



**THE CONSTRUCTION
SECTOR IN BRUSSELS**

**FINDINGS AND
PERSPECTIVES:
TOWARDS
A CIRCULAR
ECONOMY**



This brochure is published by Brussels Environment's Energy, Air, Climate and Sustainable Buildings Division, as part of the Regional Programme for a Circular Economy (Programme Régional en Économie Circulaire, or PREC).

It was produced in collaboration with the Confédération Construction Bruxelles-Capitale, CDR Construction, and the Centre Scientifique et Technique de la Construction.

It received support from a network of experts including several key players in the Brussels construction sector.

The content is based on work carried out as part of the Regional Programme for a Circular Economy and, more specifically, two initiatives piloted by Brussels Environment, namely, the Université Libre de Bruxelles (ULB) was commissioned to complete a study on the circular economy in the construction sector (measure CD01) and PWC was commissioned to complete a data collection initiative on the construction sector in Brussels (measure CD02).

FOREWORD

Do you work in the construction sector in Brussels?

If you are a contractor, architect, property developer, design office manager, materials manufacturer, public building owner, etc. - then this publication concerns you!

Over the last 40 years, the consumption of raw materials in Brussels has soared: an increase of 160% for electricity, 400% for natural gas, and 15% for drinking water. This has occurred even though the population has only increased by 1%.

Initial observations are as follows : Brussels produces only 3% of the energy and potable water it requires. Moreover, it does not have local extraction and recycling activities. The city therefore depends on external sources for the supply of raw materials and manufactured products, and for dealing with its construction waste.

Can this dependency be reduced by a combination of more restrained consumption patterns and the improved circulation of internal material flows? This would assist with major environmental, economic and employment impacts.

It was in this context that the Brussels-Capital Region decided to launch the Regional Programme for a Circular Economy (PREC 2016-2020) in order to make the Brussels economy more circular. The Regional Programme has three main objectives:

1. to transform environmental objectives into economic opportunities;
2. to anchor the Brussels economy in order to produce locally where possible, to reduce the transportation of goods, to improve land use, and create added value for local residents;
3. to assist with job creation.

In this plan, which contains 111 measures, construction is one of the four priority sectors.

Holding a significant place in the Brussels economy, the construction sector consists of a variety of occupations and businesses, greatly varying in size and objectives.

The “Urban Metabolism of the Brussels-Capital Region” study, conducted in 2014, describes the construction sector as one which:

- consumes resources: 20% of incoming material flows;
- produces a large quantity of waste: over 30% of the region's non-household waste; and;
- accounts for the largest holdings of material stock: around 84% of the total mass in the region.

¹ The measures included as part of the programme target construction companies by supporting their transition towards a circular economy. The Regional Programme is also concerned with preparing the workforce by putting in place targeted actions for Brussels job seekers and students enrolled in training for the construction industry.

The construction sector and the entire building stock are an essential driving force for transitioning to a circular economy and creating local jobs.

The circular economy. Does this mean something to you?

This publication presents the concept. It has been applied to the construction sector with highly promising results. However, it has not yet gone far enough.

What does transitioning towards a circular economy mean? Why is it necessary? What can you do to apply it to your business in the Brussels-Capital Region?

It is hoped that this publication will answer your questions. It is divided into **two complementary sections**.

The first section presents the findings.

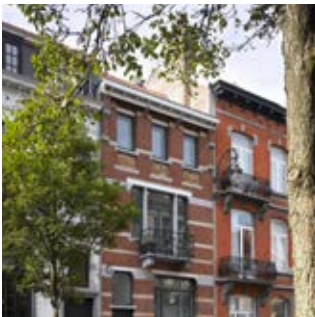
It presents a monitoring dashboard of the construction sector as designed by Brussels Environment. The selection of indicators provides a portrait of the sector: actual figures from the field and a snapshot of what is happening on the ground. It can be used to assess implemented and future actions required for a transition towards a circular economy and sustainable construction practices. In other words, it provides an inventory that will inform decision-making and monitor the evolution of the construction sector in the Brussels-Capital Region.

The second section focuses on a vision and objectives.

It sheds light on the current socio-economic context in the construction sector, and the vision for 2050 jointly envisaged by public and private stakeholders active in the sector.

Each section is structured around four thematic areas: **Buildings - Resources - Businesses - Jobs & Training**.

This publication is not intended to be a technical document. You will discover how things can and should develop over the coming 30 years.





2017 MONITORING DAHSBOARD THE BRUSSELS CONSTRUCTION SECTOR





As part of the Regional Programme for a Circular Economy, a vast amount of data has been collected from parties active in the region's construction sector. **What is the aim? Getting an initial picture of the reality on the ground will make it possible to monitor developments over the coming years and to analyse the effects of actions taken to transition the sector towards a circular economy.**

Data was provided by numerous operators, including Actiris, Brussels Environment, CDR-Construction, the Centre Scientifique et Technique de la Construction, the Confédération de la Construction section Bruxelles-Capitale, Constructiv, IBSA, VDAB, Bruxelles Formation, EFP, Cefora, Volta, and many more...

This data collection initiative goes hand-in-hand with an awareness-raising initiative within the construction sector, and the introduction of practices aimed at transitioning to a circular economy. In this respect, the study carried out by Dr Aristide Athanassiadis from the BATir department at the Université Libre de Bruxelles (ULB) explores the current socio-economic context of the construction sector, and outlines the development objectives for 2050.

The following pages give an overview of the construction sector based on available figures for 2015 and 2016. In other words, it can be seen as a tool for monitoring trends, which will enable the sector to identify priority levers for transitioning to a circular economy.

This first section is structured in the same way as the second to facilitate navigation between the two complementary sources of information. First, it examines the existing building stock, resources, and businesses in the sector, and then jobs and training. The detailed monitoring dashboard containing all the data and sources can be downloaded from: <http://www.circulareconomy.brussels/>.

The data presented come from various sources: some published periodically while others are ad hoc. This clarification is necessary to understand the scope and limitations of this information. At this stage, there is no systematic data-collection procedure. 2015 is the benchmark year used in the presented figures in most cases. However, certain ad hoc data sources may be older.

The construction sector currently has little information on practices that have been implemented to encourage the transition towards a circular economy. However, this does not prevent the monitoring dashboard from giving an initial overview of the construction sector as it exists in the Regional Programme.

² "Circular economy in the construction sector in Brussels: state of play, challenges and future model" - 2017

THEME

1

BUILDINGS

Old, poor energy performance, could be better used

A stock dominated by terrace houses

Age of the buildings, new constructions and renovated housing

Building performance

THEME

2

RESOURCES

A consuming sector, and building stock to be used

Material flows to be controlled

Stock to extract from

Consumption to be reduced

THEME

3

BUSINESSES

Potential for new developments to assist circularity

Nature of businesses

Investment and new developments

Towards sustainable development

THEME

4

JOBS AND TRAINING

Jobs created by the changing nature of occupations

What type of people work in this sector?

Shortage of labour, loyalty and staff turnover

Labour market

Training and education



THEME

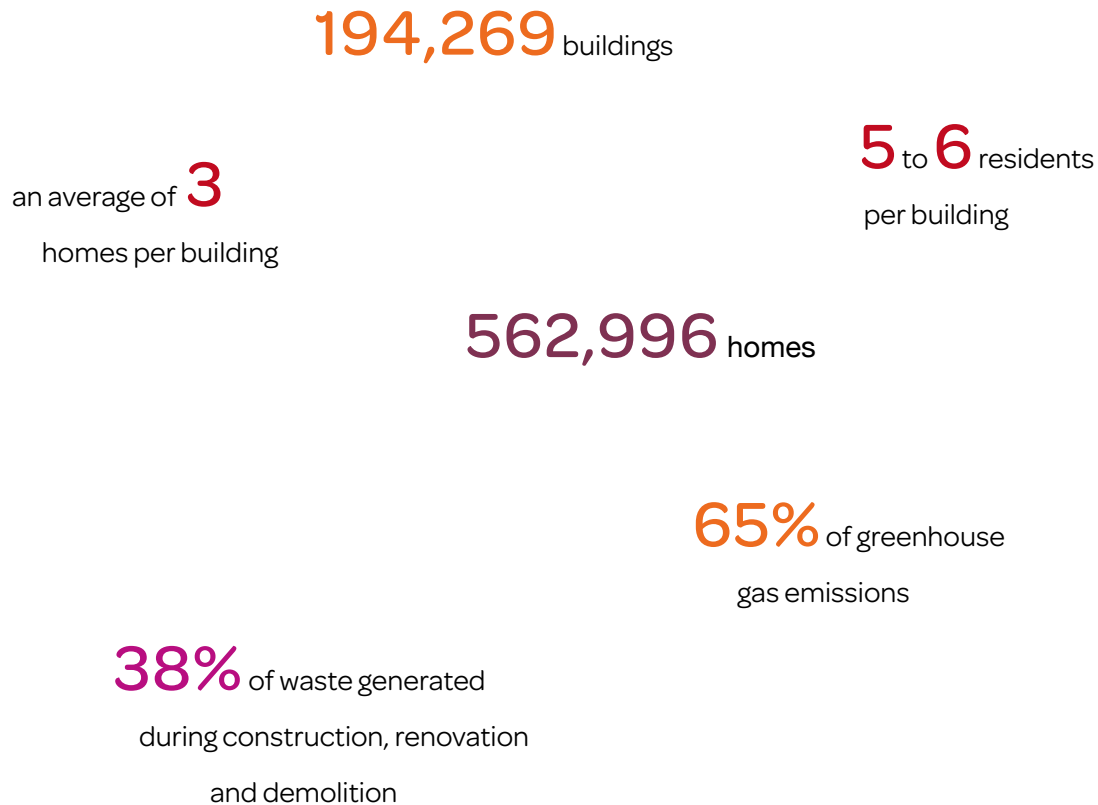
1

BUILDINGS

Old, poor energy performance, could be better used

The lack of greenfield sites explains why so few new construction projects take place in Brussels; most projects involve demolition & reconstruction or renovation.

The building stock in Brussels can be summed up as:



TODAY

The Brussels-Capital Region presents a number of features that distinguish it from the Flemish and Walloon Regions.

Its land area is very small (161 km²) and it is densely populated (7,210 persons per km² in 2014).

The demographic changes expected by 2030 combine a population increase of 100,000, an ageing population, and an increase in single-occupancy households. This situation produces an increased need for homes, connected with the development of new structures. Consequently, there is dual necessity for the existing building stock to both accommodate a greater population density and to be more adaptable.

A significant amount of office space is vacant: in 2013, 8% of offices were unoccupied, amounting to over 1,000,000 m². This unoccupied space could accommodate 10,000 homes of 100 m². This provides a practical illustration of the need to manage the building stock in a global manner, thus meeting a number of needs resulting from changing requirements.

Very dense building stock

The lack of available sites forces project managers to resort to demolition & reconstruction or renovation. The challenge - now and in the future - is to avoid demolition where possible, and promote the re-use of building materials and components.

Another characteristic of Brussels is that the building stock is older than in the other two regions: 70% of the buildings were constructed before 1945 and only 6% after 1981. This explains the predominant practice of renovating and maintaining the building stock over time. This has resulted in a large diversity of materials making it difficult to promote a single approach for their re-use or recycling.

The high density of buildings will oblige future site managers to favour prefabrication solutions. In other words, there will be less waste, and reduced logistical requirements.

Stock of materials to be managed

The stock of available resources requires efficient flow management but knowing - in real time - where available materials and components are located is a big challenge. There will also be a need to facilitate and standardise the collection and processing of this information.



In the study entitled "Circular Economy in the Construction Sector in Brussels", the three most common types of construction in Brussels were chosen to categorise the information on available and reusable material flows: office building, apartment buildings and Brussels-style houses.

More residential buildings and more renovations

The stock of Brussels buildings mainly comprises residential buildings (162,242 compared to 32,027 non-residential).

As explained above, renovation is favoured, rather than new buildings. There is nevertheless a difficulty in precisely quantifying the required renovations as only the largest projects, i.e. those requiring planning permission, are recorded. Data about minor renovations (i.e. those not requiring planning permission) are not recorded.

A snapshot of Brussels' buildings in figures

	BRUSSELS-CAPITAL REGION	FLEMISH REGION	WALLOON REGION
Population	1,175,173	6,444,127	3,589,744
Land area	161.4 km ²	13,522.2 km ²	16,844.3 km ²
Population density	7,281 persons/km ²	476.6 persons/km ²	213.1 persons/km ²
Number of built-on plots	560,082	3,686,597	1,922,198
Number of non-built-on plots	17,287	2,082,479	2,227,431
Number of buildings	194,269	2,637,506	1,641,150
Number of homes	562,996	3,093,807	1,662,102
Number of buildings built after 1981	12,008	779,418	320,695

Source: Statbel - 2015 figures

In the Brussels-Capital Region, we find all of the problems typical of a large, old and densely populated city:

There is little space available for new construction, and a **TENDENCY** to renovate rather than build.



Existing buildings show poor performance levels, so there is a **NEED** to renovate to improve the buildings' performance.



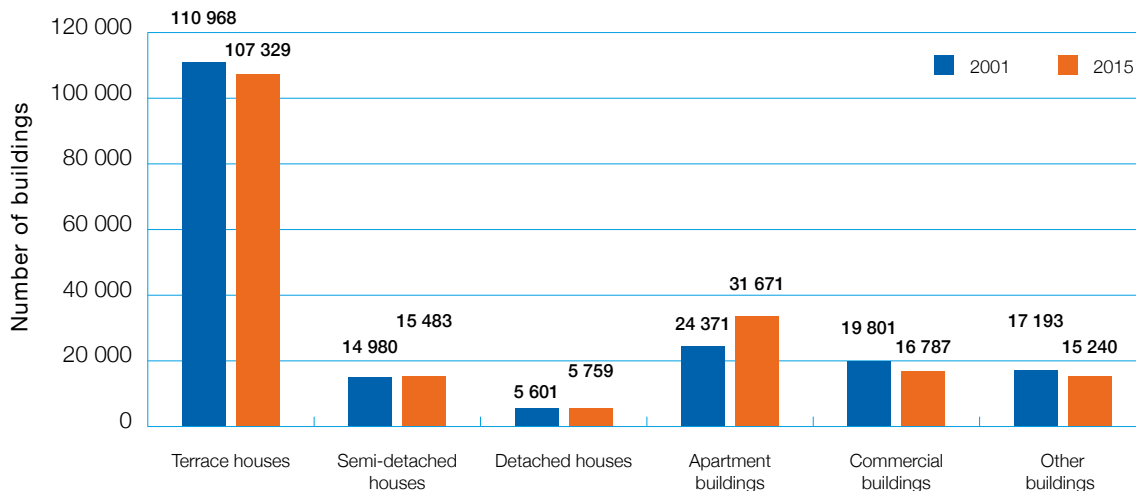
Renovation projects to come, provide an **OPPORTUNITY** to convert old buildings into urban banks of construction materials.



There is a **NEED** to maximise building occupancy, providing an **OPPORTUNITY** to initiate circular building management practices.

A market dominated by terrace housing

Changes in the number of buildings, by type (2001 compared to 2015)



Source: Statbel

- Between 2001 and 2015, the breakdown between terrace, semi-detached and detached houses, apartment buildings, commercial buildings and other buildings remained much the same.
- During this period, **an increase in apartment buildings (accounting for over 50% of homes) was observed**, at the expense of terrace houses. The latter remained in the majority, still accounting for 55% of buildings in 2015.
- Moreover, houses (of the various types) cover a larger land area, accounting for almost 20% of the area of plots in the Brussels-Capital Region, while apartment buildings cover only 12% of the land.

