick and 20Kg of glass, resulting in a total of 450 to 224 Mt of brick and 17 to 8.4 Mt of glass, and these materials can be recovered and recycled into new bricks. The application of urban mining of brick and glass materials can have benefits for the construction sector, such as energy-saving, emission reduction and cost reductions. Furthermore, on the stakeholder analysis, it was addressed that social housing associations and construction companies are money conscious; therefore, it could be assumed that urban mining could be an attractive solution for decreasing the construction time, material prices, emissions and therefore the taxes fees, without mentioning the facilitation to obtain construction permits, due to their alignment with municipal strategies.

Van Wijnen Noord, in their interview, addressed how urban mining could be more cost, time and logistic intensive than traditional construction. However, it needs to be considered that urban mining is in the pioneering stage, and therefore, the techniques to apply it are in the developing process. Furthermore, Van Wijnen is a company with more than 100 years of experience in the construction sector, and with more than 1900 employees, consequently, it can be assumed that a change in the backbone, such as urban mining, on how constructions are approached could be time, money and logistic consuming at the beginning.

Therefore, is essential to create direct communication channels between the construction companies, demolition companies, social housing associations (as the client), the municipality, and, perhaps, the companies that oversee recycling the materials.

4.3 Material Flow Analysis and monetizing of the brick and glass extracted

Section '3.2 Social Housing buildings that are projected to be demolished by 2050' quantified the number of buildings that could be demolished and their total amount of square meters (sqm), based on two estimations. The first estimation resulted in the demolition of 5,400 buildings with a total of 860,000 sqm of floor area, resulting on 450 Mt of Brick and 17Mt of Glass. The second estimation resulted in 3,235 buildings with 169,000 sqm of floor area, resulting in 224 Mt of brick and 8.4 Mt of glass. Then in the section '3.3 Monetizing of brick and glass extracted' the Mt of brick and glass were translated to their value in Euros, depending on if they are directly bought from the store, retrieved from demolition waste or recycled into new bricks or glass (Table 6 & 7). The price of the bricks when they are directly bought from the store was 0.077 €/kg, and if they are bought as recycled bricks, their price was 0.076 €/kg, nearly the same price.

On the one hand, these prices do not take into consideration the price fluctuation of the material and the economy of scale if recycled brick becomes a commonly used material. Nevertheless, during one of the interviews, New Horizon answered in behalf of Douveren (since they are significant partners in the field), a company that recycles brick and glass into new bricks, they stated that is highly improbable that their prices become lower even if recycled brick becomes a mainstream material. Since, their prices are already 20% lower (Appendix 4) than standard bricks, or other recycled bricks, making them competitive in the market. Furthermore, even if Douveren is only one of the companies that work on these fields, it gives a sample on how the recycled bricks market will develop in the following years. On the other hand, the price assigned to bricks retrieved from demolition waste, as is mentioned in the text, focuses on traditional Dutch bricks, that does not contain any unique characteristics. However, In the case the bricks are retrieved from a building built before 1940, an iconic building, or a building with unique characteristics, the bricks can have a higher value. This market is called 'Reclaimed brick', and the brick value can be even 10 times higher than traditional bricks (Cawardem, n.d.; Brickhunter, 2019).

4.4 Limitations and recommendations

The limitations and recommendations that were found during the results are explained in three sub-sections. The first sub-section is the 'Stakeholder Analysis', the second sub-section is the 'Buildings that are projected to be demolished by 2050', and the third, and last sub-section, is 'The monetizing of material'.

4.4.1 Stakeholder analysis

In the Stakeholder analysis, the results were based on the interviews done with one of the employees of Vestia, Staedion and Haaglanden. Vestia and Staedion are two of the seven social housing association in The Hague; hence, the result could change if the other social housing associations or AEDES (Social housing national organization) are interviewed. However, it needs to be taken into consideration that Staedion and Vestia are two of the three most significant social housing associations in The Hague.

Another limitation in the stakeholder analysis was a small sample of people interviewed in the C&D sector; only one person of a demolition company and one person of a construction company were interviewed. However, the person interviewed from the demolition company is the Director of urban mining and material balance of New Horizon, the company that is leading the change from traditional demolition to circular demolition. In the case of the construction company, the person interviewed is the manager of circularity of Van Wijnen Noord, one of the largest construction companies in The Netherlands.

In the results found in the stakeholder analysis, it was stated that the C&D companies, municipality and social housing associations, are willing to transform urban mining from the pioneering stage to standard practice. However, for future research it would be of great importance to assess how the stakeholders interact when they are collaborating in a project, understanding the power-interest grid and which changes in the system must be done to be able to overcome current issues. Currently, there are different processes that can be applied to formulate integrative process at the beginning of a construction project, such as the ones expressed on LEED (leadership in Energy and Environmental Design) by the U.S. Council, for more information about this topic you can see the recommended integrative process layout.

4.4.2 Buildings that are projected to be demolished by 2050.

For the quantification of the buildings that are projected to be demolished by 2050, three databases used were: 'Corporatiebezit pandan in Den Haag' (Municipality of The Hague, n.d.), the 'Datalab Energietransitie' (Municipality of The Hague, n.d.), and the 'BAG 3D' (Land Registry, 2019).

The Datalab Energietransitie made by the municipality of the Hague locates the different energy labels based on the quadrant and their coordinates. As it can be seen in Figure 16, the polygons assigned to each

energy label are not established per building, in some cases, one building can have more than one energy label, increasing the percentage of uncertainty, especially, when merging the database with the specific locations of the social housing buildings database ('Corporatiebezit panden in Den Haag') as it is shown on Figure 7. The generalization of the energy labels results in inaccuracy on building level.

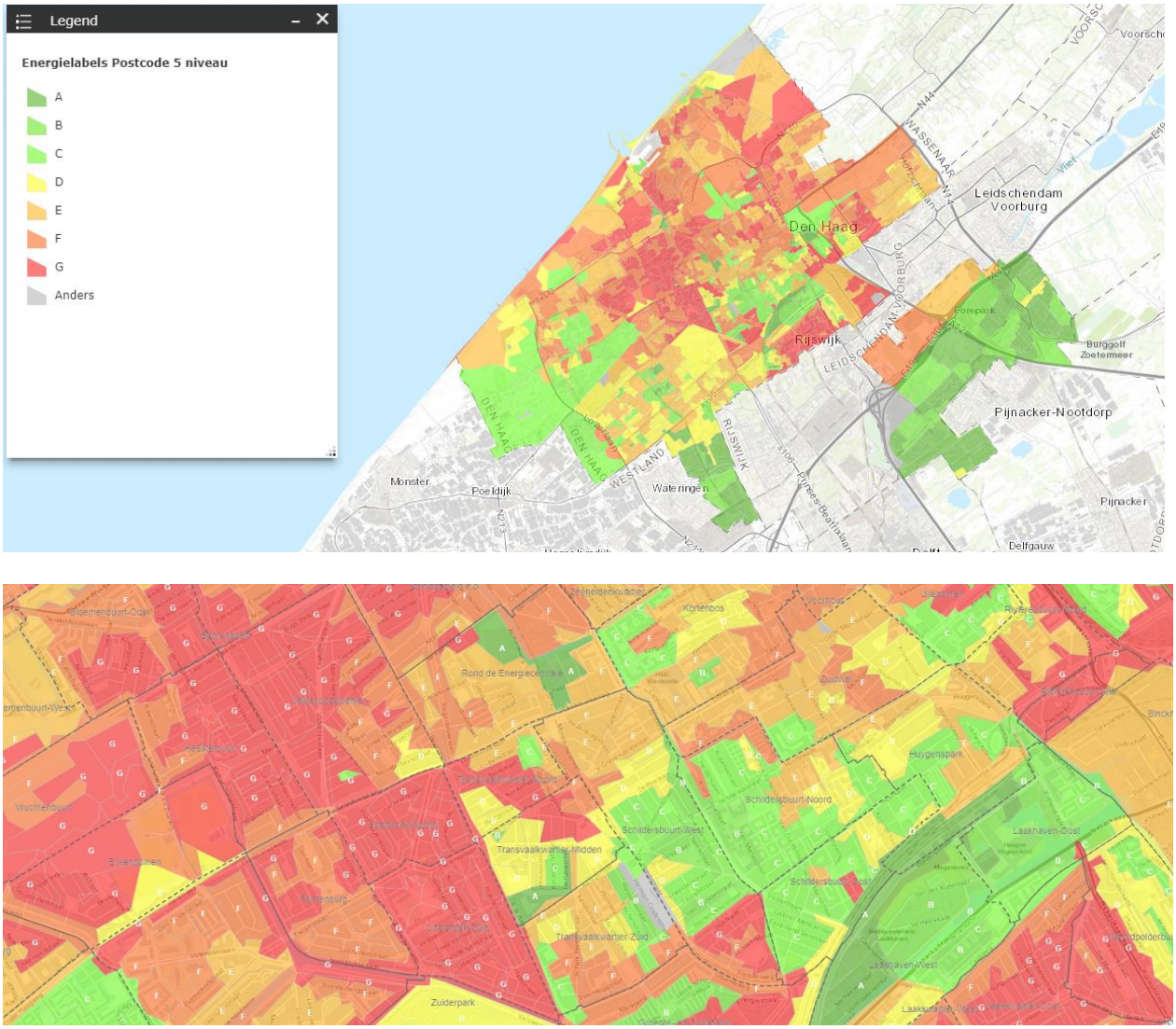

Figure 16. 'Energielabels Datalab Energietransitie' (Energy labels Datalab Energy transition) by the Municipality of The Hague (n.d.)

