# CIRCULAR PRAGUE

INSTITUT CIRKULÁRNÍ EKONOMIKY

CIRCLE ECONOMY

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# A THRIVING CITY THROUGH A CIRCULAR ECONOMY

Cities, being the centres of human activity, are in a prime position capitalise on the transition towards a circular economy. The Czech Capital of Prague has recognised this potential, and has begun to turn towards circularity as a means to achieve its ambitions to become a thriving, healthy, and resilient city. Prague has committed to offer its citizens a more sustainable way of life and provide opportunities for businesses to innovate. To help kickstart the circular transition, a Circle City Scan was carried out by Circle Economy and INCIEN, in collaboration with a consortium of local public sector stakeholders.

# THE CIRCLE CITY SCAN - A COLLABORATIVE INNOVATION PROCESS

The Circle City Scan of Prague is designed to be a participatory trajectory. Its outcome is a visual roadmap that identifies opportunities to foster a circular economy and aids the creation of practical and scalable solutions to implement circular systems throughout the city. The innovation process of the Scan is composed of three phases; 1) Socio-economic agenda; 2) Material flow analysis and circular opportunities; 3) Action plan. The collaborative 12-month process and shaped with the input of the consortium and local businesses.

# ACCELERATING CIRCULARITY IN THREE PRIORITY AREAS

Since the early 1990s, Prague has undergone sizeable change; shifting from a industrial-, to a service-oriented economy. The circular transition can tap into this growing momentum, while addressing current urban challenges. Based on the socio-economic analysis, three priority areas were identified, those being; the construction sector, households, and the utilities sector.

## CONSTRUCTION SECTOR

Prague's construction is one of the most resource intensive sectors of the economy, consuming ~13 million tonnes of materials each year to create the built environment, while producing 65% of the city's waste. However, only ~10% of the materials that are used in the sector originate from secondary sources.

### Circular tendering criteria

With public sector influencing almost a quarter of construction activities in the city, there is an opportunity to leverage public procurement through incorporating circular within the tendering process. Through driving demand in circularity in the sector, innovation can be stimulated and the environmental footprint of the sector reduced. Through the collaborative process, a tangible pilot project for Prague was developed that focused on the 'low-hanging fruit' of a building renovation.

## HOUSEHOLDS

The day-to-day activities and decisions of Prague's households have the ability to influence the overall environmental impact of the city; from the food that is eaten, to the clothes that are worn. Notably, value is lost in households through 240.000 tonnes of waste that are burned as a source of energy. There is a potential to reuse up to 70% of the currently 30.000 tonnes of bulky wastes (furniture and white goods), that are currently deposited in the city's waste collection yards, as well as increase this quantity of collected wastes overall.

### Circular ReUse Hubs

Circular ReUse Hubs was selected to be developed further into a pilot for Prague. The decentralised network of circular 'Hubs' throughout the city can focus circular activities that can utilise households' residual streams to not only create value for the local economy, but also inspire and support circular lifestyles.

## UTILITIES SECTOR

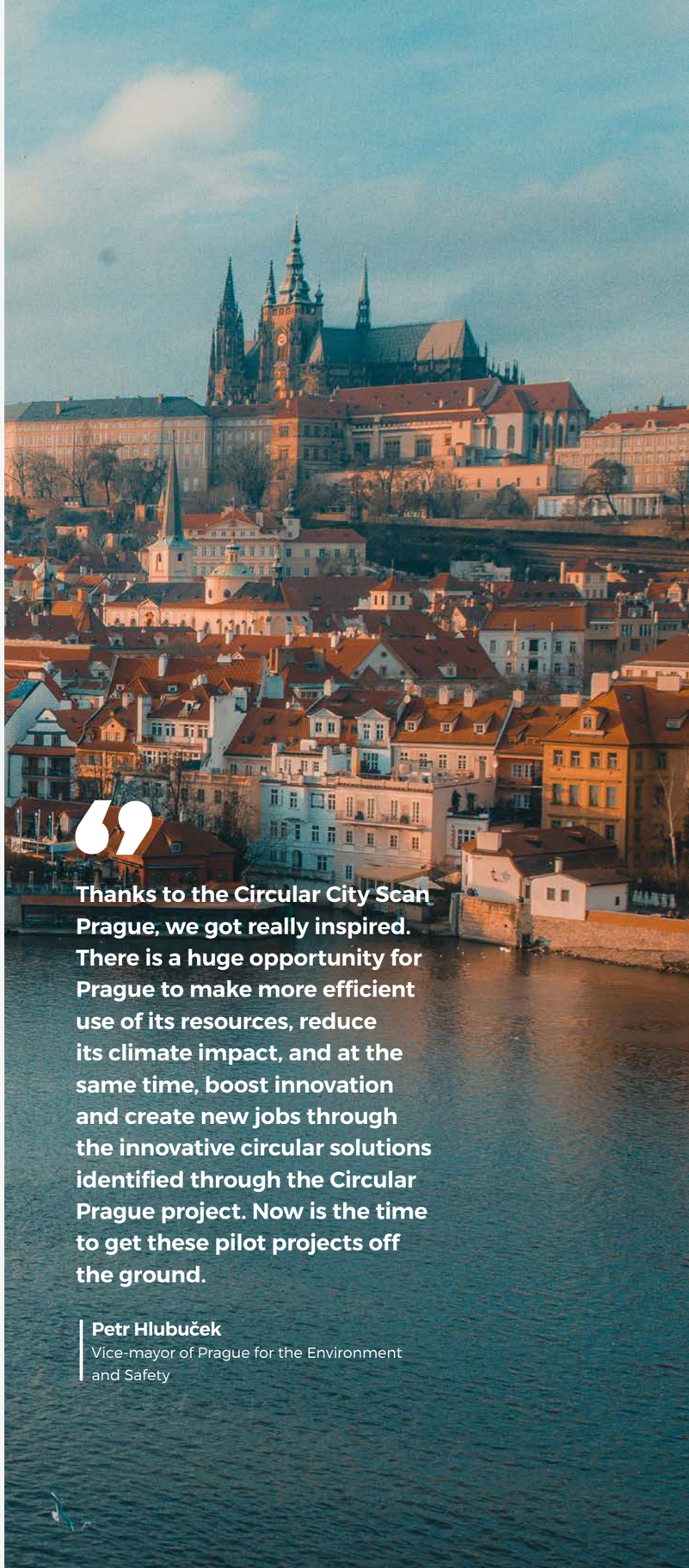
The Utilities sector, employing close to 10.000 people, is ultimately responsible for the management of the over 4,6 million tonnes of waste that are generated in Prague each year. Currently, there is no comprehensive system for the separate collection of the large quantities of waste biomass that is produced in Prague. With significant quantities of these wastes burned for energy, an opportunity has been identified to capture value through circular biomass management.

### Waste biomass to BioCNG

The development of a biomass waste to biogas plant was identified, together with the consortium, as a promising project to boost circularity and capture value in Prague. Biogas plants systems can convert biodegradable wastes into biogas, which can subsequently be upgraded into high-grade biofuel that can be used to power vehicles, such as the waste collection fleet.

# FROM INSPIRATION TO IMPLEMENTATION

To capitalise on the potential benefits of a circular Prague, it is important to build upon the momentum generated through the scan practical next steps presented in each pilot action plan to take the circular strategies from concept to reality. The city of Prague, together with businesses must take a collaborative approach to bring each circular strategy towards the practical and scalable implementation to drive Prague's circular transition.



**Thanks to the Circular City Scan Prague, we got really inspired. There is a huge opportunity for Prague to make more efficient use of its resources, reduce its climate impact, and at the same time, boost innovation and create new jobs through the innovative circular solutions identified through the Circular Prague project. Now is the time to get these pilot projects off the ground.**

**Petr Hlubuček**
Vice-mayor of Prague for the Environment and Safety

CIRCULAR
PRAGUE

# CONTENTS

## FROM A LINEAR TO CIRCULAR ECONOMY

In the current linear economy, the creation of prosperity is accompanied by the use of materials - we extract a rough 84 billion tonnes of materials worldwide every year.[1] The already incredible demand for raw materials continues to increase due to growing prosperity and an equally growing world population. In the linear system, the finite supply of raw materials leads to scarcity, price volatility, and faltering economic development.

The circular economy offers an alternative to our take-make-waste society by closing resource cycles and retaining value as much as possible, for as long as possible.

## CITIES PLAY A KEY ROLE IN THE TRANSITION

Cities represent a key enabling environment for the circular economy. All over the world, urban areas are undergoing rapid growth and it is projected that 60% of the world's population will be living in urban environments by 2030. Cities are tightly connected to economic growth, producing over 80% of the world's GDP[2] while consuming ~75% of global resources.[3] It is clear that cities hold an enormous leadership opportunity to pioneer urban spaces and ways of living that strengthen ecosystems and promote high social and economic welfare.

In the strategic report "Morgenstadt: City Insights. City Lab report Prague" developed for the city of Prague by the Fraunhofer Institute in 2015,[4] a number of areas of focus have been set for the city's sustainable and future-oriented development. Prague has highlighted areas of strategic interventions and concrete sets of actions in the fields of Energy System, Buildings, Space, Planning & Mobility, Economy & Innovation, and Governance. Various projects have also been initiated in the field of Smart City, creating a rich Innovation agenda. Circular Economy strategies could present a clear opportunity to integrate the different actions and address these and other priorities in a comprehensive agenda.

The city of Prague can exploit the opportunities of the circular economy and make optimal use of it for economic growth with a reduced impact on the environment. For example, by exploring new models of consumption, closing (waste) material cycles within the city's borders, establishing new collaborations between businesses and sectors, and piloting innovations that can make Prague an attractive and culturally vibrant place for people to live and work. This project has the ambition to set the first building blocks in place.

## THE BEGINNING OF A COLLABORATIVE JOURNEY

The Circle City Scan is designed to reveal where opportunities lie for the circular economy in the city of Prague and will help develop practical and scalable pilot projects at the city level. The process of executing the Scan depends highly on a collaborative and multi-stakeholder approach. Stakeholders from the municipality and the business community are guided through a common narrative to facilitate connections and collaboration where possible as promising circular solutions and projects for Prague are identified.

## THREE PROJECT PHASES

The three phases of the Circle City Scan form a 'guided process' that identifies key areas in the city of Prague to focus, develop and select the best circular economy strategies, and translate ideas into tangible pilot projects. The three phases are described in greater detail below:

**1**

### Socio-Economic Agenda

Provides insights into the strengths and challenges of the local economy of Prague, and identifies which focus areas hold the greatest transformative potential for a circular economy. Based on this analysis, together with a consortium of local stakeholders, three priority areas are identified.

**2**

### Material Flow Analysis & Circular Opportunities

Provides insights into the magnitude and nature of the flows of materials and products flow through the city of Prague and are managed at the end of their life. This analysis help to identify high impact material flows and opportunities for the circular economy.

In the second part of this phase, potential circular strategies are identified for each of the material flow opportunities. Each potential circular strategy is evaluated on its circular potential in Prague. Based on this analysis, one circular strategy for each priority area is selected to be developed further.

**3**

### Action Plan

In the third and final phase of the project, the selected circular economy strategies are refined down into compelling and clearly defined pilot project ideas that can serve as a starting point for the city to start its transition towards a circular economy. Together with group experts, local businesses, and city stakeholders, Action Plans are created to provide an overview of the immediate actions that the municipality and its stakeholders must take in both the short- and the long-term.

# PHASE 1

## SOCIO-ECONOMIC AGENDA



## SOCIO-ECONOMIC AGENDA

Transitioning towards a more circular economy is a complex journey that involves collaboration and coordination between (local) government, businesses, technologies and resources. To most effectively facilitate the circular transition it is crucial to understand which areas of a city hold the greatest transformative potential for a circular economy.

Transformative potential depends on the enthusiasm and energy that is already present; a momentum on which the city can build further. To this end, it is important to look carefully at the city from a broad systems perspective: from local sectors that tell us where employment and growth potential may be, as well as the city's key social and environmental impacts and priorities. The political context is key to identifying and initiating circular change in areas where there is strong political will and economic interest.

## APPROACH

The main goal of Phase 1 of the Circle City Scan is to gain an understanding of the current socio-economic and political environment of Prague, to be able to pinpoint key priority topics and sectors within the city that can drive the transition towards a circular economy.

Based on an analysis of the city's economy, households and political agenda, together with a consortium of local stakeholders, three priority areas are identified that will be analysed further in Phases 2 and 3.

**I was really inspired with the process of the whole project. Being part of it was definitely valuable - both for my understanding of the circular economy, as well for making new contacts, and identifying and applying really tangible projects for Prague. I think every city could use such a project.**

**Cyril Klepek**
CEO CYRKL Resource Platform, Member of the Board
ICT Operator Prague a.s.

## STRUCTURE OF PHASE 1:

# PRAGUE AT A GLANCE

Prague is the capital city of Czech Republic, with a population of about 1,3 million inhabitants. Prague was founded between the 6th and 8th centuries, when two Slavic tribes established themselves along the banks of river Vltava. The name of the city derives from the slavic word “prah”, which means “ford”or “rapid”, referring to the city’s origin at the crossing point of Vltava river. In its recent history, Prague has changed a lot since the decline of the communist regime in 1990 and has developed in to a prosperous city, where nearly a quarter of the country’s GDP is produced.

Like many other capital cities, Prague has gone from an industry-oriented to a service-oriented economy. Apart from all main authorities of the state administration, most financial institutions and foreign enterprises are based in Prague. All this has a significant effect on the regional economy. Education, consultancy, media, the film industry, real-estate, transport and construction are of great significance as well.

As for high-growth manufacturing industries, a dramatic increase of value added and employment have been observed in the pharmaceutical industry and the ICT sector in the period 2000-2014. These industries belong to the most innovative branches not only in Prague’s economy but the whole Czech economy as well. Their growth is driven mainly by activities of multinational enterprises as well as newly established small and medium enterprises (SMEs).

Prague has also been ranked 6th in Tripadvisor world list of best destinations and it receives about 6,4 million international visitors every year. This constant flow of tourists creates not only economic growth, but also places a burden on the historic centre of the city that has been characterized as a UNESCO World Heritage Site.

## Historical phases

**9th - 13th century - Prague's establishment**
Prague castle is founded, Prague is established

**14th century - Prague's Golden Age:**
Charles IV - rules the country (1346-1378)

**16th century - Prague's Second Golden Age**:
Prague becomes the center of science and alchemy

**17th century - Dark Age**

**19th century - Industrial Revolution**

**20th century: WWI**
Prague becomes close to Paris

- **WW11** Nazis occupy Prague
- **1945** Liberation by the Soviet Red Army
- **1948** Communist coup détat
- **1968** Prague Spring “socialism with human face
- **1989** Velvet Revolution
- **1993** Czechoslovakia Splits
- **2004** Joins EU

## Population

x **1,290,508** (2016)

| 49% | 51% |
|---|---|

Composition by age:

| 0-14 | 15-64 | 65+ |
|---|---|---|
| 15% | 66% | 19% |

## Tourism

**6th** in TripAdvisor world list of **best destinations**

**6.4 million** international visitors annually

Historic centre : **UNESCO World Heritage Site**

## Economy

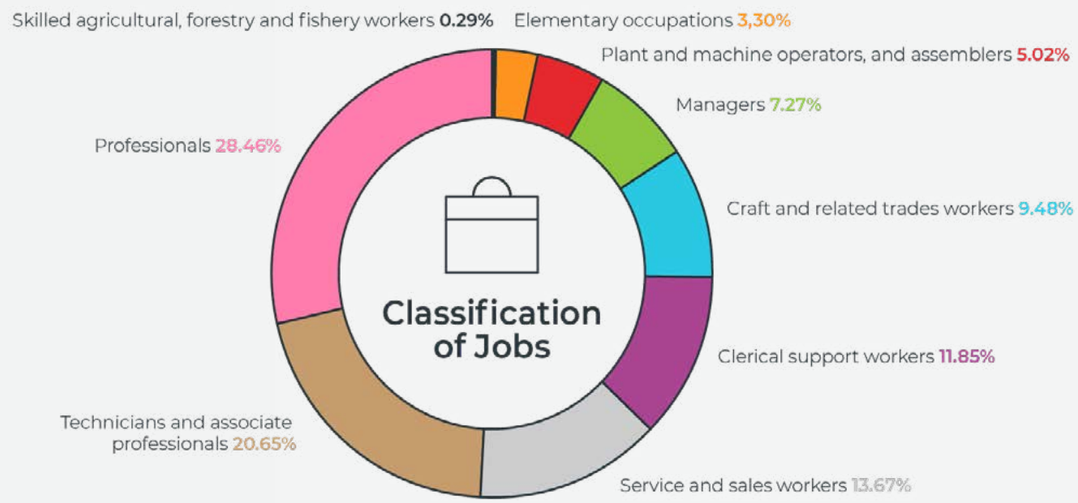
National GDP: **1.193.240 CZK mil**

**207%** CZ R average

## Employment

Total employment **663,300** (2016)

**0.35%** Agriculture
**17.41%** Industry
**82.24%** Services




*The data presented in this graphic was collected from the Czech Statistical Office (www.czso.cz) and Eurostat, the statistical office of European Union (ec.europa.eu/eurostat).*

# ECONOMIC SECTORS OF PRAGUE

To find the sectors with the greatest transformative potential for the circular economy, it is important to understand which sectors hold the highest strategic and economic importance for the city. These may not be the highest performing sectors per se, but may have the right energy and momentum to take action.

Sectors represent the production of the city and its contribution to the economy. A high-level analysis of Prague's sectors and industries has been to illustrate which sectors may be of strategic and economic importance for the city.

The sectors presented in Phase 1 are analysed on their overall importance to the city and the surrounding region. Due to limitations of time, each sector's importance is determined based on three indicators: Gross value added (in CZK), total employment (number of jobs), and total GHG emissions (tonnes $CO_2$-eq). Taken as a whole, these indicators provide a basis for comparison between sectors and a high-level rationale for prioritising certain sectors above others.

The sectors correspond to the SBI 2008 classification on the first digit, or combinations thereof. We then divide these on the basis of types of economic activity in clusters. In total, 12 sectors are taken into account over three categories:

## INDUSTRY

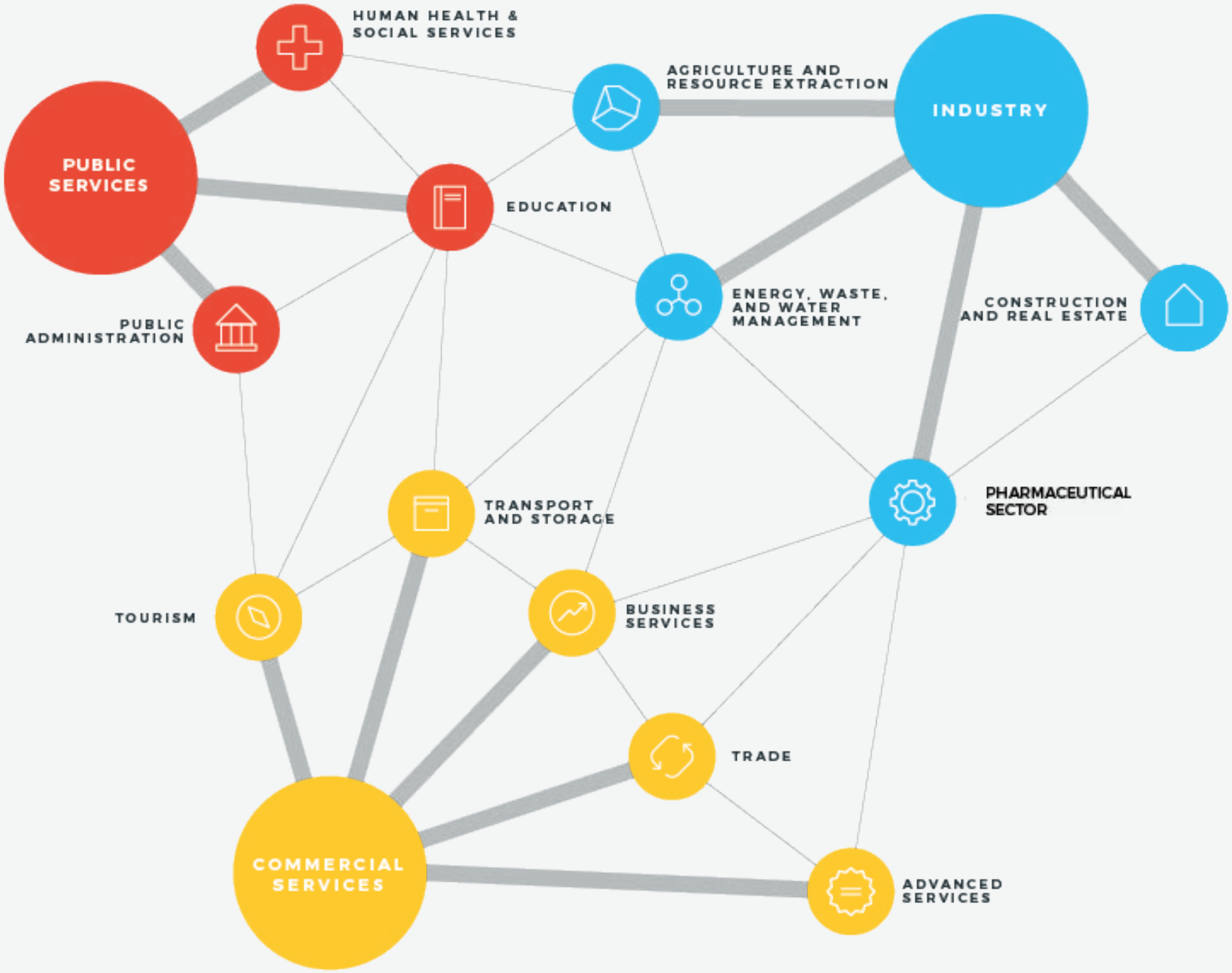
- Agriculture and mineral extraction (ie. farms, mining)
- Energy, waste and water management (ie. incineration of waste)
- Manufacturing industry (ie. industrial manufacturing activities)
- Construction and real estate (ie. building, property rental)

## COMMERCIAL SERVICES

- Transport and storage (ie. trucking, warehousing)
- Trade (ie. wholesale, retail)
- Tourism (ie. catering and culture)
- Business services (ie. advisory and legal services)
- Advanced services (ie. IT, communication, and financial services)

## PUBLIC SERVICES

- Public administration (ie. government services)
- Education (ie.schools and universities)
- Health and social services (ie. social welfare and healthcare)



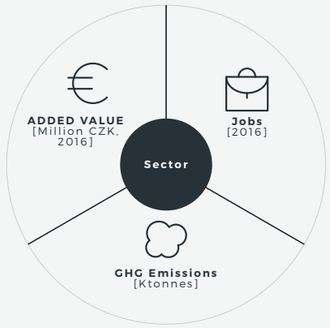

*The graphic above providse an overview of the 12 main sectors according to the 2008 SBI framework. The lines connecting the different sectors together are only indicative of relationships between sectors of the overall economy. The information presented in this graphic was collected from the Dutch central bureau for statistics (www.cbs.nl) 2018*

# ECONOMIC SECTORS OF PRAGUE: OVERVIEW

The overview on this page illustrates the relative economic performance of the 12 sectors discussed previously. The scoring of each sector's performance is based on three high level indicators: total employment in the sector, total gross added value (GVA) produced by the sector, and the total greenhouse gas emissions of the sector.

The three indicators are illustrated in a radial pie chart (see the legend below) and are made using data taken from 2016. The methodology and data sources for the indicators are described below:

**INDICATORS:**




**LEGEND**

## EMPLOYMENT:

Employment is calculated by measuring the total number of full-time equivalents per sector for the year 2016. Employment data was collected from Prague Statistical Office.[5]

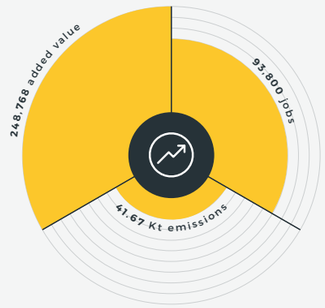
## GROSS VALUE ADDED:

Gross Value Added (GVA) is a common economic performance indicator and is measured in millions of Czech Koruna (CZK) for the year of 2016. GVA data was collected from Prague Statistical Office.[5]

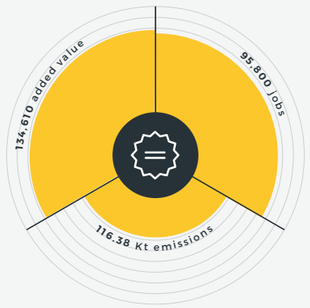
## GREENHOUSE GAS EMISSIONS:

Greenhouse gas emissions provide a rough estimate of the carbon intensity of each sector, and are measured in tonnes of CO2-equivalent. Emissions data was collected and aggregated for the year of 2015 from Eurostat.[6]

### COMMERCIAL SERVICES

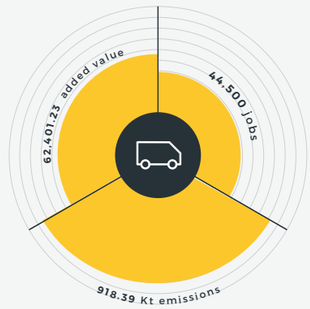



**INFORMATION AND FINANCIAL SERVICES**




**PROFESSIONAL, SCIENTIFIC, AND ADMINISTRATIVE SERVICES**


**TRADE**

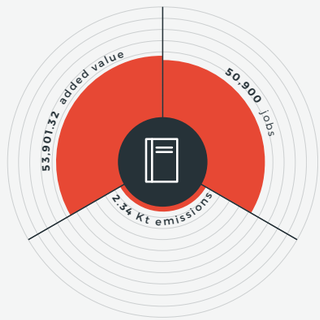



**TRANSPORT AND STORAGE**

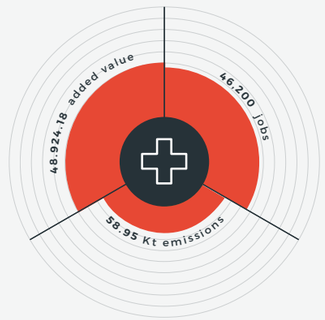
### PUBLIC SERVICES


**TOURISM**


**PUBLIC ADMINISTRATION**

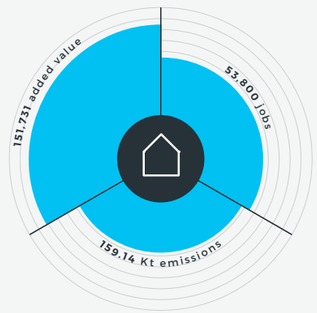



**EDUCATION**



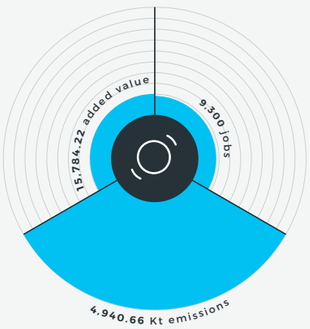

**HUMAN HEALTH AND SOCIAL SERVICES**

### INDUSTRY

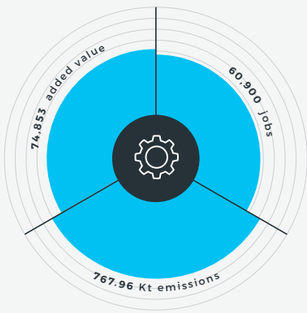



**CONSTRUCTION AND REAL ESTATE**


**AGRICULTURE, AND MATERIAL EXTRACTION**




**ENERGY, WATER, AND WASTE MANAGEMENT**



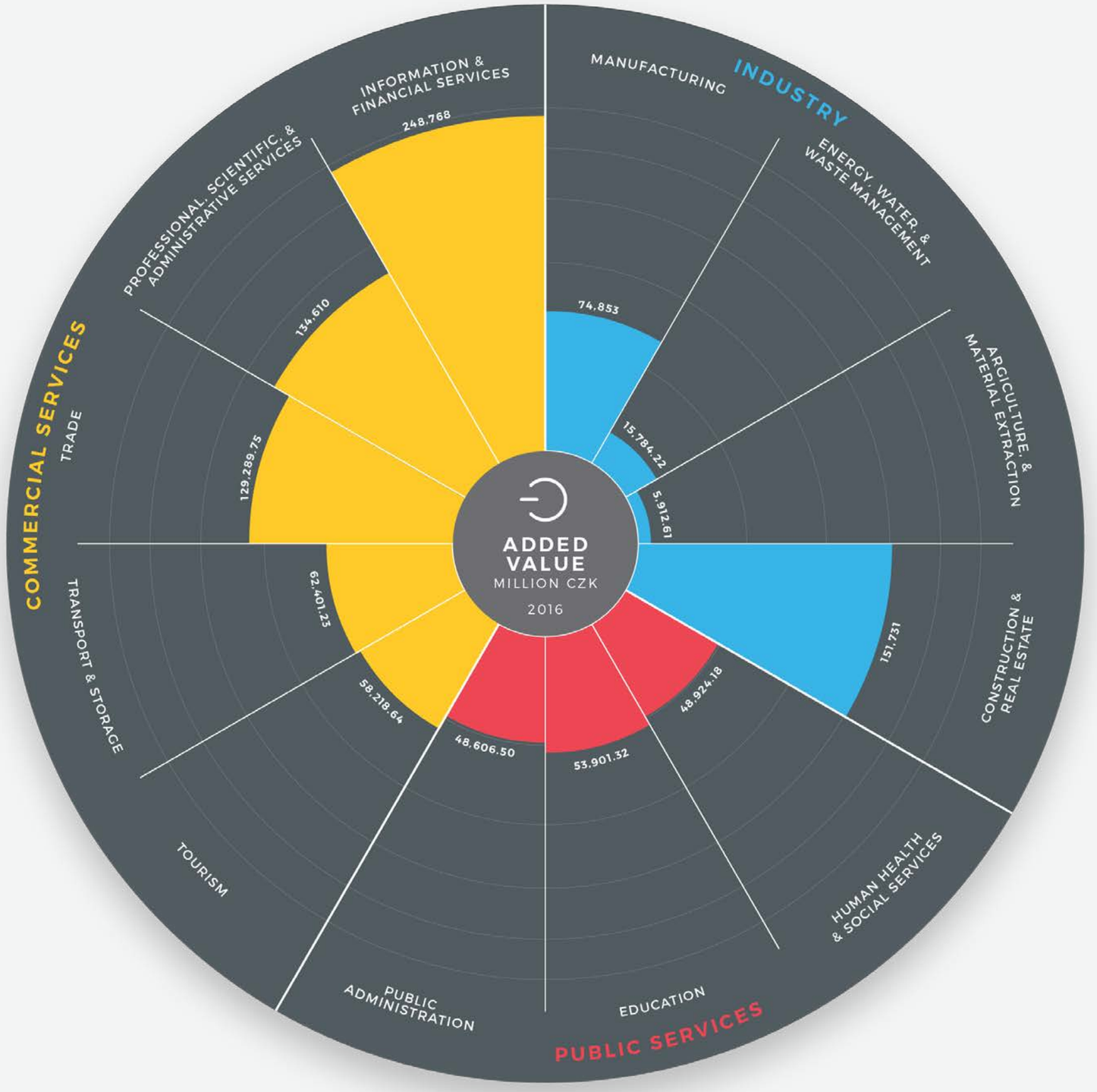

**MANUFACTURING**

# **ECONOMIC SECTORS OF PRAGUE:** GROSS VALUE ADDED

## HIGHEST VALUE ADDED SECTORS

The Knowledge & Information together with the Financial services are the most important economic sectors in Prague, producing about 250 billion CZK of added value in the year of 2016, which is about 25% of total GDP of the city. Construction and Real Estate sectors follow behind at 150 billion CZK for the same year.