To be noted

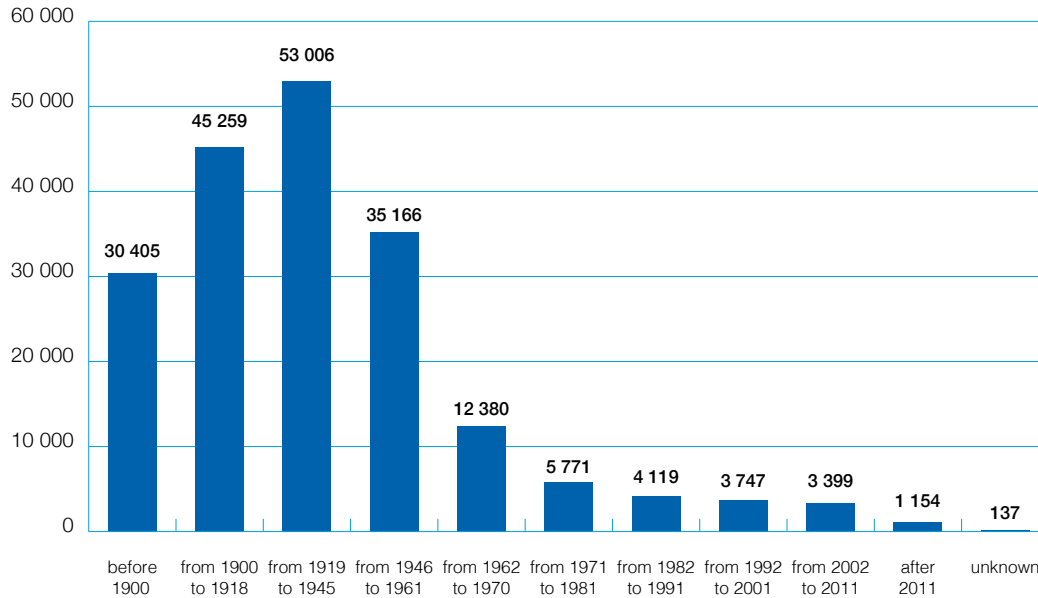
In 2015, there were:

- 33,671 apartment buildings comprising 304,520 homes, i.e. nine homes per building on average;
- 107,329 terrace houses comprising 190,560 homes, i.e. two homes per building on average.

The housing stock thus comprises mainly terrace houses although 54% of homes, i.e. 304,520 out of a total of 562,996 are located in apartment buildings.

Age of the buildings, new constructions and renovated housing

Number of buildings, by construction period

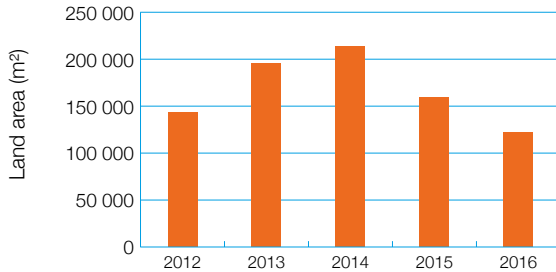


Source: SPF Economie - Statistics Belgium & SPF Finances - AG Documentation patrimoniale, figures on 1 January 2017

- The buildings in the Brussels-Capital region are typically **old**, to a greater extent than in the country's other two regions. Only 34% of the buildings were built after the Second World War.
- This explains the constant need for maintenance of the building stock. This has also resulted in a wide diversity of **materials**. Successive repairs and renovations carried out at different times on the buildings have led to the coexistence of materials which are difficult to separate from one another and thus difficult to re-use. This complicated situation makes it difficult to make good re-use or recycling of the materials.

New construction

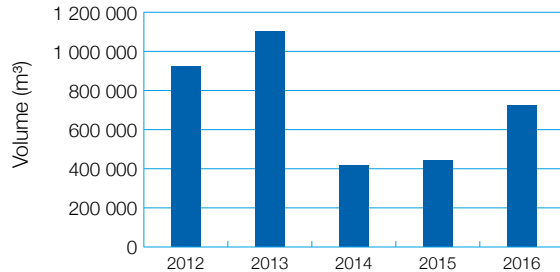
New residential buildings, by land area per year based on the number of building permits granted



Sources: Statbel

- Based on the number of building permits granted, there was a significant reduction in the land area of new **residential** buildings between 2014 (213,833 m²) and 2016 (122,118 m²). The last figure puts the 2016 figure below that for 2012 (142,916 m²).

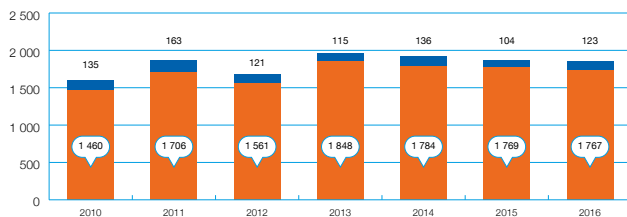
New volumes of non-residential buildings per year based on building permits granted



- However, for **non-residential** construction, and following a marked decrease in volume between 2013 and 2014, there was an increase between 2014 and 2016, rising from barely 400,000 m³ in 2014 to over 700,000 m³ in 2016.

Renovated housing

Number of building permits granted for renovation projects



- Between 2000 and 2016, the number of **residential** building permits increased from 1,031 to 1,709 but permits for **non-residential** buildings decreased from 189 to 119.

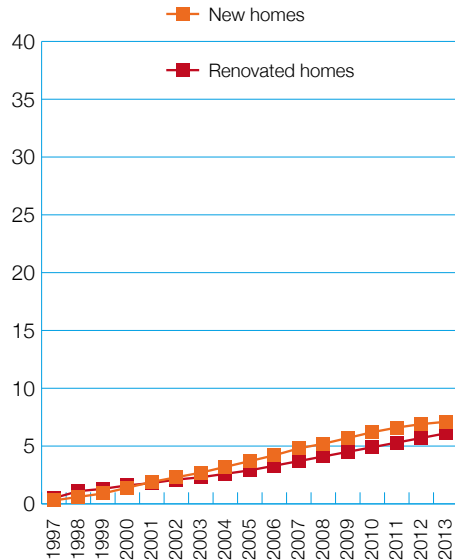
■ Residential
■ Non-residential

Source: Statbel

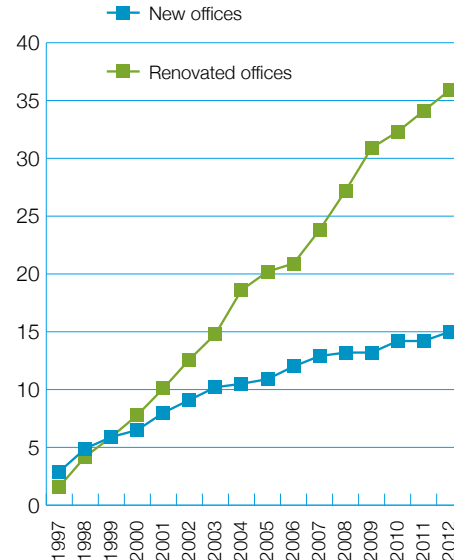
To be noted

The construction and renovation figures are based on permits granted but it is important to bear in mind that not all granted permits result in the completion of the work. Moreover, the figures given for renovations do not take into account renovation projects carried out without planning permission. The absence of this important data prevents us from having a complete overview of the situation.

Proportions of new and renovated homes in the Brussels building stock



Proportions of new and renovated offices in the Brussels building stock



Source: Cross-referenced data on homes & offices, and building permits - IBSA data processed by Brussels Environment

Since the benchmark year of 1997, new and renovated homes and offices have progressed differently.

- These graphs show the numbers of new and renovated homes and offices as compared to the numbers of existing homes and offices in Brussels;
- They are cumulative figures showing the proportionate increases in the stock over a 15-year period;
- The increases in the numbers of new or renovated homes remain relatively low compared to those for offices, and especially when compared to renovated offices.

It is paradoxical that a population that is booming produces little change in the housing market, and at the same time there is an upward trend for offices, even though there are already many unoccupied offices.

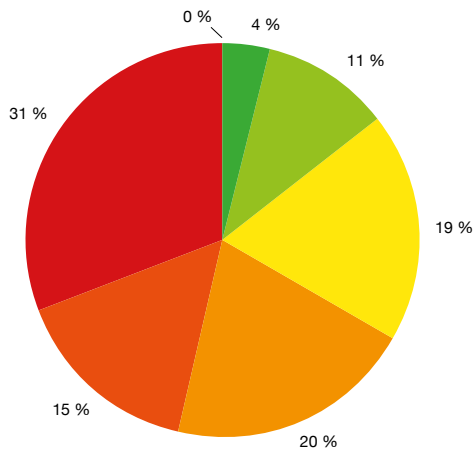
To be noted

Figures for renovated homes (red lines) must be taken with a pinch of salt as many of the renovations are carried out without planning permission. This nuance may correct the impression given by these graphs, according to which there are more new homes (orange lines) than renovated ones.

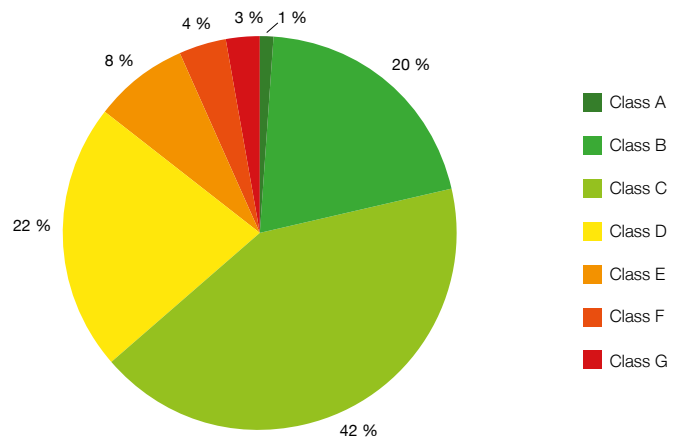
Building performance

The EPB certificate is intended for information purposes only. It has been available since 2011 and shows potential buyers or tenants information about the building's energy performance using a scale from 'A' for very good energy efficiency to 'G' for energy-hungry. This energy performance scale is based on a range of factors: energy-loss surface area, insulation, type of heating, ventilation or air-conditioning system, etc.

Breakdown of EPB certificates (2011-17 total) for homes in Brussels



Breakdown of EPB certificates (2011-17 total) for offices in Brussels



Source: Brussels Environment

Due to the age of the buildings, the Brussels building stock is also characterised by its poor energy performance.

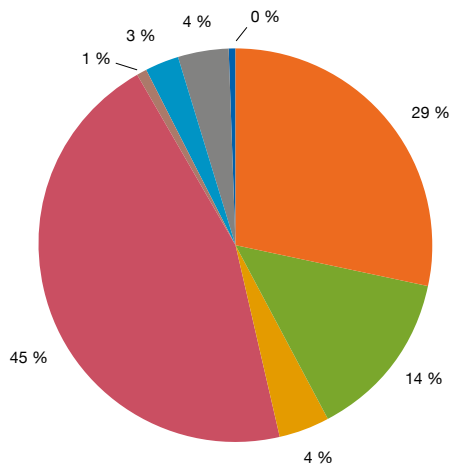
For the 2011-2017 period:

- Almost **70%** of the **homes** with a EPB certificate show a **ranking of E, F or G** - meaning poor energy performance.
- **43.8%** of **office buildings** with a EPB certificate show the building rated as **Class C**.

This confirms that there is still a considerable amount of renovation work to do in terms of the Brussels building stock.

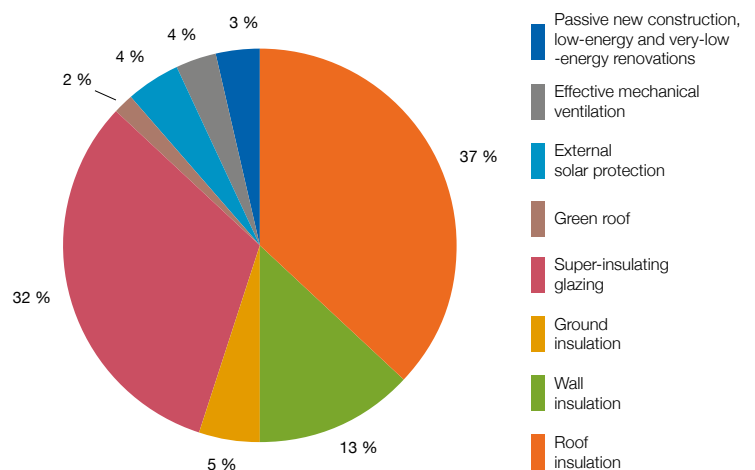
Energy premiums encourage better energy performance for all buildings in Brussels. They provide financial support to carry out work to improve the energy performance of buildings.

Breakdown of the various types of work for energy premiums granted for residential property (2015)



Source: Brussels Environment

Breakdown of the various types of work for energy premiums granted for offices (2015)



In 2015, 17,344 premiums were awarded, amounting to a total of €20,021,503, mainly for the following: **super-insulating glazing, and insulation for roofs and walls.**

- These three types of premiums account for **88% of all premiums awarded to homes and 82% to offices, which highlights the emphasis on insulation work with this incentive.**
- The use of **natural materials** is an option still underused by parties active in the sector: since 2012, only 8% (on average) of energy-premium requests relate to such materials.
- These energy premiums made it possible to insulate 11,166 buildings in 2015. The insulation of buildings presents **a real economic opportunity**, and individuals are already aware of it.



THEME
2

RESOURCES

A consuming sector, with building stock available to be used

The construction sector produces 628,000 tonnes of waste a year. Some 91% of this waste is recycled after being sorted on site or in a sorting centre. It mainly consists of inert or recycled waste used in the foundations of roads or buildings (downcycling) but also metals and wood.

Implemented for more than 10 years, the region's policy for the sustainable management of the construction sector has had a positive impact, but the rational use of materials must improve further.

There is considerable potential for developing and improving the management of waste and its conversion into useful resources. It is now time to generalise these practices.