Another limitation was the sample used to quantify the amount of brick and glass that can be extracted per square meter of floor area. The numbers were based on the information retrieved from New Horizon (Ap-

pendix 2). However, the sample is considerably small since it is based on the demolition of one single building. In order to facilitate future research, it would be recommended to have a larger sample of information from demolished buildings form different companies, to be able to compare the data and asses the different methodologies that they used for demolition.

4.4.3 The monetizing of material

One of the significant limitations for the monetizing of the material was limited information about material prices in the construction sector. Currently, there is a wide variety of digital sources available to find the price of construction materials. However, most of these sources are not clear about the units they are using. One of the major issues was that in the construction industry the material price (such as brick and glass) is dependent on the number of tones that you buy, making it challenging to calculate comparative prices. Furthermore, the prices vary depending on their location and if it sold directly from the factory or a middleman. One of the ways to calculate an accurate average price of the product in a region would be by contacting each retailer and ask for a budget, with the same characteristics for every company.

Also, it must be considered, that this research, due to time constraints, was limited to traditional Dutch bricks, with no unique characteristics, and plain 4mm flat glass, with no unique properties, these materials, might be assessed as 'common'. However, in most of the cases, the companies that produce brick and glass, want to have a unique product that differentiates from the others in the market, therefore, making the price comparison and standardization more difficult. In order to facilitate further research in the sector of urban mining, it will be optimal to have a dashboard that shows the comparable prices between the different materials depending on their location and properties.

4.5 Future applications of urban mining: Decrease of CO_2 footprint

One of the most critical issues that urban mining tackles are the reduction of CO_2 emissions, which is a global problem. This problem is currently being considered by governments, such as the Dutch government and their municipalities (Dutch Government, 2019a). The municipality of The Hague has the goal to decrease 95% of CO_2 emissions by 2050, compared to 1990 levels (Dutch Government, 2019a). The materials more used in the construction sector in the Netherlands, are concrete and brick (Koutamanis et al. 2018), for this research, the materials that were selected were brick and glass, and according to different companies and strategies, such as Kingston (n.d.), Douveren (Appendix 4), and REBRICK (n.d.), it is possible to decrease from

88% to 25% the emissions during the production of brick by combining reclaimed brick and glass from demolition waste. In the Netherlands, the company Douveren (Appendix 4) is currently recycling bricks, and they state that they can reduce the bricks footprint by 44% with this technique.

On average a one square meter of brick is equivalent to 470 Kg of CO_2, with 509 kg per sqm (Syngros, Balaras, & Koubogiannis, 2017), and considering the average kg of brick that will come available are around 330.4 Mt (Section '3.3 Monetizing of the brick and glass extracted'), the environmental impact of buying traditional new bricks would be of approximately 305 Mt CO_2 equivalent (eq.). Meanwhile, if the 44% reduction of CO_2 emissions is applied, then recycling the bricks into new ones gives a result of 134 Mt CO_2 eq. decreasing the footprint of the material significantly.

The CO_2 reduction achieved by recycling bricks is the first approach to the number of emissions that can be saved through urban mining. However, there is another factor that needs to be taken into consideration; capitalization of the materials that are urban mined. On the stakeholder analysis, it was shown that the construction companies are money-driven, and the social housing companies are budget-conscious since they are a non-profit organization. Therefore, they have a particular interest in investing in well-developed technologies, decreasing their investment risk. Furthermore, the results from section '4.3 Material Flow Analysis and of brick and glass', showed that urban mining practices are competitive with the cost of traditional C&D, even if circular demolition is not a common practice. Hence, it can be estimated that urban mining is an environmentally friendly and cost-competitive solution.

Further information about how to assess circular constructions, and their possibilities of emission reduction in the construction sector, can be found in the research 'Emission reduction possibilities by circular demolition on a local scale' by Sauer (2019).

5.CONCLUSION

5. CONCLUSION

How can urban mining of social housing help to achieve the transformation of The Hague into a resilient city by 2050?

Urban mining is a profitable and environmentally-friendly solution that can be a path for cities to become more resilient. The purpose of this thesis was assessing the possibility of urban mining in the social housing sector as a way of reaching the goal of the Hague to become a resilient city by 2050. The results showed that urban mining could be a profitable business model and could decrease the environmental impact of the C&D sector significantly. Although urban mining practices are in the pioneering stage, there are multiple companies that are working on transforming urban mining into common practice. Urban mining can help the Hague to become a resilient city by lowering material costs up to 20% and decrease CO_2 emissions up to 44%. The sustainable sourcing of materials fuels the circular economy, which could facilitate The Hague to become a resilient city by 2050. However, to overcome current barriers, the stakeholders in the system need to be aligned with the goal of moving towards a circular economy.

The stakeholder analysis showed that the municipality of the Hague, social housing associations and C&D companies have complex interaction regarding demolition processes. Typically, the social housing association would assess their dwellings, and with that, the possibility of refurbishing or demolishing them. Once the social housing associations assess the different possibilities, they contact a construction company to make the proper changes such as refurbishment. In case the construction company needs to perform a deep renovation or needs to demolish the building, the construction company reaches out to a demolition company. Then, the C&D companies need to contact the municipality to get their permits. The municipality can deny the permits if the construction plans are not in accordance with their policies, such as initiatives like 'The Hague as a Resilient City'. However, social housing associations and C&D companies work under the laws of the Dutch government and, consequently, they are not obliged to comply with the specific goals of the local municipality. However, if they want to accelerate the procedure of getting C&D permits, it is more convenient for them to be aligned with the municipality's goals, such as 'The Hague as a Resilient City'. Unlike most social housing associations and construction companies, the stakeholder analysis showed that the municipality's goals align with the interest of demolition companies, they have a common interest in the urban mining of materials. Therefore, if municipalities and demolition companies have direct communications channels with different parties, they could accelerate the process of facilitating urban mining.

Nowadays, urban mining is not a common technique because most of the construction companies and architects are not familiar with urban mining techniques and prefer to keep using their traditional catalogue of materials, which discourages demolition companies to urban mine. At the same time, social housing associations, in their majority, do not pressure construction companies or architects to incorporate reused or recycled materials in their design, since they are unaware to the idea of saving money and CO_2 emissions by doing it. To show these benefits to the construction companies and architects, in the findings, it was assessed the competitiveness of urban mining the social housing sector in The Hague, through two estimations. These estimations calculate the number of buildings that are projected to be demolished by 2050.

The first estimation was based on three criteria: land use, year of construction after 1940, and EPCs below label D, giving a result of 5,400 buildings. The second estimation used three criteria as well: land use, year of construction after 1940 and the 20-80 rule (20% will be demolished and 80% will be refurbished), giving a result of 3,180 buildings. The middle point between these results was 4,300 buildings, or 33,000 sqm, that might be demolished by 2050. From these constructions, it is possible to urban mine up to 12.4 Mega tonnes of glass and up to 330.4 Mega tonnes of brick. Materials have a different market value depending on whether they are bought first-hand from the store, as demolition waste or as a recycled material. The glass can be sold directly from the demolition site with a price of 0.146 euros per kilogram, and a price of 0.449 euros per kilogram when it is recycled, resulting in potential earnings of 3.7 million euros. Meanwhile, brick has a value of 0 when it is recovered from the demolition site, and value of 0.0765 euros per kilogram when it is recycled, resulting in potential earnings of 148 million euros.

The projections calculated in the findings show the competitiveness of implementing urban mining practices in the social housing sector in The Hague. They demonstrate how urban mining can be upscaled to other sectors that could benefit from the cost savings and CO_2 emission reduction. This research creates another step towards opening the path to further research on how to implement urban mining for resilient cities.

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APPENDIX

APPENDIX 1: Interviews

In the section, it can be found all the questions made to the different parties. The key informants interviewed are formed by the companies: New Horizon, Municipality of The Hague, and Van Wijnen Noord.

A1.1 Municipality of The Hague

Jack Amesz: Tender Board - 22nd of October 2019

I am an executive advisor on public space and infrastructure for the municipality of The Hague. My task is mainly in the field of improving the way we access the principal professional clients towards the market. Getting sustainability in our approach. [...]