Professional, Scientific and Administrative services provide the city with 135 billion CZK, and Retail and Trade contribute accordingly another 130 billion CZK per year.

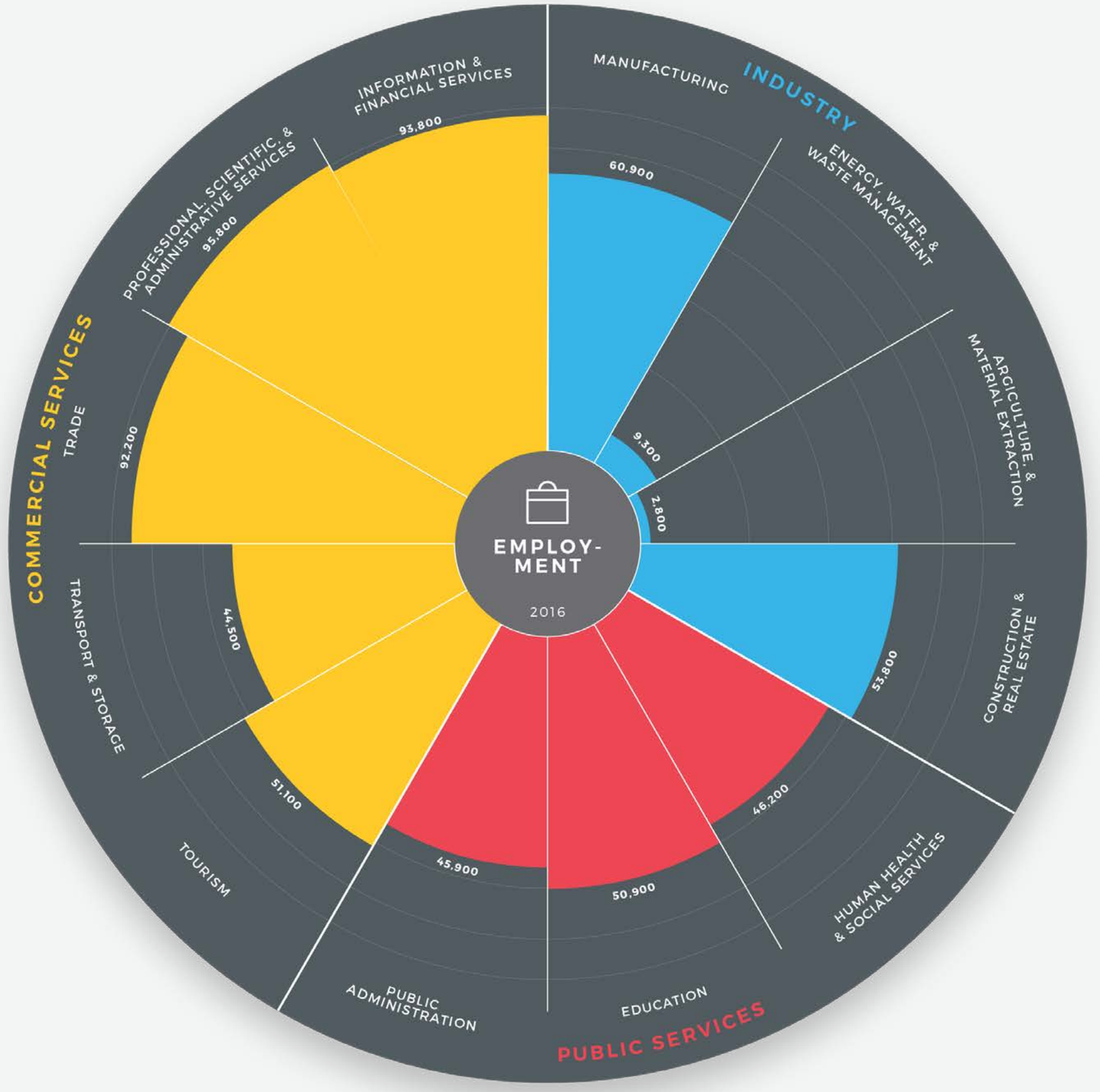


## HIGHEST EMPLOYMENT SECTORS

At first glance, the highest performing sectors in terms of employment are Professional, Scientific and Administrative Services, which provide employment to over 95.000 people, (15% of the city's total employment). The Knowledge & Information sector, together with the Financial services sector, provides another 15% of the city's total employment, proving the fact that Prague has shifted from an industry based-economy to a service-based economy.

The Retail & Trade sector occupies another 15% of the city's employment, and these three sectors, taken together, are responsible for almost half of the total working residents of the city.

The Manufacturing sector appears to employ the fourth largest share of people (approximately 60.000 people). It is important to note, though, that although the data represents a large share, it is highly likely that there are very few 'true manufacturing jobs' in Prague. This is because companies in the manufacturing sector have often their headquarters in Prague, and in that way they are classified within the city.



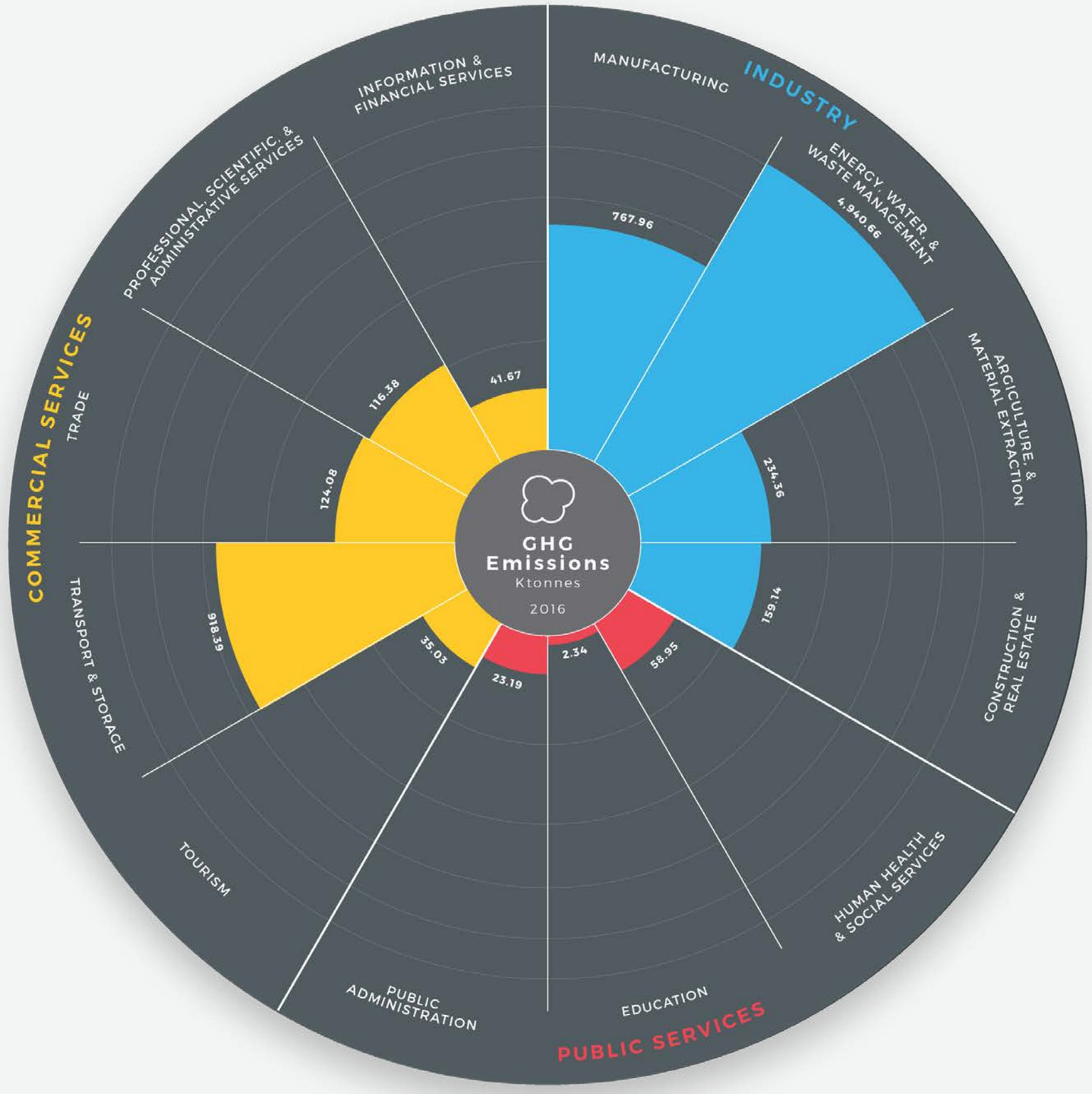
# HIGHEST EMITTING SECTORS

Prague has two sectors that stand well above the others in terms of GHG emissions* per year. These are: the Energy, Water, and Waste Management (Utilities) sector, and the Transport sector.

The Utilities sector produces almost 5.000.000 tonnes of GHG emissions per year, and it creates, by far, the largest impact in comparison to other sectors, which produce on average 100.000 tonnes. The large share of emissions attributed to the Utilities sector is not surprising, given the fact that the Czech Republic depends largely on fossil energy sources for generating electricity. The main source for electricity generation in the country is coal (66%), followed by nuclear power (30%), and the share of all energy from renewable energy sources is only less than 3.8%. Although energy sector emissions in the Czech Republic have significantly dropped since 1990, the energy sector remains one of the industries that most strongly impacts the environment, since as much as 66% of all greenhouse gas emissions come from stationary sources.

Here again, it should be noted that the data used to analyse emissions in Prague was national data extrapolated to the city level. Yet, the Utilities sector in Prague is not expected to be less emissions intensive, knowing that only 3.6 % of Prague's energy demand is covered by energy produced within the city and nearly the same value (3.5%) is the current amount of renewable energies in Prague.

The second most emitting sector in Prague is Transport & Storage. The most frequent particles in the emissions of Czech Republic are those of NO2 or particulates of PM10 or PM2.5. The main contributors of these particles are diesel vehicles, which are actually the majority of cars made in Czech Republic. Prague is one of the European cities whose commuters have very high car-dependency which, accordingly, contributes to very high emissions and air pollution produced by transport-related activities.




**The emissions data used to produce this graphic was taken from national level totals per industry and scaled down to "Basel-Stadt" using the fraction of Gross Value Added (GVA) of each sector in Basel divided by the total national GVA of Switzerland. We understand that this may not represent the most accurate city-level data, and we intend to refine this emissions data in the following phase of the Circle City Scan (Material flow analysis).*

# HOUSEHOLD EXPENDITURE

To get a clearer grasp on how the general public could be involved in shaping and implementing circular economy projects, it is important for us to look closer at households with Prague. Households allow us to have an understanding of the consumption of a city and how people live. A high-level analysis of households in Prague was conducted by examining their consumption patterns. In this graphic, data on the total household expenditure in Czech Republic (in CZK) across a full range of consumption categories is presented. National household expenditure is divided by the total households in Prague. While this doesn't produce a highly accurate picture of household consumption in Prague, it gives a first insight into the rough total expenditure and the main categories.

Total number of households in Prague

**589.371**

Average total household consumption

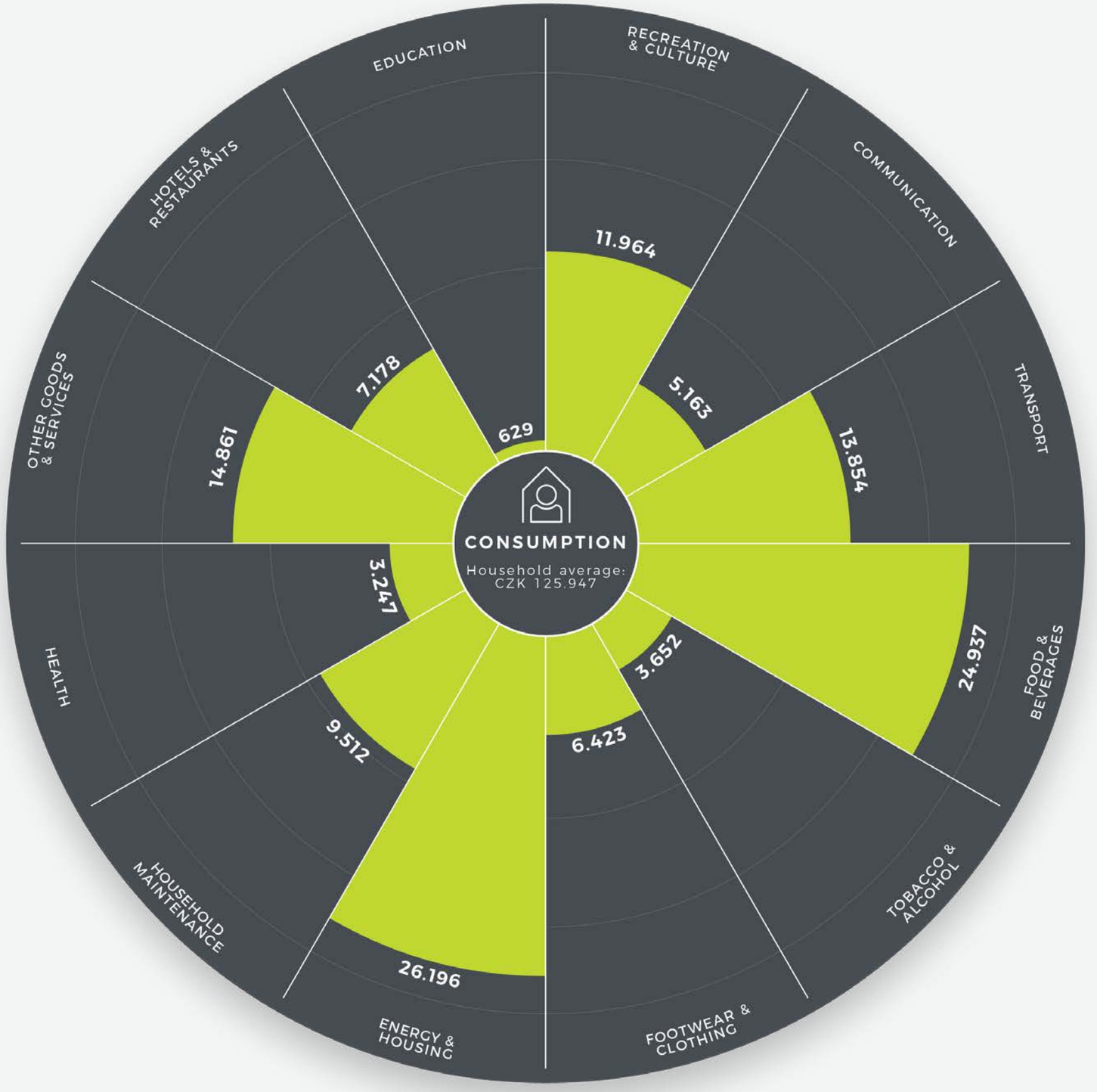
**125.947 CZK/year**

Largest expenses

**Housing & utilities: 21%**

**Food and drinks: 20%**

**Miscellaneous goods and services: 11%**




A household in Prague spends on average 125.947 CZK/year for all their needs. 21% of a household's total expenditure, which is about 26.000 CZK per year, is spent on housing, water, electricity, gas and other fuels. The high share spent on housing and utilities is a common trend among cities internationally. Another 20% of the total expenditures of a household in Prague goes to food and drinks, which is also similar to other cities. 11% is spent on miscellaneous goods and services, which actually includes personal care, personal effects, social protection, insurance and financial services.

# POLITICAL AGENDA OF PRAGUE: AMBITIONS

To understand where to gain the most traction with future circular economy projects in the city of Prague, it is important to build a good understanding of the local political agenda and strategic ambitions of the city. Policies and goals provide an outlook on the future of a city. Through a literature review, a list of political goals of the city of Prague, current efforts and measures that have been implemented, as well as different challenges that the city faces have been compiled. For each of these goals, measures, and challenges, specific sectors which could have the highest relevance have been identified.

Due to the large volume of relevant goals, only a set of aggregated "keywords" are presented that best reflect the main goals of the municipal and regional policy documents covered in the literature review. The presented list of keywords, therefore, does not reflect a comprehensive review, but are indicative of topics that are important for short- and medium-term socio-economic and sustainable developments of Prague:

## THRIVING CITY

Prague has expressed its ambition to further strengthen its political and economic importance, ensure a stable environment, guarantee excellent international accessibility, actively support its entrepreneurs, and strive to attract new investors.

## AUTHENTIC CITY

Prague has the ambition to be sought not only for the cultural tourism it offers, but also for its constant artistic and creative scene, and aims to boost its image as one of the most cultural cities in Europe.

## CIVIC SOCIETY

Prague is committed to engaging its residents more in decision-making processes and in the development of a shared vision for the city. Implementing participatory strategies is a priority for the city, which strives to create stronger local communities that can identify, plan, and implement projects of local importance themselves. The city is looking at opportunities to create community spaces, sports centres, and functional public spaces.

## SOCIAL COHESION

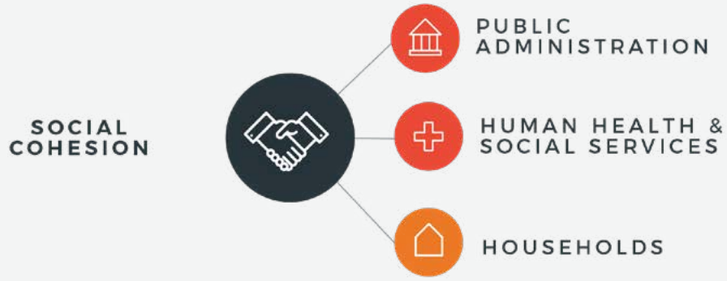
Prague aims to strengthen its social cohesion and be an intergenerational, international city, with housing and education available for everyone. The city wants to be accessible for everyone, eliminate physical barriers, and further include the senior citizens.

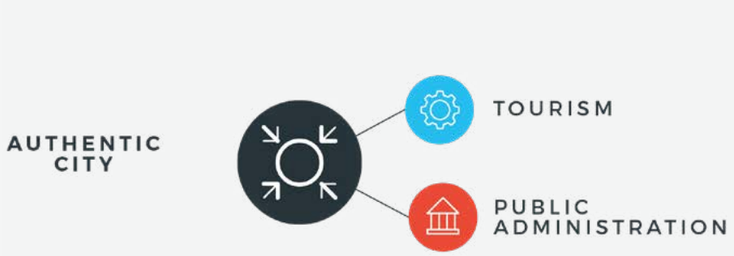
## BEAUTIFUL CITY

Prague's rich architecture is one of its strongest identity trademarks, and the city strives for maintaining and further improving the urban space. Compact building developments that allow also for the possibility of high-quality public spaces are considered, while at the same time strong priority has been given on environmentally friendly forms of transport.

## DIGITAL AND CREATIVE PRAGUE

Through a variety of initiatives and programs, Prague aims to promote smart solutions across the city. With a substantial growth of value added and employment in the ICT sector, the city has the vision of operating in the future as an IT Hub. Prague also explicitly aims to combine its smart agenda with its creative industries agenda.




# POLITICAL AGENDA OF PRAGUE: CURRENT EFFORTS

Prague has already identified a series of measures and strategic interventions that would contribute to its socio-economic and sustainable future development. On the attempt to align with the existing efforts of the city and integrate them to a comprehensive circular vision, some of the main strategic interventions that have been already considered are summarised.

## INNOVATION THINK TANK

Prague has set out a vision to be a centre of research, development and innovation and is already a member of the Innovation Network Morgenstadt ran by Fraunhofer Institute. The city's high concentration of research institutions, universities, and innovating firms has led to the idea of developing an innovation think tank, as well as an innovation district and the district of Zizkov or Holecovice are considered for this plan.

## 'SMARTIFICATION' OF HISTORICAL CENTER

Prague is also considering to work on the 'smartification' of its historical centre, which is an area receiving a vast amount of tourists currently, making the district sometimes dysfunctional. The city looks at the possibilities of using intelligent mobility strategies to improve the accessibility of the historical centre, provide better access for tourists, but also improving the quality of living of the local residents.

## ICT MANAGEMENT SYSTEM FOR CITY ADMINISTRATION

Prague has already demonstrated the will to take the necessary steps towards developing Smart Governance processes and creating an integrating management approach within the city. The city faces various challenges when it comes to strategies, projects, and measures that need to be handled in collaboration by several departments and offices, and smart management tools could play an important role on that.

## MULTIMODAL TRANSPORT APP

Prague aims to prioritize environmentally-friendly forms of transport, like walking, cycling, public transport, and shared mobility concepts, in order to reduce the car-dependency of its residents. The city envisions the development of a multimodal transport application that will connect the city's mobility hubs, including ticketing systems.

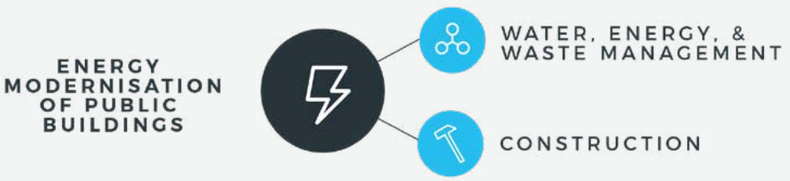
## ENERGY MODERNIZATION OF PUBLIC BUILDINGS

Prague has made efforts on improving the energy performance of its public buildings. The city looks for strategies to overcome the issues related to refurbishment of monumental buildings, and has already commenced a lighthouse project for the energetic refurbishment of a historical and iconic building: the National Theatre. Zelene Pamatky (Green Monuments) is another framework that the city has put into place and promotes the sustainable refurbishment and operation of important historic buildings.




## PRAGUE AS AN IT HUB

Prague aims to be a top destination for IT related services and software design. The IT field is already very vibrant, with many start-up companies and SMEs becoming successful. Prague would like to enforce this potential and offer the ground that will support the further development of the sector.


# POLITICAL AGENDA OF PRAGUE: CHALLENGES

Next to its dynamic development, the city of Prague also faces a series of challenges that either have not been fully addressed or have not been fully tackled:

## CONVENTIONAL MOBILITY

Prague is one of the European cities with very high car-dependency, and very low use of bicycles. The emissions also coming from the Transport sector are the second highest.

## UNSUSTAINABLE ENERGY SOURCES

Prague's high demand for energy and electricity is still covered by mostly fossil energy sources. On top of that, only 3.6% of Prague's energy demand is produced within the city and nearly the same value (3.5%) is the current amount of renewable energy production in Prague.

## ENERGY INEFFICIENT BUILDING STOCK

Prague still struggles with the modernisation of its building stock. Despite the existing efforts, the whole process is rather slow, due to issues of fragmented ownership and lack of a long-term strategy. Data about the energy performance of the city's building stock is also not available yet, and the city still needs to update the building code to match with the latest requirements about buildings energy performance.

## WEAK WATER MANAGEMENT

Prague lacks a strict legal framework to oblige water utility companies to apply technologies for wastewater purification. As a result, the increasing use of pesticides in agriculture leads to increasing water pollution. The city also has a relatively old water supply, and sewage systems, and is not resilient to flooding.

## LACK OF ORGANIC WASTE MANAGEMENT

One of the topics that the city has not managed to address yet is the management of organic waste. The city has already developed certain recycling strategies; however, organic waste management has not been tackled yet.

## MODERATE INNOVATOR

Despite Prague's large concentration of innovation firms, research institutes, and ICT services, the city is still considered as a relatively moderate innovator, with an innovation performance below the EU average. A lingering conservative mentality, and significant spatial distance from main technology hubs such as London, Berlin, Hamburg, etc. are considered to be notable reasons. Another barrier is posed by the rather weak co-operation between business and public research sectors.

# THREE PRIORITY AREAS OF PRAGUE

Prague is an ambitious city. Undergoing sizeable change since the 1990s from a industry-driven economy, towards a predominantly service-driven economy, the city has set ambitious goals to become an innovative, inclusive and inter-connected. Ultimately, there is great potential of the circular economy to help create a healthy, thriving, and competitive city.

Based on the socio-economic analysis of the city of Prague, the consortium of municipal representatives made a selection of three priority areas in which to pursue in the following phases of the Scan:

**Making the transition to a circular Prague is crucial in creating a competitive and sustainable city. Thanks to the Circle City Scan, we have been able to identify promising areas in the city for the circular economy, and practical opportunities to turn this into reality. It is great that the pilot projects such as the REUSE centres and using biowaste as fuel are moving forward thanks to this project.**

**Radim Polák**
Director of the Waste Management Department,
City of Prague

## CONSTRUCTION SECTOR

Building and Construction was recognised as an important sector where circular economy projects could have large impact. While employing 53.000 people, and contributing over 150 billion CZK into the city's economy, there is also a recognition towards the circular economy to alleviate a variety of urban challenges, from rising housing prices Prague and the need to provide affordable and sufficient housing, to the large number of vacant buildings (mostly office buildings) in the city center, as well as a lack of a management system for construction waste and material stock.

## HOUSEHOLDS

Households were identified as another priority area for Prague. Households are a good way to address the consumption patterns and behaviour. Particular interest was highlighted by the consortium in topics such as organic waste streams from households, local food production and consumption, citizen engagement and participation strategies, as well as sharing economy strategies.

## UTILITIES SECTOR

The sector of Utilities sector, with as selected as the third priority area, with a specific focus on the themes of Waste- and Wastewater Management. The activities of this sector are cross-cutting and have the ability to influence all sectors and activities throughout Prague. Currently, there are a number of distinct challenges within this sector, such as the lack of organic waste collection, and lagging wastewater management system that is prone to flooding throughout Prague. Although not explicitly pursued in the following phases of the Scan, a notable mention is made to the theme of energy.

# PHASES 2 & 3

## MATERIAL FLOW ANALYSIS, CIRCULAR STRATEGIES & ACTION PLANS



# **OVERVIEW:** PHASES 2 & 3

## MAPPING RESOURCE FLOWS THROUGH PRAGUE

A 'material flow analysis' was carried out to map how resources, such as water, energy, biomass, metals and minerals, flow through the city, as well as highlight the ways in which these streams are treated at the end of their lives: the metabolism of the city. This analysis was carried out for three priority areas identified in Phase 1. Developing a clear overview of resource flows in Prague provides a powerful understanding of the main sustainability impacts, consumers, and producers of waste. A full methodology for the material flow analysis can be found in Appendix I.

## IDENTIFYING CIRCULAR OPPORTUNITIES AND POTENTIAL STRATEGIES

From mapping the urban metabolism, it can be identified where the greatest leakages (challenges) and where the leverage points (opportunities) for a transition towards are located. Using these circular opportunities as a basis, potential circular strategies that can tangibly increase the circularity of the city are highlighted. In order to bring greater depth to each of the potential circular strategies identified, a high-level impact analysis is carried out that investigates three overarching impact areas; environmental impact potential, economic potential and feasibility. A full methodology for circular opportunities and potential strategies can be found in Appendix II.

## ACTION PLANNING CIRCULAR PILOTS

Based on the prioritisation of the circular strategies presented, the strategy with the greatest potential transformative potential for each of the three priority areas is selected in collaboration with the consortium of local stakeholders. Each of the circular strategies provides an explanation, showcases international best practices, and proposes a pilot project for Prague. This potential pilot is subsequently visualised, showcasing the necessary stakeholders, including their role, and expected benefits and investments. Finally, a detailed action plan is provided indicating the steps required for practical implementation. A full methodology for phase 3 of the Scan can be found in Appendix III.

## THE SECOND AND THIRD PHASES OF THIS REPORT IS STRUCTURED IN THE FOLLOWING WAY:

### CONSTRUCTION SECTOR



### HOUSEHOLDS



### UTILITIES SECTOR

# CONSTRUCTION



# **CONSTRUCTION SECTOR:** MATERIAL FLOW ANALYSIS

## SUMMARY

Prague's construction sector is one most resource intensive sectors of the economy, and, as such, holds huge transformative potential to help Prague transition towards a more circular economy. Despite an enormous flow of materials through the sector each year, there is a distinct lack of detailed data regarding material consumption of construction activities at the city level. Analysing data from a variety of sources, some key insights for Prague's construction sector can be highlighted:

## MAIN INSIGHTS

### More than 13 million tonnes of materials for construction activities are consumed each year

Minerals & chemicals make up the vast majority of the material profile of the sector (~97%), primarily composed of stones, concrete and asphalt, which are used in the construction of buildings and infrastructure.