The construction sector
generates **628,000**
tonnes of waste

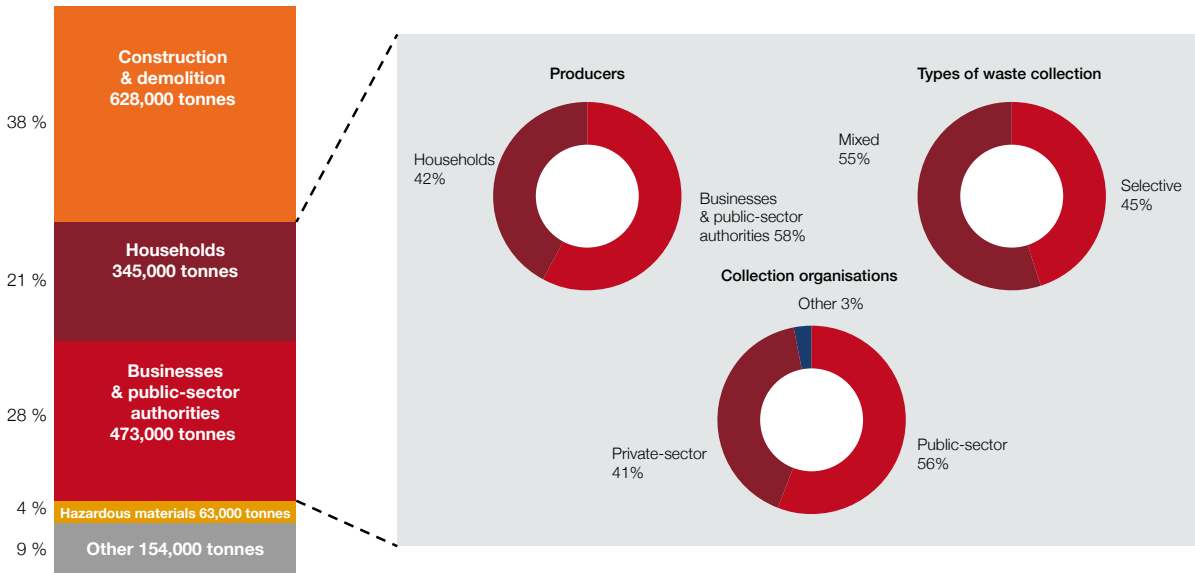
91% of the waste
is sent for recycling, mainly
downcycling

There are **150** million tonnes
of potential resources
in the Brussels Capital Region

Over **70%** of incoming and outgoing flows
in the region are inert materials

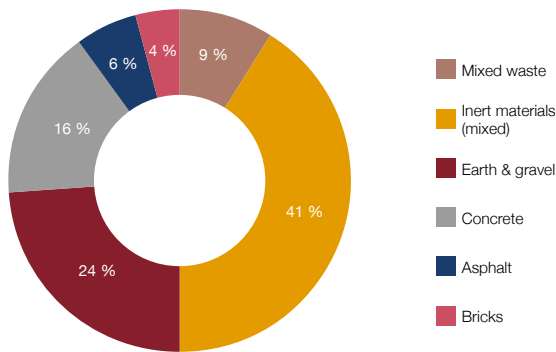
The construction sector: a significant producer of waste

Breakdown of waste production in the Brussels-Capital Region - 2014



Breakdown of waste production in the Brussels-Capital Region - 2014

Percentages, by weight



Waste produced by the construction sector amounts to 628,000 tonnes, out of a total of 1,325,000 tonnes of waste collected in the Brussels-Capital Region. The vast majority of this waste is downcycled. This means that it is recycled into materials of lower quality and functionality.

Source: Data aggregated by Brussels Environment from several regulatory sources and studies.

↑ UPCYCLING

This means recovering unwanted materials and products in order to convert them into materials or products of higher quality or value. An example is the Tomato Chilli project, which uses “waste” timber from shuttering or window frames recovered from Brussels’ building sites to build greenhouses.



↓ DOWNCYCLING

This means recovering unwanted materials and products in order to convert them into materials or products of lower quality or value. An example is inert waste used to fill the sub-base for road construction: these materials lose value during the conversion.



Flows to be controlled

Flows of materials from the construction/renovation sector in 2015 (tonnes)

	INCOMING		OUTGOING	
	(tonnes)	%	(tonnes)	%
INERT MATERIALS	652,459	74%	453,547	72%
METALS	86,313	10%	65,940	10%
WOOD	57,619	7%	45,636	7%
PLASTER	40,330	5%	31,917	5%
PLASTICS	19,296	2%	14,581	2%
INSULATING MATERIALS	27,365	3%	21,721	3%
OTHER	522		341	
TOTAL	883,904		633,683	

Source: BATir - ULB

The table above shows the breakdown of construction waste by category of material.

The flows of incoming and outgoing materials in the Brussels-Capital Region are currently high in the construction sector, which is considered a large consumer of resources. As the region cannot extract its own resources and must import what it needs, it **depends** on resources from outside.



Though based on hypotheses and theoretical extrapolations, these figures clearly show that inert materials constitute a large proportion of these flows. Out of a total of 883,904 tonnes coming in, 74% are inert, and out of a total of 633,683 tonnes going out, 72% are inert. This large amount of material is one of the greatest to be recycled by the sector but work remains to be done on the quality of recycling, as well as on other available materials.

Existing stock, to extract from

Just as with energy and water, the consumption of new material resources must be reduced.



According to the study entitled 'Urban Metabolism of the Brussels-Capital Region, conducted in 2015, buildings account for 84% of the material stock in the region. This material stock takes into account residential buildings, as well as offices and shops.

The weight of this stock in the region (only taking into account buildings) is estimated to be 155,192,545 tonnes!

It may be remembered that 194,269 buildings in the Brussels region could be converted into potential material resources!

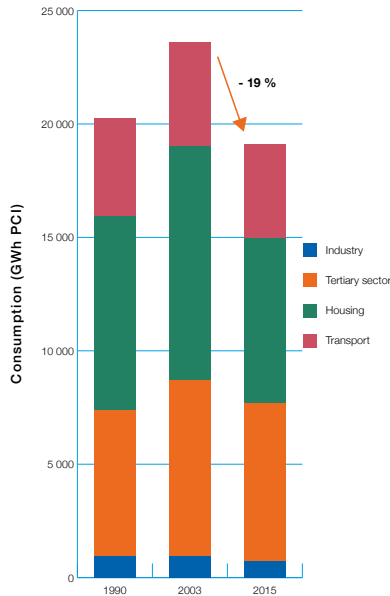
The Brussels building stock thus represents a major source of resources for the construction sector and must be considered as such in the future.



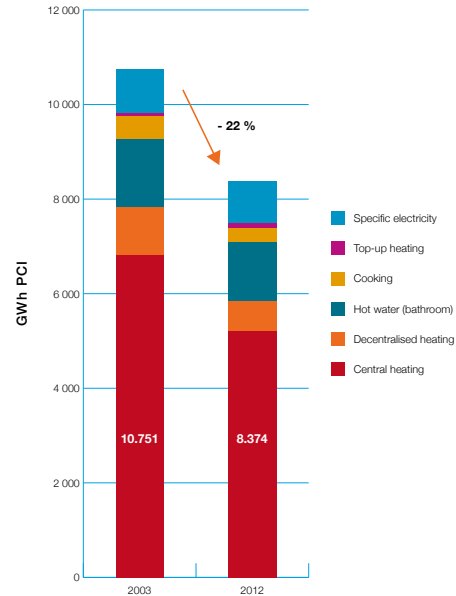
Consumption to be reduced

Energy

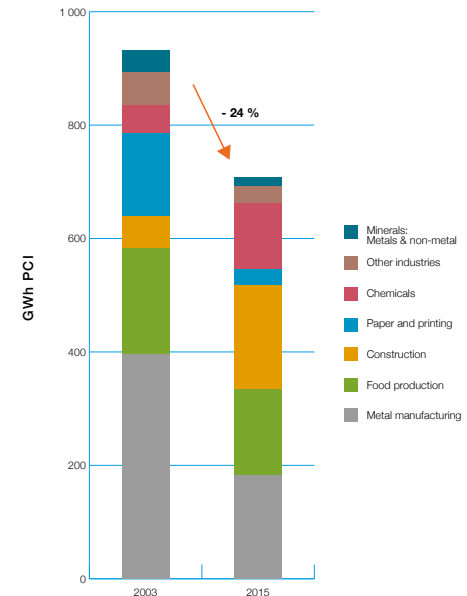
Breakdown of energy consumption by sector



Energy consumption in homes in the Brussels-Capital Region



Energy consumption in industry



Source: Energy balance of the Brussels-Capital Region - 2013 - 2015 - Brussels Environment

In the Brussels-Capital Region, **energy consumption is tending to fall: -19% between 2003 and 2015.**

In 2013, the housing sector accounted for 38% of the region's total energy consumption although the sector's consumption had decreased (-22%) over the previous decade.

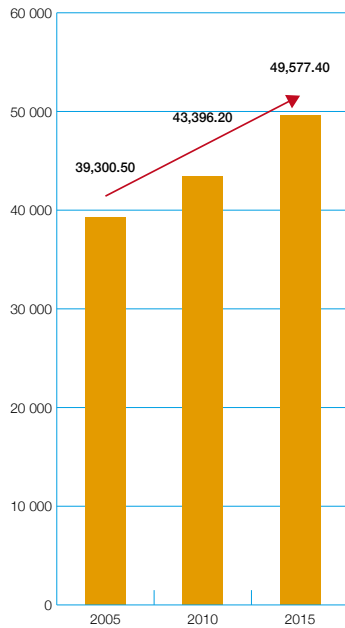
Energy consumption in the industrial sector has decreased by 31% in ten years.

To be noted

The methods used to produce energy statistics changed between 2013 and 2015 and this may have had an influence on the breakdown of data between the categories. However, the total figures are not affected.

Water

Water consumption in the construction sector NACE code 41-43



Source: Vivaqua, water consumption based on meter readings and broken down by NACE code (2003 classification): data provided to Brussels Environment

Water is not an inexhaustible resource, and it is becoming increasingly expensive. Although construction-sector businesses in the Brussels-Capital Region account for only 0.1% of the total water consumption, their consumption **increased by 26%** between 2005 and 2015.

The use of buildings is responsible for 98% of water flows in the region, so it is imperative to reduce consumption when constructing and using buildings.



THEME

3

BUSINESSES

Potential for new developments to assist circularity

Businesses that are still working according to a linear model. Attempts to adopt a new model that give good results. A need to network in order to share experiences. This is what characterises companies working in the sector today.

There are a range of promising actions within the Regional Programme:

- Support for activities that address the demand for sustainable construction & renovation;
- The accompanying of businesses in their quest to acquire better knowledge and master techniques;
- The provision of assistance to help them reposition themselves in the market;
- The stimulation of research and development to encourage innovation.

But we must go even further!

12,600 companies active
in the Brussels region

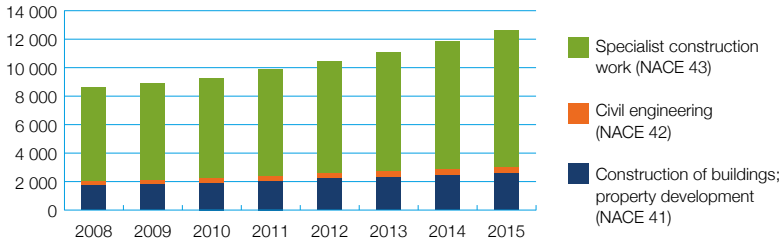
A turnover of over
8.6 billion Euros in 2016

A sector which contributes **1.84** billion Euros
of added value to the region

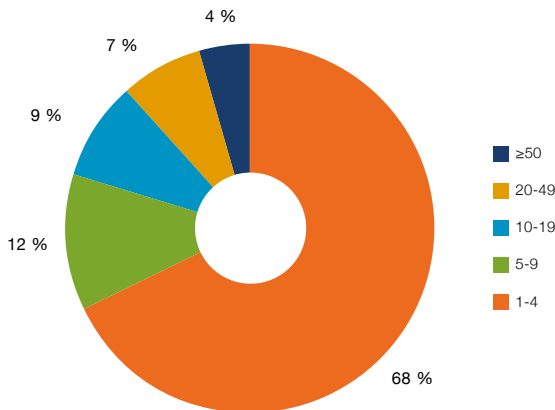
Over **90%** of the businesses are
VSEs, i.e. "Very Small Enterprises",
having 0 to **4** workers at most

Nature of businesses

Numbers of VAT-registered businesses



Breakdown of firms by size (number of workers in 2015)



Source: Statbel

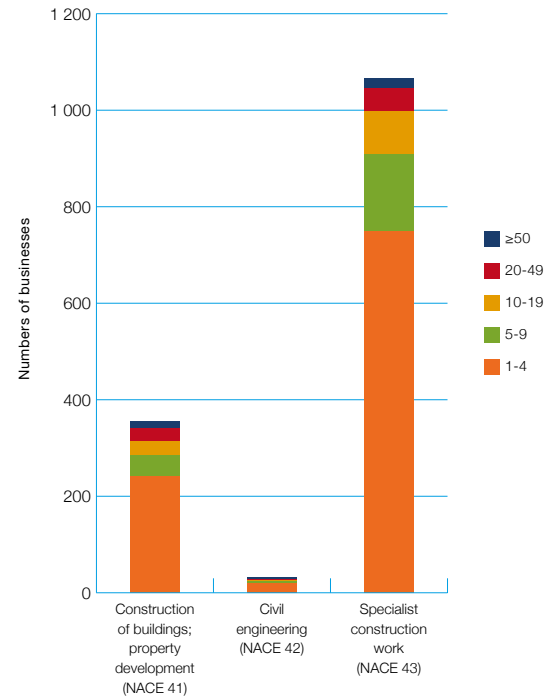
In 2015, companies active in the Brussels-Capital Region's construction sector numbered **12,600**, a 46% increase from the level in 2008.

They are mainly small enterprises:

- 68% with 1 to 4 persons;
- 12% with 5 to 9 persons;
- 9% with 10 to 19 persons;

- 7% with 20 to 49 persons;
- 4% with over 50 persons.

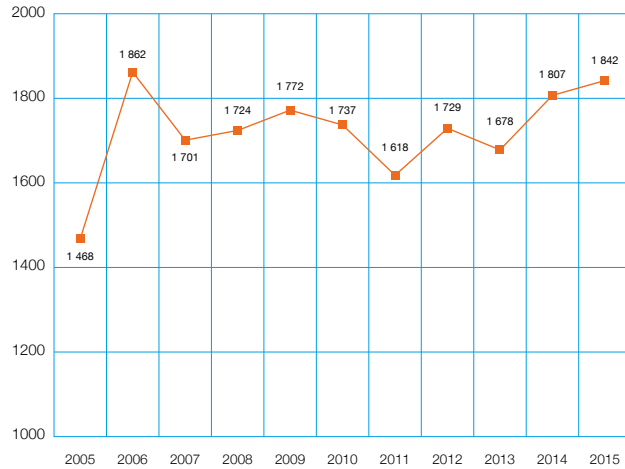
Breakdown of firms by size bracket (2015)



The breakdown within the sector has changed little, with the majority engaged in specialist construction work, followed by civil engineering, and then the construction of buildings and property development.

Investment and new developments

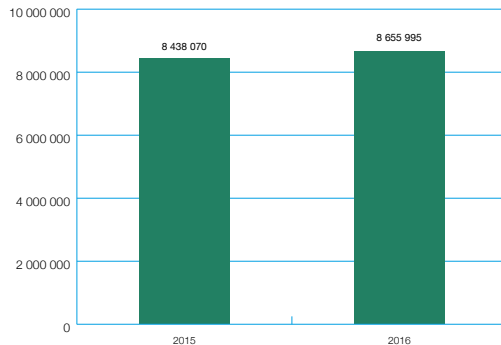
Changes in output (added value) of the Brussels-Capital Region's construction sector (million euros)



The construction sector's **output (added value)**, measured at current prices) **increased slightly** between 2005 and 2015, going from 1.47 to **1.84 billion euros**. The result was that the sector contributed **2.7%** of the region's total added value in 2015, compared to 2.4% in 2005.