Organization within the municipality, we are divided into four major activities.

1) social domain, what is people-related, such as care.

2) Services for our citizens, such as transport.

3) Finance, HR, and this kind of activities

4) Physical domain: Infrastructure, public space, construction, and city development. Within this part, we have different roles.

a) The first one is acting as a client to the market; that's where we have objectives, mandates, and money to invest in public space. In this section, we are 100% in charge of what is going to happen.

b) Facilitation role to commercial investors or social investors, such as social housing.

c) Authority, if people try to construct something in the, that is not what is supposed to. You have the permits.

d) The Hague as a principal of a project. for example, for your topic of research. In my case, I am in this section. I am part of a Tender Board. Everything that is going to be part of the market needs to pass through us. Such as the case that we know of social housing that is going to be demolished we are going to make plans for that area. In the Tener board, in this case, we have a saying into favouriting the demolition companies with a more circular approach, over companies with a more traditional approach. 08:31

Sometimes we are in a position of being the landowners of an area or a building, and sometimes we are not. This makes a combination of situations of how we can approach the development and reinforce requirements over what is going to happen. [...] The Social housing associations [...] have specific programs for investments since there is the type of tax ruling from the national government, and at the same time there is a great demand for increasing the sustainability of social housing, but that needs investment. We, as a city we are working in the energy transition, which is also in place. It's a whole construct of aspect.

Currently, there are incentives in the Netherlands for construction/demolition companies to do urban mining?

as part of the tender board, we get to know the ongoing and upcoming projects that are happening around the Hague. And It has gone to our attention that for quite a bit, it has been attractive for demolition companies to work in this way. the better they can extract the materials from the demolition site, the higher the value where they can sell it. By economic, they are already working in this way. However, it is interesting that demolition companies optimize the value chain from an economic perspective. Let's say, meanwhile, the new horizon does it from a global perspective.

From the point of view of the tender board, give an incentive about optimizing the material used in the demolition project, it appears to be quite difficult. We think that topics related to logistics, such as electrification of equipment, which has nothing to do with material use or reuse.

There are a lot of new projects using new materials. 20-30 years ago, the idea of reusing materials in the public space was on a larger scale. We have ideas for public design space ourselves, but for that, we need to understand which materials are coming out, and then we can include them in the design. The main barrier for not doing it yet is that we don't get organized and that it has to match because you need to know when the material is going to become available, the store is also something that needs to be taken in consideration. You need data about the material. We are working with building new information models, but still, you need to organize it to use it. We also have a sense that if you renew public space, it is nicer if you have new materials, that's the way of thinking nowadays. People do not want to use old materials/components, and the materials get deteriorated, which means that they might not be usable for another purpose.

How do you think the energy transition is going to change the landscape of the city?

In the Netherlands, we have almost all of our services (wiring and piping) underground, and in the historic cities, the underground is quite crowded. We would need to change the piping for the new heating system: warm water. I think in the case of housing, they will not be really different as to how they are designed today. I think it is going to take between 15 to 30 years to do it.

The Nitrogen situation:

We are affected a lot. Personally, when we point the construction sector, I think we are not looking to the right industry, I think we should be looking to projects that use more Nitrogen during the whole process, not only on the construction process. But I understand that if you have projects need to natural areas, you need to limit the amount of Nitrogen near them. I think it makes more sense to look to larger industries that actually have emissions during their processes.

Wilco Verkade: Coordination Expert and part of the bureau of engineers of the Hague – 23rd of October 2019

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What is your daily job?

> Technical management. I work in the field of construction, a lot of concrete and steel in my daily life. I work a lot with bridges. Tunnels and there are about. And, I also work for the concrete accord, is an accord The Hague has about making concrete more sustainable.

What can you tell me more about the strategy for 2024 to make the construction sector more sustainable?

> I don't know anything about Vestia and the city of The Hague.

Can you tell me a little about what is happening in the construction sector in The Hague or in the Netherlands?

> We have the concrete accord. We set the goal for 2030 to make the concrete 30% more sustainable, compared to 1990. That is the national goal. We only need to make concrete more sustainable, not steel, wood or any other material. We want to reduce the carbon deposit by 30% compared to what we did, and, we want to reuse the concrete that comes from demolition sites, we want to upcycle it instead of downcycling it.
>
> Today, concrete is broken down in little pieces, so it can be used as a foundation inroad, but that is considered downcycling. Right now, we are looking for possibilities to reuse it in another way maybe. Normally, we just destroy the old one and build a new one, but we want to extend their life instead.
>
> We are also looking in ways to make the mix of the concrete more sustainable by using all sorts of things. We are not limited to one possibility. we want to use polymers instead of cement. We are looking for alternative binders. Find ways of using less concrete, also extend the period for the cement to harden, and then use it as a carbon deposit.

What is the main barrier to achieving that goal?

> There are three main barriers. The first one is on the way of how we produce cement/concrete, and how we approach the design of structures of concrete, and how we maintain it.

Who is involved in the concrete accord?

The concrete accord is right now signed by some cities, four cities. Is also signed by the company who designs the new railways, and the governmental institution than maintenance all the roads on a national level. Some big contracts also signed that accord. but not all the organizations in the Netherlands have signed, Is a voluntary accord.

Thimo de Nijs: Corporate Advisor Sustainability

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From Gert-Jan van der Panne,

General questions

There are current accords between demolition companies, social housing associations, and the Municipality of The Hague?

Not yet, although we are talking about it and we are sharing experiences between the housing corporations and the City of The Hague. Circular demolition and urban mining at the moment seem to come at additional costs, which housing corporations in The Hague are usually not able to find the money for. We do have an agreement that translates as follows: “Housing corporations and the City of The Hague will be ready in 2024 to take up challenges in the re-use of materials, building circular, work with material passports in high-level re-use of concrete. In the coming years, we will prepare ourselves.”

Social housing

How do you see the energy transition and demographic growth affecting the social housing sector in The Hague?

The City of The Hague has the ambition to be climate neutral in 2030 and take steps towards this future in the next few years. We expect housing corporations to renovate 16.000 of their houses towards an “energy transition ready” level between now and 2024. As the City of The Hague takes in an additional 5.000 people per year (30% of which will be from the group which has a right to social housing), we need housing corporations to build a lot of extra houses. These new houses will be heated without gas and with a high standard of insulation. The houses from housing corporations will play an important role in the roll-out and realization of CO_2-neutral energy & heating systems such as geothermal heat, heat distribution networks and thermal energy storage systems (WKO in Dutch).

From Anne-Marie Hitipeuw,

The Resilient city plans of The Hague were written in cooperation with the social housing associations of The Hague?

In the preparation of the Resilience Strategy, we have involved many partners, also housing cooperation. And in our Advisory Board, we had the director of Haag Wonen present. But I think there are more links we can further develop with the housing cooperation to become resilient.

Is the Resilient city plans of The Hague developed in parallel with other national strategies that can approach social housing associations?

We have used the national strategies as input for our resilience strategy.

Ger Kwakkel: Circular Economy Advisor – 07th of November 2019

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Has the municipality of The Hague a strategy to foment urban mining?

We have some policy about the circular economy but is in the early state, so first, we have to demolish buildings in a circular way, construct new buildings with a circular concept, but we don't have any experience. First, we need to experience it our self, and then we can make policies. We don't have any policy yet for circular construction, other than we want to turn all our buildings into circular constructions for 2030. But it concerns our own buildings, which are around 1000 buildings. But currently, we don't have any policy regarding circular construction and demolition.

05:31 In The Hague when you demolish a building, you get a permit, and it's up to you want you to do with your waste. However, we want to change this in the future.

the goal is to become 100% by 2030. However, we don't know yet how we are going to get there. It is going to be a slow start and then accelerates.

How do you cooperate with the construction and demolition companies?

We have our own people, our own project leaders who demolish buildings, etc. We connect with them and external parties. For example, we had a meeting with New Horizon last week.

And what would be the material that you would be more interest in?

You need to take into consideration The Hague as a building target for 25,000 new houses the upcoming next five years, and after that, 25,000 houses for the five years after that. In 10 years', time, we have built 50,000 new houses. The city will grow by 75,000 people. We are interested in what materials do we need for that building target.

There is a special interest in a specific material?

I don't know it depends. TNO has a project where next year they will materialize the building target, they will calculate how much materials they need for that and how much materials are coming from out of the demolitions, pairing them up. However, currently is a desk study. It is more for policy-making than actually bring materials together; the name of the study is op circulaire (or upcycle in the construction area).

From the circularity point of view, what is the goal of The Hague?

We don't know yet till which percentage we can ask the constructions to be circular. We need to practice it first. But I don't think we are going to give a subsidy. For example, New Horizon already has market prices, for circular and traditional demolition, which can be the same or circular demolition that can be cheaper. Because of that, the government is not in a position to help them; they can do it by themselves. In the case the price was really different from one to the other, maybe the government could play as a party to decrease the price of circular demolition, but that is not the case.