### Construction and demolition activities make up ~65% of total waste generated in Prague

This makes the construction sector the largest producer of waste in the city, with total waste quantities in Prague tied to the construction activities of a given year. Over 90% of these wastes are mineral & chemical in nature, with excavation materials making up ~70% alone.

### Only 10% of material input are from secondary sources

About 1.200.000 tonnes of construction and demolition wastes are recycled each year. However, when it comes to material input, close to 90% of materials come from virgin sources, which have appreciably larger environmental footprints than secondary materials.

## METHODOLOGY

The following page presents the material flows from the construction sector in Prague. Below is described how to read the image.

Each material stream is represented by coloured lines. The colour of the line indicates the type of material, and the thickness of the line represents the quantity. For the material flow analysis, research has been done into energy, biomass, minerals & chemicals, and metals.

- Energy
- Biomass
- Minerals & Chemicals
- Metal
- Water
- Emissions

Waste processing has analysed in four scenarios: reuse, recycling (and material recovery), backfilling, and landfilling. Reuse is the most and landfill the least desired scenario.

- Reuse
- Recycling
- Backfilling
- Landfilling

Appendix I provides a further explanation of the material flow analysis methodology, and explains which materials products exactly fall under the six material streams, and what the end-of-life methods entail.


Input:
Water [m³]
Biomass [tonnes]
Minerals & chemicals [tonnes]
Metals [tonnes]
Energy [TJ]
97.300
13.037.000
189.300
2.300
4.107.500
30.700
59.600
700
4.170.000
31.100
60.600
700
4.759.000
35.500
69.100
800
CONSTRUCTION
Infrastructure
Non-residential buildings
Residential buildings
2.640.000
844.000
28.800
42.900
37.100
47.000
36.800
36.500
46.300
36.200
831.000
28.400
42.200
134.000
147.000
MIXED WASTE
90.000
115.000
116.000
42.300
53.700
42.000
963.000
32.900
48.900
Waste treatment [tonnes]
Recycling
1,117.000 tonnes
Other material recovery
93.900 tonnes
Backfill
1,019.000 tonnes
Landfill
306.500 tonnes
Other applications
454.900 tonnes
GHG emissions [tCO2eq]
Water & sewage [m³]
Output:
1 HIGHLIGHT
Mineral waste break-down into products
1 Circular opportunity: Increase use of secondary materials
2 Circular opportunity: Improve data on material in built environment
3 Circular opportunity: Circular construction & demolition criteria

# KEY FINDINGS

The summary of the Material Flow Analysis provided on this page highlights the insights on key material flows and significant impact areas of Prague's construction sector.

### Minerals & chemicals 97% of total material consumption

Minerals & chemicals make up, by far, the largest share of material inputs of Prague's construction sector. The more than 13 million tonnes consumed represents about 97% of the total material input of the sector. Primarily, this flow of material is comprised of stones, concrete and asphalt.[3] This dominance input of minerals & chemicals in Prague's construction sector is comparable to other European cities, such as Basel[4] and Amstelveen,[5] where ~95% of material consumption in the construction sector are minerals & chemicals.

### Over 90% materials consumed are from domestic sources

It is estimated that only 1-10% of the materials consumed in Prague's construction sector originate from imported sources.[3] The remaining share of the material inputs are sourced domestically.[1] As significant raw material deposits (of gravel, stone, and other construction materials) are located towards the East of the Czech Republic, the related transport activities increase the overall costs and environmental impacts of the materials.[1, 3] Therefore, there is an opportunity for the sector to reduce these associated environmental impacts through utilising the resources already present within the city.

### Minerals & chemicals are the single large waste stream

Minerals and chemicals also represent the single largest flow of waste generated from the sector, making up over 90% of the total waste generated by mass. Further detail to the composition of this dominant waste stream is provided on the following page (pp.22).

### Recycling is the most common method of waste treatment

Approximately 1.170.000 tonnes of waste materials generated from the sector are recycled. Compared to the total quantities of materials that are being consumed in the sector (input) (13.0323.600 tonnes), there is a large difference. Ultimately, only a small proportion (~10%) of the waste materials generated in the construction sector are from these secondary sources.[1] The majority of material inputs (90%) are from virgin sources, such as mining. Thus, increasing the share of secondary materials through the circular economy has a great potential to reduce the overall environmental impact of the sector.

### Majority of excavation materials are backfilled

Backfilling is the second most important method of waste management for construction and demolition wastes (1.019.000 tonnes). This practice of re-applying construction materials directly to the land, although not inherently damaging, limits the prioritisation of high-value and circular practices. Almost 90% of the material that is backfilled is soil and stones from excavation activities (900.000 tonnes), which can be utilised through circular strategies.

### Lack of data on materials within the building stock

It is important to note that, currently, there is no centralised database providing detailed data around the resources within the sector, such as the types and quantities of materials currently stored in Prague's building stock, or even material and waste. This, this lack of detailed data limits the ability of the sector to implement effective resource management practices. Therefore, reducing the large data and reporting gap that has been identified presents an opportunity to reduce the negative impacts associated with resource ineffective resource management.

# 1 HIGHLIGHT 1 - MINERAL & CHEMICALS WASTE PRODUCTS

Minerals and chemicals make up the vast majority (~90%) of the total wastes generated in Prague's construction sector. Yet, there are many different types of products and/or materials that make up this significant waste flow. Therefore, it is important to break-down this material flow in further detail.

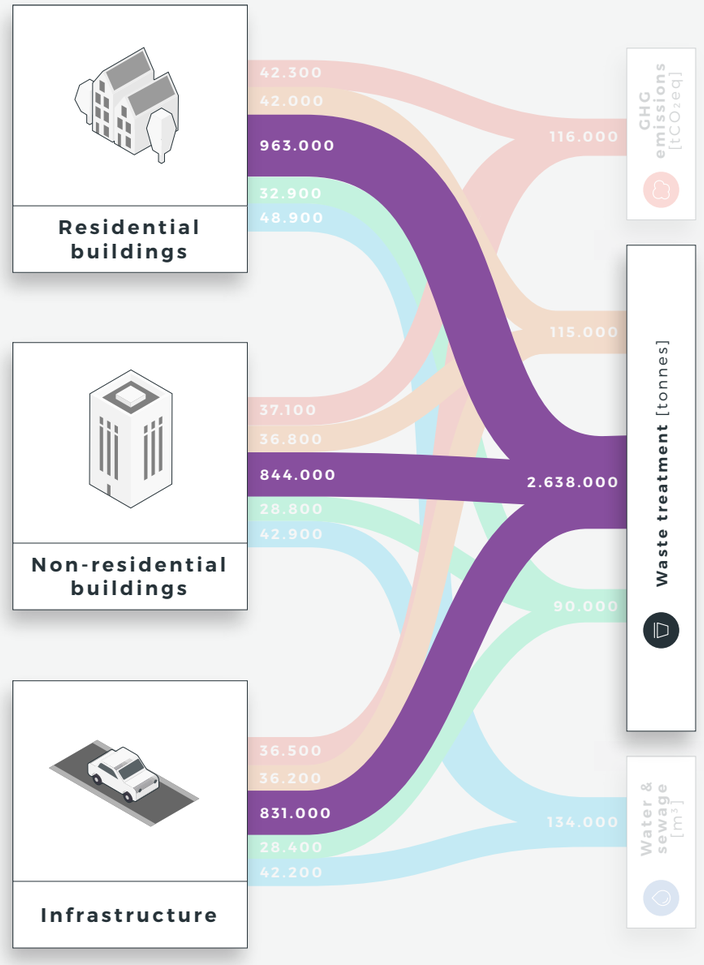
The diagram on this page presents a 'zoomed-in' and detailed look at the composition of the mineral and chemical wastes that are generated by Prague's construction and demolition activities.

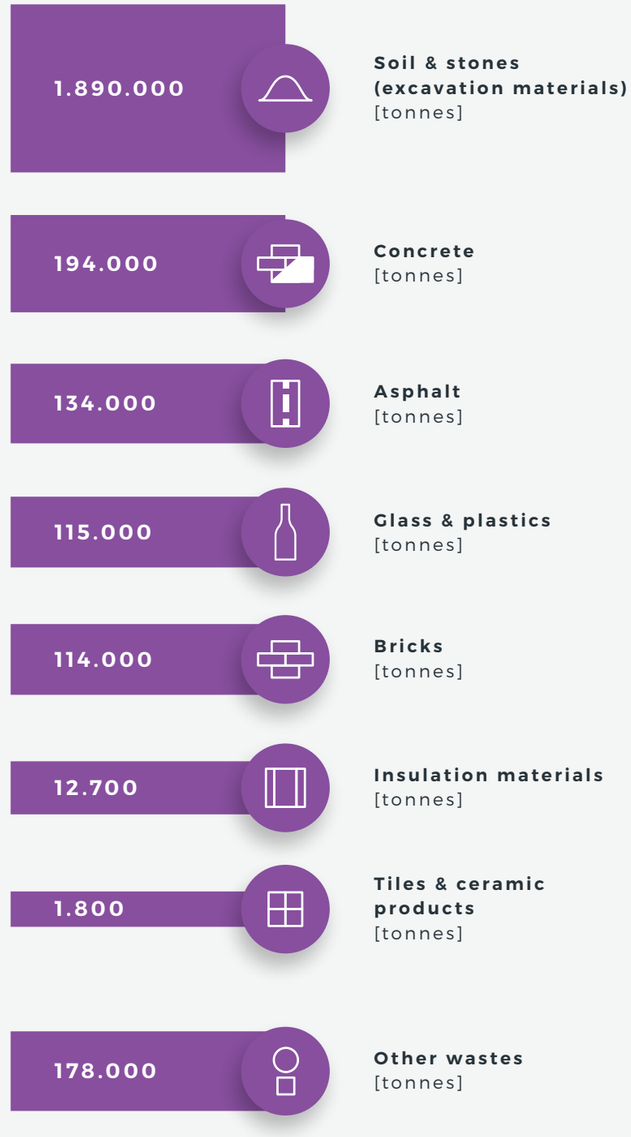
## Excavation materials are the largest waste stream and is backfilled

- By far the largest waste product comes in the form of soil and other excavation materials, such as stones (1.890.000 tonnes). These materials are related to new construction activities, where large quantities of soil and stones are removed from the ground to make way for the built environment. The largest share of this material (~900.000 tonnes) is backfilled and, thus, the potential value of the material is not captured.

## Waste concrete and other mineral waste used as crushed aggregate

- Concrete also comprises a large quantity of waste generated in the sector. At 194.000 tonnes, the sector generates almost twice the quantity of waste concrete than waste bricks (114.000 tonnes), and 1,5x greater than waste asphalt (134.000). Although it is challenging to produce fully recycled concrete, these construction materials can be used as aggregate input to reduce the overall costs, demand for, and impact of, raw construction materials.[2]




**PRODUCTS**

# **CONSTRUCTION SECTOR:** CIRCULAR OPPORTUNITIES AND POTENTIAL STRATEGIES

## CIRCULAR OPPORTUNITIES

Based on the insights from the material flow analysis of Prague's construction sector, three distinct opportunities to accelerate the circular economy in the city have been identified and pinpointed on the figure on the following page. The key opportunities for the construction sector are presented on the right of the page.

In the following pages potential circular strategies are presented for each of the three circular opportunities that can help the sector transition towards a more circular economy. For each opportunity, international best practices were analysed in relation to local activities identified through local roundtable discussions.

ENVIRONMENTAL IMPACT POTENTIAL:

The environmental impact potential explores the environmental benefits that each direction could generate. It is important to note that this evaluation is only completed to the extent that information was available, and was not intended to offer a quantitative assessment. Indicators include; waste reduction potential, emissions reduction potential, and raw material consumption reduction potential.

ECONOMIC POTENTIAL:

The economic potential for each direction was explored further to give insight into the approximate costs and economic benefits that could be expected from each direction. Indicators include; jobs creation potential, investment costs, and return on investment.

TECHNICAL FEASIBILITY:

Technical feasibility: It is important to understanding the overall feasibility to practically implement a pilot project of the circular strategy in Prague. This information is critical in identifying strategies that are likely to succeed in the near future. Indicators include; technology readiness level, legal barriers and institutional barriers.

### Increased use of secondary materials

In an ideal circular city, all materials consumed by the construction sector will originate from renewable and/ or reused/recycled sources with minimal environmental footprints.

Only ~10% of construction materials currently come from secondary sources,[1] with the remaining ~90% being primary raw materials, with significant environmental footprints.[2] Therefore, there is an opportunity for Prague's construction sector to increase the overall share of materials that are consumed from secondary sources to decrease the overall environmental footprint of the sector.

### Improve data on materials in the built environment

In an ideal circular city, all materials within the built environment will be monitored throughout their life-cycle, to enable effective end-of-life decision making to increase material circulation.

To date, there is a significant lack of a centralised database relating to materials flowing through, and stored within, Prague's built environment. There is a clear opportunity, therefore, to increase the quality and quantity of data regarding these materials in Prague's built environment to enable effective circular decision making and resource cycling.

### Circular construction and demolition criteria

In an ideal circular city, all construction and demolition activities within the city will adopt circular materials, technologies and designs to directly, and indirectly, close material loops.

In Prague's construction sector, only ~10% of all materials currently consumed are from secondary sources, and over 1.300.000 tonnes of residual materials are not utilised. There is a clear opportunity to develop and apply circular construction and demolition criteria to encourage the adoption of best circular practices throughout Prague's construction businesses.

# OPPORTUNITY 1
## Increased use of secondary construction materials

In an ideal circular city, all materials consumed by the construction sector will originate from renewable and/or reused/recycled sources with minimal environmental footprints.

Only ~10% of construction materials currently come from secondary sources,[1] with the remaining ~90% being primary raw materials, with significant environmental footprints.[2] Therefore, there is an opportunity for Prague's construction sector to increase the overall share of materials that are consumed from secondary sources to decrease the overall environmental footprint of the sector.

### 1. Online secondary materials marketplace

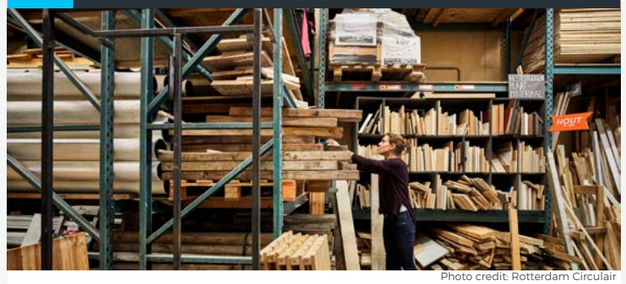


Photo credit: Rotterdam Circulair

An online marketplace for secondary materials provides an open-access platform to facilitate the growth of secondary materials market within the city by matching of supplies of residual material streams to the demand. This increased accessibility and information about secondary raw materials can increase the overall use of these materials in construction projects.

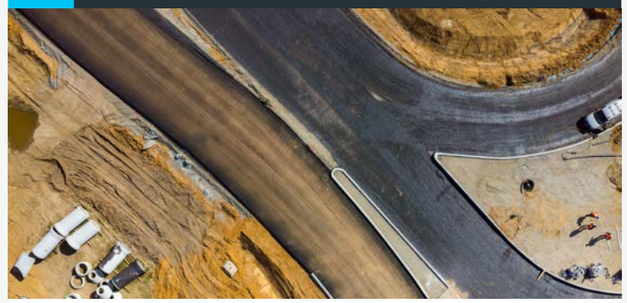
Case study: **Austin Materials Marketplace (US)**

### 2. Cycling sludge as construction material

Sludge generated in WWTPs holds attractive material properties and can be utilized as an alternative input for the manufacture of bricks. Clay and ceramic bricks can contain ~<25% sludge without substantial reduction in material strength.[6]

Case study: **ECOCERAMICA (EU)**

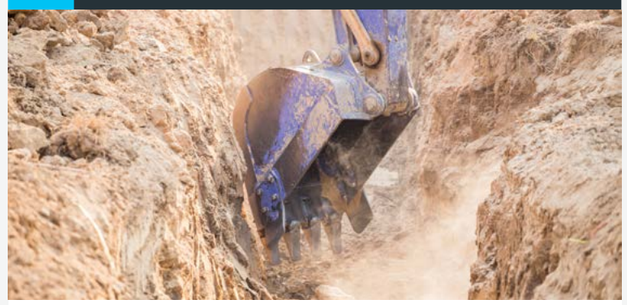
### 3. Cycling bottom-ash in road construction



Slag/bottom-ash generated from incineration activities can be used as an alternative raw material in construction projects, most notably road construction. It is possible to use a blend slag into aggregate for road infrastructure projects,[7] but regional legislation may restrict blend proportions.

Case study: **Harsco (SI)**

### 4. Cycling excavation material into construction material



Excavation materials (most commonly comprised of soil, stone and gravel) produced in the construction activities can present a potentially large source of raw materials. These residual flows can be remanufactured into bricks to be used again in new construction.

Case study: **The Boring Brick (US)**

# **CONSTRUCTION SECTOR:** CIRCULAR OPPORTUNITIES AND POTENTIAL STRATEGIES

## OPPORTUNITY 2
### Building stock materials database

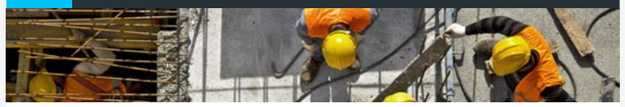
In an ideal circular city, all materials within the built environment will be monitored throughout their life-cycle, to enable effective end-of-life decision making to increase material circulation.

### 1. Building stock materials database

It is possible to a geological map of the city can showcase the presence and availability of certain metals (iron, copper and aluminium), with a focus on the built environment - Prague's 'Urban Mine'. With this information, strategies can be developed to further explore the possibility of most effectively extracting materials from this 'urban mine'.

Case study: **P.U.M.A. (NL)**

### 2. Material passports in construction projects



A materials passport makes it clear which materials have been used in a building and in what quantities. In addition, it contains information about the quality of the materials, the location and the financial and circular value. Such a digital platform can act as a public, online library of materials in the built environment to facilitate a greater understanding of materials used within Prague's construction sector as well as facilitate greater reuse of secondary materials.

Case study: **MADASTER (NL)**

## OPPORTUNITY 3
### Circular construction and demolition criteria

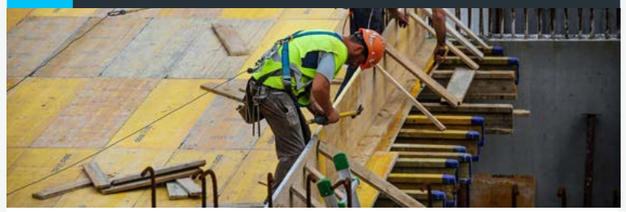
In an ideal circular city, all (de-)construction activities will adopt circular materials, technologies and designs to close material loops.

### 1. Circular tendering criteria in construction projects

Municipal government can influence the demand for circular design and construction practices through the incorporation of circular criteria in the tendering process. For example, these criteria could demand a minimum proportion of secondary materials in the project, or that the building is modular, or designed to be deconstructed.

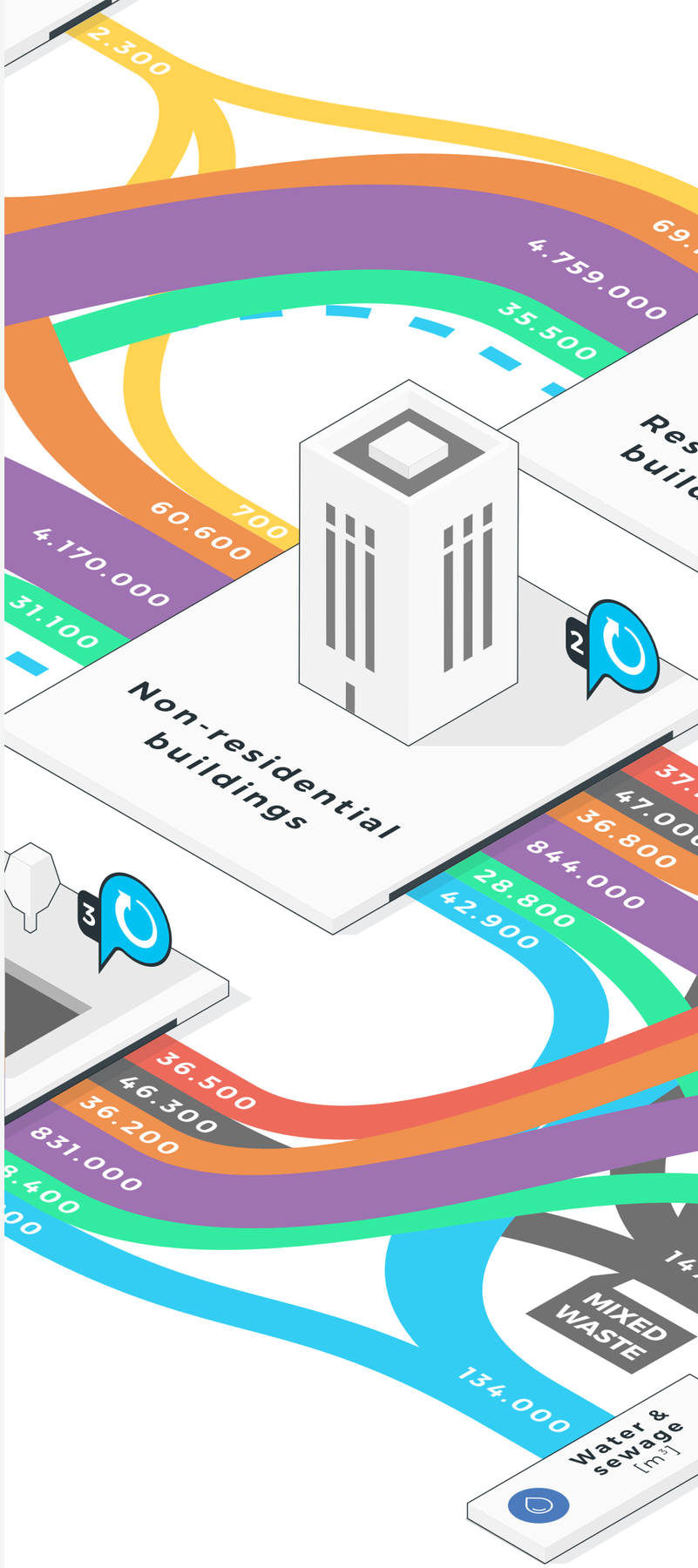
Case study: **Brummen Town Hall (NL)**

### 2. Circular (de-)construction practices



By dismantling existing buildings through more effective methods, such as the selective removal of structural components like window frames and doors, materials and components of old buildings can be maintained at higher values.

Case study: **BIG Reuse (US)**



# OVERVIEW

Based on the circular opportunities and potential strategies identified for Prague's construction sector, the consortium selected a particular potential circular strategy to be developed further.

## Circular construction and deconstruction criteria

The City of Prague could have a significant ability to influence activities in the construction sector through its enormous purchasing power; influencing ~24% of all (de-)construction activities in the city. At present, only 10% of materials consumed by the sector are from secondary sources. Through the incorporation of core principles of the circular economy into public tenders, the city could drive the market demand for circular products and promote new business models for companies working in the sector.

## Action planning a pilot for Prague

The chosen circular strategy was further developed in the third phase of the Circle City Scan. The following pages provide (i) A short overview of the circular strategy showcased with international best practices, and resulting pilot project, (ii) A visual strategy canvas which details roles, processes and stakeholder, and (iii) a detailed step-by-step action plan to take the pilot from conceptualisation to implementation.

# CIRCULAR STRATEGY

## Circular construction and deconstruction criteria

There is no 'one-size-fits-all' approach to the incorporation of circular criteria in public construction and deconstruction projects (circular public procurement). Each city will possess its own ambitions and priorities, and every project will present unique opportunities to close material cycles, and reduce the environmental impact of the sector.

## Reductions in Total Cost of Ownership, while boosting local innovation

Potential benefits of circular procurement are not just environmental, circular procurement can also bring savings to the Total Cost of Ownership (TCO) and -Use (TCU) of buildings and infrastructure, while also boosting innovation and the competitiveness of the local construction sector.

## Circular procurement as a means of meeting municipal targets

The decentralised nature of public procurement in the Czech Republic provides an opportunity for Prague to incorporate circularity into its procurement practices.[9] This has, until now, been largely been held back by a lack of awareness, motivation and clear responsibilities.[10] Although no specific targets for circular procurement have been set by the Municipal Tendering Department, circular procurement can play an important role in meeting existing targets of Prague's Waste Management Plan 2016-2025,[12] such as "Ensure[ing] mandatory use of recycling materials [...] in construction activities financed from public funds[...]" and "Increase[ing] by the year 2020, to at least 70% by weight, the rate of preparing for re-use and the rate of recycling of construction and demolition waste".

# A PILOT IN PRAGUE

As circular procurement is a new concept for the City of Prague, it is important not to immediately aim for 100% circular procurement, but to learn-by-doing; start with the 'low hanging fruit', give space to experiment, learn and iterate, and gradually establish best practices to scale-up.

## Start with renovation projects

Such 'low hanging fruit' in the construction sector can be found in renovation projects. These projects, be it the renovation of a wall, roof, floor or insulation, often involve manageable quantities of materials with a relatively short tendering cycle. The relatively low-risk profile of these projects lends themselves well to piloting, learning and iterating.[13]

## Piloting at Holešovická tržnice

A promising and tangible project in Prague that could apply circular tendering criteria could be the renovation of (hall 23 in) Holešovická tržnice, a historical, yet neglected, marketplace in Prague 7. Already scheduled for renovation, the halls in the marketplace require the refurbishment of roofs, floors, insulation, and windows - a promising elements to pilot circular criteria - to transform the location into a vibrant cultural and retail space.[14]

# KEY PERFORMANCE INDICATORS

Specific criteria can be incorporated into the construction tender to ensure that pilot projects can contribute to the larger goals of the city. The following criteria are developed based on the targets outlined in Prague's Waste Management Plan 2016-2025. However, it is important that the ultimate selection of criteria are aligned with the priorities of the City and local market conditions.