Source: ICN

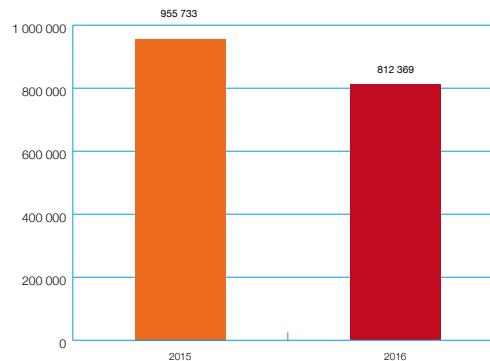
Turnover (sales values) of businesses in the Brussels-Capital Region's construction sector (thousand euros)



Source: SPF Economie

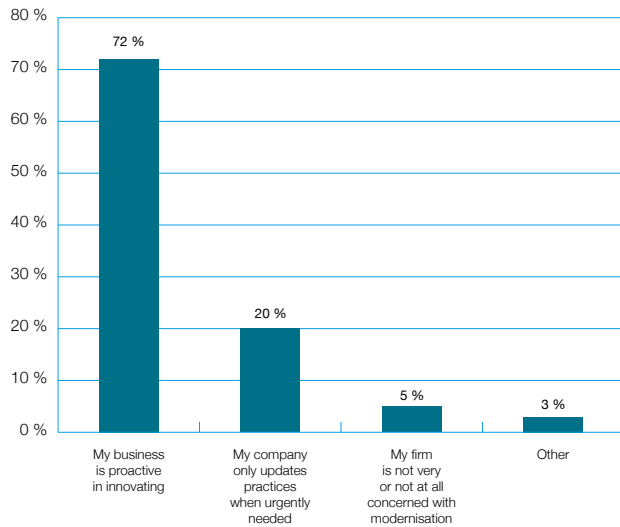
The **turnover** value is also increasing. At over 8.6 billion euros in 2016, it had risen 3% compared to 2015.

Investment in the Brussels-Capital Region's construction sector (thousand euros)

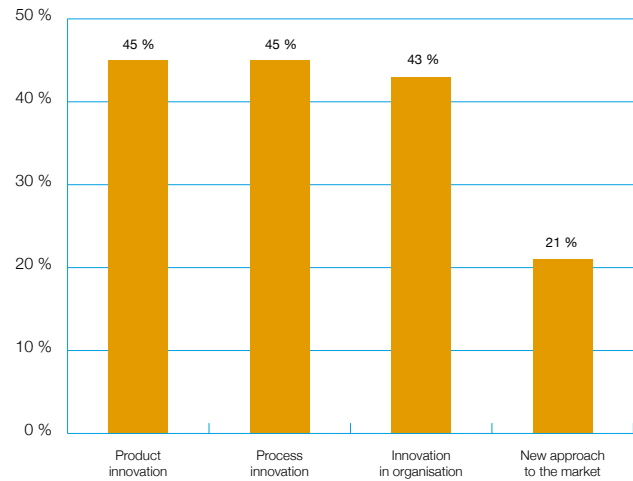


The **investment** value fell 15% between 2015 and 2016, going from 955 to 812 million euros in 2016. There were fewer purchases of machines and materials: perhaps this is due to an increase in the pooling of resources?

Current innovation practices



Types of innovation introduced over the last five years



Source: CSTC - "Enquête Innovation Construction Bruxelloise - 2014"

A growing number of companies are making **innovation** part of their business. A 2014 CSTC study shows:

- Over 70% of businesses in the sector say they are proactive when it comes to innovation;
- More than 50% of companies say they have introduced a process innovation once a year over the previous 5 years;
- Updated practices mainly involve **product** innovation, **process** innovation or an **updating of internal organisation**.

To be noted

These figures were derived from a survey carried out with a small sample of 92 people, from 87 companies.



Towards sustainable development

RENEWABLE
ENERGY SYSTEM:
20
BUSINESSES

PREMIUMS:
3,772
BUSINESSES

“BATEX”
(EXEMPLARY BUILDING):
244
BUSINESSES

AVERAGE AGE
OF BUSINESSES:
7.9
YEARS



How can businesses be involved in sustainable development?

- In 2016, the Brussels-Capital Region had 20 companies employing **people with a SER certification** (certification for renewable-energy-system installers). This was just 2% of the total number in Belgium (973);
- Between 2013 and 2015, **3,772 Brussels** firms working in the sector were involved in **building projects where there were energy premiums**. These firms represent 58% of all firms benefitting from the premiums;
- Between 2007 and 2013, 244 **Brussel-based** companies took part in **Exemplary Building projects**, which is one in four of the total 1,032 companies that participated;
- **The average age of businesses operating** in the Brussels-Capital Region's construction sector is 7.9 years.

An exemplary building is one which meets certain criteria related to energy, eco-construction, profitability, reproducibility, architectural quality and visibility. These exemplary-buildings projects result from calls organised by Brussels Environment until 2013.



THEME

4

JOBS & TRAINING

Jobs created by the changing nature of occupations

Due to the recurring qualitative and quantitative shortage of labour, social-dumping effects and high levels of staff turnover, the Brussels-Capital Region's construction sector has potential for development. The number of employees has decreased while the number of self-employed workers has increased. Additionally, the number of businesses working in specialist niches is increasing: plumbers, electricians, plasterers, painters, etc. This combination of factors is producing a fragmented and constantly changing sector, making it harder to share information and disseminate best practices.

The construction sector has:

20,300 workers, of whom

- **13,002** are employees
- **7,298** are self-employed workers

50% of employees
aged over 40

6,912 job seekers registered
in the construction sector

11% women

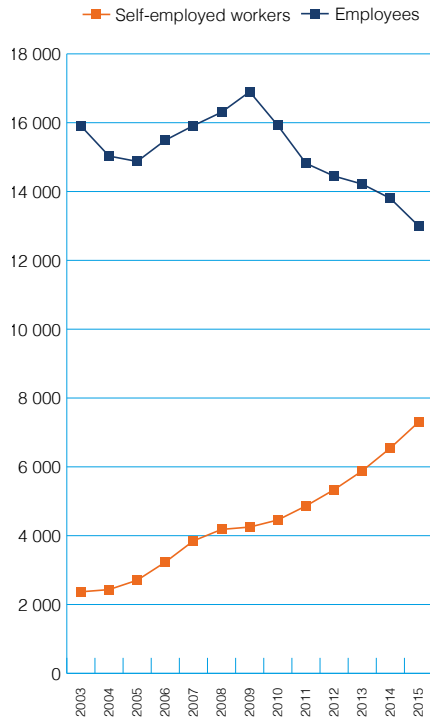
6,600 professional with certifications
relevant to EPB regulations

2,875 people enrolled
in French-language
Construction courses

An average of **1,000** people a year
attend Brussels Environment's
"sustainable buildings"
training courses and seminars

Who works in the sector?

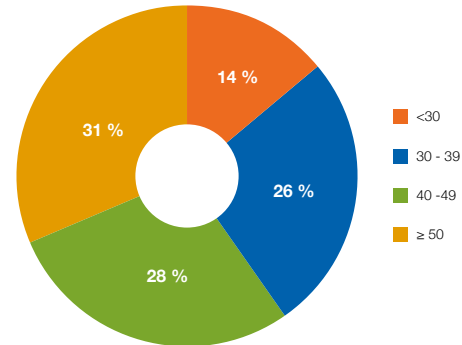
Changes in the numbers of workers in the sector



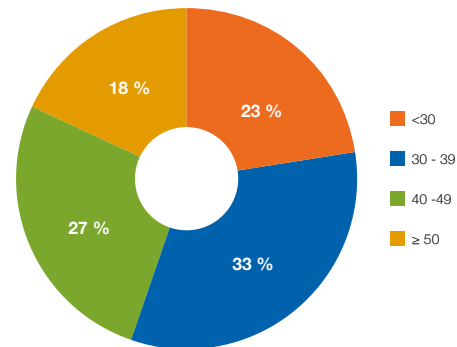
Source: ICN

Around **20,000 people** work² in the construction sector in the Brussels-Capital Region. Some **11%** of workers in the sector are **women**, and most (**13,000** of the 20,000) are **employees**. However, over the last 12 years, the trend has been reversed: the number of self-employed workers has more than doubled, and the number of employees has fallen by 18%.

Breakdown by age - Employees (2015)



Breakdown by age - Self-employed workers (2015)



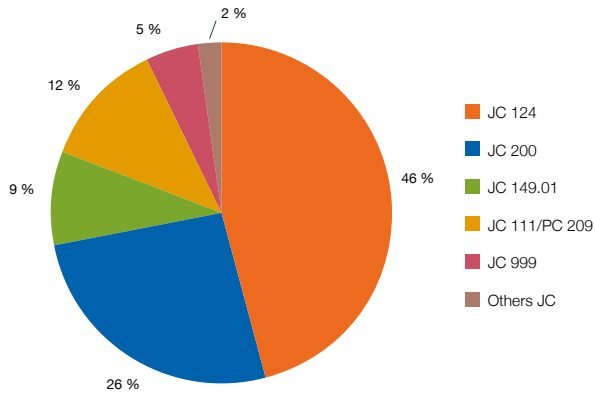
Source: ONSS, INASTI

We also looked at the age breakdown of workers in terms of their status (2015 figures):

- **Employees:** 31% of employees are aged over 50, 26% are between 30 and 39, and 14% are under 30
- **Self-employed workers:** 18% of self-employed workers are aged over 50, 33% are between 30 and 39 and, 23% are under 30

² The data quoted in this section relating to NACE codes 41-42-43 takes account of the location of each firm's establishment in order to determine the relevant region. It is not currently possible to isolate the information for construction sites located in the Brussels region.

Breakdown of workforce by Joint Commission



Source : ONSS - 2014 figures

In Brussels, some 46% of the jobs in the sector originate from JC 124, the Joint Commission for the manual workers of the construction sector!

Then come employees (26%) and finally the Joint Commissions that cover more specific trades such as metal, mechanical and electrical construction, and electricians, installation workers and distributors.

JOINT COMMISSIONS* (JCS):

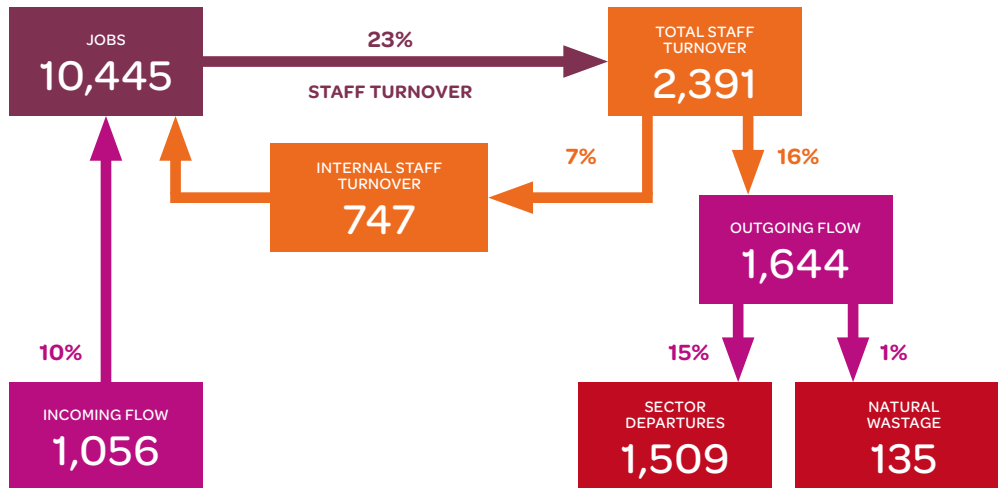
- a. **JC 124**: Joint Commission for the manual workers of the construction sector;
- b. **JC 200**: National Auxiliary Joint Commission for employees;
- c. **JC 149.01**: sub-Joint Commission for electricians (installations and distribution);
- d. **JC 111/PC 209**: Joint Commission for metal, mechanical and electrical construction, and metal manufacturing.

(*) Joint Commissions are bodies set up within the various branches of economic activity (merchant or not), regrouping businesses with similar activities. They form a place of social negotiations composed of an equal number of representatives of employers and representatives of trade union organizations. In January 2018, there were 100 Joint Commissions and 66 sub-Joint Commissions in Belgium.



Labour shortage and staff turnover

Staff turnover in the construction sector (2013/2014) - JC 124



Source: Constructiv

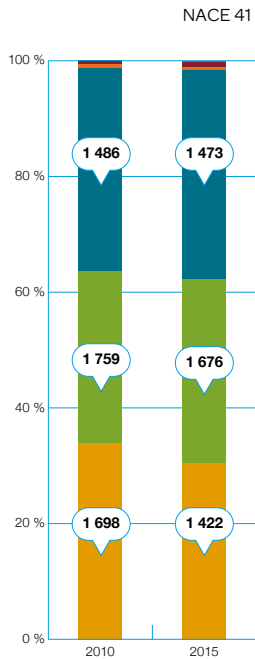
16% of workers leave the sector each year!

The construction sector suffers from a **lack of skilled labour**, as shown by the turnover of workers in the Brussels-Capital Region in 2013-2014. The **inflow** of 1,056 workers, i.e. **10%** of jobs in the construction sector, was insufficient to compensate for the **outflow** of 1,644 workers, which was equivalent to **16%** of jobs. Out of the 16% of departing workers, only 1% was accounted for by natural wastage, while 15% moved to another sector.

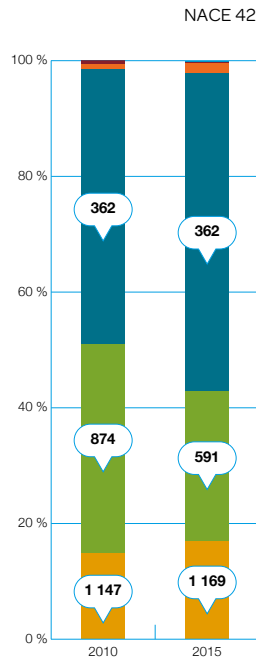
These findings show the extent to which training and awareness-raising in the sector play a key role in addressing the lack of skilled labour.

Breakdown of workers in the construction sector based on their place of residence

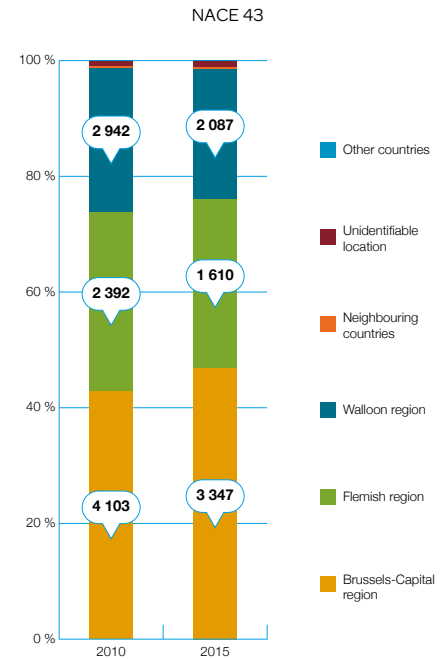
Construction of buildings & Property Development



Civil engineering



Specialist construction work



Source: ONSS

Where do the workers come from?

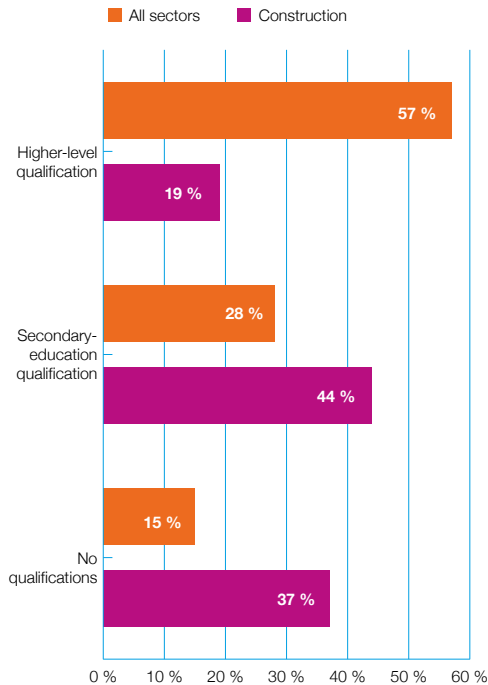
According to the information provided by the economic classification for the three codes corresponding to the construction sector:

- Workers from the **Construction of buildings & Property Development category (NACE 41)** come in equal numbers from the Brussels, Flemish and Walloon regions.
- Workers from the **Civil Engineering category (NACE 42)** mainly come from the Walloon region. Only 17% of workers in this category come from Brussels.
- More than 40% of workers in the **Specialist Construction Work category (NACE 43)** come from the Brussels region, and they are mainly involved in specialised construction trades e.g. electrical installation, plumbing and heating, and site preparation

These proportions did not change much between 2010 and 2015.