What is going to be the first step to become a circular city in the construction/housing area?

We are thinking of doing a material hub, the other day we talked with other companies about us as a government provides a storage area in the city for their secondary materials. And they said that this is not going to help. It is very expensive to store the materials; the best is to move materials from A to B or bring them to the place where B will be built. If you have a storage unit, you end up with a lot of materials that are in the back that never sell. Normally you can only sell 20-30% of all the materials that you collect. I think for the first step we need to show everyone, our own people, and the market that it is possible to build a circular building with the same cost as in the traditional way. that has to be in everyone's mind.

What happens right now with the construction waste?

As a demolition company, you have to separate it, but how you do it and what you do the materials is up to you. We don't have any insight or information; we just say to the constructor that is their problem. We don't know if it is used again on The Hague.

Slowly there is more interest in circularity. However, not at the management level, not at a city council level; for them, this is not an issue. More project leaders are getting involved.

There is any limitation about the number of constructions at the same time that can be done per neighbourhood or in the city?

No, there is no such guideline, I think. It is more a capacity question; how many people can work at the same time.

A1.2 Social Housing

Social Housing association – Martin Roders: Senior Policy Advisor Sustainability at Vestia - 22nd of October 2019

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First, can you tell me about your job in Vestia: the program manager of sustainability, Vestia has 4 main departments:

One is the department that relates to the customer contact and people having problems or those kinds of things, Maintenance and development department, maintenance and improvement of the dwellings, Financial department, and Strategy department.

The strategy for sustainability is 80% energy transition and 20% climate adaptation. And I want to get sustainable materials more involved. Some of the project's leaders are interested in reusing materials, but there is no mainstream policy on that topic.

I personally think we should do something with all the materials that we have on our buildings, then just demolish and separate the materials. But till now, that's the level of technology from Vestia. 04:09

There are any current accords between the municipality of The Hague, the social housing associations, and the demolition/construction companies?

> As far as I know, there is nothing. In The Hague, they made a long term, 4-5-year agreement on sustainability agreements, and in there we say that on materials that we will work in a plan. But we cannot promise more, because the municipality wants us to do certain things and we cannot offer everything, because we cannot afford it, or we don't have enough people that can work on it. We end up with agreements where we work in a plan, and if it ends up well, we continue with the next step. Anyway, this is the first time that they speak about circularity.

> According to a document, the municipality of The Hague published, the social housing associations have till 2024 to reuse the materials, involve circularity construction, involve material passport, and reuse of concrete. However, I think this an ambition plan. They say that in the upcoming years, all parties should prepare for that, so we will be prepared to get the opportunities for doing circular buildings, that's what we agreed upon. But now we need to fill in the blanks.

So, the idea is that you are going to have everything prepared for 2024 to be circular? 09:24

> Yes, however, I think it is an early start. This can help to make a process; people start to think about it and strategy about the future. If they don't put it in this kind of agreement, we don't think about

it. Vestia is a traditional social housing association, using the traditional ways of construction and demolishing and downcycling the materials by putting them in landfills or under the road. Thinks can be improved, and this can help to make the change.

When you have a social housing building, when do you know when you are going to refurbish it or demolish it, where is the turning point? 10:59

Well, to be honest, the main turning point is financial. If the investment of the refurbishment is too high for the quality that can be achieved, then is demolished. However, I would prefer to refurbish the building, and in some cases, it is really difficult to refurbish a building with the same quality that you want. For example, we have some social housing in Scheveningen that are row houses. The insulation is not very good. The areas are not really big. Sometime in the past, they build really small houses with really small bathrooms that didn't have space for the shower, so they place the shower somewhere in the corridor or somewhere they didn't use, like a closet. So, in this case, how can you refurbish a building like this? so, those kinds of dilemmas where we need to acknowledge that we might not be able to fit a decent bathroom. the combination of these factors pushes us to demolition. 13:09

However, they change something in the financial regulations, and now demolition is more expensive than a few years ago. You have to count the value of the dwelling that you are demolishing and the economic value as well, meaning that with your new building, you need to recover the value of the old building as well, making it way more expensive. If it stays, you only have to pay the refurbishment.

Do you think it is going to be attractive to extract the materials from the building and then reuse them again in the same building?

Yeah, but there needs to be a system to know what is in the building and to be able to be reused in that building or in another. You need to create a database and assure the quality of the materials. Create a balance if you are going to refurbish it in small pieces or only the bad parts, or do you start all over again.

Do you think it is better to reuse the components (such as sockets and window frames) or the materials?

My mind says to use the concrete and make it better. But my heart says to use the windows. In some cases, it is really time-consuming to reuse the components. In the end, if you reuse the components, you use fewer materials, which is better for the environment. If you start to improve those ways of construction and to think with other people as well, things get easier. But nowadays, people want something new and waste is accepted. Sometimes the tenants say: "I don’t want to live in this house, I want to live in a new one," and some really want to stay in their house and not want things to be changed.

I was reading a paper about the social housing sector and how there is this stigma around the housing from 1945 and how they don't like to live in these massive constructions?

> Yeah, the gallerij flats, It was mass construction. Actually, because of how the buildings were made, the quality of those buildings is quite ok. The apartments are spacious by themselves; they are quite monotonous. Those buildings are so significant that it is ok to make the investment of refurbishment. We actually have some buildings in Scheveningen that are being refurbished at this moment, but we take out everything, we only leave the concrete structure, but that was a cheaper way than demolishing the whole building.

Does it make a change that demolition companies invest in technologies for doing urban mining? would social housing use the extracted materials?

> It the materials make the construction cheaper. for us, you can use the number of dwellings and the replacement rate of buildings. If one building lasts 100 years, you need to refurbish or replace 1% of your building stock every year. Then it takes 100 years to star with the first one again. and you can calculate more or less the material flow that would come out if you demolish everything. If the materials that are coming out are used to improve current materials and are either cheaper or less intrusive for the tenant, if we refurbish than then is added value. We continuously try to improve the buildings, right now, especially in energy performance, but also, the quality of the interior needs to be at a certain level. Things are used, and they biodegrade, and if they are replaced, they need to have better quality or equal quality of a new one. If the material urban mined has the same or better quality, I don't see any problem with that. Even better, if it adds value to the waste and is even cheaper, we will use it for sure.

Do you do your own demolitions and constructions, or do you hire another company?

> No, we hire a construction company. We make plans with the architect, and then we hire a construction company. We are the principal of the work; we assign the work to the construction company, and then they carry it out. Nowadays, the construction company helps in the development of the plans already, and we are trying to have a closer collaboration, but there is still quite a gap between the integration. 25:30
>
> We are not really working integrated yet but, in some projects, more than others. I think it is better that we used the integrated way of building.

How do you think of making social housing more resilient? 26:13

> I think we design more for the demand. I don't think construction is built thinking about possible changes in the future. One of the possibilities is that we take into account that people stay longer in their houses, especially old people, and maybe some modifications are done due to that purpose.

We look at what kind of people need houses, and we construct for them. Very traditional, at least as far as I know. The plans that are being developed, there is a lot of refurbishment meanwhile the tenant stays in the house, so you have a tenant, and you are going to refurbish their building, there is no need to think about the future because why would you change the dwelling if there is a tenant already. I don't think there is a lot of thinking in the long term. this is the purpose, and this is the demand, you just need to fill it in. In some urban developments that we are still planning, they are trying to take out some of the fourth story buildings, they take out one of two blocks, and then they build back single houses or row houses, and that's kind of shift in the purpose. First, it was a family with one or two people and in a row house, it can be four or five people. The purpose change, but we are not planning to change it back if the demand changes. In case it happens, we will make another plan.

What about the net-zero houses or carbon-neutral houses? 31:29

We stated in a policy that we are not focusing on these highly insulated buildings because they are costly to make renovations to that level. We are here in quite dense urban areas were the expectation is that there is going to be a lot of district heating and the district heating can produce quite a lot heat, that you can also use in not such insulated buildings. When you have a net-zero building, you need to work with heat pumps, well low-temperature heating. We are focusing more on high-temperature heating because it will be available. And a remark about Vestia is that 8 years ago we were almost bankrupt due to some financial issues and we are still in this bad financial position. We need to be careful with the money we spent. The level of renovation we put it a little bit slower, but still feasible for us.

As a social housing company, how many demolition and construction permits do you get per year?

I think we get 1000 refurbishments per year, on the three locations where we work: Rotterdam, The Hague, Delft, and Zoetermeer. for each municipality is based on the production (this is how we call it), and out of that 20% is new construction (after demolition) and 80% is refurbishment.

Do you get any incentive from the government to do urban mining?