- **Theoretical reusability of materials or components:** This indicator evaluates the extent to which elements and materials can, theoretically, be reused and recovered with equivalent functionality at the end of their lifespan.[15]
- **Quantity of secondary materials used in construction project:** This indicator evaluates the quantity of secondary materials that are used in the construction of the building or infrastructure.[15]
- **Environmental impact of procured materials:** This indicator is able to evaluate various aspects of the environmental impact of the materials procured for construction, including greenhouse gas emission, and biodiversity loss.[15]

# INTERNATIONAL BEST PRACTICES

Circular Procurement is increasingly being adopted by cities throughout Europe, serving as inspiration and highlighting the potential benefits of circular procurement:

### Reused bricks in building renovation, Copenhagen (DK)

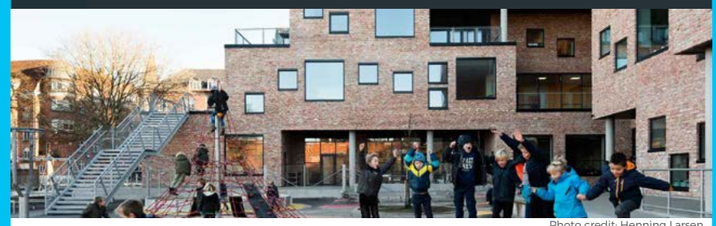
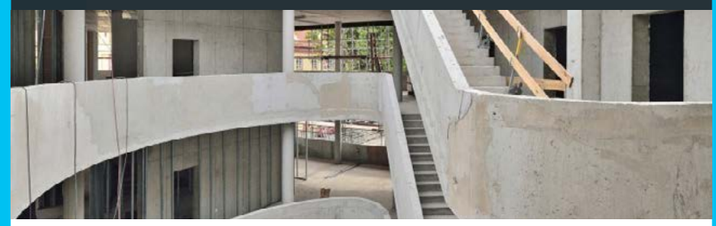


Photo credit: Henning Larsen

The City of Copenhagen explicitly required the use of reused bricks in the renovation of a school. The winning sourced bricks from the ongoing deconstruction of local hospitals, reducing the total cost of ownership over its life-time, while cutting 70 tonnes CO2 emissions.[16]

### Tender for recycled concrete, Berlin(DE)



To overcome the prejudices of, and stimulate market demand for, recycled concrete in construction, the State of Berlin clearly specified the use of recycled concrete in the construction of a new University building. The tender reduced 880m$^2$ of virgin materials, as well as 66% of energy demand.[18]

# **ACTION PLAN:** CIRCULAR TENDERING CRITERIA IN CONSTRUCTION PROJECTS

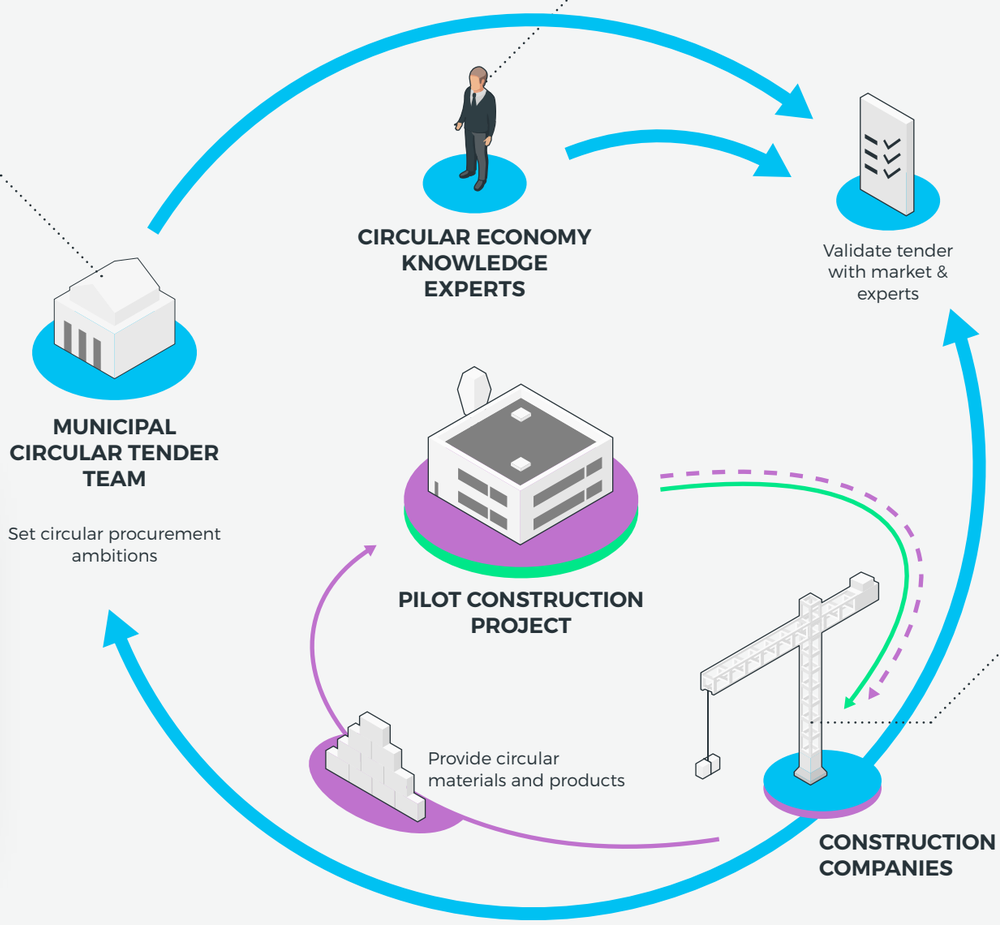
## Municipal circular tender team

**The Circular Tender Team are responsible for the creation of clear circular ambitions, criteria and ultimate tender, and selection of an appropriate pilot project.**

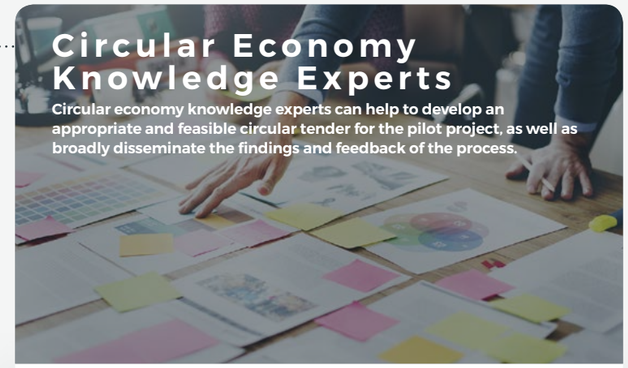
- Reduction in Total Cost of Ownership & Total Cost of Use
- Positive environmental impacts
- Stimulates innovation & competitiveness in construction sector
- Knowledge creation & skill development in circular procurement

- Leadership, internal coordination, and management support
- Market consultation
- Internal learning and innovation process

- The Circular Tender Team should be composed of representatives from local district departments of: Real estate, Sustainability, and Procurement; IPR; City Council




## Circular Economy Knowledge Experts



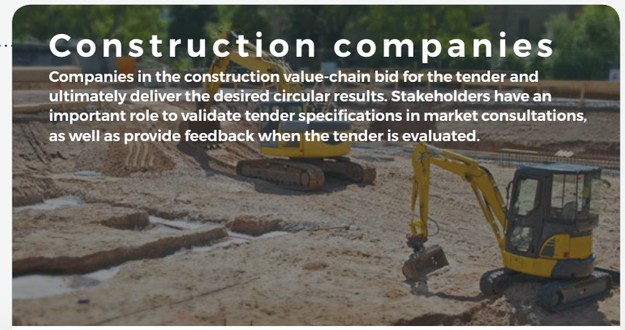
**Circular economy knowledge experts can help to develop an appropriate and feasible circular tender for the pilot project, as well as broadly disseminate the findings and feedback of the process.**

- Gained knowledge on the circular economy in the construction sector
- Access to a network of circular stakeholders, both within the Municipality of Prague, and the Construction sector.

- Time to partake in market roundtables

- UCEEB, INCIEN, Ministry of Labour and Social Affairs

## Construction companies



**Companies in the construction value-chain bid for the tender and ultimately deliver the desired circular results. Stakeholders have an important role to validate tender specifications in market consultations, as well as provide feedback when the tender is evaluated.**

- Gained knowledge and experience in working with circular materials and business models.
- Access to a network of circular construction stakeholders
- Competitiveness and innovation through experience with working with circular products, materials and business models.

- Time to both partake in market roundtables as well as write a proposal for the tender
- Expertise and skills to provide circular products and materials

- Skanska, Sekyra Group, Metrostav, AZS 98, ERC TECH, Czech Chamber of Architects

**BENEFITS**
**INVESTMENTS**
**LOCAL STAKEHOLDER**

**KNOWLEDGE & INFORMATION**
**MATERIALS**
**MONEY**

## Scoping circular ambition phase

### 1 Kick-off and set circular ambitions

Formulate the ambitions for a circular tender. Make sure to take into account the objectives of the municipal department and broader municipal objectives and be as specific as possible.

**Stakeholders:** Municipal Circular Tender Team

**Outcomes of this phase:**

- ☑ Defined specific need for the tender.
- ☑ Defined the ambitions and impact priorities of the circular tender

## Internal and external engagement phase

### 2 Establish Circular Tender Team

Create a tender team that will develop the circular tender, involving all relevant municipal departments. Internal collaboration between various departments is important, as there are often separate budgets for the construction, maintenance and end-of-life of a project. Align on shared circular ambitions and possibilities and identify a promising pilot for circular tendering.

**Stakeholders:** Municipal Circular Tender Team

### 3 Market engagement and validation of circular tender

Organise market consultations with relevant construction companies (such as materials suppliers, developers, and architects) to present the ambitions, needs and specifications of the pilot project. Validate the feasibility and opportunities of circular materials and business models to ensure that the tender criteria can be fulfilled. Any unforeseen risks in the circular tendering process can also be voiced.

**Stakeholders:** All

**Outcomes of this phase:**

- ☑ Creation of Circular tender team who are responsible for the development of a circular tender.
- ☑ Internal alignment between relevant municipal departments on vision, ambitions and potential for circular procurement.
- ☑ Fully scoped a potential pilot for circular tendering
- ☑ Validated circular tender criteria with local stakeholders
- ☑ Developed a detailed business case for your circular procurement proposal

## Specification and tendering phase

### 4 Develop specification and awarding criteria

Translate circular ambitions into assessment criteria for the selected circular construction tender keeping in mind the outcomes of market validation. Be sure to acknowledge the specific context and possibilities and needs of each project. Keep in mind the full lifecycle of the project, from design, construction, use and deconstruction, and ensure KPIs are embedded within the contract.

**Stakeholders:** All

**Tip**: Functional, rather than technical, assessment criteria can stimulate innovation in the market to fulfil the required needs.

### 5 Publish and evaluate tender

Publish the tender with explicit circular evaluation criteria. Evaluate the tender based on the pre-defined circular criteria.

**Stakeholders:** Circular Tender Team

**Outcomes of this phase:**

- ☑ Developed a detailed specification document for your circular procurement proposal, with clarity and transparency on how the tender will be evaluated
- ☑ Tendered, evaluated and awarded the contract of the pilot project

## In-use phase

### 6 In-use contract management

Monitor the contract against KPIs that have been embedded into the contract. Ongoing improvement throughout the contract can be achieved by building requirements into the contract and managing the contract appropriately once awarded.

**Stakeholders:** Circular Tender Team, Construction companies

### 7 Evaluate process and share experiences

Evaluate the performance of the pilot project. Were the intended circular ambitions, criteria and outcomes able to be met? What were the (dis)advantages of circular procurement? Think about how this process can be streamlined and scaled in the future. Be sure to consolidate these learnings and share with all relevant stakeholders, but between other municipal departments, as well as externally.

**Stakeholders:** All

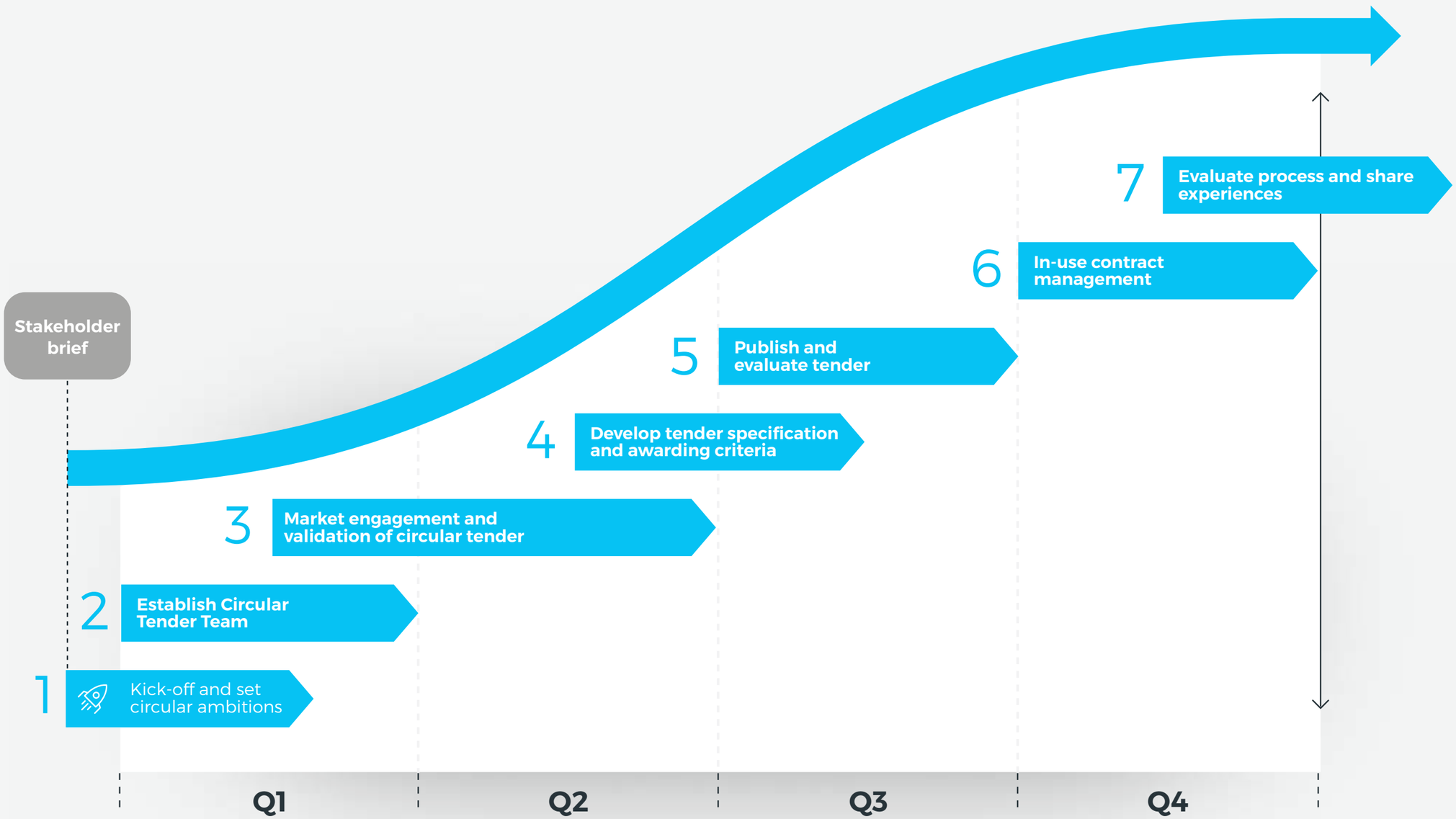
**Outcomes of this phase:**

- ☑ Understood the costs, benefits and risks of alternatives to linear procurement
- ☑ Understood the potential to roll-out, replicate and scale-up
- ☑ Disseminated learnings throughout other municipal departments

### ▲ Scale-up

Circular tendering has a great potential to be scaled to all public construction projects throughout Prague's districts. Use the lessons-learnt from the pilot project to create a circular tendering process document, and begin applying circular tendering criteria to all renovation projects in the city. Make sure to continually monitor and evaluate to build upon the successes and lessons-learnt, and establish a concrete case of the benefits. Once a refined process has been established and documented, start developing and applying circular criteria to the procurement of all public construction projects in Prague.

# ACTION PLAN: CIRCULAR TENDERING CRITERIA IN CONSTRUCTION PROJECTS



# HOUSEHOLDS



# HOUSEHOLDS: MATERIAL FLOW ANALYSIS

## SUMMARY

Households have a crucial role to play in the transition towards a more circular economy. The day-to-day activities and decisions of households in Prague have the ability to influence the overall sustainability of the city. Through the analysis of households consumption and waste data from a variety of sources, some key material flow insights can be identified:

## MAIN INSIGHTS

### Prague's households consume more than 950.000 tonnes of food each year

Biomass represents the single largest flow of materials that are consumed by households each year, making up approximately two-third of total material consumption. Of this, food and beverages correspond to ~90%, and represent a huge potential to reduce the embodied environmental impacts of households, particularly in meat and dairy consumption.

### The majority of household waste is collected via mixed systems

Approximately 65% of household waste is collected through mixed systems. These mixed steam collection systems contaminate the various material streams, ultimately limiting their high-value cycling opportunities. Notably, there are no large scale separate schemes for household biomass waste.

### More than half of households wastes are burned for energy

Over 240.000 tonnes of household wastes are burned at the end of their life, with the vast majority of these activities also recovering energy from the process. This is related to the large quantities of wastes that are collected via mixed systems, and often does not represent the highest value options available.

## METHODOLOGY

The following page presents the material flows through households in Prague. Below is described how to read the figure.

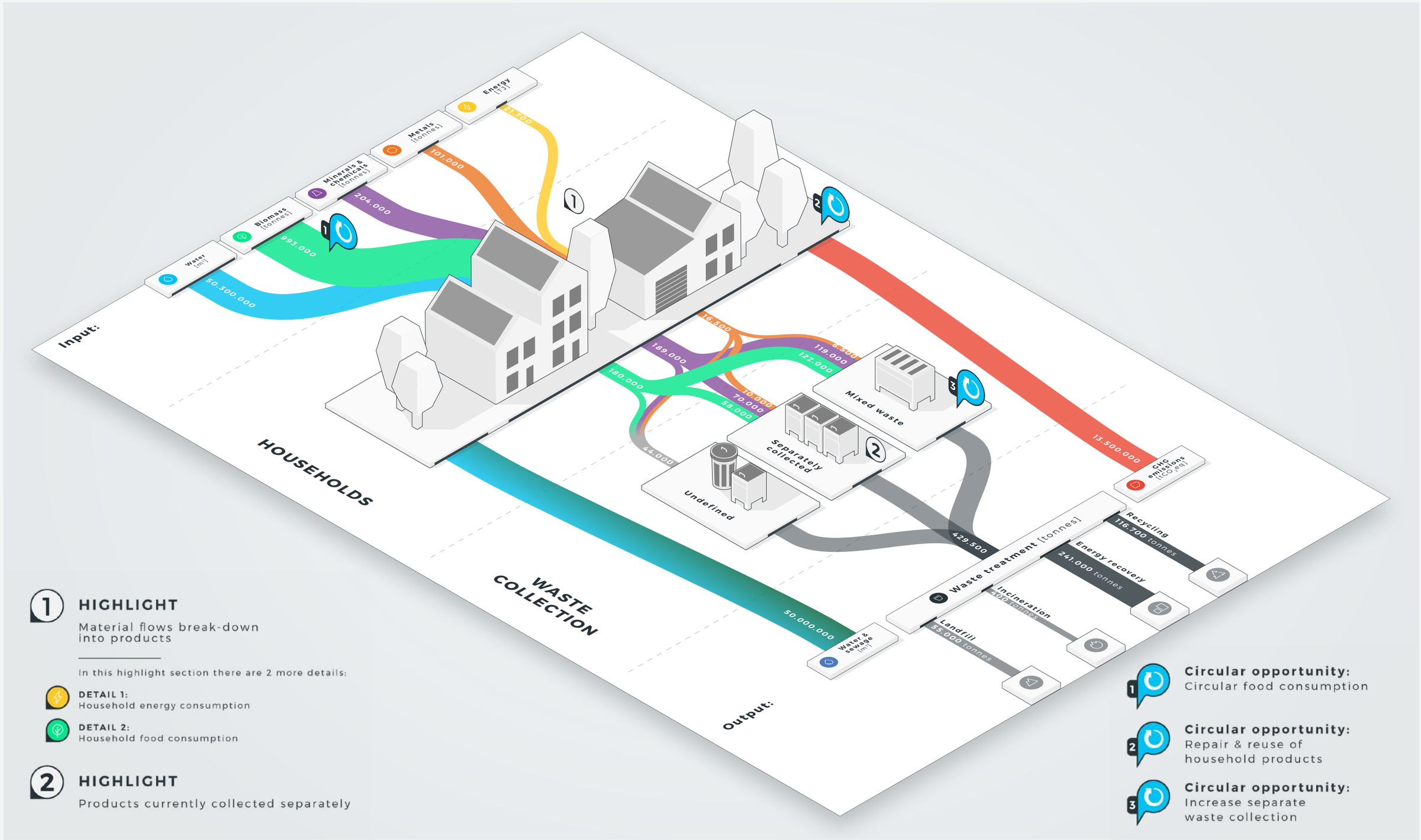
Each material stream is represented by coloured lines. The colour of the line indicates the type of material, and the thickness of the line represents the quantity. For the material flow analysis, research has been done into energy, biomass, minerals & chemicals, and metals.

- Energy
- Biomass
- Minerals & Chemicals
- Metal
- Water
- Emissions

Waste processing has analysed in five scenarios: reuse, recycling, energy recovery, incineration and landfilling. Reuse is the most and landfill the least desired scenario.

- Reuse
- Recycling
- Energy recovery
- Incineration
- Landfilling

Appendix I provides a further explanation of the material flow analysis methodology, and explains which materials products exactly fall under the six material streams, and what the end-of-life methods entail.




1 **HIGHLIGHT**

Material flows break-down into products

In this highlight section there are 2 more details:

**DETAIL 1:**
Household energy consumption

**DETAIL 2:**
Household food consumption

2 **HIGHLIGHT**

Products currently collected separately

1 **Circular opportunity:**
Circular food consumption

2 **Circular opportunity:**
Repair & reuse of household products

3 **Circular opportunity:**
Increase separate waste collection

# KEY FINDINGS

The summary of the analysis provided on this page highlights key material flows and significant impact areas on the Households sector*.

### 1,3 million tonnes of materials are consumed to meet the needs of households

Households in Prague consume a total of 1.298.000 tonnes of materials, 21.700 TJ of energy and 50.300.000m³ of water to fulfil a variety of needs. The following section provides greater detail on the types of products that are consumed (pp. 35).

### Biomass is the single largest flow of materials into Prague's households.

Biomass is the single largest flow of materials into Prague households. The 993.000 tonnes represent ~75% of total material consumption of households. Food and beverages make up ~95% of this input (see pp.37 for further information). This large share is unsurprising and observed in other European cities, such as Basel.[2]

### Large quantities of biomass are consumed by households, and flow out through sewerage

Quantities of solid biomass input (993.000 tonnes) are substantially greater than the quantities of biomass flowing out of Prague's households (180.000 tonnes). As food and beverages make up the majority of this input, this is unsurprising, as these resources are consumed for sustenance. Some of this biomass does, however, flow out of households in the form of nutrients in the 49.850.000m³ of wastewater.

### Prague's households produce relatively low quantities of waste per capita

Looking at the generation of waste, Prague's households produce an average of ~305 kg/year per capita. However, compared to other European countries, such as UK (494 kg/yr), Germany (614 kg/yr), or Switzerland (712 kg/yr), this per capita generation of municipal solid waste is relatively low.[3] Of this total, approximately 307.000 tonnes are consumer goods (non-food products).

### Majority of household wastes are collected through mixed collection

Prague's household wastes are collected via different methods. Of the total 429.500 tonnes of waste that is generated in the households of Prague, the greatest share (65%) is collected via mixed collection, while ~35% are separately collected. Critically, the collection of municipal wastes through mixed collection contaminates the quality of residual streams, and reduces the potential value recoverable from the stream.[4] More information on the methods of separately collected wastes is provided in Highlight 2 (pp.35).

### Majority of household wastes are burned for energy

Approximately 240.000 tonnes of household waste is processed by means of energy recovery, representing the most common waste management activity for the municipal solid waste of the city (~56%). This relates to the large shares of mixed wastes that are collected, and subsequently burned. In Prague, ZEVO Malešice is the main waste-to-energy facility and processes just over 200.000 tonnes of waste each year.[5]

* Importantly, the scope of this analysis has been defined as the resources consumed within the 'four walls' of a house. For example, the body of a car is considered, however, the fuel required to run the vehicle is considered outside of the 'four walls' and outside of the scope.

# 1 Highlight 1

## Material flow breakdown into products

The figure presented on this page further breaks down the materials consumed by households into product categories.*

### Households in Prague consume ~20.000 Olympic swimming pools worth of water

- Households in Prague consume a total of 50.300.000m³ each year, the equivalent to ~20.000 Olympic-sized swimming pools. Per capita, this relates to ~39m³/person/year - similar to the Czech average (33m³/person/year), yet, lower than Amsterdam households (50m³/person/year).[6]

### As well as 3,5 million barrels of oil-equ.

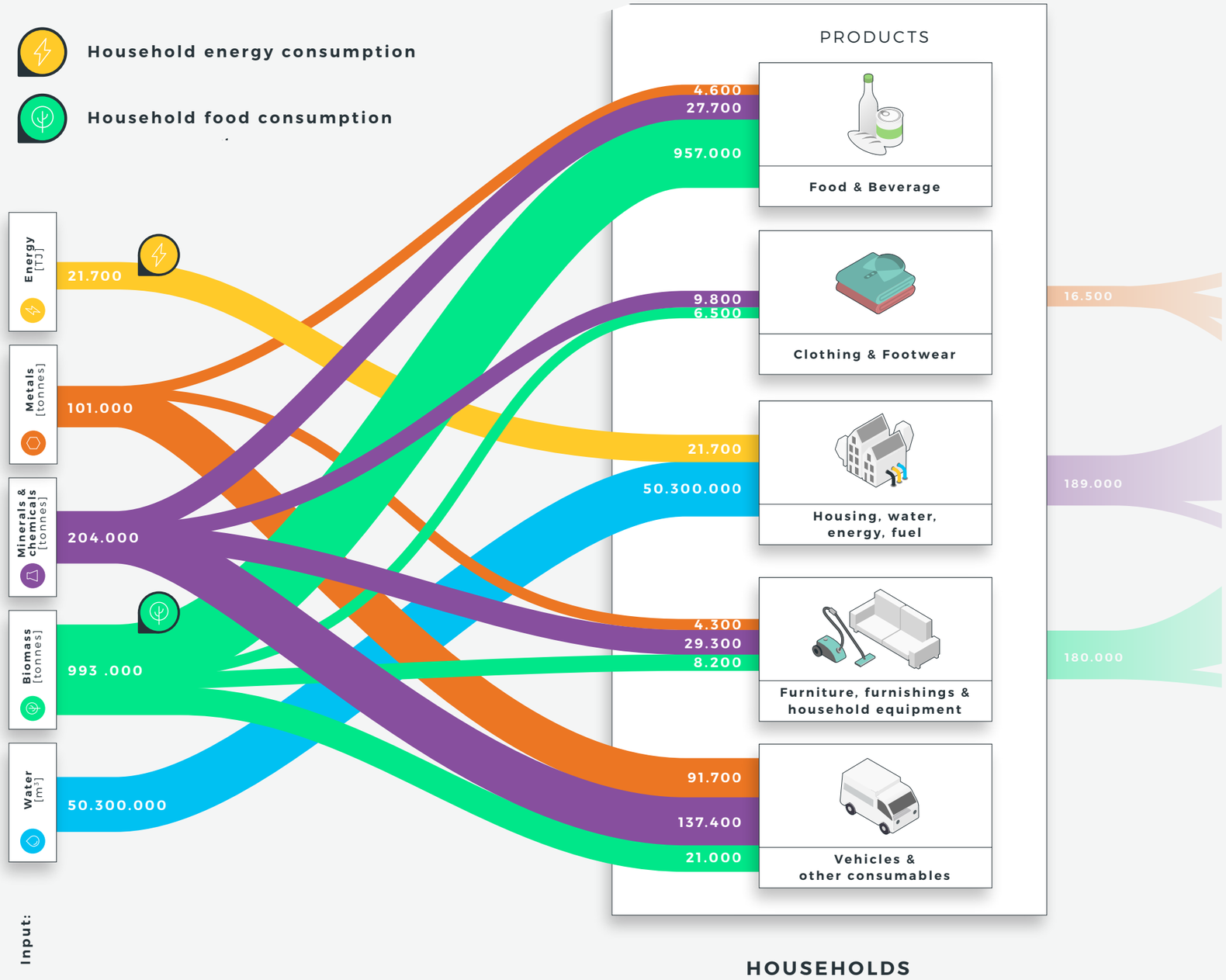
- Households in Prague consume a total of 21.700TJ energy each year, equivalent to 3,5 million barrels of oil. 5.000TJ of which is in the form of electricity, with the remaining 16.700TJ coming from fossil fuels. Detail 1 provides further detail as to the type of energy consumed for particular household activities (pp.36).

### Biomass makes up the largest materials consumed

- Biomass represents the largest material category consumed by households in Prague, accounting for ~75% of total material consumption (993.000 tonnes). Of this biomass, over 95% relates to food and beverages (957.000 tonnes). Further detail as to the types of food and beverages consumed by Prague households is provided on page 37.

### Over 300.000 tonnes of metals and minerals & chemicals consumed by furniture, vehicles and other consumables

- Furniture, household equipment, vehicles and other consumables**, together, are responsible for approximately 95% and 80%, respectively, of the total input of metals and minerals & chemicals by households, respectively.




* The consumption product categories follow the COICOP classification. 'Vehicles and other consumables" aggregate COICOP categories 6-10

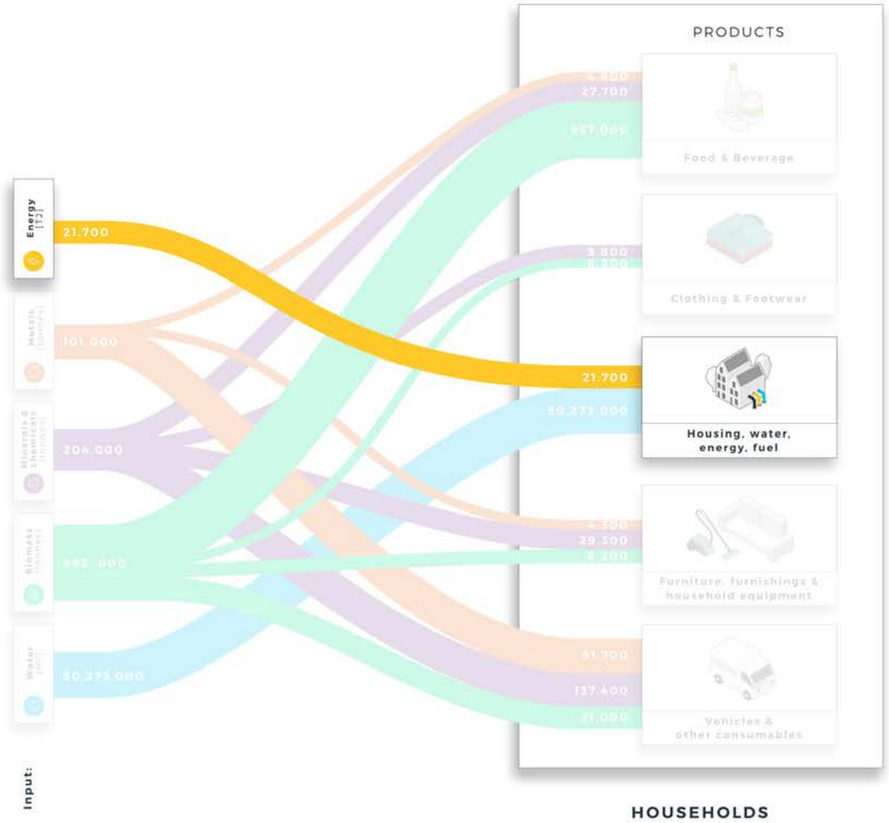
** Such as recreational equipment, cosmetics and reading materials

# Highlight 1 - Detail 1 - Energy consumption

In total, households consume a total of 21.700 TJ energy each year. Different sources of energy are used for a range of activities. The figure on this page showcases the main type of energy consumed for a particular purpose in households.

## Fossil fuels are still an important energy source for households

- The main source of energy for the heating of buildings is primarily supplied by natural gas (27%) and energy from incineration (i.e. the burning of solid fuels such as wood) (36%). Natural gas also makes up an important energy source for the heating of water (40%), with purchased heat (i.e.district heating networks) making up the second largest proportion (32%). For cooking, natural gas and electricity are the two dominant sources of energy, supplying 51% and 44% respectively.