Labour market

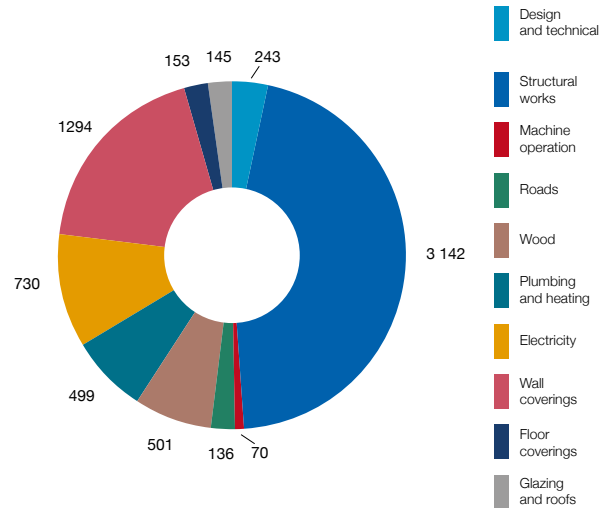
Breakdown of vacancies by level of qualification (2013-15 average)



Source: SPF Economie, Actiris

Some 81% of job vacancies are accessible with a secondary-education qualification or equivalent.

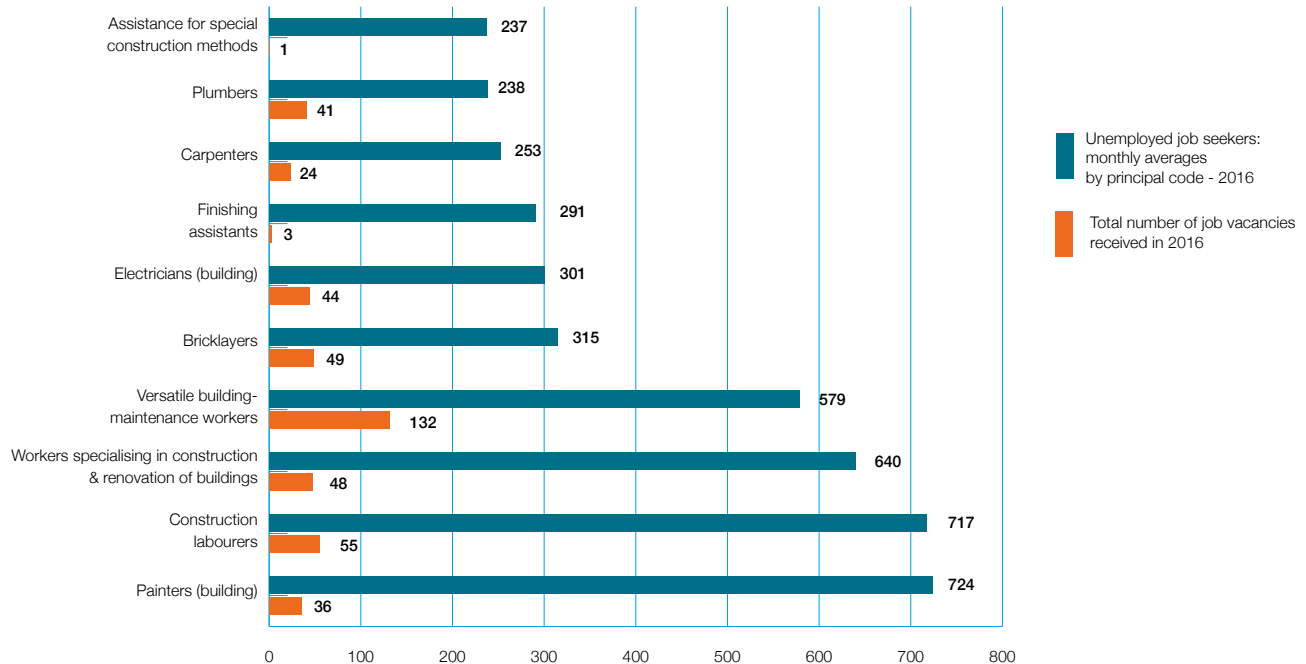
Unemployed job seekers in the construction sector (2016)



Some 7% of unemployed job seekers (6,912 people) in the Brussels-Capital Region come from the construction sector. **Almost half** of them specialise in **structural works**. The next most numerous category of job seekers are in the categories of wall coverings, electricity, wood, design and technical.

However, these figures should be taken with a pinch a salt as a large number of unemployed job seekers registered for a specific occupation do not have the necessary qualifications or training to perform the job.

Job vacancies compared to unemployed job seekers in 2016 for the ten occupations in the construction sector having the greatest labour reserves



Source: Actiris

There is a **disparity between the demand** for jobs within the sector, **and actual job vacancies** received and passed on by Actiris. In 2016, out of the ten occupations receiving the most job applications without identifying suitable job offers, four stood out in particular:

- versatile building-maintenance workers;
- workers specialising in construction & renovation of buildings;
- construction labourers;
- painters (building).

Note, however that responding to job vacancies is not the most common way of finding work in the sector. Rather than conventional channels (Actiris, temping agencies, etc.), word of mouth is a very common recruitment practice in the sector. This can help put into perspective the figures for job vacancies and demands.

Training and education

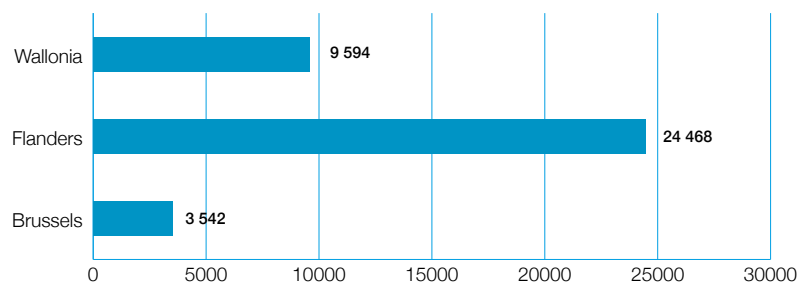


73,359 hours of training
undertaken in 2015

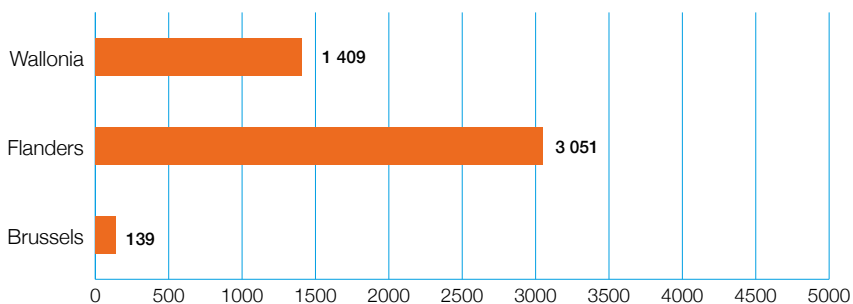


3,542 workers
trained in 2015

Number of workers trained in 2015 - JC 124



Number of businesses involved in the training in 2015 - JC 124



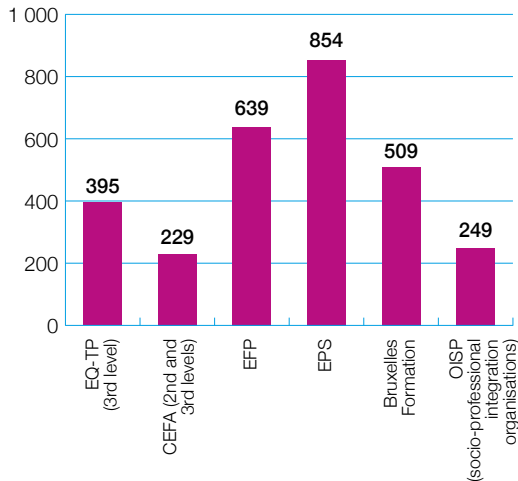
Source: Constructiv

The Brussels construction sector decided to focus on vocational training in 2015:

- **One worker in four in the sector** (3,542 workers out of 13,000) **received training**, totalling over 73,000 hours of training. The main training programmes were for: roofers, foremen/women, lorry drivers and security officers.
- **139 businesses**, out of 1,450 in the sector, have at least one worker who undertook these types of training programs.

Training for construction-related occupations

Number of persons enrolled in this type of course in the Brussels-Capital Region (2014)



Source: Constructiv, Actiris

In 2014, 2,875 people were enrolled in **French-language construction courses** in the Brussels-Capital Region. The year was marked by 854 people being enrolled in Brussels' **adult-education establishments**. A further 639 people were enrolled by **EFP** and 509 by Bruxelles Formation.

To be noted

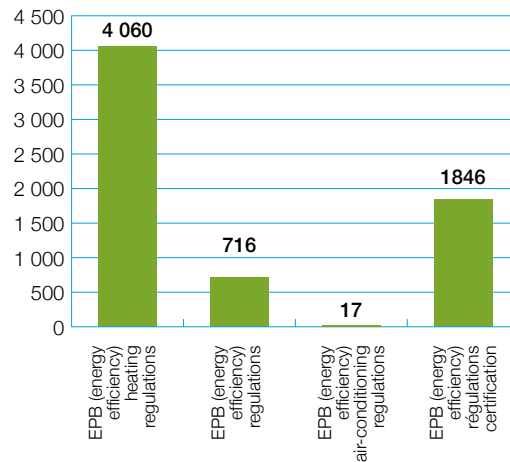
The low number of people enrolled in this speciality (for which qualified workers are in great demand) means recruitment opportunities should be plentiful.

EQ-TP: Enseignement qualifiant - technique & professionnel
CEFA: Centre d'éducation et de formation en alternance
EFP: Centre de formation des classes moyenne
EPS: Enseignement de Promotion Sociale
OISP: Organisme d'Insertion Socio-Professionnelle

These abbreviations have no equivalent in English.

Training related to energy performance and sustainable construction

EPB (energy efficiency) training (2016)



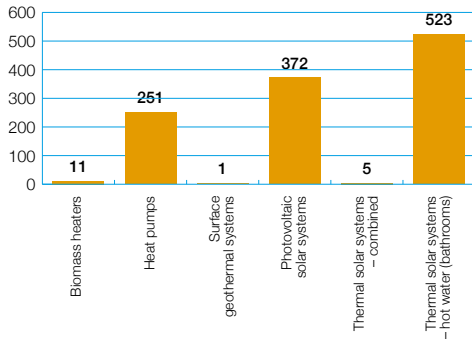
Source: Brussels Environment

In 2016, **6,639** workers obtained qualifications related to EPB (energy efficiency) regulations. Of these, 4,060 (61%) gained a qualification in EPB **heating** regulations and **1,846** people obtained an **EPB certification**. The numbers drop in other categories, as only 716 people received training in EPB works regulations and a mere 17 in EPB air-conditioning



Specialist training

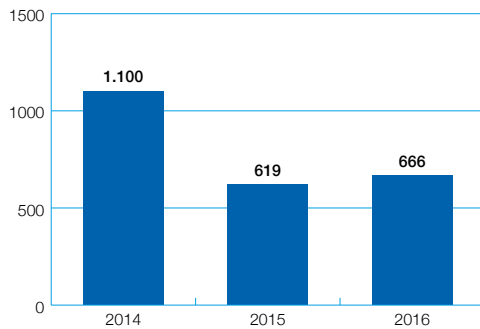
Training and exams for Renewable Energy Systems Installers (2016)



- In 2016, training programmes and exams for **installing renewable energy systems** resulted in the certification of **1,163** installers in Belgium, mainly for hot water - thermal solar systems (**523 workers**), photovoltaic solar systems (**372 workers**), and heat pumps (**251 workers**).

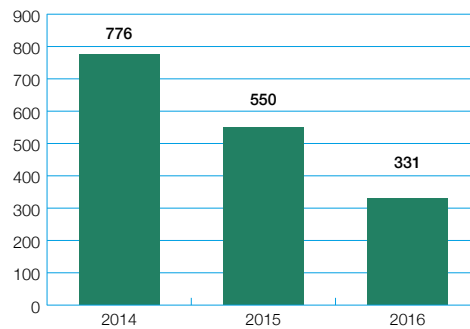
Source: Rescert

Number of people enrolled in sustainable-building seminars



Source: Brussels Environment

Number of people enrolled in sustainable-building training courses



- Between 2014 and 2016, **4,000** people took part in training courses and seminars on **sustainable buildings**: architects, design workers, contractors, etc. The fall in enrolments between 2014 and 2015 can be mainly explained by the decrease in budgets earmarked for this type of training and not a lack of interest from the sector. Contrary to the impression one might initially get, participation in the courses and seminars remained very high.












HORIZON 2050
THE CIRCULAR ECONOMY IN BRUSSELS,
AN OPPORTUNITY FOR
THE CONSTRUCTION SECTOR



Designing buildings with an eye to their future use, considering existing buildings as stocks of material resources, creating new local economic activities based on new business models... Taking into account the economic, environmental and social advantages, there are definitely opportunities for everyone. Positioning the Brussels-Capital Region as a pioneer in this field presents an exciting challenge for the sector.

In contrast with the current linear economic model, this section presents the circular economy concept as well as its application to the construction sector. A change of approach is seen as a necessity.

Applying it to the design of new construction or renovation projects, making better use of existing buildings, and creating local economic value must become the starting point for any new construction or renovation project. Re-using existing nearby materials, transforming them to extend their lifespan, and pooling resources are all practices that will help the construction sector achieve a circular economy.

Providing high quality jobs to trained workers so that they can respond to changing occupations, and thus creating local jobs, will allow the implementation of circular-economy principles in Brussels.

Focusing on four thematic areas · buildings, resources, businesses, jobs & training· i.e. the same ones as used in the first section (a monitoring dashboard for the construction sector), various pathways are addressed with the aim of placing the circular economy at the heart of all actions between now and 2050. The themes were identified following consultation with stakeholders from the Brussels construction sector and a study³ commissioned from the Université Libre de Bruxelles (ULB) on the circular economy in the construction sector.

Change is possible! This is demonstrated by examples of best practices and actions implemented by parties who are active in the sector.

³ Circular economy in the construction sector in Brussels: state of play, challenges and future model, ULB October 2017

CONTEXT

Construction, a sector with great circular potential

THE BRUSSELS CIRCULAR-ECONOMY MODEL

What vision for the future?

THEME

1

BUILDINGS

Adaptable, flexible and reversible design, using sustainable materials

THEME

2

RESOURCES

Viewing buildings as a new source of materials, from the managing of waste to the managing of resources

THEME

3

BUSINESSES

New business models and new ways of working together

THEME

4

JOBS AND TRAINING

A local economy that creates employment opportunities for Brussels residents

CONTEXT

Construction, a sector with great circular potential

We must stop thinking that resources are inexhaustible. We must look at things in another way!



The current economic model relies on the assumption that raw materials are virtually inexhaustible. Their consumption has continued to increase, far exceeding their rate of regeneration, and this is unlikely to change.

The model which the world relies on today can be characterised by the features described below.