No, I haven't seen it yet. But I don't know if it is really there. I think they are starting to create awareness now, and, in a few years, they will put money on it. But we haven't investigated possibilities. It is still in a real stage of development, is more the pioneers that are looking for possibilities, and the majority is still working on the old fashion way. Maybe if they put more price in landfills or recycling, people will start thinking about different options.

How do you think the energy transition is going to affect the social housing sector?

Well, we have to take out the natural gas connections from all the houses, and we want to improve the insulation value of the dwellings, so they can be connected to district heating maintaining the comfort level — two main points we set for ourselves: insulation and installation. We are still working on making a road map, saying which dwelling and neighbourhoods have to be refurbished in the coming 10-20 years. We focus in 2050. The municipality of The Hague says they want to be climate neutral in 2030 (37:55), but we focus on 2050 because of the time constraints of our operations. However, the development that we do in the next years is going to help them to get closer.

And do you plan to add other technologies to the homes, such as solar panels?

Yeah, if possible. But it has to be financially feasible for us since we are in a bad financial position, we need to earn back all the investment, making it less attractive for tenants, because they need to pay for the solar panels. The more they pay, the less they receive as a gain from the electricity. So, we are not putting a lot of effort into it.

So, you would say that your main barrier, in general, is finance?

Yes.

Is the nitrogen problem affecting the social housing associations right now?

Actually, I haven't heard much about it, because as I said 80% is renovation. and there is not a lot of stress about projects being delayed or stopped. Until now, we haven't heard much about it, and maybe it's because of the refurbishment or because we are not close to natural areas.

Koen van der Most: Data Analyst – Sociale Verhuurders Haaglanden

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There are current accords between demolition companies, social housing associations, and the Municipality of The Hague?

The social housing associations and the municipality have agreement on the growth of social housing. In "lokale prestatie afspraken" for example, they can make an agreement on how many houses the associations will develop in a certain period.

How do you see the energy transition and demographic growth affecting the social housing sector in The Hague?

They both have a profound effect on the social housing sector. The energy transition is a massive operation that will cost a lot of money. It's a big investment and the social housing sector in The Hague doesn't have the funds to make all the investment, also, because we have a lot of other

challenges for the upcoming years. Because of demographic growth and developments on the housing market (an increase of prices for buying a home), in de last few years we saw an increasing demand for social housing. We're expecting an ongoing increase in the demand for social housing in the next years. So, we have a lot of challenges and probably not enough funds to finance those investments.

Social housing

How many demolition and construction permits do you transact per year?

SVH does not issue permits. The local municipalities are in charge of permits. However, we do monitor yearly demolition and construction.

Where is the turning point in a social housing building from being refurbished to be demolished?

It depends on the specific situation. At some point, it's not feasible anymore to refurbish a building. There are some exceptions. For example, when it comes to old buildings (monuments).

Do you design your buildings with resilient criteria or for current demand?

The answer is both. Social housing tends to look at current demand. For example, we see a lot of small households (1 person, 2 persons, no kids) looking for a home in The Hague area. So, in the last couple of years, there is an increased focus on the construction of 1- and 2-bedroom apartments. However, based on market research, we know that two-bedroom apartments are probably the more resilient criteria of the long-term future. A two-bedroom apartment attracts a broader public. The construction of smaller 1-bedroom apartments, however, is a bit cheaper and fits current demand.

Resilience City strategy

The Resilient city plans of The Hague were written in cooperation with the social housing associations of The Hague?

The municipality of The Hague and the social housing associations are working together to create city plans. In the end, it's the responsibility of the local government. So, the role of social housing associations is mainly in consulting the local government. We can strongly advise adopting some policy or a certain city plan. Every year the local government, the social housing associations, and renter organizations make "lokale prestatie afspraken." These are local agreements on the activities of the social housing associations.

Is the Resilient city plans of The Hague developed in parallel with other national strategies that can approach social housing associations?

The Hague makes its own city plans. However, on a regional level "Haaglanden" (9 local municipalities, The Hague, Delft, Zoetermeer, etc.) the local governments and social housing associations are working together to make sure we are meeting current demands for social housing. So, on a regional level.

Urban Mining

How is the perception of urban mining in the social housing sector?

> It's a bit of a buzzword at the moment. It's something we're looking in to together. But because it's a relatively new subject, I say the social housing sector is still exploring urban mining. The energy transition is what is dictating the agenda at this moment.

Guido van de Wijgert: Sustainability program Manager– Staedion – 24th December 2019

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There are current accords between demolition companies, social housing associations and the Municipality of The Hague?

> Er zijn momenteel geen (prestatie)afspraken tussen Staedion, de gemeente of sloopbedrijven. Er zijn wel contacten met sloopbedrijven die op dit gebied actief zijn.
>
> Translation: *There are currently no (performance) agreements between Staedion, the municipality or demolition companies. There are contacts with demolition companies that are active in this area.*

How do you see the energy transition and demographic growth affecting the social housing sector in the Hague?

> De opgave in de energietransitie en de demografische groei zorgen voor een druk op de sociale woningbouw. De verduurzaming en het gasloos maken van woningen vragen om een integrale benadering, vergaande maatregelen en hogere investeringen. Tegelijkertijd neemt de vraag aan betaalbare woningen alleen maar toe. Door het beperkt aantal beschikbare bouwlocaties en stijgende bouwkosten is het heel lastig aan deze vraag te voldoen. In elk nieuwbouwproject is duurzaamheid een onderwerp en daarbij zijn de wettelijke normen (bouwbesluit) van toepassing. Bij renovaties streven we er naar om complexen transitiegereed te maken en indien mogelijk aan te sluiten op duurzame energievoorziening. In Den Haag ligt de focus daarbij vooral op de uitbreiding van bestaande warmtenetten.
>
> Translation: *The task in the energy transition and demographic growth are putting pressure on social housing. Making homes more sustainable and gas-free requires an integrated approach, far-reaching measures and higher investments. At the same time, the demand for affordable housing is only increasing. Due to the limited number of available construction sites and rising construction costs, it is very difficult to meet this demand. Sustainability is a topic in every new-build project, and the legal standards (building decree) apply. With renovations, we strive to make complexes ready for the transition and, if possible, to connect them to sustainable energy supplies. In The Hague, the focus is primarily on the expansion of existing heat networks.*

Social housing

How many demolition and construction permits do you require per year (on average)?

Circa 2 tot 3 per jaar (nieuwbouw).

Translation: *Approximately 2 to 3 per year (new construction).*

Where is the turning point in a social housing building from being refurbished to be demolished?

De technische staat van een complex in combinatie tot de renovatiekosten, de internal rate of return bepalen en overige omstandigheden bepalen het omslagpunt

Translation: *The technical state of a complex in combination with the renovation costs, the internal rate of return and other circumstances determines the turning point.*

Do you design your buildings with resilient criteria or for current demand?

Grotendeel bouwen we conform de geldende normen en deels ook wel met nog hogere duurzaamheidsambities. We hebben onlangs groen en klimaatadaptatie en circulair materiaalgebruik toegevoegd als een van de 6 thema's binnen ons programma Samen Duurzaam (duurzaamheid). De focus ligt vooral bij de energietransitie. In de bestaande bouw kijken we naar klimaatadaptatie maatregelen, afhankelijk van de specifieke opgave per wijk (stresskaarten). Wij werken als partner samen in Klimaatkrachtig Delfland. Voor nieuwbouw zullen we in toenemende mate natuurinclusief gaan bouwen.

Translation: *We build for the most part in accordance with the applicable standards and partly also with even higher sustainability ambitions. We have recently added green and climate adaptation and circular material use as one of the 6 themes in our Together Sustainable (sustainability) program. The focus is primarily on the energy transition. In the existing building, we look at climate adaptation measures, depending on the specific task per neighbourhood (stress maps). We work together as a partner in Climate-Powerful Delfland. For new construction, we will increasingly start building, including nature*.

Resilience City strategy

The Resilient city plans of the Hague were written in cooperation with the social housing associations of the Hague?

Wij zijn deels bij de duurzaamheidsplannen van de gemeente betrokken. Zo werken we samen met andere stakeholders mee aan de Haagse Energie Strategie, wijkenergieplannen en het programma duurzaamheid van de gemeente. Hiervoor zijn gezamenlijk met de andere Haagse corporaties ook diverse overlegstructuren.

Translation: *We are partly involved in the municipality's sustainability plans. For example, we collaborate with other stakeholders on the Hague Energy Strategy, district energy plans and the sustainability program of the municipality. There are various consultation structures for this, together with the other corporations in The Hague.*

Do you work in close collaboration with the Municipality and the Demolition companies?

Er is nog geen directe samenwerking met de gemeente en sloopbedrijven. De selectie van sloopbedrijven vindt plaats vanuit de corporatie.

Translation: *There is no direct collaboration with the municipality and demolition companies. The selection of demolition companies is made by the corporation.*

Urban Mining

How is the perception of urban mining in the social housing sector?