### SPACE HEATING

| | |
|---|---|
| Electricity | 4% |
| Natural gas | 27% |
| Purchased heat | 13% |
| Fuels | 20% |
| Energy from incineration | 36% |

### WATER HEATING

| | |
|---|---|
| Electricity | 21% |
| Natural gas | 40% |
| Purchased heat | 32% |
| Fuels | 3% |
| Energy from incineration | 5% |

### COOKING

| | |
|---|---|
| Electricity | 44% |
| Natural gas | 51% |
| Purchased heat | 0% |
| Fuels | 3% |
| Energy from incineration | 2% |

### LIGHTING & ELECTRICAL APPLIANCES

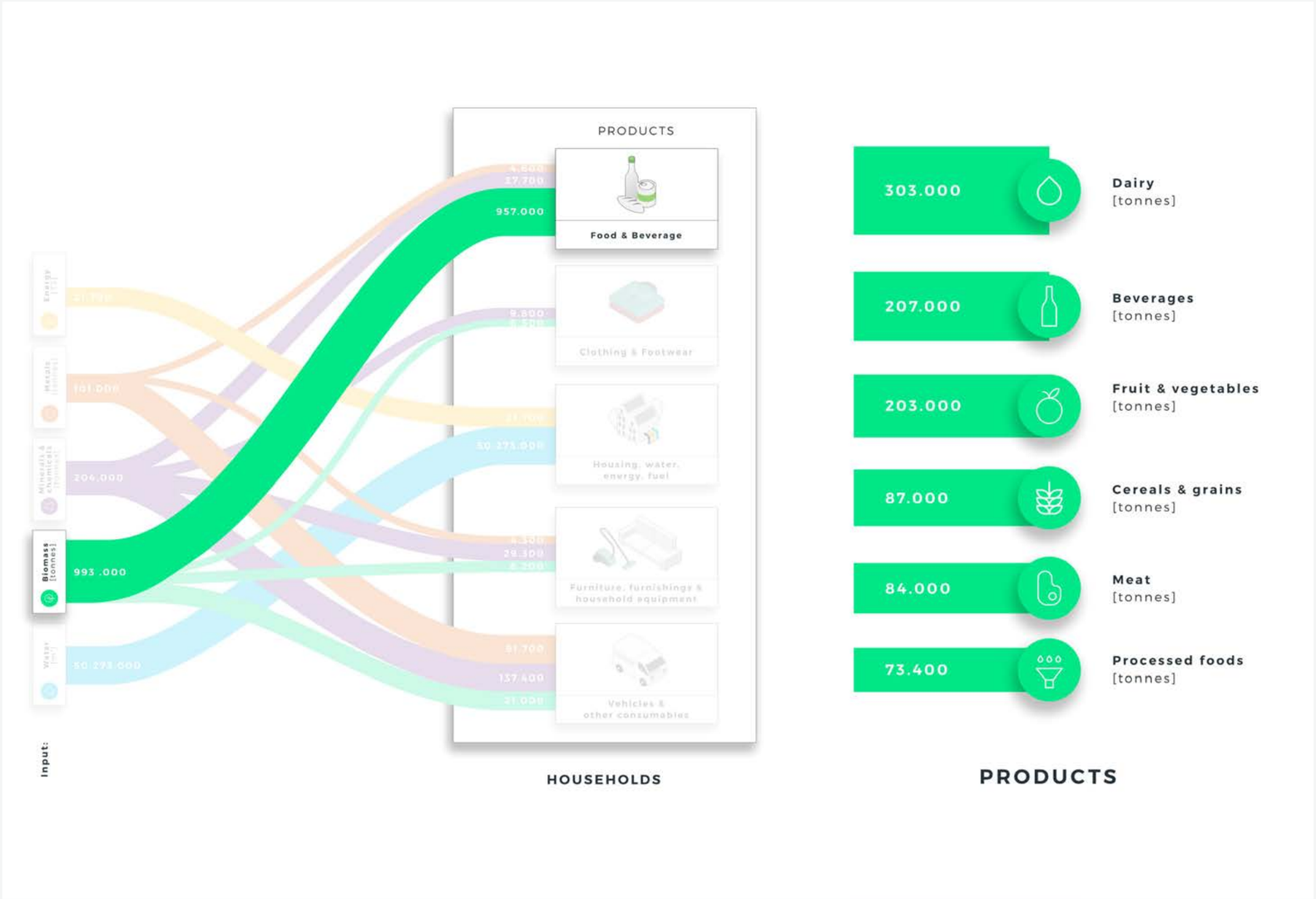
| | |
|---|---|
| Electricity | 100% |
| Natural gas | 0% |
| Purchased heat | 0% |
| Fuels | 0% |
| Energy from incineration | 0% |

# Highlight 1 - Detail 2 - Food consumption

In total, households in Prague consume ~993.000 tonnes of food and beverages each year, constituting the single largest material flow input into households. The figure presented on this page further details the consumption of different types of food in the diet of households.

## Food is the largest material input of household, and holds many embodied impacts

- The largest food category consumed by households, by mass, is Dairy, at 303.000 tonnes. This high dairy consumption matches with other European cities, such as Basel.[2] In terms of meat, total quantities of consumption are considerably lower than fruit, vegetables, beverages and dairy products, at around 84.000 tonnes. Nevertheless, meat products possess high embodied environmental impacts, such as greenhouse gas emissions.[8] Prague has an average per capita consumption of meat at ~65kg/person/year,[7] when compared to the EU average of 69kg/person/year.



# 2 Highlight 2 - Products currently collected separately

In Prague, there are currently three key methods of separate waste collection.[9] The figure on this page presents a detailed overview of each of these methods, and highlights the main types of products that are recovered from each.

## Separate waste collection of household waste is relatively low

- Notably, only 33% of the total generated municipal solid waste is collected separately (139.875 tonnes). This proportion is significantly low, especially when compared to Switzerland, where 51% of municipal wastes are separately collected.[10]

## Significant quantities of bulky waste are already separately collected

- The largest quantity of waste that is separately collected comes in the form of bulky waste (30.846 tonnes), which is collected in the city's waste collection yards and street containers. Although no specific information is available as to the composition of this bulky waste, a significant component is assumed to be furniture.[11]

## Separate household biowaste collection is lacking in Prague

- Despite making up a significant material in- and output of Prague households (pp.30), there are minimal quantities of separately collected biowastes (~8.000 tonnes), particularly from food.

## DIY projects creating construction wastes

- Construction wastes also make up a large quantity (~27.000 tonnes) of wastes collected in the city's waste collection yards. It is assumed that these wastes are predominantly created from household DIY projects, however, will also include some small construction business activity.[12]

## Take-back schemes increasing separate E-Waste collection

- Take-back schemes for E-waste are estimated to collect a total of 3.632 tonnes of end-of-life electronics. There is, however, likely potential to increase these quantities, as 20% of Czech households still throw small electronic appliances into mixed waste bins.[1]

### SEPARATE WASTE COLLECTION

(i.e. the specific waste bins that the municipality has for glass, plastics, cartons, metals etc.)

**57.534 tonnes**

- Paper 22.488
- Glass 17.333
- Plastics 13.181
- Beverage cartons 981
- Metal covers 144
- Bulky waste 3.407

### COLLECTION YARDS

(specific locations where citizens can throw special waste, like big objects (furniture), biowaste, wood, etc.)

**78.709 tonnes**

- Bulky waste 27.439
- Construction waste 26.908
- Wood 12.803
- Biowaste 8.167
- Metals 1.816
- Paper 452
- Glass 189
- Plastics 112
- Other 823

### TAKE-BACK SHEMES

(i.e. collection bins where you can bring back your batteries, or land, and other electronics etc.)

**3.632 tonnes**

- TV and monitors 820
- Other electrical equipment 416
- Light sources 23
- Stationery containers 225
- Refrigerators 882
- Large and small appliances 1.228
- Batteries 38

# **HOUSEHOLDS:** CIRCULAR OPPORTUNITIES AND POTENTIAL STRATEGIES

## CIRCULAR OPPORTUNITIES

Based on the insights from the material flow analysis of households in Prague, three distinct opportunities to accelerate the circular economy have been identified, and highlighted on the figure on the following page. The key opportunities for households are presented on the right.

In the following pages potential circular strategies are presented for each of the three circular opportunities that can help the sector transition towards a more circular economy. For each opportunity, international best practices were analysed in relation to local activities identified through local roundtable discussions.

ENVIRONMENTAL IMPACT POTENTIAL:

The environmental impact potential explores the environmental benefits that each direction could generate. It is important to note that this evaluation is only completed to the extent that information was available, and was not intended to offer a quantitative assessment. Indicators include; waste reduction potential, emissions reduction potential, and raw material consumption reduction potential.

ECONOMIC POTENTIAL:

The economic potential for each direction was explored further to give insight into the approximate costs and economic benefits that could be expected from each direction. Indicators include; jobs creation potential, investment costs, and return on investment.

TECHNICAL FEASIBILITY:

Technical feasibility: It is important to understanding the overall feasibility to practically implement a pilot project of the circular strategy in Prague. This information is critical in identifying strategies that are likely to succeed in the near future. Indicators include; technology readiness level, legal barriers and institutional barriers.

### Circular food consumption


In an ideal circular city, all food consumed by households will be sustainably produced, healthy, and local, to minimise negative environmental impacts. Food waste will be reduced, and unavoidable residual food streams are utilised in cascading cycles.

Food is the single largest material input to Prague households, making up ~70% of total materials consumed each year, while, at the same time, there is currently no mainstream separate collection of these biowastes in the city. Therefore, there is a significant opportunity to reduce the environmental footprint of households, and increase the potential value recovered from this residual stream.

### Repair and reuse of household products

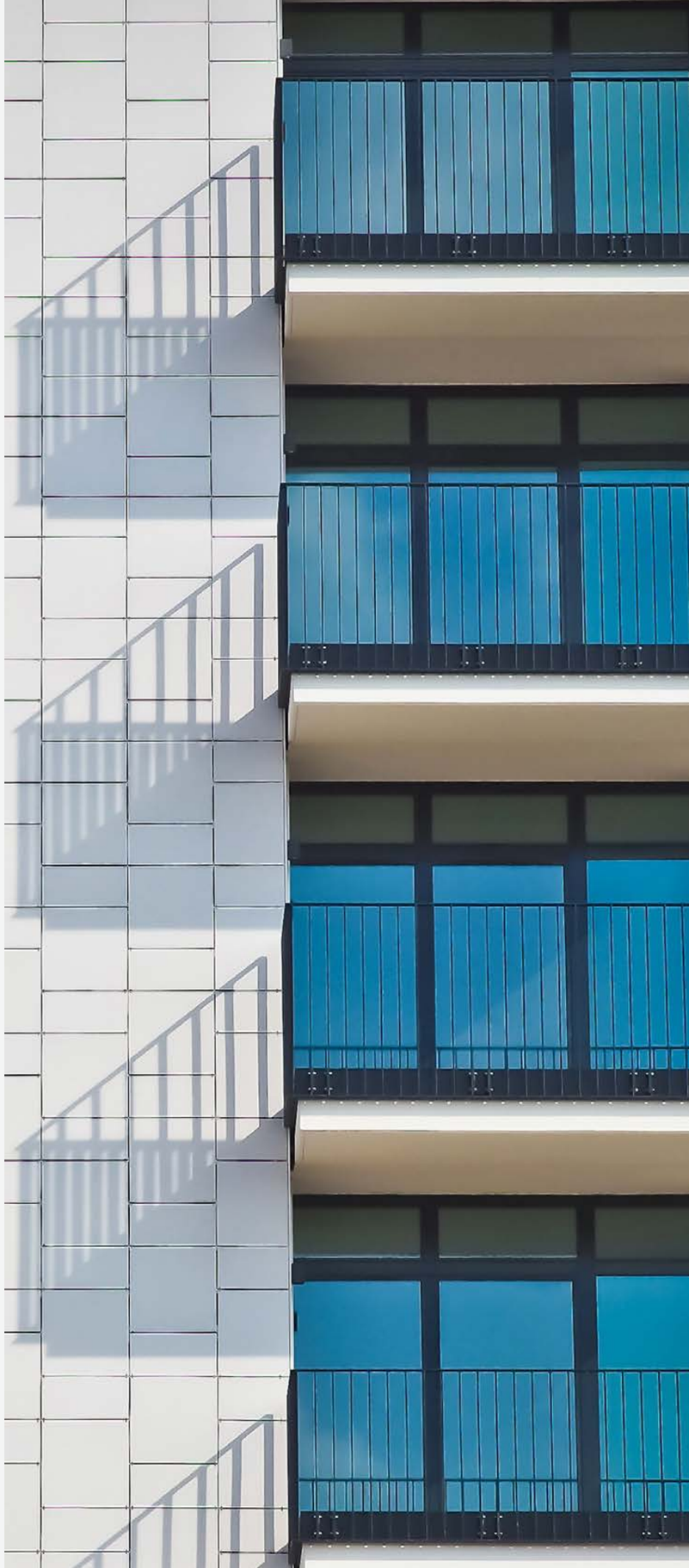

In an ideal circular city, all household products will be used at their highest value for as long as possible, through reuse and repair, to reduce demand on the consumption of new products.

Each year, Prague households consume approximately 307.000 tonnes of non-food products, while not always disposing of these products correctly to maximise their high-value lifespan.[1] There is an opportunity to increase the repair and reuse of these household products to reduce Prague household's overall demand for new products.

### Increased separate waste collection


In an ideal circular city, all residual material flows are collected separately to enable utilisation at their greatest value for as long as possible.

Currently, in Prague, only ~33% of total municipal wastes generated are separately collected, with 51% collected via mixed systems. Therefore, there is a significant opportunity to increase the share of separately collected municipal wastes to, ultimately, increase reuse/recycling rates.



# OPPORTUNITY 1
## Circular food consumption

In an ideal circular city, all food consumed by households will be sustainably produced, healthy, and local, to minimise negative environmental impacts. Food waste will be reduced, and unavoidable residual food streams are utilised in cascading cycles.

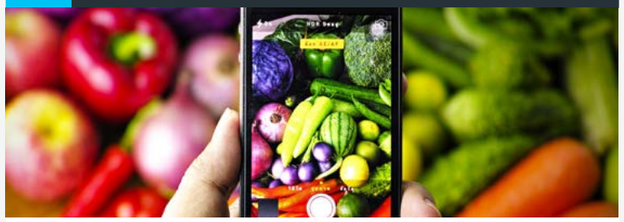
### 1. Urban food production strategy

Urban agriculture can serve as an effective strategy to shorten the supply-chain of food goods for urban consumption and facilitate the increased consumption of sustainably produced and healthy foods.

Developing strategies to facilitate urban agricultural initiatives can increase participation and appreciation for sustainable food choices within the city, and rejuvenate derelict lots of land. The City can support urban agriculture by, for example, amending the zoning ordinance to recognise urban and community farms, as well as directly supporting urban farming initiatives through nonprofit partnerships.

Case study: **City of Chicago's 'Green Healthy Neighbourhoods' (US)**

### 2. Digital tools for food sharing



Although a share of food wastes are unavoidable and unsuitable for human consumption, such as preparation wastes and other non-edible components, there is an appreciable quantity of residual biowastes that are edible and can be redirected from the garbage. A digital application can provide the opportunity households to list their surplus, edible food items, offering the opportunity for other households to purchase or collect these items.

Case study: **OLIO (UK)**

# **HOUSEHOLDS:** CIRCULAR OPPORTUNITIES AND POTENTIAL STRATEGIES

## OPPORTUNITY 2
### Repair and reuse of household products

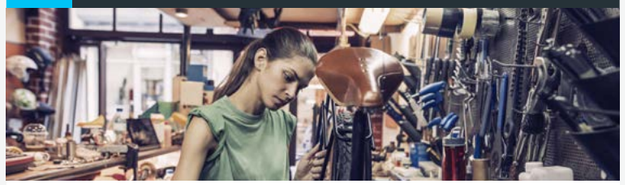
In an ideal circular city, all household products will be used at their highest value for as long as possible, through reuse and repair, to reduce demand on the consumption of new products..

### 1. Circular shopping centre

Establishing a dedicated location which exclusively sells products to be reused, or made from recycled materials can both encourage and can demonstrate the viability of circular business models, such as leasing and 'as-a-service' models, as well as generate greater public interest in the culture of reuse, repair and a more circular lifestyle to extend the value of products and materials for as long as possible.

Case study: **ReTuna (SE)**

### 2. Repair 'hubs'



The knowledge and skills to repair household products can already be found within the citizens of Prague. Establishing a network and community of decentralised, citizen-run spaces that offer services (and education) to repair a variety of household products, including furniture, electronics and clothing.

Case study: **Repair Café**

## OPPORTUNITY 3
### Increased separate waste collection

In an ideal circular city, all residual material flows are collected separately to enable utilisation at their greatest value for as long as possible.

### 1. Community-based reward and recycling platform

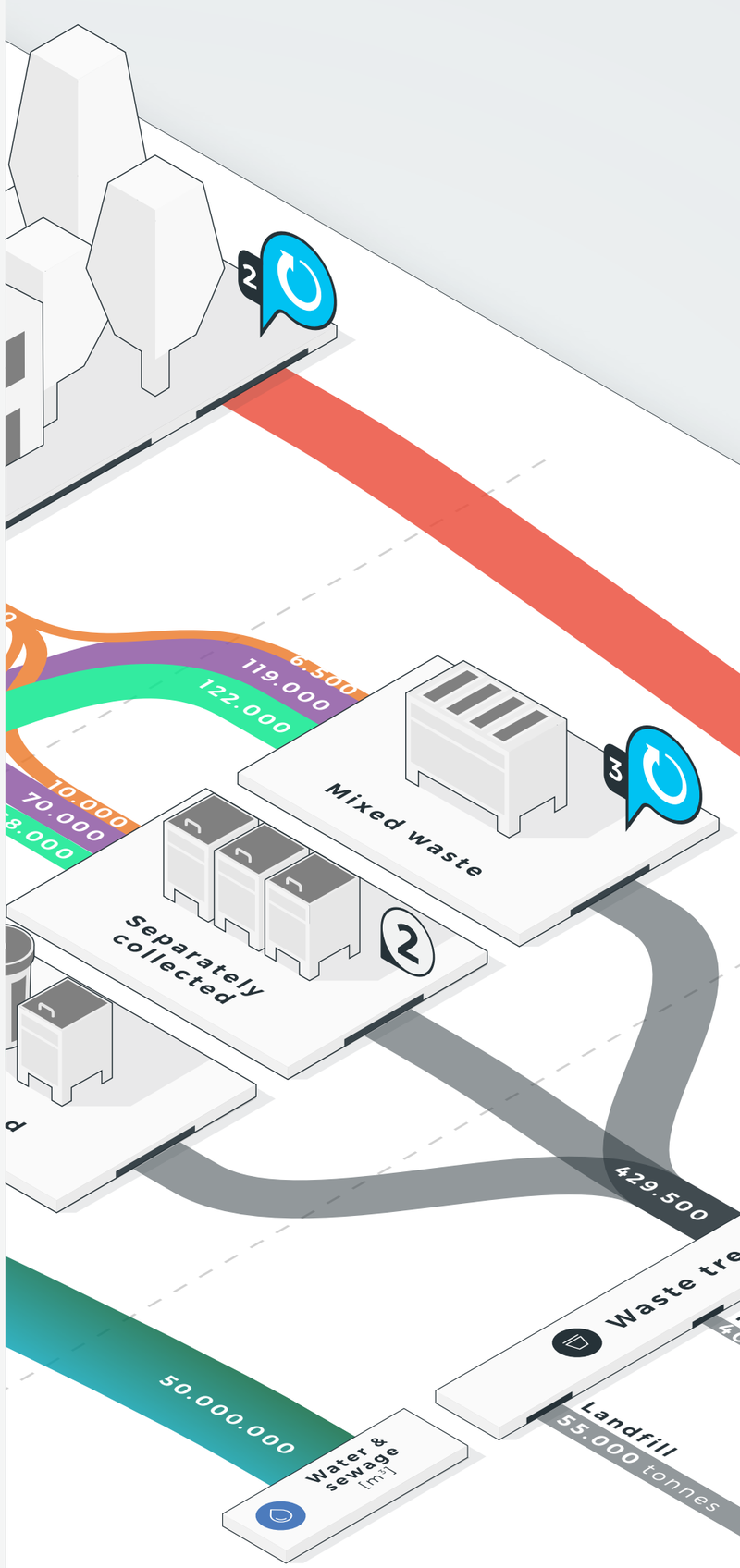
Effective behavioural incentives for consumers are a crucial element to release a circular economy. Incentives can reward a variety of circular behaviours, such as the take-back of products to the producer at the end of use, and proper separate waste disposal. Rewarding citizens with a local currency of 'coins' or 'points' that can be redeemed in local businesses can enable and educate good household behaviours.

Case study: **WASTED Lab (NL)**

### 2. Reverse logistics for E-waste

Reverse logistics platforms can increase the effectiveness of EPR-take back schemes by offering a convenient and cost-effective solution for citizens to dispose of end-of-life E-wastes to enable high-value reuse and recycling. By combining with existing logistics networks, such as postal services, these services can be provided without any added pressures to transportation networks.

Case study: **WEEElectric (NL)**



# OVERVIEW

Based on the circular opportunities and potential strategies identified for Prague's households, the consortium identified the strategy with the greatest transformative potential to be developed further in the action plan phase, taking inspiration from circular strategies in both the households and utilities sector.

## Circular ReUse Hubs

Up to 70% of the ~30,000 tonnes of bulky waste that is currently disposed of in Prague's Municipal Waste Collection Yards could be reused immediately, or with minor repairs (if brought non-compacted). Yet, the current system distributes them in such a way that they are fed to lower value-cycling opportunities or even incinerated, significantly limiting the potential value and their life cycles. There is a significant potential, and ambition in the city, to increase the rate of reuse of the ~307,000 tonnes of consumer goods that are disposed of as waste each year through the development of a network of ReUse Hubs throughout Prague.

## Action planning a pilot for Prague

The chosen circular strategy was further developed in the third phase of the Circle City Scan. The following pages provide (i) A short overview of the circular strategy showcased with international best practices, and resulting pilot project, (ii) A visual strategy canvas which details roles, processes and stakeholder, and (iii) a detailed step-by-step action plan to take the pilot from conceptualisation to implementation.

# CIRCULAR STRATEGY

## Circular ReUse Hubs

A valuable strategy to increase reuse of consumer goods in Prague involves the creation of ReUse Hubs.[15] ReUse Hubs would concentrate reuse and circular activities showcase the viability of, and generate a greater public interest towards, reuse, repair and more circular lifecycles. These Hubs would not only provide attractive and accessible locations for citizens to deposit unwanted household items, but also support more circular consumption habits by providing spaces for the sale/lease of reusable items, as well as host supplementary circular activities, such as repair, upcycling workshops and education programmes.

## Creating a network of decentralised ReUse Hubs

With Prague covering an area of almost 500km², an important part of this strategy would be to create a decentralised network of ReUse Hubs that can be accessible to all citizens. As such, ReUse Hubs in Prague could take a variety of forms to suit the various spatial characteristics of the city.

## Upgrading existing municipal collection yards into Hubs

ReUse Hubs could capitalise on existing infrastructure through the upgrading of the 20 Municipal Collection Yards. These points can already provide facilities and labour for the collection of reusable bulky and other household wastes, and can be upgraded to provide the rental of dedicated spaces for circular activities and organisations, such as the preparation and sale/lease of reusable items.

## ReUse Labs can provide education and repair services

In districts lacking Municipal Collection Yards (particularly in central areas) and with greater limitations on space, ReUse Hubs could take a 'softer' approach and, rather, aggregate a range of circular organisations and activities such as textiles exchanges, awareness-raising workshops, repair services, and a library of things, forming a 'living-lab' of sorts. Similarly, this ReUse Hub will enable citizens to accessible adopt more sustainable consumption.

## Collaboration between ReUse activities is crucial

Ultimately, the successful implementation of ReUse Hubs throughout Prague requires the coordination between these complementary activities. For example, surplus quantities of household items collected at the 'ReUse Courts' can be distributed to inner-city 'ReUse Labs' to support circular activities at these locations.

# A PILOT IN PRAGUE

An initial pilot project could involve the implementation of the city's first ReUse Hub. With their existing collection and storage infrastructure, space and staffing, one of Prague's Municipal Collection Yards can offer a promising location in which to test and demonstrate the viability of the concept.

## Creation of the first ReUse Hub

This first pilot project would fundamentally involve the upgrading of a collection yard into a more vibrant and accessible location that would attract citizens. Alongside the provision of a suitable location to sort, store, and upcycle household items, a café, educational workshops or other 'pop-up' shops could attract a steady flow of people to the location, and build awareness over time. This pilot could also serve to stimulate a community of organisations and entrepreneurs that can contribute circular services within the ReUse Hub(s).

# KEY PERFORMANCE INDICATORS

A number of KPIs can be used to guide implementation of evaluate the success of the pilot project in relation to the overall circular vision[16]:

- **Total quantities of materials recovered:** This indicator can help to measure the effectiveness of ReUse Hubs in increasing the separate collection of household objects and materials.[17]
- **Total revenue from the sale/leasing of reused objects**: This indicator is important to understand the quantities and value of household items that are being reused through the ReUse Hubs
- **Annual number of visitors to the ReUse Hub:** This indicator is vital to help gauge engagement to and suitability of the ReUse Hub. However, this indicator should be understood in relation to the above, as visits without active engagement does not imply increased rates of reuse.

# INTERNATIONAL BEST PRACTICES

ReUse Hubs are increasingly being recognised by cities throughout the world as an effective strategy to increase reuse and more sustainable consumption. Several international examples can be referred to for inspiration and further information:

### ReUse Centre and Repair Cafe, Ljubljana, (SI)

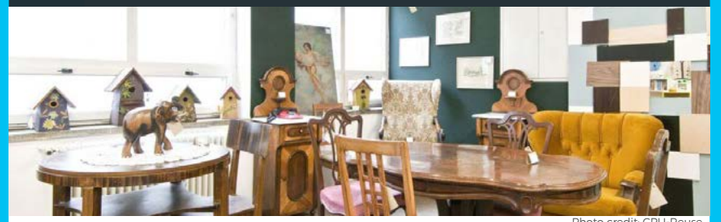


Photo credit: CPU-Reuse

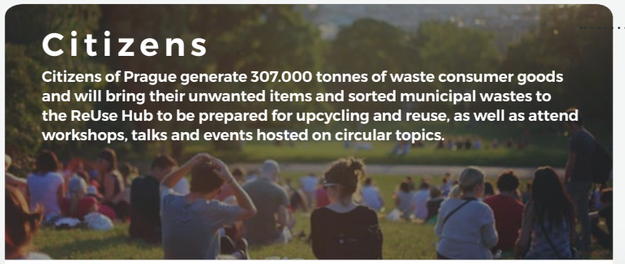
In a collaboration between a public waste management company, and social enterprise (CPU), the site of an existing waste collection point was transformed into a ReUse Centre, composing a 'Green Shop' and reuse/repair workshop. The ~150-200 items sold each day are diverted from landfill and incineration, while providing employment opportunities for the city's vulnerable population.[18]

### Paris' network of ReUse Centres (FR)


Photo credit: City of Paris

The City of Paris has supported the creation of a network of 'Ressourceries' (reuse centres) throughout the city that support the reuse of over 3.000 tonnes of objects and materials that would otherwise have been discarded.[20]

# ACTION PLAN: CIRCULAR REUSE HUBS



## Citizens

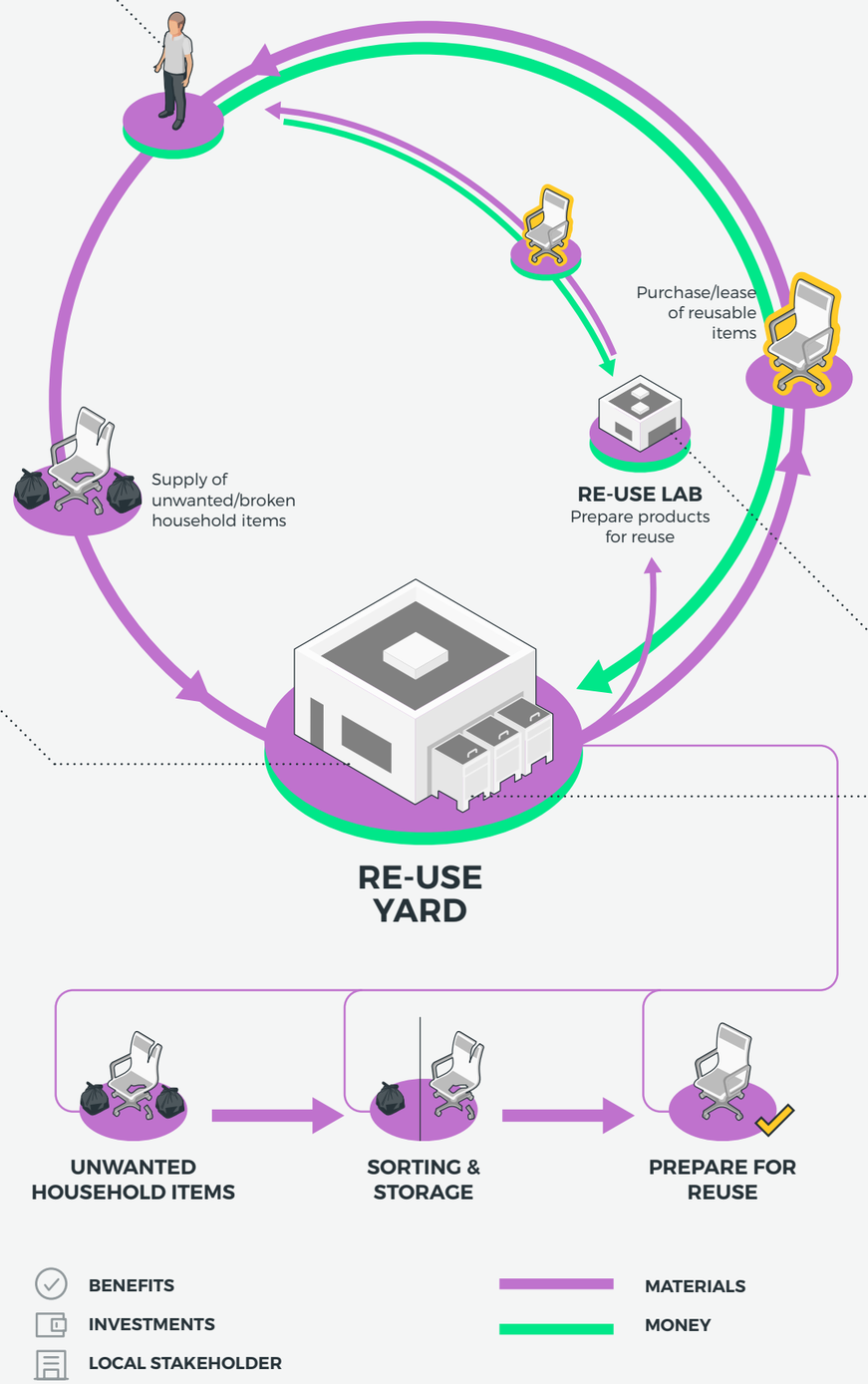
**Citizens of Prague generate 307.000 tonnes of waste consumer goods and will bring their unwanted items and sorted municipal wastes to the ReUse Hub to be prepared for upcycling and reuse, as well as attend workshops, talks and events hosted on circular topics.**

- Education and awareness of the circular economy
- Economic savings in purchasing reused products
- Deposit of unwanted products and wastes to the ReUse Hub
- Time to participate in stakeholder roundtables to shape the requirements of the ReUse Hub.
- Households in Prague

## Waste managers

**This stakeholder is responsible for leading the project and translating the concept into a tangible pilot; taking the input from all stakeholders, and ultimately shaping the pilot to maximise its potential benefits for the City of Prague. The staff of the municipal waste collection yards are responsible for the initial collection and sorting of the deposited items to be reused.**

- Cost reductions in waste treatment.
- Revenue generated from the rental of space at the ReUse Court
- Reduced quantities of waste generated as ~70% of the items that are donated can be reused[14]
- Employment and training opportunities particularly for citizens with a distance to the labour market
- Reduced CO2equ. Emissions estimated between 200 - 1,300 tonnes per year[14, 21]
- Time to organise, plan and host stakeholder roundtables
- Leadership and project management skills to coordinate a large number of stakeholders
- Communication campaign to showcase the ReUse Hub to citizens
- Financial support for the initial investment costs of a ReUse Hub
- Physical location with sufficient dry space for storage
- Pražské služby a.s.