A linear system

Raw materials are extracted and processed into products, which are consumed and then thrown away.

A system with exhaustible resources

The linear economic model based on "Take · Make · Consume · Throw away" considers resources as inexhaustible. However, in a

closed system, resources are not unlimited, and their extraction, which is becoming increasingly difficult, harms our environment.

A globalised system

The depletion and increasing difficulty of exploiting raw materials increases price volatility in a context where European markets depend on world markets.

An accelerating system

A growing urban population and an economic system based on the consumption of goods and services is compromising the earth's biocapacity.

This assessment is especially apparent in the construction sector, which is both a major consumer of resources and a major producer of waste.

The European Union has made compelling observations on the construction and operation of buildings, energy consumption and waste management (see below). It has implemented a range of actions, notably through the “Circular Economy Package,” in order to transition from waste management to resource management.

Constructing and operating buildings in the European Union is responsible for:

50% of all extracted materials

33% of water consumption

40% of energy demands

36% of greenhouse-gas emissions

38% of waste generated

Constructing and operating buildings in Brussels involves:

98% of water consumption

75% of energy demands

65% of greenhouse-gas emissions

33% of waste generated

Like the European Union, the Brussels-Capital Region has painted an alarming picture despite the considerable work already carried out by the “Alliance Emploi Environnement⁴” to enable the sector to meet the energy-performance requirements of buildings. It is now time to take control – in practical terms – of how material resources are managed.

Conventional economic models based on economic growth are now revealing their economic (price volatility), environmental (pollution, and global warming), and social (relocation of firms impacting employment) limitations.

The circular-economy concept aims to decouple economic growth and the depletion of natural resources. The aim is to limit the extraction of raw materials and create new economic activities and jobs through innovative business models. This principle can increasingly be seen as the only possible alternative to the current linear model.

Today, by overhauling its economic development, the Brussels-Capital Region is aiming to take advantage of opportunities in the sector to meet the challenges which it must face: jobs, training, education and quality of life.

These **opportunities** are:

- employment potential to be maintained and created for the city’s residents, and especially those less-well qualified;
- a context of significant change with great potential for innovation;
- new skills to be acquired offering competitive advantages to Brussels residents who are active in markets subject to growing competition;
- significant flows and stocks of materials that become resource pools, limiting adverse external effects and narrowing material loops from source to market.



⁴ L’Alliance Emploi-Environnement is a regional scheme established during the period 2010-14 to help the sector’s transition towards sustainable construction.

Is it a utopia? No: just development opportunities!



Being competitive with firms that do not have circular economy know-how

Winning future public contracts that include circular-economy clauses

Developing existing activities by including circular-economy principles

Developing new markets and new activities

Developing a new client segment that is alert to the circular economy

Meeting clients' changing expectations and needs

Retaining clients and business

Improving supply security and maintaining access to resources

Improving price stability

Attracting, retaining and mobilising staff

Creating new partnerships

Creating and maintaining your firm's good reputation



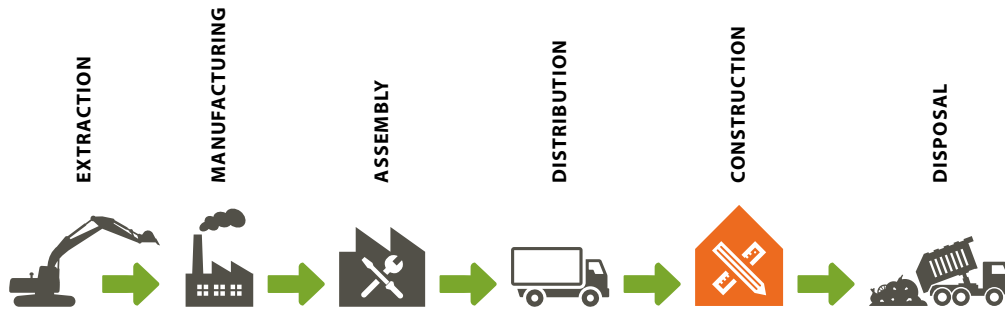


THE BRUSSELS CIRCULAR-ECONOMY MODEL

What vision for the future?

This is the production model on the basis of which we currently function: raw materials are extracted or harvested to make parts. These are assembled into components, which are then put together to make products. The products are sold through distribution networks to consumers, who throw them away after use.

TODAY'S LINEAR ECONOMY



A NEW MODEL IS NEEDED: THE CIRCULAR ECONOMY

From a global perspective, working alone is no longer an option. A change in paradigm is essential, one which provides an alternative to the linear model. The Regional Programme for a Circular Economy (PREC) highlights this political ambition. Producers and firms alike are, of course, affected by this development, as well as governmental authorities and consumers.

The Regional Programme presents Brussels' vision of a circular with a draft proposed by the Government in Brussels' 2025 Strategy, adopted on 16 June 2015. *"The aim is to encourage the transformation of the linear economy into a circular economy by developing a strategic and operational vision of the environment as a resource for creating local jobs. In particular, this involves anchoring economic activities through narrow closed loops to obtain a value chain that is as complete as possible within our region."*



What are the implications of such an economic transition for the construction sector and its stakeholders?

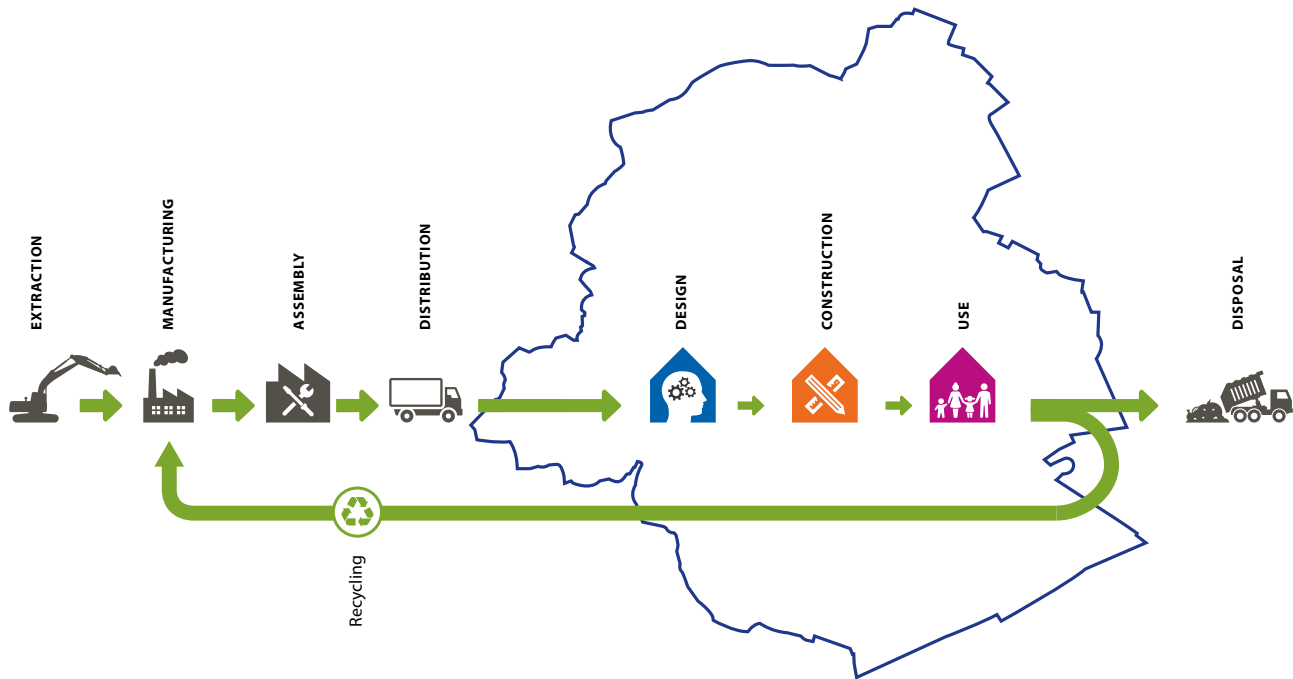
In this new model, waste materials become resources. A consequence is that we minimise the harvesting and extraction of new resources and re-use what is already in use.

Unlike the linear model where all resources and products are eliminated after use, the circular model keeps them in the loop through strategies shown in the diagram (page 59).

Buildings, resources, businesses, and jobs & training are the four themes that are key to the circular economy for the Brussels-Capital Region. They are also the guiding themes throughout this publication.



2018: a linear model



- Extraction, manufacturing, assembly, distribution and the processing of waste are carried out **outside of the Brussels-Capital Region**;
- Few buildings are designed to be adapted or reversible.

> SOCIAL AND ENVIRONMENTAL IMPACTS
> EXTERNAL DEPENDENCE

- A recycling loop has been developed (mainly for inert materials) but it is primarily **downcycling**.

> LOSS OF VALUE OF THE MATERIAL

2050, a circular model for Brussels



- The design, construction & use of buildings is organised in ways that is circular, adaptable and reversible.
- By considering **buildings as a resource**, a large proportion of these “waste-resources” could be reintroduced into new projects in Brussels.

> REDUCED WASTE
> REDUCED EXTRACTION

- Many economic activities are being developed:
- Notably, **maintenance & repair** of new products and services;
 - Auditing, dismantling and preparation prior to **re-use**...
 - **Re-manufacturing** using recovered materials and products;
 - **distribution** associated with these new activities.

> STABILISING AND CREATING EMPLOYMENT



BUILDINGS

Adaptable, flexible and reversible design, using sustainable materials

Today

Already having a very small surface area (161 km²) with a high population density (7,210 persons per km² in 2014), the Brussels-Capital Region's population is continuing to grow. The housing stock is characterised by a large number of dilapidated and poorly insulated.

Density of the building stock (average)

Brussels-Capital Region: **5 to 6** inhabitants per building

Flemish and Walloon regions: **2** inhabitants per building

Housing density (average)

Brussels-Capital Region: **3** homes/building

Flemish and Walloon regions: **1** home/building

Tomorrow, circular buildings

Designing buildings to be versatile over the course of their lifecycle is a key principle of circular building. As early as the design stage, buildings are thought out to be adaptable and flexible, facilitating deconstruction and the preparation of various materials and products for reuse. During the building stage, materials must be chosen with this in mind. Finally, the occupants are encouraged to practise sustainable consumption and take care to maintain and renovate their property in order to extend its lifespan.

VISION FOR 2050

Construction and renovation will have achieved a high level of circularity.

All buildings will be maintained and occupied in a sustainable manner.

CIRCULAR DESIGN

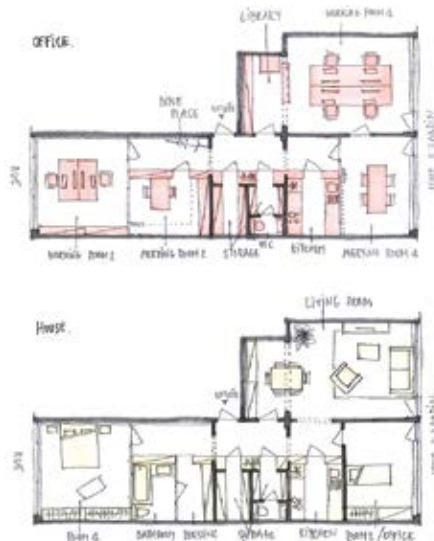
Adaptable and flexible design

Buildings' design must be **flexible and adaptable** in order for them to change their purpose over time, to facilitate upkeep and to integrate technological advances.

Open planning, modularity, easily accessible ducts and ceiling height are all factors that must be taken into account during the design phase in order to meet the changing needs of users and changing economic functions.

AN OFFICE CONVERTIBLE INTO A HOME

The architect planned for a future change in use from the start of the office-renovation design phase in the central Brussels district of Ixelles. With the exception of installing bathrooms, the office could be transformed into a home without considerable effort. In the event of a change of use, few new materials will be required and no waste will be created.



MOD'S - FOR DESIGNING CIRCULAR

In Brussels, MCB Atelier (a design firm) designs 3D products made from locally sourced wood (FSC or recovered), used to minimise transport and storage requirements.

One of the firm's flagship products are its **MOD'S**, which may be temporary or permanent structures. They incorporate all the features of circular design: modularity, customisable, reusable, dismantlable and adaptable to any purpose.

The firm erects and dismantles these partitions, thus providing the product primarily as a service according to the circular economy principle of functionality.



Designing to deconstruct

Reversible design takes into account the building's end of life: all choices concerning products and assemblies are made with an eye to re-using and recycling the materials, preserving the value of the materials so they can be integrated into new projects.

It is therefore necessary to consider the following during the design phase:

- selecting materials and products that are easy to handle and easy to dismantle at the end of their lifespan;
- selecting visible and reversible connections and assemblies to ensure that they can be easily separated;
- using modular and/or standardised products making it easier to re-use them at a later date;

- using pre-fabricated elements to ensure that the construction and deconstruction generate little waste;
- collecting information about the products used and their composition (materials passport, BIM, inventory, etc.) to facilitate their re-use: composition of the products, materials, components, assembly methods and building systems used, re-use options, etc.

REFURBISHING STUDENT ACCOMMODATION DESIGNED IN THE LATE 1960S IN A REVERSIBLE WAY

The 'Circular Retrofit Lab' was created in the context of the EU Buildings as Material Banks (**BAMB**) project. It was developed by the VUB's TRANSFORM group in order to renovate four student accommodation modules on the university campus in Etterbeek. Designed in the late 1960s, the modules were initially planned to be temporary.

Instead of demolishing the buildings as planned, the project is piloting a range of reversible renovation solutions.

The objectives? To extend the life of the buildings and introduce flexibility in terms of new uses while ensuring modern standards of comfort. A further aim is to facilitate dismantling the various elements in anticipation of their re-use when the building reaches its end of life. A final aim is focusing on the quality and performance of technical and energy utilities, and their accessibility.



Layered design



- Stuff – a day to a month
- Space plan – 3 to 30 years
- Services – 7 to 15 years
- Skin – 20 years
- Structure – 30 to 300 years
- Site – eternal

Source: S. Brand, *How Buildings Learn*

Designing independent layers, based on the constructive hierarchy of layers of durability, is essential. The structure, skin, services and interior arrangement (Brand's "Space plan") are designed separately to allow independent interventions on each of these layers throughout the building's life. In other words, layers can be worked on independently.

- **The site** corresponds to a geographical location. It is relatively permanent.
- **The structure** is the building's supporting layer. It comprises supporting structural elements and foundations. The structure is the layer with potentially the building's longest lifespan. However, it is the most limiting layer in terms of adapting the building, and the one which can generate the most waste.
- **The skin** comprises elements of the façade and other exterior surfaces, such as the roof. In order to allow later adaptations to the building, it is advisable that the façade be independent of the structure.
- **The services** form a layer comprising all the ventilation, heating, plumbing and electricity systems.
- **The interior arrangement** (or "space plan") comprises partitions, walls, floor and ceiling coverings, and the spatial finishes. These have relatively short lifespans.
- **Stuff** is Brand's term for furniture, supplies and consumable items: numerous products that have the shortest lifespan in the building.

CIRCULAR CONSTRUCTION

Choosing materials based on their environmental impact and what they will become at the end of their life

Sustainable supplies

- Sustainable materials and products should be selected, and when possible from the existing building stock;
- The use of virgin substances with a low ecological value should be avoided in order to reduce the extraction of non-renewable materials.

The construction phase is key to implementing circular economy principles as it is at this point that the right choices must be made to limit the extraction of natural resources and the production of waste. Sustainable materials should be selected and the reuse of existing and available materials prioritised.