We hebben in het verleden op projectniveau een ambitiedocument geschreven over circulaire nieuwbouw en een verkenning gedaan voor hergebruik in de vorm van urban mining (met New Horizon). Komend jaar gaan we het beleid voor circulair materiaalgebruik opstellen en pilots voorbereiden. Onderdeel hiervan is het onderzoeken van kansen voor hergebruik.

Translation: *In the past, we have written an ambition document at the project level about circular new construction, and we have done exploration for reuse in the form of urban mining (with New Horizon). Next year we will prepare the policy for circular material use and prepare pilots. Part of this is investigating opportunities for reuse.*

From the constructions you refurbish or demolish, which materials are currently extracted and reused?

De meeste materialen worden door de betrokken sloopbedrijven gerecycled. Hergebruik of re-use is nog minimaal. Wij willen dit op basis van het bovenstaand beleid in de vorm van pilots gaan uitbreiden. We gaan begin volgend jaar bijvoorbeeld starten met een pilot op het gebied van materialenpaspoort voor nieuwbouw en bestaande bouw.

Translation: *Most materials are recycled by the demolition companies involved. Recycle or reuse is still minimal. We want to expand this in the form of pilots based on the above policy. For example, we will start early next year with a pilot in the field of materials passport for new construction and existing construction.*

A1.3 Construction/demolition companies

VAN WIJNEN NOORD – Manager of Circulatiry: Marije Kamphuijs – 17th of October 2019

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As a construction company, do you follow national or municipal laws?

No, national

How is the cooperation between construction companies and the municipality?

We follow Bouwbesluit law. We need to check all the different parts of the buildings based on that law. Then the municipality checks it, and they will say if they agree or not.

How many permits do you get for construction per year?

It depends on the project, but you also need a construction permit if you want to refurbish on a depth level. If you want to do something superficial, you don't need a construction material.

What is the percentage of leftover materials that become waste after a new construction?

I think it is quite a lot. we are trying to change that; we don't want waste in our construction site. it would be around 15%.

Do you work closely with demolition companies?

Yes, that is something that is changing. We used to work with traditional demolition companies. traditional demolition companies normally downcycle the material; because of this, we are slowly changing to demolition companies with another approach. Companies that can use all the material, they can upcycle or reuse the material. However, in the past, we didn't do it that closely, it is something new.

Do you use the material that demolition companies extract from the demolition sites?

More and more.

Which materials are the construction sector more open for reuse?

The demolition companies take all the material to the industry where they came from. Then the material is updated/refurbished, and then we implement them. We need to have a

Which materials are reused the least?

insulation, they are developing fast, so there are new technologies that can be applied. Also, tapestry and cables.

Do you work with social housing associations?

Yes, they are a large client — mostly social housing, in the area of Groningen.

Which criteria are they implementing to make it more resilient?

They are trying, but money is the biggest barrier. Most of the time, they approach resilient as something that is nice to have, not a need to be circular. even if we design the building to be more circular, we need to design the building keeping the same price.

When you say circular, what would be an example?

We made a house where we can take all the elements, then take them out and put them in another. so, we can reuse all the elements in another building.

Do you know the reason behind demolishing a building?

- Earthquake in the case of Groningen

- Not suitable for the purpose of the new building

- Old, no historical value

- Change of land use

But if they have the same use?

- year of construction

- Too much to refurbish can be related to the energy label

Do you work in collaboration with New Horizon?

We try to work together, but it is difficult. Because they make things so different for what we used to, it took us time to get used to it.

Duration of the construction permit:

Till the end of the project depends on how long it takes. If you don't start in one year or so you need to do the process again.

Demolition process:

3 weeks

If the construction company responds to a national level, then how do you collaborate with the municipality?

It is not really a collaboration, is more if they want to; they make plans on how they want to do it. And then we see if we can provide some projects and if it can help us a company and if it can fit in our own project. But the most the strategy can help us, the more we implement it even in on own projects. They don't need to work with construction companies. They can design their own strategy and from there, force us to collaborate through the permits or by providing opportunities. They have all the power to change stuff.

NEW HORIZON – Urban Mining and Material Balance: Edwin Baars – 9th of August 2018

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Asbestos Inventory is used to determine what is to be harvested and whether it is cost-effective in terms of costs. Asbestos and soil research determine the price. Asbestos determines whether you can harvest hardwood and frame, 2500 different applications in which asbestos has been applied. An external Company Doing this research determines with samples where the asbestos is in. With this information, you can see what is possible to harvest in the building, or whether asbestos remediation should be first.

New Horizon takes the risk-bearing with the asbestos remediation, in order to make as many harvests as possible. They make harvest cards, as recordings of the building. Completely in development yet, working on an app and scanner to convert it digitally. At the moment, it is measured by hand, and that is labour-intensive. The specifications that are written in the construction are usually no longer correct and therefore cannot be taken from the demolition. You have to go through the building again to see what it brings. The BIM also does not describe everything in the numbers of the parts, and the description is a mismatch. The link between BIM model numbers and parts database is not quite correct yet. Prevents it from integrating to make it a program instead of different loose.

3D photos, measuring by hand, now they go towards a scanner that recognizes what the standard beams are. Dimensions, material, bolts that are then predicted. There is still no good solution for system ceilings. The composition of the material consists of several materials, which makes reuse difficult. Each plate has a different composition so that there is no constant composition to guarantee, in production, this is so determined. This is a challenge of New Horizon, is currently being put away as waste. They have a jar to support/stimulate initiatives.

The tool of New Horizon then scans, says this is a door, this is a window. Scans dimensions and grabs a density for the determination of the material. The form is assessed, and they are also checked. How it is fixed is specialist knowledge that people know, but the program does not. The development of lamps goes so fast that with old lamps little to do, T5 fluorescent lamps (just before LED) are difficult to bring back or re-use. The trays where the lamps are in are still to be used. An architect usually wants led lights for new projects, and that prevents reuse of this.

Plaster walls are used by Knauf for fire-resistant partitions. Canned products already deform during demolition, so it is difficult to use at the product level. New Horizon tries to maintain the product level as much as possible, but if that cannot be at the material level. Copper piping is cut off per x meter because in new projects you can do some more with it. The other pieces are then a certain form of waste. Floor tiles from offices are reused, are a business case. They are sold, cleaned, and reused. Art projects are also done. Noise absorption is also made.

Radiators, especially high-temperature radiators, are very low demand but are destinations for it. Sockets are different. Yellowed parts do not matter, companies, startups, and companies. They like to reuse, and some companies are full of it. Fire prevention products must be re-inspected but can then be taken again.

From the inside out, the stripping is done, first the low-hanging fruit and then the rest. Cable trays are possible, and cables should not be reused according to new fire safety standards. Heavy thick cables high voltage in shafts of the building are cut out, and new cables need to be pulled. Takes a lot of money to get cables to pull, why don't they let it sit at renovation/transformation? Already once done at an old Philips office and these cables in a new office re-threaded. Doors are also an example; they need to be ever higher and wider. Old doors are difficult to reuse. New Horizon is now working on a partner that makes old doors smaller/bigger to promote reuse. The wood in the building, wooden skirtings, in the Netherlands, you have to pay to pour hardwood. Windowsills are stuck so that you no longer lose them without damage.

Heating pipes are steel and good to use. The concrete skeleton of a building remains, but as much content as possible is attempted to get a destination. The construction of a building is not much to do with it, and much energy needs to be put in to get the steel out. That's not profitable, so back to the material level. This also applies to the foundation. It is, therefore, mainly about the content/furnishing of a building. The glass that comes out of a building is mixed with masonry to make bricks. Shorter baking times and less CO_2 impact by using glass in bricks.

CV-piping, radiators, boiler boilers are sometimes only 5 years old, always maintained, and are normally thrown away. Lift machines exactly the same, no batch wants those machines back, if only for parts. The

specifications of aluminium windows are 80 years, and normally they are discarded directly. The life span of these products is longer than the use case.

Bitumen on the roof they now also have a solution for, is now also re-use by a partner and which creates a new underlay on the roof. Gravel is washed and reused. Refrigeration installations may not be reused in NL, but they are sold in Belgium and Poland. Aluminium products like window frames are currently being melted down. Chinese buy this aluminium, melt it, and use it themselves.

The archive is the list in Excel; everything that comes out is inspected and tested. The partners process as much as possible, and the remainder is sold. Materials flow per piece, per component, per mass available. Specifications per building available, how many cubes of concrete etc. Material lists are guiding for what comes out.

NEW HORIZON – Urban Mining and Material Balance: Edwin Baars– 19th of November 2019

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Which materials do your urban mine the most?