## Municipality of Prague

**The Municipality of Prague plays an important supporting in the creation of ReUse Hubs. Support comes in the form of political leadership, communication through official channels, as well as provision of financial support.**

- Contribute towards municipal goals of:
- Increase proportion of reuse and recycling
- Employment opportunities, particularly for citizens with a distance to the labour market
- Reduce CO2equ. emissions
- Political support and leadership to secure implementation
- Financial support for initial investment costs
- Communication of the ReUse Hub through municipal channels
- Department of Waste Management;

## ReUse organisations

**ReUse Organisations maintain clean and attractive aesthetic and additional circular activities, such as the repair of items and provision creative arts and handicraft workshops. Organisations can be located both in ReUse Courts, and ReUse Labs.**

- Employment opportunities, particularly for citizens with a distance to the labour market
- Revenue from the sale (and/or leasing) of reused products and provision of workshops
- Time to participate in stakeholder roundtables
- Staff to perform the required services at the ReUse Hub
- Communication of the ReUse Hub both on- and offline online
- Opravárna.cz, Knihovna věcí, Z Pokoje do pokoje, SWAP Prague,

# ACTION PLAN: CIRCULAR REUSE HUBS

## Scoping and engagement phase

### 1 Form a project team and set ambitions

Form a project group that will be responsible for the development of the pilot ReUse Hub. This group should align on the core objectives of the pilot project; such as increasing the quantity of reused products, and creating employment opportunities.

**Stakeholders:** Waste managers; Municipality of Prague

**Outcomes of this phase:**

- ☑ Defined specific need for the tender.
- ☑ Defined the ambitions and impact priorities of the circular tender.

### 2 Internal and external engagement phase

### Conduct conceptual study and start monitoring waste

Conduct a conceptual study to scope the ReUse Hubs, including their design, costs, and regulatory aspects. At the same time, start to gather data on quantities and qualities of products and materials that are already being disposed of municipal waste collection yards to clarify circular opportunities

Stakeholders: Waste managers; Municipality of Prague

### 3 Engage stakeholders in Re-Use Hub roundtable

Identify potential parties (such as social enterprises, circular entrepreneurs, repair organisations, etc.) that could help to deliver the goals of the pilot. Bring them together in collaborative workshops, meetings and roundtables to help to shape the pilot to suit the requirements and priorities of all stakeholders, and decide on an appropriate site in which to launch the first pilot project.

Stakeholders: All

**Outcomes of this phase:**

- ☑ Collection of data on the quantities and quality of deposited products and materials.
- ☑ Identification and engagement of local circular stakeholders, including citizens
- ☑ Clear conceptualisation of ReUse Hubs in Prague and identification of pilot location

## Preparation and implementation phase

### 4 Develop pilot plan and secure funding

Co-create a project plan with all relevant stakeholders. Make sure to include the following elements; (i)  and KPIs to monitor and evaluate; (ii) align on 'Hub' activities, roles and responsibilities, (iii) identify relevant regulation (such as health and safety, and trading standards, (iv) economic plan.

**Stakeholders:** Waste managers; ReUse organisations; Municipality of Prague

### 5 Upgrade Collection Yard into ReUse Hub

Prepare the selected Municipal Collection Yard as outlined in the pilot plan and stakeholder meetings. This upgrading could require renovation, or the addition of a structure to provide dry space for donated products and materials. Try to make the most of existing infrastructure to minimise environmental footprint. As soon as possible, start separately collecting reusable products to build up the supply.

**Stakeholders:** Waste managers; Municipality of Prague

### 6 Training of staff on ReUse Hub operations

Provide training to staff of both the collection yard and ReUse Hub to make sure all stakeholders understand which items can be reused, as well as how to manage stock and operate the reuse hub safely. Utilise the existing knowledge of ReUse organisations.

**Stakeholders:** Waste managers; ReUse organisations

**Outcomes of this phase:**

- ☑ Clearly defined project plan, and an appropriate location to pilot first ReUse Hub.

  Secured project funding.
- ☑ An operational contract between all stakeholders outlining roles and responsibilities.
- ☑ KPIs to be monitored and evaluated.
- ☑ Upgraded municipal collection yard with clean and covered space for collection and ReUse Hub activities.
- ☑ All staff relevant staff and stakeholders have received appropiate training.

## Launch and operation phase

### 7 Communication campaign

Create a communication campaign to spread awareness of the ReUse Hub to citizens. Communication of the project is important to generate a buzz its opening but also to maintain interest. Social media is an effective method to showcase the range of items through attractive and themed displays.

**Stakeholders:** Waste manager; ReUse organisations; Municipality of Prague

### 8 Opening event and operation

Host an opening event for the ReUse Hub to generate buzz around the project. Organise a programme of workshops and speakers around reuse and the circular economy. Engagement of citizens can be maintained by a regular offering of workshops and events.

**Stakeholders:** All

### 9 Monitoring and evaluation

Monitor and evaluate the performance of the ReUse Hub against the pre-selected KPIs, and adjust the operation of the Hub accordingly to maximise impact.

**Stakeholders:** Waste manager ReUse organisations

**Outcomes of this phase:**

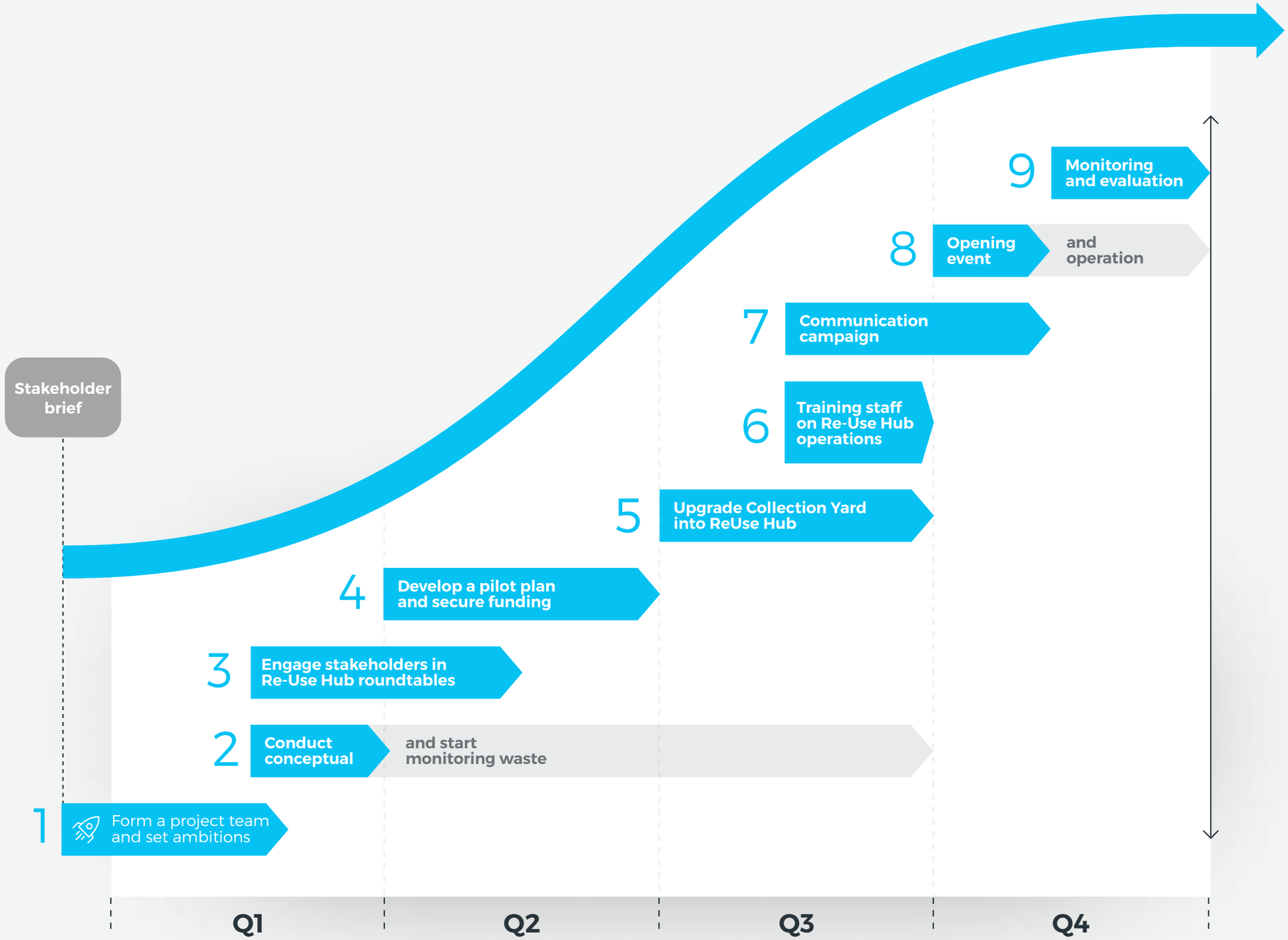
- ☑ Clearly defined project plan, and an appropriate location to pilot first ReUse Hub.
- ☑ Secured project funding.

### ▲ Scale up

This pilot project will form the first node in the creation of a decentralised network of ReUse Hubs and activities throughout Prague's districts. With the learnings from the pilot project, establish a full-scaling strategy to upgrade other Municipal collection yards throughout the city. It can be effective to coordinate the upgrading of existing Municipal collection yards to ReUse with planned renovations.

With continued engagement and stakeholder roundtables, a greater network of circular-minded entrepreneurs and businesses can be formed. This network can support the development of circular 'living-labs' which have flexible demands on space and can be implemented in the city centre of Prague, such as in the Kampus Hybernská, where additional circular services can be provided

# ACTION PLAN: CIRCULAR REUSE HUBS



# UTILITIES



58 ACTION PLAN: WASTE BIOMASS TO BIO-CNG



# **UTILITIES SECTOR:** MATERIAL FLOW ANALYSIS

## SUMMARY

Being responsible for the handling and processing of the 4,6 million tonnes of waste that are generated in Prague annually, the Utilities sector has a huge transformative potential to increase the circularity of the city. While the circular economy is as much about start of the value chain as the end-of-life, there are significant opportunities to capture the inherent value of residual streams produced in the city. Some key insights of the material flows of the sector can be identified:

## MAIN INSIGHTS

### Over 990.000 tonnes of waste biomass are generated in the city each year, yet lacks separate collection

Residual waste biomass streams can hold many promising opportunities for high-value cycling within a circular economy, yet only approximately 50.000 tonnes of organic materials are recovered within Prague. Food and other biodegradable wastes make up a notable share of residual biomass, yet, to date, there is no comprehensive separate collection system.

### A third of water in Prague's sewerage system comes from rainwater, which can lead to flooding

Combined with the 80 million $m^3$ of water produced by the city;s activities each year, the irregularity of precipitation events (which are intensifying as a result of climate change) can inundate the city's sewerage system and cause flooding. However, this 40 million m3 of rainwater can be managed in a manner to capture its value while reducing its risk.

### Almost three-quarters of the waste generated in Prague is not treated in the city

This represents a large leakage of potential value from the local economy. Approximately 70% of Prague's wastes are exported from the city, most commonly to other areas of the Czech Republic. Yet, due to the presence of the ZEVO Malešice waste-to-energy facility within the city, it is likely that the majority of municipal solid waste is processed in the city itself.

## METHODOLOGY

The following page presents the material flows through waste and wastewater management sector of Prague. Below is described how to read the figure. Each material stream is represented by coloured lines. The colour of the line indicates the type of material, and the thickness of the line represents the quantity.

It is important to know that not all residual materials that are produced in Prague, are treated in the city itself, rather large quantities are treated elsewhere in the Czech Republic and overseas. The resource outputs from the utilities sector are also represented on the material flow analysis.

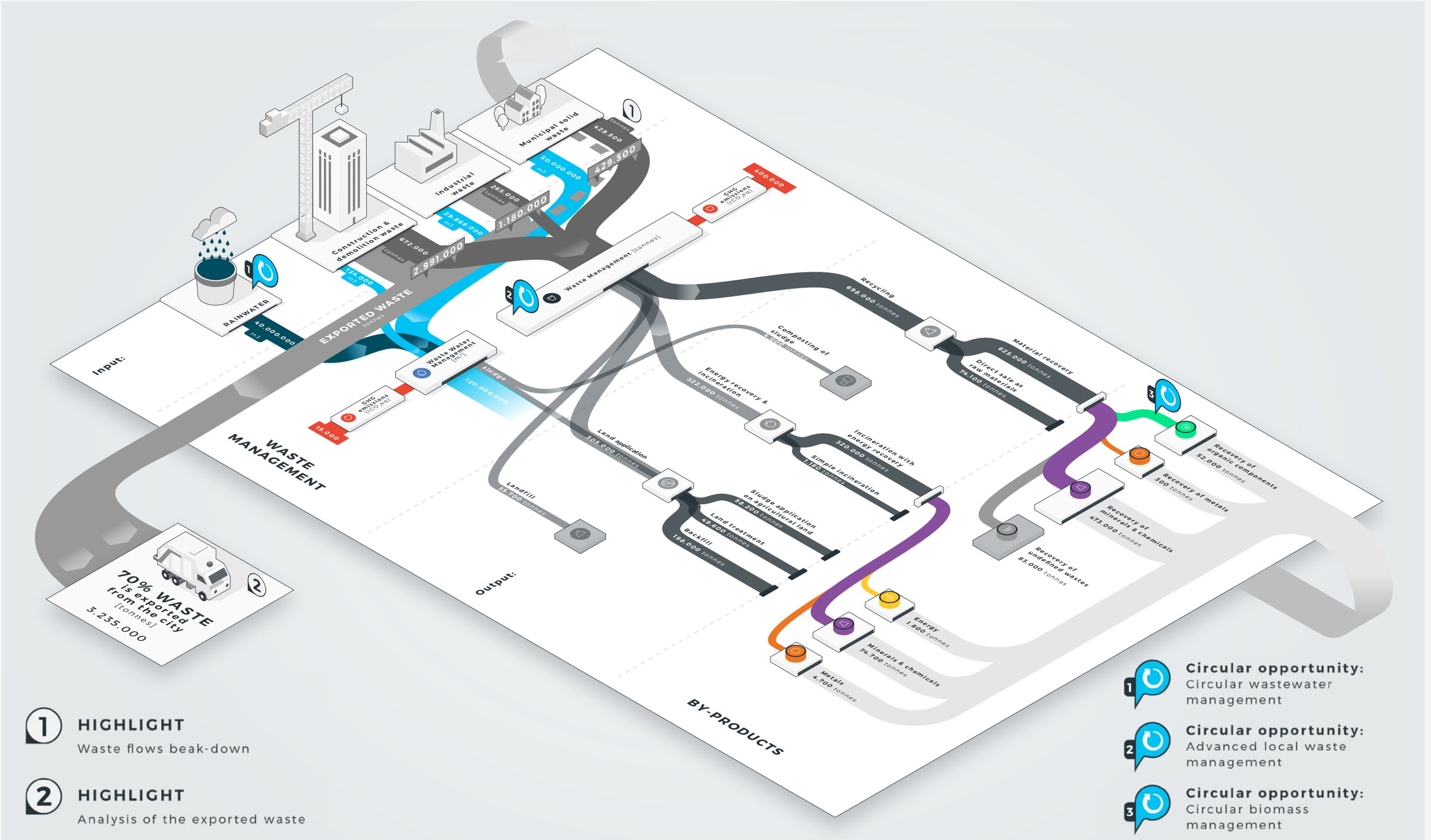
For the material flow analysis, research has been done into energy, biomass, minerals & chemicals, and metals.

- Energy
- Biomass
- Minerals & Chemicals
- Metal
- Water
- Emissions

Waste processing has analysed in six scenarios: reuse, recycling, energy recovery, land application, incineration and landfilling. Reuse is the most and landfill the least desired scenario.

- Reuse
- Recycling
- Energy recovery
- Land application
- Incineration
- Landfilling

Appendix I provides a further explanation of the material flow analysis methodology, and explains which materials products exactly fall under the six material streams, and what the end-of-life methods entail.


Input:
RAINWATER
40.000.000 m3
Construction & demolition waste
672.000 tonnes
134.000 m3
Industrial waste
265.000 tonnes
29.966.000 m3
Municipal solid waste
429.500 tonnes
50.000.000 m3
429.500
1.180.000
2.991.000
EXPORTED WASTE
tonnes
WASTE MANAGEMENT
Waste Water Management [m3]
15.000
GHG emissions [tCO2 eq.]
sludge
120.000.000
Waste Management [tonnes]
400.000
GHG emissions [tCO2 eq.]
Recycling
698.000 tonnes
Material recovery
625.000 tonnes
Direct sale as raw materials
74.100 tonnes
Composting of sludge
Energy recovery & incineration
322.000 tonnes
Land application
305.000 tonnes
Incineration with energy recovery
320.000 tonnes
Simple incineration
1.130 tonnes
Landfill
35.700 tonnes
Sludge application on agricultural land
59.200 tonnes
Land treatment
49.600 tonnes
Backfill
198.000 tonnes
Recovery of organic components
52.000 tonnes
Recovery of metals
300 tonnes
Recovery of minerals & chemicals
475.000 tonnes
Recovery of undefined wastes
85.000 tonnes
Output:
BY-PRODUCTS
Energy
1.900 tonnes
Minerals & chemicals
74.700 tonnes
Metals
4.700 tonnes
70% WASTE
is exported from the city
[tonnes]
3.235.000
1 HIGHLIGHT
Waste flows beak-down
2 HIGHLIGHT
Analysis of the exported waste
1 Circular opportunity:
Circular wastewater management
2 Circular opportunity:
Advanced local waste management
3 Circular opportunity:
Circular biomass management

# KEY FINDINGS

The material flow analysis presents an overview of the residual (waste) streams generated in the city of Prague (input), as well as how these residual streams are processed and the by-products that are generated (output). The summary of the analysis provided on this page highlights key material flows and significant impact areas.

## Prague's annual waste generation is linked to the level construction activity

The City of Prague generates a total of 4.601.000 tonnes of waste in one year. Waste in the city is generated by three key sources; Municipal solid waste* (14%); Industrial activities** (26%), and; Construction and demolition (C&D) activities (65%). Due to the dominance of C&D wastes, the total waste generated in the city each year are linked to the magnitude of construction (and demolition) activities.[1]

## ~70% of the waste generated in Prague is not treated in Prague

Not all of the waste that is generated within Prague is treated within the city itself. It is estimated that only ~30% of total wastes produced (1.366.000 tonnes) are treated within the boundaries of the city, with the remaining ~70% treated outside of the city's borders.[1] Page 52 provides further details as to the nature of this exported waste.

## Rainwater makes up one-third of water in sewerage system

A total of 120.000.000m$^3$ of wastewater are produced and treated within the city of Prague. There are three key sources of water into the city's sewerage system, with each supplying relatively equal volumes of water.

- Wastewater from households and industry are responsible for about two-thirds of total wastewater.
- The final third is supplied by rainwater. In times of intense precipitation, this inflow of water can inundate the city's sewerage system which can lead to flooding. As an inherent resource, there is an opportunity for the circular economy to both fully utilise this flow, while reducing flooding risks.

## There is room to expand recycling activities in Prague

The largest share of wastes treated in the city are recycled (689.000 tonnes). Yet, this quantity does not reflect the full potential of recyclable wastes. Comparing the quantity of recycled wastes to the total 4,6 million tonnes of waste that are produced in the city, there is a large quantity of waste that could be recycled within Prague. There is, therefore, an opportunity for the City of Prague to increase the quantities of wastes that are recycled in the city itself, retaining the value of this resource within the city.

## Almost a quarter of wastes treated in Prague are burned for energy

Energy recovery processes almost one-quarter of wastes managed within Prague (320.000 tonnes). Prague is home to the ZEVO Malešice waste-to-energy facility,[3] which processes an ~200.000 tonnes each year, and produces enough energy to power 25.000 houses.[4] It is estimated that biomass makes up the largest share of materials managed by energy recovery, including food, paper and wood wastes.[5] As energy recovery loses most of the value of resources, there is potential for Prague to further utilise cascading cycles to recover maximum value from this residual biomass.

## Land application is a common treatment for excavation materials

Land Application processes 305.000 tonnes of waste annually. Within this broad waste management categorisation, the largest share of wastes are backfilled (198.000 tonnes). As highlighted in the Construction sector analysis, a large proportion of this backfilling waste is made up of excavation materials from construction activities.

* Originating from households, small businesses and street cleaning.

** Industrial activities such as manufacture, repair services, and wholesale logistics, amongst others.

# 1 Highlight 1 - Waste flow breakdown by source

The figure presented on this page provides further detail as to the material composition of the three key waste streams generated in the city; those being; municipal wastes, industrial wastes and construction and demolition wastes.

## Construction and demolition wastes make up two-thirds of Prague's waste

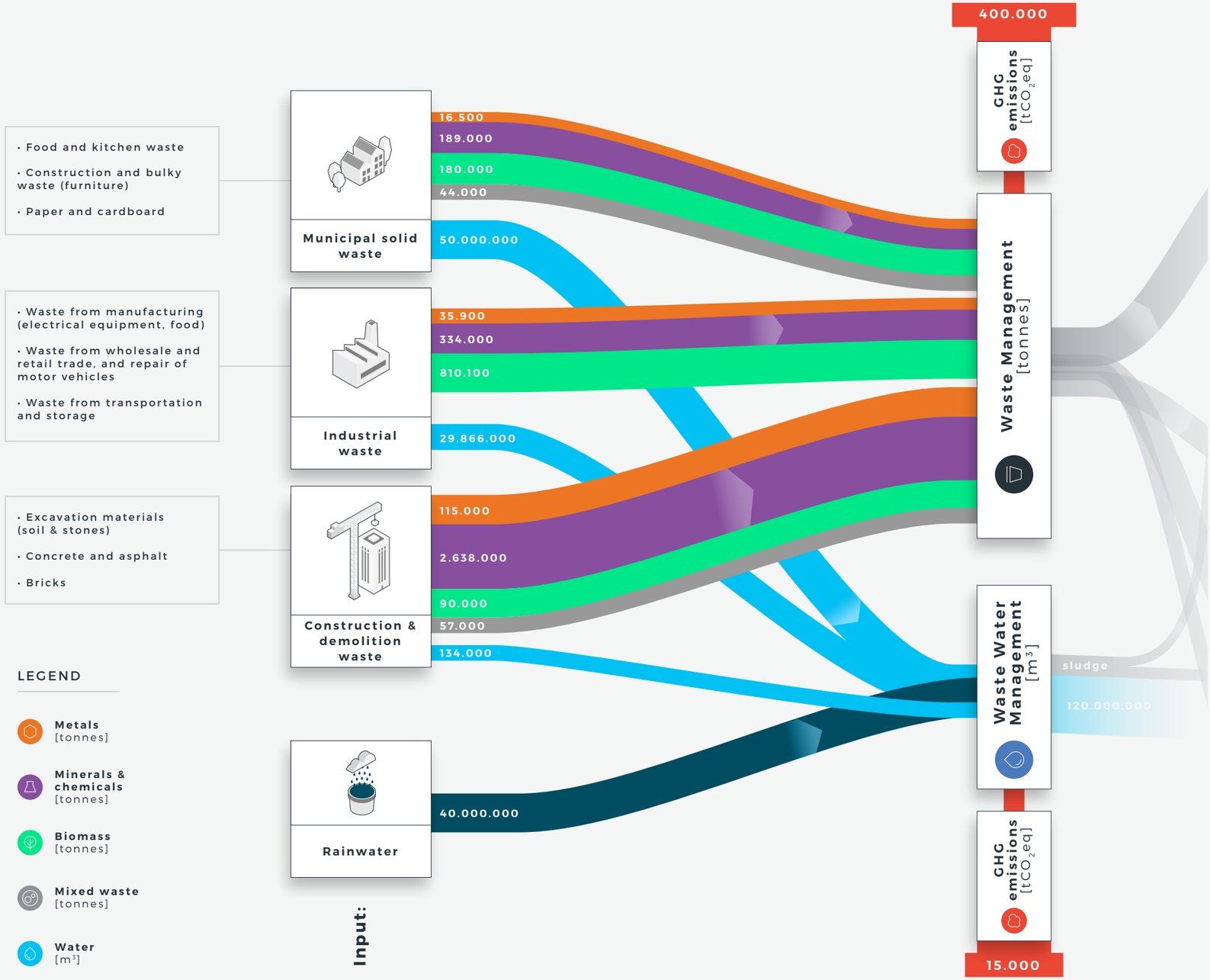
- Construction and demolition activities are the single greatest source of waste in generated in Prague, making up ~65% (2.991.000 tonnes). As highlighted in the Construction sector material flow analysis, excavation materials are, by far, the largest type of waste generated. This significance of construction wastes in the overall share of wastes is a common feature of urban systems.

## Manufacturing activities produce the largest share of industrial waste

- Industrial activities within Prague are responsible for the generation of ~26% of the city's total wastes (1.180.000 tonnes). Of the total industrial waste generated, the largest waste-producing activities are; manufacturing activities, including the manufacture of electrical equipment, food, and other products (31%), the wholesale and retail sector (40%), and transportation and storage (15%).

## Prague lacks comprehensive waste biomass collection

- Of the 990.100 tonnes of biomass waste that are produced in both municipal solid waste and industrial approximately 93.500 tonnes are food, kitchen and other biodegradable wastes. Currently in Prague, there is a lack of any comprehensive biodegradable waste collection.



# ② Highlight 2 - Exported waste

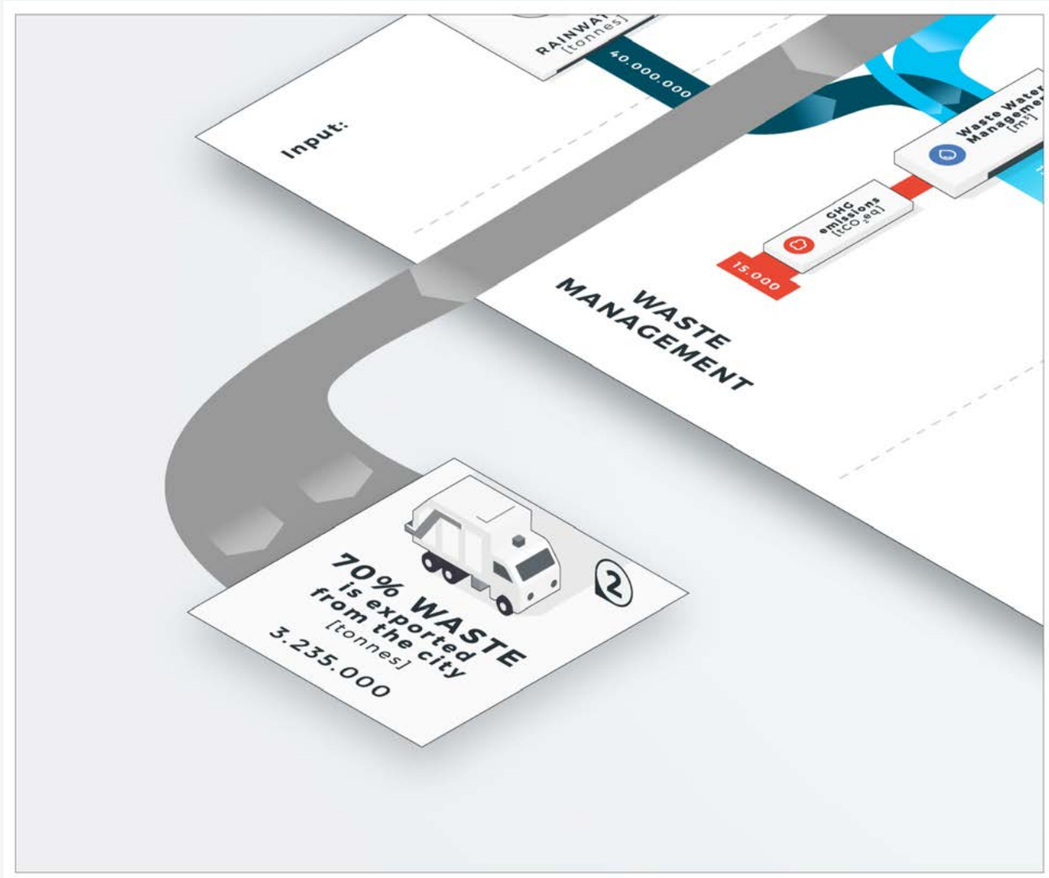
Not all wastes that are generated within the Prague are processed within the boundaries of the city. It is estimated that only approximately 30% of total wastes generated within the city are processed within Prague itself.[1]

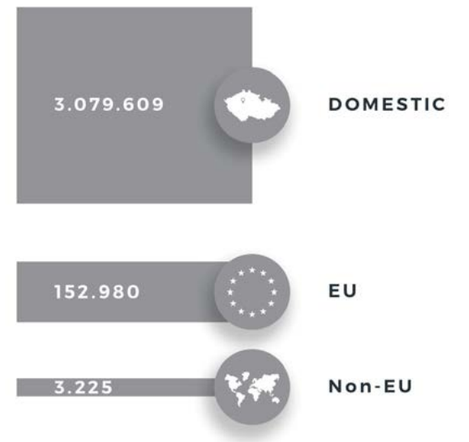
## ~70% of total wastes generated in Prague are managed outside of the city

- It is estimated that approximately 70% of Prague's waste streams are transported outside of the city's boundaries to be processed (3.235.000 tonnes). The largest proportion of this waste estimated to be transported to other waste management facilities domestically (95%). Almost 5% of Prague's wastes are exported to other member countries of the European Union, with almost 1% exported to nations outside the EU.