Selecting materials

Precautionary principle

- **Materials**
 - The number of types of materials is minimised;
 - Composite materials whose components cannot be separated out must be avoided.

- **Waste**

- The production of waste during implementation is minimised through optimal construction techniques and site management practices;
- Building sites draw up and execute waste management plans. With what aim? In order to make qualitative and quantitative predictions of how much waste will be generated. In other words, to plan for any waste-management interventions required on the building site;
- Clients are made aware of their responsibilities in terms of planning for and managing the wastes, i.e. preparation, organisation and recycling (“upcycling”).

Reversibility principle

- Preference is given to modular and/or standardised materials.
- Pre-fabricated elements are favoured.
- The materials can be easily dismantled at the end of their life and then re-used or upcycled.
- All connections and assembled components are visible and reversible.

Eco-design principle

- The materials used do not contain contaminants or substances that are toxic, hazardous or otherwise harmful to health or the environment.
- The materials are selected on the basis:
 - of their declared environmental credentials;
 - of their lack of negative environmental impact.
- Raw materials are obtained locally, from renewable sources.



NOW THAT'S A GREAT IDEA

Sourcing construction materials from re-use firms – now that's a great idea! Thanks to **Opalis** - the directory of professional re-use firms in Belgium - architects, clients and other firms can source the materials they need for their construction project and access useful documents such as a handbook for off-site re-use and examples of contract clauses regarding the technical specifications for the re-use of materials.



CIRCULAR USE

The building occupant's role is key to ensuring efficient resource management. Upkeep, maintenance and repairs must become automatic reflexes. Only after this first step is it necessary to turn to renovation, using material banks and special services.

The level of efficiency in terms of managing building resources (e.g. energy and water) will not only depend on the design but ultimately on how it is occupied and managed. Regulation and upkeep, as well as how the premises are occupied, must be taken into account, making the occupant a key player.

Clients and/or users have to make optimal use of resources (energy, water, materials and space) in their buildings



Materials

- Priority is given to upkeep, maintenance and repairs rather than installing new solutions;
- Renovation is favoured over demolition and reconstruction;
- Local material banks are used for supplies at all stages of the building's life;
- The use of special services, such as leasing a product, is favoured over the outright purchase of products as these will ultimately become waste.

RENTING LIGHTS

Here, usage replaces ownership! **Philips' Pay-per-Lux** system is a way of renting lights based on the amount of light used: a system providing lighting points. What are the advantages? The company is responsible for upkeep of the lights but also removing, recycling and replacing the systems at the end of their life.



Space

The owner is careful to plan for a combination of different ways that a building can be used to maximize the use of space. For example, in Brussels this could be routinely favouring the temporary use of unoccupied buildings.

OCCUPYING EMPTY BUILDINGS

How can the problem of unoccupied property be turned into a local development opportunity? *Communa* is an enterprise started by young “dreamers looking for meaning” in 2013. It matches owners of empty buildings with community projects.

In Brussels, there are between 15,000 and 30,000 buildings standing empty. At the same time, more and more people are looking for an affordable place to stay or to carry out a wide variety of activities. To mitigate the negative consequences of empty property (which adversely affects the urban landscape, erodes the social fabric and devalues neighbourhoods), *Communa* renovates this accommodation and makes it temporarily available for social initiatives. The result is a proliferation of urban activities and a laboratory illustrating creative potential which can intermix social, economic and charitable activities, while also accommodating cultural gatherings. While promoting new developments and socio-cultural diversity, **Communa** keeps unoccupied property under control, tackling it at the source and transforming it into an opportunity for local development.





RESOURCES

From waste management to resource management

Now

The region's policy for the sustainable management of the construction sector has been successful for over ten years, but the rational use of materials must improve further. Considering existing buildings as resources is a necessity.

Tomorrow

Thanks to inventories of available resources being organised, the re-use of existing stock is becoming more common. We can find examples of selective deconstruction, preparation for re-use, documentation and the inventorying of resources.

Recycling is facilitated by sorting materials when deconstruction takes place and a newly defined end-of-waste status allows certain materials to be recycled on site.

VISION FOR 2050

- Buildings and materials are retained. **Renovating** and **adapting** what already exists is favoured over demolition.
- Materials, products and components from buildings are listed in **material banks**.
- Buildings and materials are used wherever they will be of **greatest use and value** throughout their lifespans.
- Construction and demolition waste is minimised through the **use of an adaptable and reversible design approach** to buildings and materials (**prevention**).
- **Re-using construction materials is routine**.
- **Construction and demolition waste** is treated in such a way to maximize and sustain value.

MAKING USE OF THE BUILDING STOCK - URBAN MINING

Documentation

- An inventory of buildings is made and kept up to date in order to have a record of the available stock of products and materials (materials passports, BIM, etc.);
- All materials are identified prior to deconstruction:
 - hazardous waste;
 - reusable materials and components;
 - recyclable materials.

Deconstruction

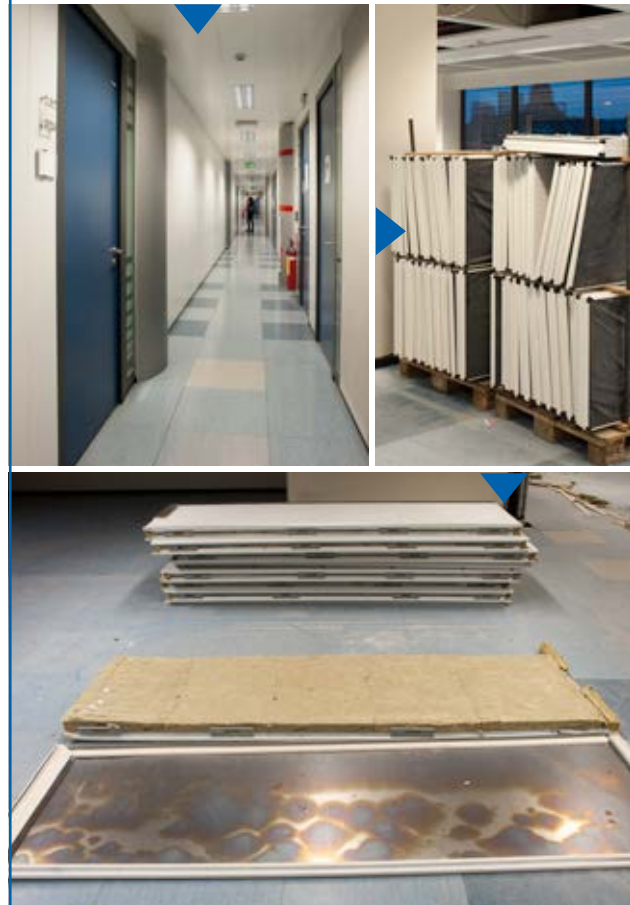
- Any remaining hazardous waste is collected and processed separately by workers who have received special training;
- The selective deconstruction of buildings is planned so as to:
 - obtain continuous high quality flows of recyclable materials;
 - supply the local market with reusable products.

Reuse and preparation prior to reuse

- New reuse channels are created;
- Materials with high potential are prepared for reuse, and locally sourced when possible;
- Materials from such local reuse sources are used;
- A regulatory framework is developed, which is favourable to the reuse of materials from deconstruction and the preparation for reuse.

GOING FROM WASTE TO RESOURCE

When renovating the Horta-ONSS office building, four kilometres of partitioning was dismantled and put on the market for resale. The insulation in these partitions was carefully salvaged. After checking its thermal performance with BBRI, the insulation will be reused on another building site, providing insulation to 341 Brussels social housing units.





RE-USE, ADVANTAGEOUS FOR ALL PARTIES

Trialling reuse as part of the sustainable Tivoli district in Laeken, the renovation of the former Belgacom building has tested a three-stage process that goes from inventorying materials to an assessment of the outcome. With what aim? To deconstruct (in accordance with selective deconstruction techniques) certain components prior to demolition to enable their reuse in the new construction.

Stage 1: the inventorying of materials. Components that could be reused (on or off-site) were identified, removed, quantified and entered into a summary table. The contractors then carried out deconstruction tests to confirm (or dispute) the data and formulate the best plan for the site.

Stage 2: the deconstruction. The dismantling and preparation work required provided employment for low-skilled workers, as well as an opportunity to increase their awareness of the importance of careful deconstruction and to gain skills in this area. The recovered elements were subsequently packaged in containers that facilitated their removal. Once on the deconstructor's premises, they were cleaned, inventoried, studied and prepared for optimal reuse.

Stage 3: the outcome. This was positive for all parties involved. The general contractor made savings by disposing of materials free of charge, which otherwise their firm would have had to pay for. The deconstructor covered the cost of the deconstruction work by selling the carefully dismantled materials, and the architect satisfied the client by reducing the environmental impact and utilising reused surfacing materials with high heritage value.

To be noted: This selective deconstruction experiment was made possible by coordinated planning between the firms involved, and the client's willingness to be involved in a pilot scheme.

Re-manufacturing

- New re-manufacturing channels are being created.
- Materials with high potential are recovered with the aim of manufacturing new products, and locally sourced where possible.
- Materials from local re-manufacturing channels are used on Brussels construction sites.
- A regulatory framework is developed, which is favourable to the use of materials sourced from deconstruction practices to provide supplies to re-manufacturing channels.

IN SITU RESOURCE MANAGEMENT

In central Brussels, a project to convert a former foundry into a multi-purpose centre is a good example of the circular-economy approach, paying particular attention to the conservation of the existing construction and the repair or modification of components rather than their demolition. The focus is firmly on in situ reuse. During the demolition work, bricks were recovered, cleaned and reused on site, producing savings amounting to tens of cubic metres of new materials. Wooden beams and Belgian bluestone were dismantled to be reused in furniture and interior-design elements. Old timber (formerly used for shuttering) is also to be reused to make large new doors.



Recycling

- Materials with a high content of secondary raw materials, preferably sourced from local dismantling and recycling processes;
- An end-of-waste status is defined, enabling certain materials to be recycled on site.
- The on-site sorting of waste is optimized.
- New recycling channels are created and existing ones improved.





THEME

3

BUSINESSES

New business models and new ways of working together

Today

The linear model predominates in construction companies' practices. Attempts to change the paradigm which show promising results. A need to network to share experiences. This is what characterises businesses working in the sector today.

Tomorrow

Optimising economic resources in the Region to prevent waste and save energy in existing companies. Businesses that innovate in terms of governance and management models.

VISION FOR 2050

- The entire fabric of the Brussels construction sector has successfully transitioned to a circular-economy model.
- Trailblazers have created innovative activities and are taking advantage of unprecedented market opportunities. Brussels-based companies have seized these opportunities in niche markets.
- The regulatory, fiscal and administrative context provides support to the circular economy and innovation. This may involve the simplification and optimisation of administrative procedures, public-private partnerships, availability of industrial space, favouring mobility and access, support for the organisations involved, exemplary public specifications, etc.

TRANSFORMING BUSINESS MODELS

The five main economic models of the circular economy:

Circular supply chains

- Sustainable and renewable resources;
- Closed loops;
- Short circuits;
- Local jobs.

Recovering resources and industrial symbiosis

Pooling human and material resources between a number of building sites and optimising the reuse of materials in situ.

Extending lifespans

A producer can set up arrangements to collect and refurbish the products sold.

- Components re-enter the production cycle.
- No manufacturing uses new material resources.
- The lifespan of products is extended.

To ensure viability of its business model, the business establishes incentives or enters into contractual agreements with its clients to ensure the return of its products. Otherwise, the materials would be wasted. The products and their components are thus kept in circulation, and can even be improved by repair, upgrading or re-manufacture.

BOONDAEL: BUILDING CONSERVATION, REUSE AND POOLING RESOURCES

The Boondael project concerns the complete renovation of two former residential buildings. They are adjacent to each other and in a very poor state. This building site is exemplary in several ways:

- The architect and client aimed to limit the use of natural resources, building their thinking and actions upon a circular-economy approach.
- They did everything in their power to keep the existing buildings. The result was that over 90% (of the two buildings) was kept.
- A range of reuse initiatives were implemented: the dismantled wood was re-used in situ; the old bricks were used to strengthen and repair the walls; end-of-site materials (scrap iron, masonry blocks, wooden beams, flooring, etc.) were purchased at an affordable price to supply the site.
- Human and material resources were also pooled with the neighbouring Petite Suisse building site.



The collaborative and sharing economy

Materials, products and buildings are shared to ensure their optimal and effective use.

This economic model relies on three pillars:

- **The creation of platforms to link supply and demand.**

Whether physical or virtual, these exchanges imply a sharing of resources, skills, tools and information.

- **Access to products and alternative ownership models.**

These alternative solutions can include renting, lending, subscribing, exchanging, donating, etc.

- **An opportunity for businesses to adopt more collaborative working practices.**

In the construction sector, site management has the most potential to develop sharing practices and contribute to a collaborative economy.

DESWAEF AND DEBATTY: SHARING SITE FACILITIES AND HUMAN RESOURCES (TRAINEES)

The Deswaef project concerns the renovation of the Deswaef Cultural Centre that has not been used for 15 years. The Debatty development, located nearby, is concerned with the renovation of buildings (80 homes) owned by the local authority, intended to yield 52 new and affordable homes, an after-school and community centre, a day-care centre, and the redevelopment of the estate.

These two building projects coexist on the same site. They benefit from shared site facilities: access points, site huts and equipment. This leads not only to a more cost-effective approach to site facilities, but also to stronger synergies between the two developments, both of which are trying to preserve the existing buildings and implement on-site re-use practices. The integration of trainees is also jointly undertaken. The social objective is further reached through the hiring of a social enterprise to clean the shared site huts.



The functionality economy is an economy of services

This model favours use over ownership and the sale of services rather than the sale of goods.

- The goods are supplied as services and remain the property of the producer, or alternatively may be sold with long-term contracts that include upkeep and repair clauses;
- Products that have reached the end of their lives are sent back to the producer or to a specialised firm.

The functionality economy also goes hand-in-hand with a change in consumption patterns: changes in purchasing behaviour (purchasing second-hand or reconditioned products, etc.) or even the development of shared consumption (collective purchasing, with shared use).

TOMATO CHILI PROJECT

Exemplary greenhouse project

"It was when I was watching Tivoli's containers near Greenbizz that I realised how little building-site waste was being utilized. That's when I came up with the idea of a circular-economy project based on recovering and taking advantage of this type of waste. When I talked to other entrepreneurs working at Greenbizz, possibilities for synergies appeared. Home Perspective was able to recover a large number of old windows on its sites, Plant Design has expertise in everything related to plants, Réconfort + is an eco-construction and professional reintegration firm, and the carpentry firm - Florian Girault and Visuality - was able to translate all of these ideas into visuals. The Tomato Chili Project was born!" This is how Olivier Breda, an architect working at Dzerostudio Architectes, sums up this exemplary project. The greenhouse is modular, dismantlable and reusable elsewhere, and is designed to be marketed according to principles associated with the functionality economy. It will be made available to users together with support, maintenance, and instruction on greenhouse cultivation to produce fruit and vegetables. Can they go even one step further? That's the goal, as future greenhouses will rely on short supply circuits connected to construction and demolition projects in Brussels and be built by workers recruited through a specific program of occupational integration. *aanvoertijnen vanuit bouw- en afbraakwerken in Brussel.*



DEVELOPING COLLABORATIVE WORKING PRACTICES WITH OTHER BUSINESSES

Sharing information

Learning from one another by encouraging the sharing of information between the various parties active in the construction sector's value chain. Avoiding the one-way flow of information that typifies the linear economy.