Currently, we have 62 products that are reused one-to-one in new constructions. Both the material that we urban mine the most is concrete, wood and brick. Make new bricks in Limburg. Those three are the biggest now and have the largest impact on CO_2 reduction.

brick is a basic material; the brick itself when you extract it from the demolition site is damaged and has concrete. However, brick is the base material to make new bricks. There is a company that recycles them, is a family company in Limburg. To make the bricks they crush the bricks and they mix it with glass. Because glass will take the heat from the oven and glass keeps the warm inside. Glass has the ability of store heat, which decreases the amount of heat needed, making the process more efficient and decreasing the CO_2 emissions. The baking process is reduced by 25% on the moment you add the glass and Is a quick process.
The properties of these bricks are the same as new bricks, they can be used for structure, and you even have different colours from where to choose.

How open are the construction companies to use this material?

Very open, the government has a new rule that in 2050 you must reuse 100% of the materials that come from the building, and for 2030 you need to use 50%. Construction companies cannot fulfil these rules without reusing materials. Now the company has already sold around eight million bricks, and they are all used for construction and inside and outside decoration.

Is the cost the same as a standard brick?

Yes, it is the same price. We want to have a competitive business model, and if you make it more expensive than the normal way of working, then no one will want to buy it.

Last four years, New Horizon gathered with new partners around urban mining, and those companies are getting together to make urban mining more profitable. For every element that we extract certain aspects that need to be fulfilled, so when we gather with these partners, all the elements need to comply with all the properties. If they don't comply, then they will not buy it, they need a guarantee that can show to the clients and partners.

What is the main barrier?

More people are still in the same circle. They want to keep it traditional. They think a new way is more expensive or more troubles. The direction of the developer knows what I mean, they understand how we work, but the layer below them they don't. Their own personally have problem thinking in the way they do. Sourcing department is normally the biggest problem, because they stay with their old safe zone, not exploring new materials or ways of doing a building. It's a mindset that needs to be changed, all the things that are on the earth are limited, if we can reuse products, then why not reuse it?

The architect needs to think about this process. It needs to be considered from the beginning of the project. It cannot be just added at the end when it is useless. Also, think about how to design in a circular way, to be able to extract materials and elements that can be reused on other constructions later. The main barrier is the way architects design.

You can have reused bricks and glass with the same amount of money, but they don't think about it. And most of the time, you cannot reuse glass since it has other characteristics, that doesn't comply with the new building. Then the glass is thrown away, but whit the principle of urban mining, you can reuse the glass and the bricks, that means that the production cycle will reduce by 25%. On this moment we are trying to make the difference by making this new urban mining games for architects and builders to let them know on how to look a building, and how different materials such as steel will bring some money to the pocket. But other materials that you see as waste they can be reused or recycled. During the urban mining games, we go through a building, and we get to explore the materials, which is an eye open for the majority, and they get to understand what we are doing.

In the network that evolves urban mining, where do you think the pressure point should be to make urban mining more mainstream?

The architect must specify that he/she wants to use reused or recycled material. Every building has an inventory. It needs to determine which materials must be used. If the materials are described, the construction company will follow them.

There are two kinds of architects the old ones. They don't want to change because they keep holding to what is familiar to them, old school. And there are new architects, on the early days, those were the people that were looked as a little bit strange. In real life, they look further than normal architects. And now there is a switch on the market, new architects are the ones that make the difference, and the old ones are looking up to the new ones because they must. The old school architects now that they need to change, if not they will be out of work in 5-10 years. But the process is slow, the fact that we need to be 50% circular for 2030 is still doubtful.

On a previous interview, I talked with Van Wijnen Noord, and I was informed that they are working with New Horizon, but the process is going slow?

Yes, also for us. There is always the doubt if the characteristics are the same and how to implement the materials. The construction company sees more problems than they see challenges, they don't want to think in another way, because the way they work right now is easier, familiar. At the beginning of the process is the easiest way to get involved, because if an architect tells from the beginning, I want to reuse that beam, then the builder is going to agree. And if you want to reuse and you are sure that has the same properties then is fine.
The social housing companies have already another way of thinking within the process, they write it down, and then they find a matching builder because most of the time they are farther than the builder in urban mining. The social housing associations are more into urban mining than the builders, they are already thinking a lot more out of the box, but only some of them, not all. The University of Leiden is a client of ours, and they wrote down on purpose which materials will be reused on the new building. For example, we had a building where the beams from red pineapple and they were reused on the same building. Also, we have the Circl (https://circl.nl/themakingof/) project in Amsterdam with Amro Bank, which is one of the major players on urban mining. There is a lot of companies that want to be number one in the Netherlands, and urban mining gives them that opportunity. On the Circl project, we created a floor made with all the different kinds of wood that came from the demolition waste, the floor looked amazing. There are some architectural firms, such as Heembouw architects who are more than open to build in a circular way.

How is the relation between New Horizon and the Municipality of The Hague?

More and more municipalities are interested in the way they are working now because a lot of the companies say that they want to become circular, but in reality, they recycle or downcycle. We are working on some buildings in The Hague, Utrecht and other parts of the Netherlands.

Normally how is the relationship between New Horizon and the Municipality where you are working?
Most of the times the request comes from other parties, builders or architects. But also, from municipalities. Our relation is good, but I expect that they are also good with other companies, so normally there is a question from the municipality directly to a builder or to an architect, and via that architect or builder is when they see that they need to meet with New Horizon as well. And then New Horizon will be part of the meeting as well. However, this is not the way we want to work. We want to work directly with the municipality and not through the builder since the builders do not understand urban mining at the moment.

Normally, the national government communicates an end goal, and from the municipality takes the mindset to achieve the middle points. In this way, the municipality can force the builders to follow the middle points to achieve the end goal. The current problem is the request from the municipality

are so close that the builders cannot meet the request, the time frame is too short. Which makes it difficult to achieve, this results in delay after delay. That's why it is necessary to communicate better with the municipality to be able to level with them, or they level with us. We can assure that the reduction of CO_2 is already more than they expect, but when we are looking to the builder, they don't want to know that, they work with a timeframe and we cannot influence that. The builder is too strict with their time frame if they are not allowed to start; we are not allowed to start, and then is just frozen. And when we talk directly with the municipality, then we already know we can start earlier. It is better to start at the beginning of the process, and that is also with the architects, but also with the municipality to make sure that they are involved on the process from the beginning, so they are sure as soon they can start on the building when is empty, the better. If they start now the building is empty, they can take out the products in a proper way, and they are not damaged from vandalism. The buildings are less intact, so they can reuse more products than when the building is standing alone with no one inside. The longer it takes, the more vandalism is done, and the fewer components can be used due to damage. The municipalities understand this, but the builders don't care, because they want to keep their timeframe. There are some demands that the builder needs to fulfil before starting the construction from the customer, they only care about the amount of material reuse or CO_2 reduction the customer ask if the customer doesn't ask for more they don't care, they don't try more. For us, for example, 10% is no problem, even 50%, and they don't care that they could go 40% over. They stay with the amount the client asked. For us, the more time you let us do our job, the more material we can reuse, but the more time is between emptying the building and us entering the less material we can recover. As an example, if someone tries to steal the copper, they might damage the pipes, which results in leaking, and this can rot the wood.

Where do you see more future, on the reuse of components or the material exchange?

Components, we have already some clients that prefer components over the material but is depending on the architect who is leading. We are trying to have the least demolition waste as possible. We try to see if all the elements can be reused, and only in case, they cannot be due to different reasons they are recycled.

What is the percentage of brick that you take from the demolition site and turn into new bricks?

Almost 100%. All the normal red bricks we can use, the ones that are in the outside, structure and most of the ones inside. We already have a storage unit where we have all the bricks needed for doing recycled bricks for one year. The storage is always producing to keep the production constant. If the production stops, the cost is 80,000 Euros per hour. The only bricks we cannot use are the ones that sometimes they put in the inside to make the division walls. They are made from plaster and concrete. 49:59

How often do you work with social housing associations?

A lot.

What do you think is the main reason a social housing building is demolished?

The buildings are too old, a lot of maintenance, leakage. The building on its own cost more than the renews of itself. Also, they want to have the energy label from A to D, if that is not possible, they demolish the whole building. And if they need to do something to the building that is not financially good, then demolition is the best solution.

One of the main struggles you have with social housing associations.

The government has thrown them some laws. Is hard for a company like that to make a living. The government has set some rules for the social housing associations, and they need to meet with those rules. Those rules are so high that social housing associations cannot build social housing at this moment, is difficult for them to construct new housing. 54:14

Currently, the construction of buildings is too expensive, so they are trying to insulate the buildings, upgrading the energy label. It's really difficult to build on this moment, right now is too expensive. The building market is probably going to collapse in five months, and then you will see normal prices again. So, after that, the prices for new constructions are going back to normal.