## The majority of municipal solid wastes are managed locally

- Due to limitations of data, it is not possible to determine which types of wastes are managed within the city, or exported. However, due to the presence of the ZEVO Malešice waste-to-energy facility within Prague, it is assumed that the majority of municipal solid wastes are managed within the city itself.[5]



# **UTILITIES SECTOR:** CIRCULAR OPPORTUNITIES AND POTENTIAL STRATEGIES

## CIRCULAR OPPORTUNITIES

Based on the insights from the material flow analysis of Prague's utilities sector, three distinct opportunities to accelerate the circular economy have been identified. These opportunities are also highlighted on the figure on the following page. The key opportunities for the utilities sector are presented on the right of the page.

In the following pages, potential circular strategies are presented for each of the three circular opportunities that can help the sector transition towards a more circular economy. For each opportunity, international best practices were analysed in relation to local activities identified through local roundtable discussions.

ENVIRONMENTAL IMPACT POTENTIAL:

The environmental impact potential explores the environmental benefits that each direction could generate. It is important to note that this evaluation is only completed to the extent that information was available, and was not intended to offer a quantitative assessment. Indicators include; waste reduction potential, emissions reduction potential, and raw material consumption reduction potential.

ECONOMIC POTENTIAL:

The economic potential for each direction was explored further to give insight into the approximate costs and economic benefits that could be expected from each direction. Indicators include; jobs creation potential, investment costs, and return on investment.

TECHNICAL FEASIBILITY:

Technical feasibility: It is important to understanding the overall feasibility to practically implement a pilot project of the circular strategy in Prague. This information is critical in identifying strategies that are likely to succeed in the near future. Indicators include; technology readiness level, legal barriers and institutional barriers.

### Circular rainwater management


In an ideal circular city, rainwater that falls in the city will be managed sustainably to reduce peak discharge and risks of flooding and utilised as a resource through a number of cascading applications.

In Prague, rainfall makes up ~33% of total water input into the sewerage system of the city. At times of heavy precipitation, the city's sewerage systems can be inundated and are prone to flooding. Therefore, there is an opportunity to sustainably manage this rainwater to capture value from this potential resource, and reduce the risk of flooding.

### Advanced local waste management

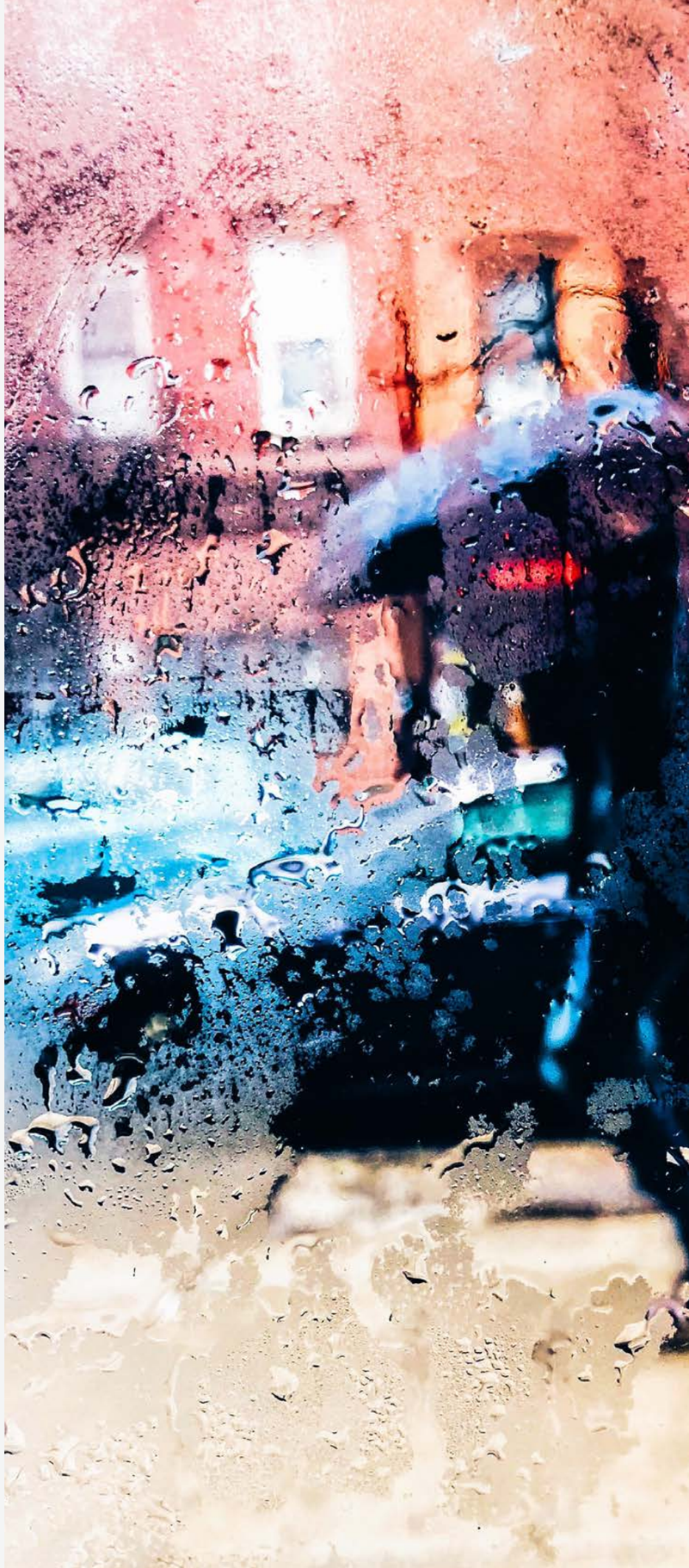

In an ideal circular city, all residual streams that are generated within the city are maintained at the highest value for as long as possible within local resource loops in the city. This way, the value of these secondary resources is maintained within the city.

Approximately 70% of the total wastes generated in Prague are transported and processed outside of the city itself. There is a huge opportunity to increase the capacity of the city to process these residual streams within the city itself,[1] to maintain this residual value within Prague.

### Circular biomass management


In an ideal circular city, the generation of residual biomass streams is minimised, while unavoidable wastes are circulated at their highest possible value for as long as possible.

Of the total 1.082.000 tonnes of waste biomass that are generated in Prague each year, only ~56.000 tonnes are recovered within the city. With no mainstream collection of biowastes originating from municipal solid wastes, there an opportunity to increase the rates of separate collection of biomass,[2] as well as high-value utilisation within Prague.



# OPPORTUNITY 1
## Circular rainwater management

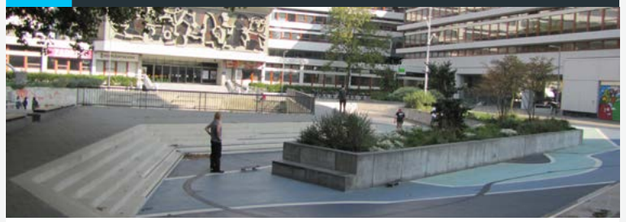
In an ideal circular city, rainwater that falls in the city will be managed sustainably to reduce peak discharge and risks of flooding and utilised as a resource through a number of cascading applications.

### 1. Urban green roof strategy

Green roofs within urban environments can reduce the runoff of water into the city's sewerage system, while at the same time, mitigate the urban heat island effect. Incentivisation programmes under a municipal green roof strategy can boost the implementation of green roofs through subsidies and other fiscal incentives.

Case study: **Basel Green Roof Strategy (CH)**

### 2. Decentralised rainwater management



Decentralised rainwater management systems can be implemented throughout Prague's built environment. Rainwater can be stored, harvested, and productively utilised, for example, to provide passive cooling for the building and irrigate surrounding vegetation.

Case study: **Benthemplein, Rotterdam (NL)**

### 3. Rainwater management platform

There is no one-size-fits-all approach to the rain management of a city, with strategies varying in type and scale. Platforms can collect and connect solutions, products and initiatives to enable a movement of citizens, public servants and entrepreneurs to work together to implement sustainable strategies to management rainfall.

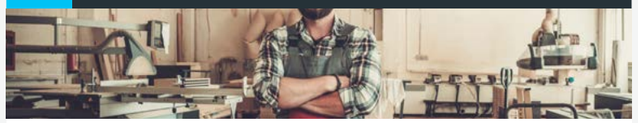
Case study: **Amsterdam Rainproof (NL)**

# **UTILITIES SECTOR:** CIRCULAR OPPORTUNITIES AND POTENTIAL STRATEGIES

## OPPORTUNITY 2
### Advanced local waste management

In an ideal circular city, all residual streams that are generated within the city are maintained at the highest value for as long as possible within local resource loops in the city. This way, the value of these secondary resources is maintained within the city.

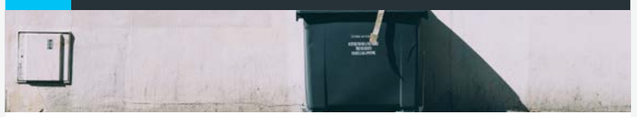
#### 1. Decentralised ‘circular hubs’



To further develop a number of the City Collection Yards from simple collection points into Circular Resource Hubs. Each of these decentralised ‘Hubs’ throughout the city can focus on-site, high-value waste management activities, such as the sorting of mono streams, reuse, recycling and upcycling, and repair. By managing waste streams in a decentralised manner, there is the opportunity to capture a greater share of the residual value of waste streams.

Case study: **City of Amsterdam Resource Hubs (NL)**

#### 2. ‘Smart’ waste collection infrastructure



Incorporating IoT enabled ‘smart’ meters to waste collection containers can enable the more effective and efficient waste management activities through waste container monitoring, data analytics, and route planning. Also, implementing ‘smart’ tracking on waste management within the city can improve data resolution as to the type and destination of given waste streams throughout the city.

Case study: **ENEVO in Rotterdam (NL)**

## OPPORTUNITY 3
### Circular biomass management

In an ideal circular city, the generation of residual biomass streams is minimised, while unavoidable wastes are circulated at their highest possible value for as long as possible.

#### 1. Biomass waste to biofuels

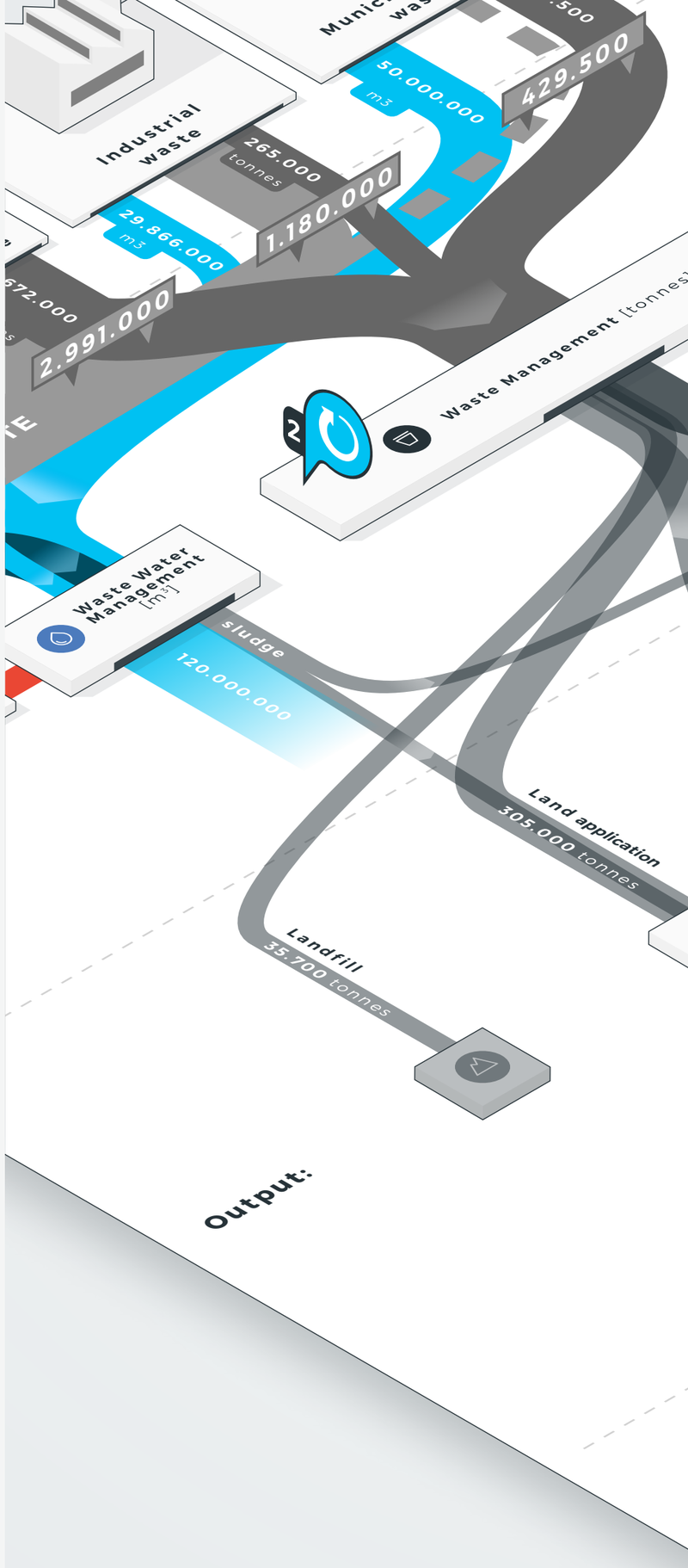
Anaerobic digestion systems convert waste biomass into biogas in the absence of oxygen. Subsequently, this biogas can further be upgraded to bioCNG, a compressed biogas with high methane content, which can be used as an effective fuel in vehicles, and a promising alternative to conventional fossil-fuels with lower CO2 emissions, noise and particulate pollution..

Case study: **BioCNG powered waste collection Berlin (DE)**

#### 2. Decentralised biomass waste collection and processing

Dedicated urban logistics services can collect manage, and deliver urban biowaste to a network of strategically located micro-scale waste-to-biofuel facilities that can process these residual streams to energy, and/or nutrient-rich inputs for use in local agricultural projects. Thus, the value of these residual streams is maintained in locally. These decentralised facilities have the potential to process solid residual biowastes, as well as wastewater.[6]

Case study: **GroenCollect and Stadsgas (NL)**



# OVERVIEW

Based on the circular opportunities and potential strategies identified for Prague's Utilities sector, the consortium selected the strategy with the greatest transformative potential in which to further develop in the action plan phase.

## Waste Biomass to BioCNG

There is a significant potential for the city of Prague to more effectively capture and process the approximately 93.500 tonnes of biodegradable and kitchen wastes generated households and restaurants, to the catering and food processing industries. Through the development of a biogas plant, the city could generate value for the local economy at the same time as closing resource loops.

## A project to fulfil Prague's growing demand

At present, Prague lacks complex facilities to process these residual streams at their potentially high value and, overwhelmingly, these waste streams are incinerated and partly composted. While energy produced from the incineration process is captured, moisture from of these wastes is known to reduce the thermal efficiency of the waste to energy plants. Therefore, the opportunity for the development of a biogas plant has been recognised, and selected, by the consortium to be developed further in the third phase of the Scan.

## Action planning a project for Prague

The chosen circular strategy was further developed in the third phase of the Circle City Scan. The following pages provide (i) A short overview of the circular strategy showcased with international best practices, and resulting project, (ii) A visual strategy canvas which details roles, processes and stakeholder, and (iii) a detailed step-by-step action plan to take the project from conceptualisation to implementation.

**This project and study helped us to better understand Prague's material and waste flows. As a result of the process, we have several great pilots projects ideas which we are currently looking to implement. Soon maybe our entire fleet will be running on biofuel from waste.**

**Patrik Roman**
CEO Pražské Služby a.s.

# CIRCULAR STRATEGY

## Waste biomass to BioCNG

Waste biomass is increasingly being seen as an attractive alternative fuel to fossil-fuel. By decomposing biowastes in an enclosed space without oxygen, termed anaerobic digestion (AD), large quantities of biogas can be produced (composed mainly of methane - 60%, and CO2 - 40%).

Biogas produced from waste biomass can be further processed to remove CO2, upgrading it into biomethane, or compressed natural gas (CNG), which has a concentration of methane in excess of 90%. Approximately 73.8m$^3$ of BioCNG can be produced from 1 tonne of residual biomass, enough energy to power a CNG-bus for 123km.[8]

## BioCNG as a renewable fuel for urban mobility

This upgraded biofuel (BioCNG), can ultimately be used as fuel for urban vehicles, most notably large, fuel intensive vehicles such as waste collection vehicles and city buses. Natural Gas Vehicles (NGVs) exhibit low emissions and a reduced carbon footprint. What is more, the residue 'digestate' from the AD can be utilised as an organic fertiliser for use on agricultural land.

## A circular strategy to meet existing ambitions

In the city's Regional Waste Management Plan 2016-2025 the City of Prague have already established clear priorities for the increased separate collection and high-value utilisation of residual biomass* through, among other things, supporting the construction of anaerobic decomposition and energy recovery.[9] In parallel to this, stricter $CO_2$ and pollution limits will start to hit transportation in Prague,** and will be difficult to achieve without exploiting the potential of biomethane production.

# A PROJECT IN PRAGUE

## Developing a biogas plant for Prague

A biomass to biogas and Bio-CNG plant can hold significant potential for the city of Prague. The 93.500 tonnes of biogenic wastes that are produced each year can generate approximately 6,900,300m$^3$ of biomethane.[8]

## Powering waste collection fleet with waste biomass

Just 67% of the total estimated potential of bio-fuel can power the entire fleet (147 passenger and 573 freight vehicles) of the largest waste management company of Pražské služby (Prague Services). Thus, the entire fleet of Pražské služby can be powered on the energy generated from the very waste it collects, with enough remaining biomethane to power 63 city buses year-round.[8]

Although there is significant potential to operate a large range of urban vehicles on BioCNG produced from waste biomass, the initial scoping of the initial project will focus specifically on supplying BioCNG to power the municipal waste collection fleet of Prague. This is due to its existing CNG capacity of the fleet.***

# KEY PERFORMANCE INDICATORS

For this project to support Prague's transition towards a to a more circular economy, KPIs can be used to guide the project process[10] :

- **Total quantities of biowastes processed in biogas facility:** This indicator is important to understand the total quantities of biowaste that are being utilised at a high(er) value, which is the motivation of the project.
- **Percentage of Municipal Waste Collection Fleet powered by BioCNG:** This indicator helps to measure the extent to which the BioCNG that is produced is being directly utilised in the city.
- **Total share of biowastes that are separately collected:** This indicator measures the proportion of the total biowastes generated in Prague that are collected separately, that can be utilised as a feedstock for biogas and BioCNG production.

# INTERNATIONAL BEST PRACTICES

As a flexible and mature technology, there are many international best practices of processing residual biomass into biogas and BioCNG which can serve as inspiration and provide further information.

### Biofuel-powered waste collection, Berlin (DE)

In the German capital, 150 waste management vehicles are fuelled by biogas that is produced by the over 60,000 tonnes of organic wastes that are collected. These vehicles not only provide a reduction in pollution, and two-thirds lower CO2 emissions, but are 50% quieter.[11]

### Biogas upgrading into BioCNG, Vienna (AU)

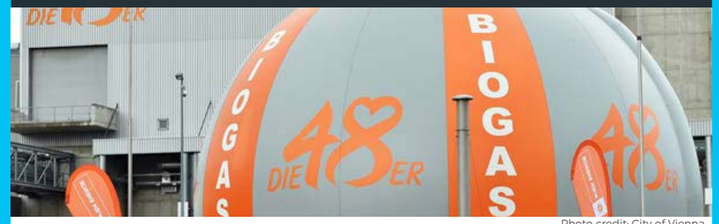



Photo credit: City of Vienna

Since 2015, the Vienna-Simmering biogas plant upgrades biogas into BioCNG which is distributed into the national grid; supplying 900 households with biomethane, saving more than 3,000 tonnes of CO2.[12]

* By at least 50% of the overall level of preparation for reuse by 2020 and recycling of household waste
** By 2030, at least 14% of energy for transport will have to come from renewable energy, with BioCNG able to contribute significantly to this.
*** Although buses in Prague are not currently CNG-ready, with an average of 110 buses replaced each year, there is potential to gradually transition the bus fleet towards CNG within the natural replacement cycle of the fleet towards the future.

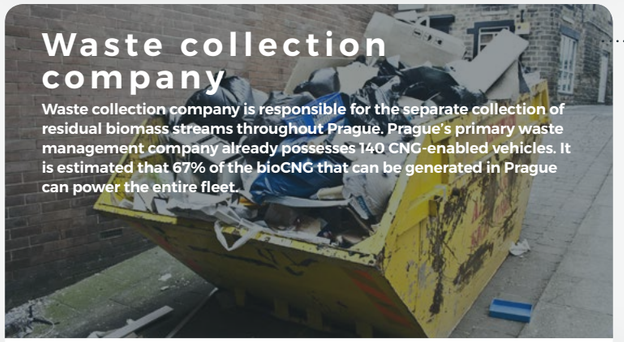
# **ACTION PLAN:** WASTE BIOMASS TO BIO-CNG

## Households, Food retail & catering industries

**Approximately 93.500 tonnes of biodegradable wastes are produced from Prague's households and food industries each year, which can be separately collected and transformed into biofiels.**

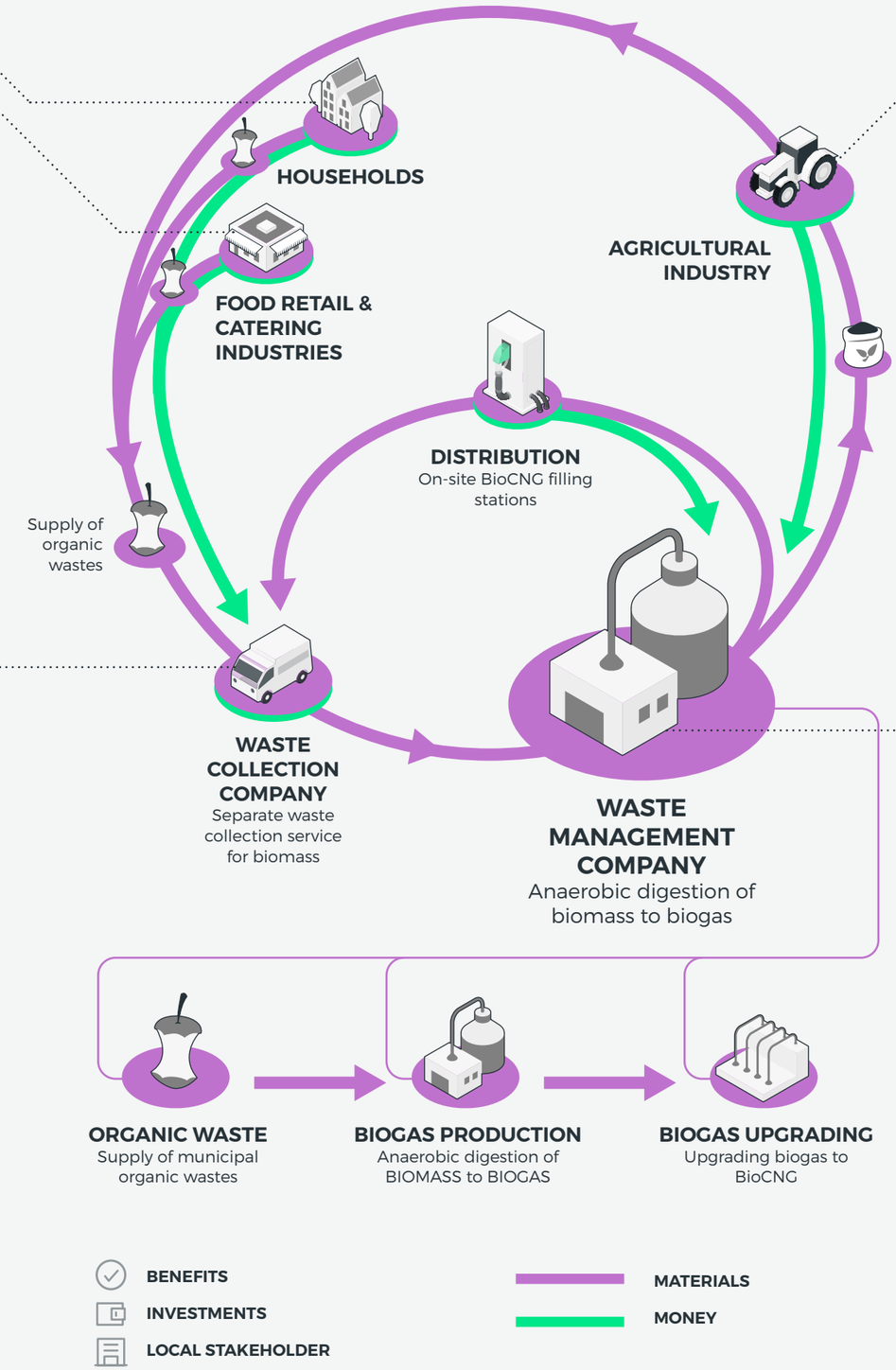
- Reduced costs for waste collection
- Healthy and livable environment through reduced noise and pollution of waste collection vehicles
- Shift of behavioural habits to separately dispose of organic wastes
- Households; Supermarkets; Farmers markets; Hotels; School canteens; Cafés; Restaurants

## Waste collection company



**Waste collection company is responsible for the separate collection of residual biomass streams throughout Prague. Prague's primary waste management company already possesses 140 CNG-enabled vehicles. It is estimated that 67% of the bioCNG that can be generated in Prague can power the entire fleet.**

- Reduced greenhouse gas emissions of the waste collection fleet by ~65%[11]
- Reduced pollution of NOx and fine dust emissions[1]
- Reduced noise of waste collection fleet by a perceived 50%
- Reduced and more stable cost of fuels
- Sustainable image
- BioCNG enabled vehicle fleet
- Training for drivers to manage new fleet requirements
- Increased costs for the separate biowaste collection service of approximately CRK 20,000,000[8]
- Pražské služby a.s.

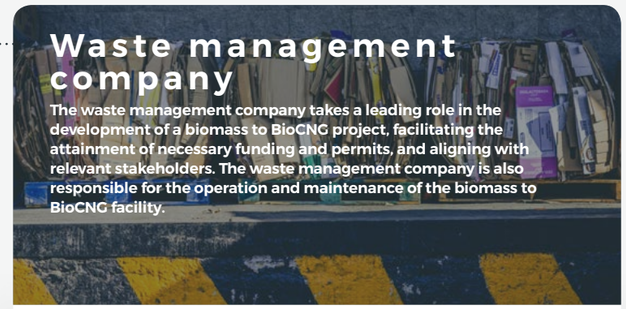



## Agricultural industry

**The potential 100.000m3 of digestate that are produced from the biomass to BioCNG process can be utilised by the agricultural industry as a natural fertiliser.**

- Substitution of chemical fertiliser with a renewable source of organic fertiliser produced from digestate
- No additional requirements
- Local farmers; City of Prague (owner of agricultural land, parks & forests)

## Waste management company



**The waste management company takes a leading role in the development of a biomass to BioCNG project, facilitating the attainment of necessary funding and permits, and aligning with relevant stakeholders. The waste management company is also responsible for the operation and maintenance of the biomass to BioCNG facility.**

- High-value cycling of residual biomass
- Revenue from sale and supply of BioCNG and digestate, Return on Investment dependent on attainment of subsidies
- Increased efficiency of Zevo Malešice waste to energy plant due to the diversion of wet biomasss
- Staff for the operation and maintenance of the plant, of which 5 are part-time service staff, 1 office worker, and 1 sales representative
- Time to manage the development of the project
- Investment costs depending on the size of plant of which 45% could be funded through environmental subsidies
- Pražské služby a.s.

# ACTION PLAN: WASTE BIOMASS TO BIO-CNG

## Project scoping phase

### 1 Establish action group & Project kick-off

Create a committed core working group to navigate the full process. Strong political backing of the initiative is also invaluable.