BIM, COMPREHENSIVE 3D DATA

The Building Information Model (BIM) is a process that involves creating and using smart 3D models. In concrete terms, it creates a digital representation of a structure based on a 2D/3D digital model that includes and links all the information (cost, materials, U value, etc.) associated with each element (windows, roof, walls, washbasins, etc.) included in the project. Automatically updated, any change to any of this information has repercussions on the other parameters. This tool accordingly enables everyone involved in a project to better visualise the compatibility of their interventions and to simulate a variety of scenarios. BIM is also useful for contractors thanks to the 3D modelling. This type of collaborative tool helps reduce costs resulting from errors as conflicts can be detected in real time and there is optimal communication between the various parties.



Working in bouwteam(s)

This is a collaborative practice involving the architect and contractor, from the design phase of a construction project. It can take a variety of forms from an informal bouwteam to 'Design, Build, Maintenance, Finance & Deconstruct' versions, as well as public-private partnerships.

BOUWTEAMS TO IMPROVE COLLABORATION

In the context of the comprehensive Boondael renovation project in Ixelles, two old apartment buildings will be converted into nine homes with an internal courtyard. Using the Bouwteam principle, i.e. involving the architect, various contractors and specialists, made it possible to plan the project from the beginning according to the respective approaches of all actors. This Bouwteam principle was just one of the circular-economy practices applied on this site.



Optimising a business' procedures and organisation

By optimising in-house resources and procedures, and circulating information internally, waste is reduced. The consumption of materials, and the production of waste and pollutants is minimised. Various structured construction methods are applied, as well as specific organisational practices that are effective for each party.

LEAN MANAGEMENT: INCLUSIVE BUILDING-SITE MANAGEMENT

This way of managing a building site can be both more efficient and of higher quality.

By focusing on greater versatility of entrepreneurs and workers, LEAN Management advocates for the creation of times and places for the collaboration and dialogue between contractors, workers and sub-contractors, with the aim of reducing errors, waste and hence costs for everyone involved. It is beneficial at all levels.

On the building site, it results in greater efficiency, fewer errors and hence less waste materials and reduced costs, better adherence to schedules, and increased responsibility of all involved.

For the client, costs associated with waste are eliminated and construction defects, unreasonable stock levels, excessive transportation, and underused capacities are eradicated or reduced.

In brief, it is a procedure that makes the building project more stable, predictable and effective. It leads to cost reductions and better-respected delivery times, as well as increased quality and security.

With the LEAN Management:

Reduction of the failure rate: **6%** ⁽¹⁾

Reduction of the construction time: **30%** ⁽²⁾

Reduction of costs: **15%** ⁽²⁾

Sources:

1. Magazine Construction, le LEAN ou la systématisation de l'efficacité
2. World economic forum, Shopping the future of construction

Local high-quality employment

Thanks to high quality training, the majority of job seekers and students leaving construction courses secure high-quality jobs in the sector, and especially in new activities related to the circular economy e.g. circular design, deconstruction, pre-demolition audits, installing new equipment for leasing, reuse, recycling, etc.

FAVOURING LOCAL EMPLOYMENT

DRTB is an all-trades firm involved in construction, renovation and maintenance, which has been applying sustainable construction and technical practices for approximately 15.

The Leemans depot project, consisting of the construction of two apartments and an office above an existing warehouse, applies several circular-economy principles. It especially focuses on the team and making the most of human resources. DRTB has been taking this approach for years. The labour is 100% local. An example of local and high-quality employment: DRTB possesses all the skills it requires in-house and employs only local workers on its sites.







4 JOBS & TRAINING

A local economy that creates new and innovative employment opportunities for Brussels residents

Today

The construction sector accounts for a large proportion of employment in the Brussels-Capital Region. However, this fragmented and constantly changing sector suffers from a high rate of staff turnover, the effects of social dumping, and a recurrent shortage of skilled labour, as presented in the section above on the monitoring dashboard. However, there is potential for improvement. This encouraged the Alliance Emploi-Environnement agency to address these employment, training and educational challenges.

Tomorrow, circularity will contribute to job creation.

This should minimise the waste of human resources, and enable students, job seekers and workers to obtain and retain high-quality jobs. Access to new skills will be favoured, examples being product-service maintenance and upkeep solutions, conducting pre-demolition inventories, dismantling end-of-lifecycle materials and products, re-use preparation, using re-use materials and products, designing and making new products from recuperated materials, etc.

VISION FOR 2050

- Young people, job seekers and workers will be trained in circular-economy methods.
- High quality jobs of significant added value will be created in the Brussels-Capital Region.

JOBS

Creating a positive image of the sector

Creating a positive image to attract young people and job seekers, showing the potential for innovation and change, setting up **new management methods** that resonate with younger generations: these are the challenges faced by the construction sector in order to meet the expectations of workers, students and job seekers. Changes in jobs and the emergence of new roles will provide careers for diverse profiles.

Combating illegalities and inequalities

An exciting challenge:

- Relocating, creating and maintaining jobs at the local and regional levels;
- Guaranteeing social and societal diversity as a result of varied and plentiful job offers, as well as mitigating inequalities in the construction sector the region.

High-quality jobs and worker protection

Having a job that allows you to live in Brussels means having the financial means and the well-being to participate in the region's social, economic and cultural life.

Access to employment

The circular economy needs considerable human resources. The construction sector is already the sector mobilizing and creating the most jobs in Brussels, providing a great opportunity for employment on the condition that the jobs created are of high quality.

By transitioning from a linear to a circular economy, the construction sector will not only be able to sustain current jobs but also help to reduce the unemployment rate by employing Brussels residents, especially in the niche sectors pre-identified within the Alliance Emploi-Environnement's initiative and the Regional Programme.

By taking advantage of opportunities in the circular economy, firms can develop and hire job seekers who are aware of this new model and who are trained to adapt to the changing nature of the current occupations and the new roles created.



Training

A sector which is developing and is training its workers:

- A skilled workforce with transversal expertise is required to support the sector's circular development;
- Specific personal skills, know-how and cross-cutting expertise;
- Special skills relating to circular design, deconstruction, pre-demolition audits, installing new equipment and systems for leasing, re-use, recycling, demountable construction, etc.;
- Availability of high-quality training that allows workers to adjust to and anticipate changes in the sector, or reorient their careers;
- Adapted career plans allowing the most experienced workers to pass on their knowledge to industry newcomers;
- Brussels workers trained in Brussels (at training centres and schools, and in firms);
- Brussels construction companies recruiting Brussels workers for their up-to-date skills.

Trainers have the tools required to prepare Brussels workers and job seekers for the new jobs as effectively as possible. What is their role? To provide firms with **skilled labour** which meets the needs of the circular economy.

Trainers strive to ensure that these principles are accessible both in their reference works and in on-the-job training (internships, visits to businesses and construction sites, etc.). How? By including circular-economy principles in the existing training programmes, by developing new educational tools and training courses, and through the collaboration of the public and private sectors, etc.

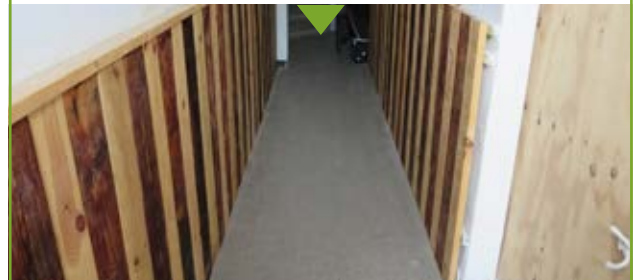
Such collaboration occurred between the **Cluster eco-build.brussels**, **Brussels and the City of Brussels'** Local Mission in order to train workers in deconstruction waste management and eco-renovation through information sessions and on-site visits.



PETITE SUISSE

Four workers received training at this building site.

One aim of the Petite Suisse building site is to train workers in collaboration with the City of Brussel's Local Mission. Four workers visited the site to learn about the various techniques for re-using materials on site and assembling a modular wooden frame, which can be dismantled and then re-assembled. A great role model for other small-scale building sites.



Integration, professional transition and sustainable employment

As an extension of the technical-educational aptitude tests, the training operators work on evaluating and **valuing the skills of job seekers** in relation to the niche sectors of the circular economy. By building appropriate training and educational tools, they match the skills of future workers with the needs of the market.

BE.CIRCULAR

As part of this call for projects, the nearby Debatty and Deswaef renovation projects integrate the approaches of conservation of the existing building, reuse on site, resource pooling, and also the use of social economy enterprises and integration of trainees in training, whose supervision is provided jointly.



A TRAINING SPACE DEDICATED TO DISASSEMBLY/ASSEMBLY OF REPLACEMENT CONSTRUCTION MATERIALS

The objectives of the Reuse Centre in Anderlecht are to provide training in the reuse of building materials and an introduction to construction through:

- Getting started with the DIY guides (Do It Yourself sheets) related to the chosen materials;
- Handling small tools safely through having carried out assembly/disassembly;
- Understanding the constructive method;
- Development of a material library containing the main "deconstructible" building materials.



EDUCATION

Schools and training centres lead by example and, in collaboration with the construction sector, train workers who are aware of environmental issues and practices. **Issues related to the circular economy are included in courses** as well as in teacher training and the technical management of schools. All teaching staff promote these practices:

- **Schools:**
 - adopting exemplary environmental management practices, which can be used as an educational tool;
 - taking part in model pilot projects (see opposite);
 - training in eco-design, eco-construction and waste management in the relevant occupations and subdivisions;
 - investing in environmental education and implementing specific educational projects.
- **Students** are made aware of circular-economy ideas as early as primary school.
- Raising **newcomers'** awareness of the circular economy is a key part of their integration.

CONSTRUCTICITY, BRINGING TOGETHER BUSINESSES, TRAINERS AND WORKERS

This is an organisation at the heart of the teaching · employment · businesses triangle in the Brussels-Capital Region. It aims to promote construction occupations, contacts with construction companies (site visits, etc.), inform students (about post-training opportunities, job prospects, finding internships, etc.), and support job seekers in their search for work. The Brussels Confederation of Construction set-up helps firms take on trainees and apprentices.

STUDENTS DESIGN AND BUILD REVERSIBLE BUILDINGS

Modüll 2.0

Since 2013, young people from Brussels who have studied construction have been taking part in the Passif Durable contest. In 2016-17, the Modüll 2.0 project enabled them to work on methods and processes to make an autonomous modular construction. What's the objective? Gaining experience in modules that can be dismantled and transported, exploit renewable forms of energy, intelligently manage water, and have optimal life cycles.



BRIC

The BRIC project includes the design, construction and deconstruction of a sustainable, scalable and reversible module. It also incorporates reused materials in order to demonstrate circularity and short circuits, as well as reversibility. In addition, it provides an opportunity to reflect on circular practices for the various occupations in the construction sector.



CONVINCED?
WANT TO BE PART OF THIS CIRCULAR VISION?
NEED HELP?
THE CLIENT

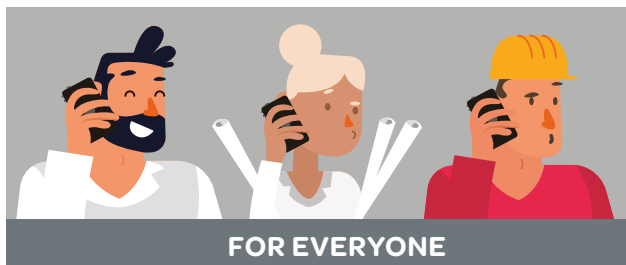


WWW.GUIDEBATIMENTDURABLE.BRUSSELS



WWW.PORTAILCONSTRUCTIONDURABLE.BE

YOU ARE...



CONTACT YOUR FACILITATOR

Sustainable Buildings

0800 85 775

faciliteur@environnement.brussels

Soil

02 775 75 75

soilfacilitator@environnement.brussels

Sustainable neighbourhoods

0800 85 775

fac.qdw@environnement.irisnet.be

Sustainable construction

02 545 57 83

environnement@cnc.be

Management and innovation

02 545 58 33

gestion@cnc.be

Support and technical research

02 529 81 06

michael.de.bouw@bbri.be

Network and exchanges

02 422 00 20

ecobuild@impulse.brussels

The following projects were used to illustrate this publication:

CALL FOR PROJECTS - BE CIRCULAR

Tour à plomb, Brussels, 2017 winner · Pages 1, 6, 57, 72, 81
Debatty/Deswaef, Anderlecht, 2016 winner · Pages 2, 5, 12, 28, 33, 77, 86
Horta - ONSS, Saint-Gilles, 2017 winner · Pages 12, 70
Clos Dupont, Evere, 2016 winner · Pages 25, 48
Boondaël, Ixelles, 2016 winner · Pages 68, 76
© Bernard Boccara
Tivoli, former Belgacom building, Laeken, 2016 winner · Page 71
© Rotor
Tomato Chili, Bruxelles, 2017 winner · Pages 23, 78
© Tomato Chili
Dépôt Leemans, Berchem-Sainte-Agathe, 2016 winner · Pages 37, 74, 80
© DRTB
VLA, Ixelles, 2017 winner · Page 62
© VLA Architecture
MOD's · Page 62
© MCB Atelier
Petite Suisse, Ixelles, 2016 winner · Page 85
© Cenergie srl

CALL FOR PROJECTS - EXEMPLARY BUILDINGS

Hankar, Saint-Gilles, 2009 winner · Pages 5, 10, 60, 66
Locquenghien, Brussels, 2009 winner · Page 12
Petite Senne, Molenbeek-Saint-Jean, 2013 winner · Page 43
Van Crombrughe, Woluwe-Saint-Pierre, 2013 winner · Page 45
© Yvan Glavie

PILOT PROJECTS IN BRUSSELS

MÖDÜLL 2.0 · CDR Construction project in collaboration with EFP auditors Pages 5, 34, 87
Construction week organised by CDR Construction et Constructiv Pages 32, 37, 53, 84
© CDR Construction
BRIC · EFP project · Pages 73, 82, 87
© EFP
BAMB · Circular Retrofit Lab project · VUB student accommodation · Page 63
© Transform VUB
© Lamiot/wikipedia.org · Page 23
© Opalis · Pages 25, 65, 66
© 21solutions · Page 37
© CCBC · Page 55
© Communa · Page 67
© Yvan Glavie · Page 67
© ecobuild.brussels · Page 85
© CDR Construction · Page 86
© www.shutterstock.com

Page 5 and 20: HildaWeges Photography · Page 24: Aisyaqilumaranas
Page 25: FreeProd33 · Mironmax Studio · Page 27: P A · Shutterstock.com
Page 52: Heller Joachim · Page 65: eWilding · divgradcurl · Page 92: Felix Catana

© <http://www.thinkstockphotos.fr/>
Page 37: alexeyrumyantsev · Page 56: Design Pics · Digital Vision · guruXOOX · diepre /
Page 79: MacXever · Rawpixel · Page 91: Hindenberg





For more information

Authors: Corinne Bernair, Isabelle Sobotka, Ambroise Romnée, Lara Pérez Dueñas, Charline Boyer, Philippe Van Ginderdeuren, www.oselacom.com

Reading Committee: Dirk Steurs, An Verspecht, Jennifer Timmermans, Nicolas Forrez, Pierre Masson, Nicolas Scherrier, Pierre-François Michiels, Emilie Gobbo, Edgar Towa, Martin Vanandruel, Molly Steinlage

Legal submission: D/5762/2018/02 · February 2018

Managing editors: F. Fontaine & B. Dewulf · Avenue du Port 86C/3000 · B-1000 Brussels
Printed with vegetable-based ink on recycled paper