Currently, based on other interviews, I made quantification of the number of buildings that are going to be demolished by 2050. The criteria that I considered are the year of construction, land use and energy label. Based on this, one of my scenarios estimates that around 5000 buildings will be demolished in The Hague by 2050. According to your experience, what do you think of this number?

I think 95% of these buildings will be demolished. Till now the demolition of buildings was too expensive, but the prices are going down, so I believe that from that 95% of the buildings will be demolished. For the past years, social housing associations have been challenging their buildings, and these buildings keep getting older, so the cost is getting higher.

Which percentage of material from these buildings could you use?

On 2050, 90% of the materials of the building can be reused. Is almost impossible to reuse 100% since there are hazardous materials and the quality of the content. At this moment, we can reuse 62 elements that we can reuse in the building, and we are trying to reduce the demolition waste as much as possible.

There are regulations about the limit amount of demolitions sites that can be in a city per year, or at the same time in a neighbourhood?

No, there is no such thing as that. There are some areas in Rotterdam where the building doesn't have any foundations, and on those areas, they are really strict with anything that involves vibration.

What is the main interest for New Horizon? 1:12:17

I think a lot of demolition companies that will join us, and there is a lot of companies that are changing the mindset. For us, the vision is to reuse all the materials. Now we can even reuse paint. There

are more and more partners that are more interested in joining to do urban mining. More companies realize that urban mining is something that needs to happen. Our vision is to change the mindset, reuse all the materials.

What is the main difference between you as a circular demolition company and a traditional demolition company? 1:16:28

The other companies crush all the material, downcycling it and putting it on roads. They don't quantify it. They just look for metals, which is the material that can give them money. We have the same tools as them, but we have a really different mindset

From the demolition market, which percentage is handled by New Horizon?

we are part of the big 5 demolition companies in the Netherlands. Every day it changes, we have been working for 4-5 years.

NEW HORIZON – Urban Mining and Material Balance: Tessa Terlaak – 5th of February 2020

tessa@newhorizon.nl - +31 6 12 96 74 46

1) What is the average amount of CO_2 emissions per Kg of Brick in the Netherlands, and what are the emissions of your product?

Please refer to the attached MKI-product sheet.

2) When you say that your product saves up to 25% of emissions than standard bricks, do you consider externalities, such as transportation?

Only the CO_2-emissions during transportation from the demolition site to production site are considered. The final transportation to the construction site is not considered as the distance from production to construction site differs.

3) What is the expected lifetime of the product?

The expected lifetime of the product is in line with regular bricks. Attached please find the CE-declaration for Urbricks

4) What is the value of the bricks when you get them from the demolition site?

The value of the bricks when harvested at the demolition site is set to zero. Disposing building materials normally costs money. We produce building materials from this waste. Therefore the value of the bricks is embedded in the sales value.

5) And lastly, based on an economy of scale, how much do you think the price of your product will drop on the following years if urban mining becomes a popular alternative?

Currently, we do not foresee any price decreases, as we already offer a competitive price towards regular or other circular bricks. Competitive products are currently priced twice as high as our circular bricks.

APPENDIX 2: New Horizon data

In this section, it can be found the Information obtained from the company New Horizon in November 2019 about the buildings they have demolished and the amount of material they were able to extract.

Table 1. Kilograms of material per square meter of floor area per type of residence building.

Type of Residential Building	Bitumen	Ceramic	Concrete + Brick	Brick	Concrete	Gypsum	Glass	Wood	BSA
Row	12.32	16.11	425.40	110.60	314.79	8.45	19.63	35.62	36.87
Single	12.47	16.11	1609.41	635.29	974.12	6.78	19.63	216.47	81.18
High rise	6.70	16.11	945.31	245.78	699.53	5.11	19.63	30.86	42.24
Apartment	20.08	16.11	2008.37	522.18	1486.19	6.78	19.63	34.87	60.00
Residential Total	12.47	16.11	924.33	635.29	974.12	6.40	19.63	36.43	44.01

Table 2. Information about the different residential buildings New Horizon has demolished in the past years.

Building type	Subtype	YOC	#Buildings	m2	m2 Total	Roof covering	(Stone) Rubble	Glass	Wood	BSA	SOM	ton/m2
Residential	Row	1931	141	71,3	10053,3		2880	19.63	282	264	3426	0,34
Residential	Apart-ment	1965	1	7170	7170	144	14400	19.63	250	430,2	15224,2	2,12
Residential	Row	1960	35	72	2520	31,05	1828	19.63	71	145	2075,05	0,82
Residential	Row	1957	34	100	3400		2087	19.63	216	180	2483	0,73
Residential	High rise	1974	1	9398	9398	63	8884	19.63	290	397	9634	1,02
Residential	Single	1958	1	425	425			19.63	92	34,5	810,5	1,91

APPENDIX 4: UrBricks

This information was given by New Horizon, through email, on the 5th of February 2020, about the company 'Steenfabriek Douveren', that produces the bricks called 'Urbricks'. These bricks are done by combining crushed brick and glass, decreasing the energy use due to the material properties of glass, resulting in a 20% reduction in price and a 44% reduction in emissions.

URBAN MINING COLLECTIVE

Urbicks

DOUVEREN
SUSTAINABILITY YOU CAN BUILD ON

Productomschrijving waalformaat

Steenfabriek Douveren produceert de innovatieve Urbricks. Met deze steen zorgt Douveren voor serieuze CO2-besparing en roept het verspilling een halt toe. Urbricks zijn kwalitatief hoogstaande, betaalbare bakstenen, met een goed verhaal.

Deze circulaire klus klaart Douveren in een voormalige steenfabriek in Zuid-Limburg. Deze reeds lang bestaande steenfabriek – inmiddels voorzien van de nieuwste technologie – maakt een herstart om Nederland te voorzien van 100% circulaire gevelstenen.

Klinkt goed, zo'n 100% circulaire baksteen. Maar waar wordt die steen precies van gemaakt en hoe zit het met de kosten? De grondstoffen voor de Urbricks komen voor een deel uit de sloop van oude gebouwen. Door het gebruik van deze grondstoffen te combineren met een eerlijke prijs, ontstaat er een goede balans voor natuur en economie. Voor hetzelfde geld koop je een beter product. Duurzaam hoeft tenslotte niet duurder te zijn.

Productspecificaties

Het assortiment waarmee we als eerste op de markt komen bestaat uit gevelstenen in Waalformaat. We brengen dit formaat in de kleuren rood, geel en antraciet. Vanzelfsprekend wordt dit assortiment verder ontwikkeld in de komende jaren. We zijn in staat om, voor grotere hoeveelheden, op afwijkende formaten en kleuren te produceren.

	Urbrick	Primair alternatief	Verschil	Reductie
Totaal schaduwkosten	€ 2,31	€ 2,88	€ 0,57	20%
CO2 schaduwkosten	€ 1,44	€ 2,54	€ 1,11	44%
CO2 in kg eq.	28,7	50,85	22,15	44%

"Data betreft LCA data op basis van de gehele levenscyclusfase van het product (winning t/m afvalverwerking, A1-D) volgens bepalingsmethode 3.0. LCA Urbrick ongereviewd én nog niet volledig afgerond, wachten is tot steenfabriek op volle last draait, zodat brandstofemissies goed in kaart kunnen worden gebracht.
Betreft conceptberekening, gegevens kunnen dus nog wijzigen".

1 kg CO2-eq bedraagt € 0,05 | Hoeveelheden zijn per m2 metselbaksteen.

Figure 1. The product information of Urbrick.

Steenfabriek Douveren B.V. Wolfsweg 75 6471 CP Eygelshoven Tel: +31 (0)45 206 9960 info@douveren.com www.douveren.com **2019** CE-Nr: 0957-CPD-0623	
NBN EN 771-1 Categorie , metselbaksteen Type: Strengpers geperforeerd Beschikbaar in: WF (±217 x 104 x 51 mm), DF (±215 x 103 x 65 mm), ±288 x 90 x 48 mm	
Beoogde toepassing Buitentoepassing decoratief	
Afmetingen en maattoleranties: • **Tolerantiecategorie** • **Maatspreidingscategorie**	*Klasse T 2* *Klasse R 1*
Verschijningsvorm:	Gestructureerde geperforeerde strengperssteen
Gemiddelde genormaliseerde druksterkte:	8 N/mm²
Vormstabiliteit:	*NPD*
Porositeit:	≤ 8%

Hechtsterkte:	*0.15 N/mm² voor metselwerk en 0.30 N/mm² voor lijmwerk*
Gehalte oplosbare zouten:	*S 0*
Brandgedrag:	*Euroklasse A1*
Initiële wateropname:	IW 2
Bruto volumieke massa:	*1.540 kg/m³ D1*
Lambda waarde	*NPD*
Netto volumieke massa:	*1.590 kg/m³ D1*
Vorst/dooi bestandheid:	F2
Gevaarlijke stoffen:	NPD

Figure 2. Material properties of the 'Urbrick'.