**Stakeholders:** Waste management company; Waste collection company

### 2 Commission full feasibility study

Undertake a full feasibility study to scope the development of the most appropriate project for Prague, including analysis into; (i) appropriate size and technologies, (ii) expected quantities of feedstock and yields, (iil) the current legislating environment, (iv) life cycle analysis of the project, (v) financial feasibility and financing strategies.

**Stakeholders:** Waste management company

**Outcomes of this phase:**

- ☑ Confirmed support from the City of Prague, such as the official Council votes.
- ☑ Completed full feasibility study.
- ☑ Defined viable scope and approach for the project.

## Separate collection of residual municipal biomass

### 3 3a. Pilot separate biomass collection

While the technical development of a bioCNG process can take many months to develop, the piloting of separate biowaste collection can start immediately and can be seen as a regret-free commitment. Although an important prerequisite of a biomass to bioCNG initiative, the separate collection of biowastes is also a key part of a circular city more generally, with many other possible high-value applications for these biowaste streams.

### 3b. Scale-up separate biomass collection

Continual monitoring of the separate biowaste collection pilot should be undertaken to identify strengths, opportunities and challenges. With these insights, more additional pilot projects can be implemented in other districts of Prague to dramatically increase the quantities of separately collected residual biomass.

**Stakeholders:** Waste management company; Waste collection company

**Outcomes of this phase:**

- ☑ A pilot of a door-to-door separate biomass waste collection system in one district in Prague.
- ☑ Expansion of separate residual biomass pilot projects throughout multiple districts in Prague
- ☑ Feedback from citizens regarding viable separate biowaste collection

## Development of the project phase

### 4 Engagement with stakeholders

Conduct early stakeholder engagement to align on roles and responsibilities, positively involving all parties as early as possible. Make sure these discussions are open and transparent, and allow sufficient time for public consultation.

**Stakeholders**: All

### 5 'Entrepreneurial Plan' and project funding

Create the necessary Entrepreneurial Plan. Outline potential project funding, revenue, and return on investment periods. Once established, apply for relevant project funding opportunities such as the investment subsidy from the Operational Program Environment (OPE).[13] The subsidy rate is 45% of the investment costs but an early and individual conversation with the funding provider is crucial.

**Stakeholders:** Waste management company

**Outcomes of this phase:**

- ☑ Conducted public consultations engaged stakeholders.
- ☑ Conducted Entrepreneurial plan.
- ☑ Secured project funding

## Permitting phase

### 6 Obtain necessary permits

Following the permitting procedure for a BioCNG project in the Czech Republic. The permitting scheme includes the following elements; (i) Incorporation in Regional development plan, and Community land-use plan; (ii) EIA; (iii) Land control permit; (iv) Building permit; (v) Building acceptation.[14]

**Stakeholders**: Waste management company; external impact assessment consultants

Tip: As many permits build upon the same core information, it is advisable to have a common, continually updated information base that is accessible to all parties, in order to streamline the permitting process. Support from external experts can build capacity, to get through the "complex process".

**Outcomes of this phase:**

- ☑ Obtained all necessary permits for the biomass to bioCNG project
- ☑ Approved vote in the City Council

## Project implementation phase

### 7 Write and publish a tender for the plant construction

Write up a tender document for the construction of the final, approved biomass to BioCNG project. Make sure to consider the lifecycle of the project in the tender, including the potential reusability of materials and components post-service-life.

**Stakeholders**: All

### 8 Train necessary staff

Provide appropriate trainings for staff that will be operating the biomass to BioCNG facility, as well as drivers of the bioCNG waste collection vehicle fleet.

**Stakeholders:** Waste management company

**Outcomes of this phase:**

- ☑ Conducted public consultations engaged stakeholders.
- ☑ Conducted Entrepreneurial plan.
- ☑ Secured project funding

## Operational phase

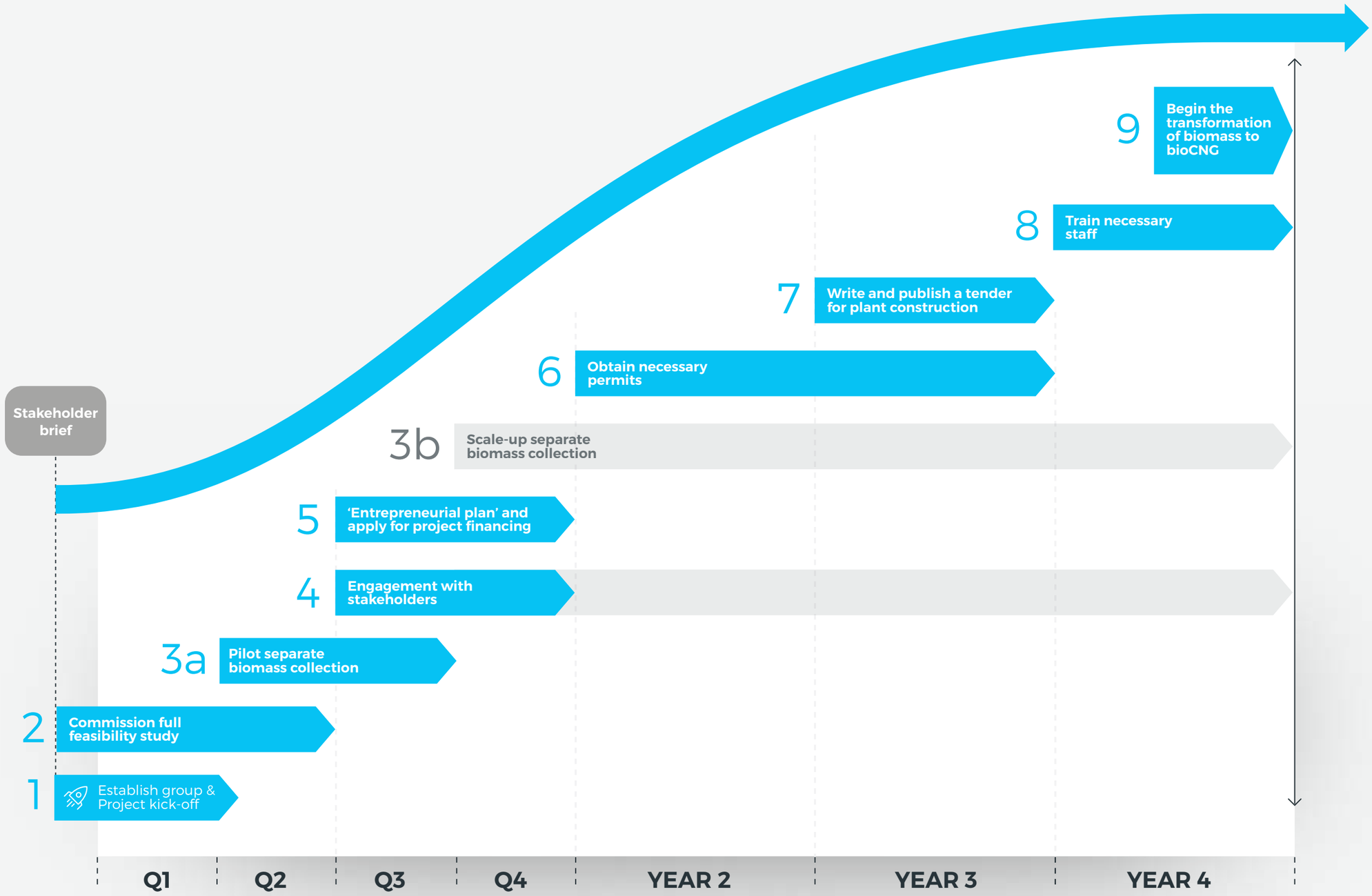
### 9 9. Train necessary staff

Start full operation of biomass to BioCNG plant Continue to monitor and evaluate the performance based on KPIs.
**Stakeholders:** Waste management company

**Outcomes of this phase:**

- ☑ Separate biomass municipal waste collection fleet fuelled by the organic waste that they are collecting.

# **ACTION PLAN:** WASTE BIOMASS TO BIO-CNG



# CONCLUSION

## PRACTICAL AND SCALABLE SOLUTIONS FOR A CIRCULAR FUTURE

The city of Prague has kick-started their transition towards a circular economy through the process of the Circle City Scan. Following a collaborative and fact-based innovation process, three circular strategies have been presented that hold significant transformative potential for Prague in three priority areas; construction, households, and utilities. Each strategy has been identified based on its potential influence on key material flows, while taking into account the local context to secure implementation.

For the construction sector, its large virgin material footprint presents itself as an opportunity to improve the environmental performance and stimulate circular activities in the sector. A tangible pilot project has been suggested to develop and apply circular criteria to the renovation of hall 23 in the historic market of Holešovická tržnice, which can serve as a 'quick-win' to test and iterate on the concept.

Prague's households, on the other hand, currently dispose of a large quantity of products, which overwhelmingly are burned as an energetic fuel. The development of a pilot ReUse Hub, that can cluster circular activities and organisations to stimulate reuse, can serve as a prime opportunity to stimulate employment while capturing value within the local economy.

The utilties sector of Prague is responsible for the management of the 4,6 million tonnes of waste each year. Analysis of the flows of materials of the sector pinpointed an opportunity for high value applications of waste biomass streams through the development of a biogas plant to generate a sustainable source of fuel municipal waste collection fleet.

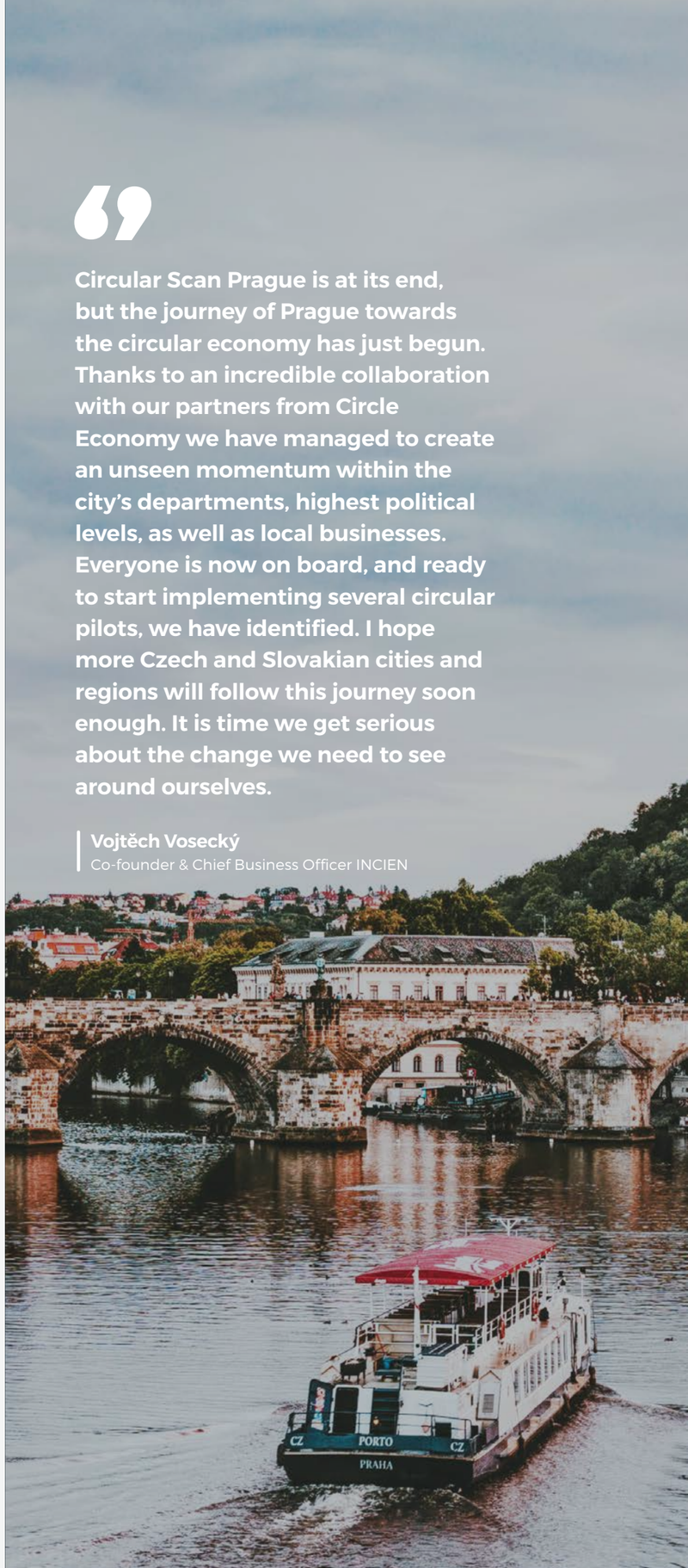
## CONTINUED PUBLIC AND PRIVATE SUPPORT

Transitioning towards a more circular economy is a complex journey, and will not happen overnight. Thus, sustained action and commitment is required from both the public and private sectors, capitalising on each other's strengths. Throughout the process of the City Scan, momentum towards the circular economy has been created within Prague. In order to create the tangible benefits that are presented by the circular economy, it is important to capitalise on this existing momentum and take a collaborative, step-by-step approach to take each pilot from concept to reality.

Based on the insights from this Scan, the city of Prague has already taken steps towards the implementation of a waste biomass to bioCNG project through the commissioning of a full feasibility study. Similar proactive and collaborative actions are required to take each circular strategy from a circular inspiration towards practical and scalable implementation to drive Prague's circular transition.

## SUSTAINED MOMENTUM FOR A CITY-WIDE TRANSITION

Three projects will not secure the transition alone. Thus, the city of Prague must continue to build upon this momentum and pursue a comparably collaborative approach engage and support the circular transition in other sectors, stakeholders and strategies throughout Prague. To facilitate this broader circular transition, it is recommended for the city to embed circular thinking into vision and strategy for the city. Though this, the public sector, businesses and civil society alike can be rallied behind a unified vision for a circular Prague to drive the transition.




**Circular Scan Prague is at its end, but the journey of Prague towards the circular economy has just begun. Thanks to an incredible collaboration with our partners from Circle Economy we have managed to create an unseen momentum within the city's departments, highest political levels, as well as local businesses. Everyone is now on board, and ready to start implementing several circular pilots, we have identified. I hope more Czech and Slovakian cities and regions will follow this journey soon enough. It is time we get serious about the change we need to see around ourselves.**

**Vojtěch Vosecký**
Co-founder & Chief Business Officer INCIEN

## PHASE 1:

[1] Circle Economy. (2019). “The Circularity Gap Report 2019: Closing the Circularity Gap in a 9% World”. Available online via: https://docs.wixstatic.com/ugd/ad6e59_ba1e4d16c64f44fa94fbd8708eae8e34.pdf

[2] The World Bank. (2018). “Urban Development Overview”. The World Bank. Online via: https://www.worldbank.org/en/topic/urbandevelopment/overview

[3] UNEP. (2017). “Resilience and resource efficiency in cities”. United Nations Environment Programme. Available online via: https://wedocs.unep.org/bitstream/handle/20.500.11822/20629/Resilience_resource_efficiency_cities.pdf?sequence=1&isAllowed=y

[4] Fraunhofer Institute. (2015). “Morgenstadt: City Insights City Lab Report Prague”. Available online via: http://www.iprpraha.cz/uploads/assets/dokumenty/ssp/SMART%20Cities/Full_Morgenstadt_CityReport_Prague_EN.pdf

[5] Prague Statistics Office. (2016). Available online via: www.czso.cz

[6] Eurostat. (2016). Available online via: ec.europa.eu/eurostat

[7] European Commission. (2017). “Commission Staff Working Document - The EU Environmental Implementation Review - Country Report - Czech Republic” European Commission.

[8] IPR. (2015). “Comparing Prague with selected European cities from the perspective of land use, housing and management: Strategy and Policy Section”. IPR, Prague.

[9] Cenia. (2008). “Energy Sector - The Environment of the Czech Republic.” Cenia, the Czech Environmental Information Agency.

[10] Czech Statistical Office. (2017). “Generation, Recovery and Disposal of Waste for the period of 2016”.

[11] Czech Statistical Office. (2014). “Green Growth in the Czech Republic - Selected Indicators 2013”.

[12] Ministry of Industry and Trade Czech Republic; Confederation Industry of the Czech Republic & Czech Statistical Office (2015). “Panorama of the Manufacturing industry of the Czech Republic 2015”.

[13] R&Dialogue. (2015). “National Discussion Paper, Czech Republic. Document created in the framework of the European project R&Dialogue”.

[14] Cenia. (2014). “Report on the Environment of the Czech Republic”. Cenia, Czech Environmental Information Agency.

[15] IPR. (2016). “Smart Cities Agenda - Project Morgenstadt- A Triangulum”. IPR Prague, Department of Strategy and Development.

[16] Cenia. (2016). “Statistical and Annual Report by the Ministry of Environment” Cenia, Czech Environmental Information Agency

[17] Regional Office of the Czech Statistical Office in the Capital City of Prague. (2017). Statistical Yearbook of the Capital City of Prague.

[18] IPR. (2016). “The Strategic Plan of Prague”. IPR Prague.

## MAIN MATERIAL FLOW ANALYSIS SOURCES:

[1] Ministerstvo Prumyslu A Obchodu. (2012). “Surovinová Politika České Republiky”. Available online via: http://www.spov.org/data/files/surovinovapolitika072012.pdf

[2] City of Prague (2018). “Vyhodnocení Komplexního Systému Nakládání S Komunálním Odpadem Na Území Hl. M. Prahy V Letech 1998-2017”. Available online via: http://portalzp.praha.eu/jnp/cz/odpady/souhrnne_informace/index.xhtml

[3] Ministry of Agriculture of the Czech Republic. (2016). “Report on water management in the Czech Republic in 2016”. Ministry of Agriculture of the Czech Republic.

[5] Czech Statistical Office (CZSO). Available online via: https://www.czso.cz/

[6] Praha: Portal of the Environment. Available online via: http://portalzp.praha.eu

[7] Ministerstvo zivotniho prostredi. VISOH: Public information on production and waste management. Available online via: https://isoh.mzp.cz/visoh

## CONSTRUCTION SECTOR:

[1] Ministerstvo Prumyslu A Obchodu. (2012). “Surovinová Politika České Republiky”. Available online via: http://www.spov.org/data/files/surovinovapolitika072012.pdf

[2] Material Economics. (2018). “The Circular Economy: A powerful tool for climate mitigation”. Available online via: https://media.sitra.fi/2018/06/12132041/the-circular-economy-a-powerful-force-for-climate-mitigation.pdf

[3] Insights from local construction sector stakeholders at the roundtable discussions

[4] MatCH. (2016). “Bau Material und Energieressourcen sowie Umweltauswirkungen der baulichen Infrastruktur der Schweiz”.

[5] Circle Economy. (2018). “Amstelveen Circulaire”. Available online via: https://www.amstelveen.nl/wonen-leven/publicatie/duurzaamheid_duurzaamheidsprojecten_circulaire-economie-in-amstelveen

[6] Cusidó, J.A. & Cremades, L.V. (2012). “Environmental effects of using clay bricks produced with sewage sludge: Leachability and toxicity studies”. Waste Management. Vol.32 pp.1202-1208.

[7] Hainin, M.R.; A. Aziz, Md. M; Ali, Z.; Putra Java, R.; Elsergany, M. & Yaacob, H. (2015). “Steel slag as a road construction material. Jurnal Teknologi. Vol.73(4) pp.33-38.

[8] CZSO. (2018). “Housing construction in the Capital City of Prague by administrative district in 2017”. Statistical Yearbook of Prague. Czech Statistical Office.

[9] European Commission. (2015). “Public procurement - A study on administrative capacity in the EU: Czech Republic country profile”. European Commission.

[10] MLSA. (2016). “Law Governing Socially Responsible Public Procurement in CR”. Ministry of Labour and Social Affairs. Available online via: http://sovz.cz/en/law-governing-socially-responsible-public-procurement-in-the-cr/

[12] Ministerstvo životního prostředí. (2015). “The regional waste management plan of the Capital City of Prague 2016-2025”. Ministerstvo životního prostředí.

[13] Green Deal on Circular Procurement Project Group. (2016). “Added value: Reaping the benefits of 3 years of the Green Deal on Circular Procurement”. REBus.

[14] Deník. (2019). “Pražská tržnice je ostudně zanedbaný areál. Město dá na její obnovu 100 milionů”. Available online via: https://www.denik.cz/ekonomika/prazska-trznice-ostudne-zanedbany-areal-mesto-da-na-jeji-obnovu-100-milionu-20190211.html

[15] Metabolic & SGS Search (2018). “Roadmap Circular Land Tendering: An introduction to circular building projects”. Gemeente Amsterdam. Available online via: https://amsterdamsmartcity.com/projects/roadmap-circular-land-tendering

[16] Alhola, K.; Salmenpera, H.; Ryding, S-O & Busch, N.J. (2017). Circular Public Procurement in the Nordic Countries”. Nordic Council of Ministers.

[17] Ellen MacArthur Foundation. (2016). “Circularity in the built environment: Case Studies. A compilation of case studies from the CE100”.

[18] European Commission. (2017). “Using recycled concrete in the construction of new buildings”. GPP In practice, Issue no.75.

[19] European Commission. (2017). “Public Procurement for a Circular Economy: Good practice and guidance”.

[20] Padding, T.; Croon, G.; van Haastrecht, D. & Dijkstra, R. (2015). “A framework for circular procurement”.

### Case studies construction sector:

Austin Materials Marketplace - (2018) Online via: https://austinmaterialsmarketplace.org/

Eco-Ceramics - European Commission (2009) “ECO-CERAMICS - Ecological ceramics optimization. Alternative to sludge disposal”. Available online via: http://ec.europa.eu/environment/life/project/Projects/index.cfm?fuseaction=search.dspPage&n_proj_i=2896&docType=pdf

HARSCO. Available online via: http://www.harsco-m.com/271/Harsco-Wins-Green-Plant-Of-The-Year-In-Slovenia.aspx

The Boring Company. Online via: https://www.boringcompany.com/faq/

PUMA. Available Online via: https://amsterdamsmartcity.com/projects/puma-prospecting-the-urban-mines-of-amsterdam

MADASTER. Available Online via: https://www.madaster.com/en

Brummen Town Hall. SPP Regions. (2017) “Circular procurement: Case study collection”. Available online via: http://www.sppregions.eu/fileadmin/user_upload/Circular_Procurement_Case_Study_Collection.pdf

BIG Reuse. Online via: https://bigreuse.org/about/

## HOUSEHOLDS:

[1] Varvazovska, P. & Prasilova, M. (2015). “Waste production as one of the problems of postmodern society” Procedia Economics and Finance. Vol.23 pp.1674-1679.

[2] Federal Statistical Office (FSO) (2016): 871-1600 Taschenstatistik 2016, Landwirtschaft und Ernährung.

[3] OECD. (2015). “Environment at a glance 2015”. OECD. Available online via: https://www.oecd-ilibrary.org/environment/environment-at-a-glance-2015/municipal-waste_9789264235199-14-en

[4] Lakhan, C. (2015). “A comparison of single and multi-stream recycling systems in Ontario, Canada”. Resources. Vol.4 pp.384-397.

[5] Prazske Sluzby (N.d.). “Roční bilance materiálu a energie”. Availableonline via: http://www.psas.cz/index.cfm/sluzby-firmam/zarizeni-pro-energeticke-vyuzivani-odpadu/rocni-bilance/

[6] Van Leeuwen, C.J. & Sjerps, R.M.A. (2015). “The City Blueprint of Amsterdam: An assessment of integrated water resources management in the capital of the Netherlands”. Water Science & Technology: Water Supply. Available online via: https://www.watershare.eu/wp-content/uploads/015020404.pdf

[7] OECD. (2018). “Meat consumption (indicator)”. Available online via: https://data.oecd.org/agroutput/meat-consumption.htm

[8] UNEP. (2010). “Assessing the environmental impacts of consumption and production: Priority products and materials”. United Nations Environment Programme. Available online via: http://www.unep.fr/shared/publications/pdf/dtix1262xpa-priorityproductsandmaterials_report.pdf

[9] City of Prague (2018). “Vyhodnocení Komplexního Systému Nakládání S Komunálním Odpadem Na Území Hl. M. Prahy V Letech 1998-2017”. Available online via: http://portalzp.praha.eu/jnp/cz/odpady/ souhrnne_informace/index.xhtml

[10] FOEN. (2018). “Waste and raw materials: In brief”. Available online via: https://www.bafu.admin.ch/bafu/en/home/topics/waste/in-brief.

[11] WRAP. (2012). “Composition of kerbside and MWRC bulky waste”. Waste and Resources Action Programme. Available online via: http://www.wrap.org.uk/content/study-re-use-potential-household-bulky-waste

[12] Insights from local construction sector stakeholders at the roundtable discussions

[13] Ellen MacArthur Foundation. (2019). “Urban Products System Summary”. Available online via: https://www.ellenmacarthurfoundation.org/assets/downloads/Products_All_Mar19.pdf

[14] Pre-Waste. (2012). “Alelyckan Re-use Park, Sweden”. Pre-Waste & INTERREG IVC. Available online via: http://www.ambiente.marche.it/Portals/0/Ambiente/Rifiuti/PW_Traduzione/030_Pre_waste_30_SE_Alelyckan_reuse_park_17_07_2012.pdf

[15] NCIEN. (2017). “Opětovné Využití A Re-use Centra”. Institut Cirkulární Ekonomiky, Praha.

[16] WRAP. (2018). “Household waste recycling centre (HWRC) guide”. WRAP, UK.

[17] EEA. (2018). “Waste Prevention in Europe - Policies status and trends for reuse in 2017: Waste prevention country profiles - focus reuse”. European Environmental Agency.

[18] Ljubljana ReUse Centre. Available online via: http://www.snaga.si/en/reuse-centre

[19] Aggesund, P. (2018). “The sustainable development way of implementing circular economy: A system thinking approach”. Papers from the Department of Human Geography, Stockholm University.

[20] Mairie de Paris. (2017). “Paris Circular Economy Plan: 1st Roadmap”. Available online via: https://api-site-cdn.paris.fr/images/97396

[21] C40 Cities. (2019). “Municipality-led circular economy case studies”. Climate-KIC & C40 Cities. Available online via: https://www.c40.org/researches/municipality-led-circular-economy

### Case studies households:

City of Chicago. Available online via: https://www.cityofchicago.org/city/en/depts/dcd/supp_info/green-healthy-neighborhoods.html

OLIO. Online via: https://olioex.com/about/our-story/

ReTuna. Online via: https://www.retuna.se/sidor/in-english/

Repair Cafe. Online via: https://repaircafe.org/en/shop/

Wasted Lab. Online via: https://wastedlab.nl/en/#numbers

WEEElectric. Online via: https://www.weeelectric.nl/

## UTILITIES SECTOR:

[1] Prague Statistical Office. (2017). “Odpadové hospodářství v hl.m. Praze”. Available online via: http://portalzp.praha.eu/jnp/cz/odpady/souhrnne_informace/odpad_hospodarstvi_vPraze_strucnashrnuti.html#2015

[2] City of Prague (2018). “Vyhodnocení Komplexního Systému Nakládání S Komunálním Odpadem Na Území Hl. M. Prahy V Letech 1998-2017”. Available online via: http://portalzp.praha.eu/jnp/cz/odpady/souhrnne_informace/index.xhtml

[3] Ministerstvo zivotniho prostredi. (2014). “Waste management in the

Czech Republic”. Available online via: https://www.mzv.cz/file/1122615/

Prezentacja_SOSEXPO_MZP.pdf

[4] Prazske Sluzby (N.d.). “Roční bilance materiálu a energie”. Available online via: http://www.psas.cz/index.cfm/sluzby-firmam/zarizeni-pro-energeticke-vyuzivani-odpadu/rocni-bilance/

[5] Insights from local waste management stakeholders at the roundtable discussions

[6] Ministry of Agriculture of the Czech Republic. (2016). “Report on water management in the Czech Republic in 2016”. Ministry of Agriculture of the Czech Republic.

[7] Trendsetter. (2003). “Biogas as Vehicle Fuel: A European Overview”. Miljo Ilar, Stockholm Stad, Civitas.

[8] INCIEN. (2019). “BioCNG pro Prahu: Využití bioodpadů vyprodukovaných na území hlavního města Prahy k produkci biometanu, jakožto paliva pro vozový park města či dodávku do sítě”. Institut Cirkulární Ekonomiky, Praha.

[9] Ministerstvo životního prostředí. (2015). “The regional waste management plan of the Capital City of Prague 2016-2025”. Ministerstvo životního prostředí.

[10] IRENA. (2018). “Biogas for road vehicles: Technology brief” International Renewable Energy Agency.

[11] Gosten, A.; Rücker, T. & Winkelmann, W. (2010). “The Berlin Biogas-Project: The production of Biomethane from Organic Waste”.

[12] EBA. (N.d.). “Austria: The first biogas upgrading plant has successfully started operation”. European Biogas Association. Available online via: http://european-biogas.eu/2015/09/09/austria-the-first-biogas-upgrading-plant-has-successfully-started-operation/

[13] BiogasIN. (2012). “Permitting procedures for biogas plants in Bulgaria, Croatia, Czech Republic, Greece, Latvia, Romania and Slovenia”. IEE Project ‘BiogasIN’.

[14] Biogas Action. (2017). “Country profile and actions in BiogasAction: Czech Republic”. Biogas Action.

[15] BiogasMax. (2010). “BiogasMax 2006/2010 the synthesis”. BiogasMax.

### Case studies Utilities sector:

Basel Green Roofs - Climate-ADAPT. (2015). “Green roofs in Basel, Switzerland: Combining adaptation and mitigation measures”. European Climate Adaptation Platform. Available online via: https://climate-adapt.eea.europa.eu/metadata/case-studies/green-roofs-in-basel-switzerland-combining-mitigation-and-adaptation-measures-1

Benthemplein - De Urbanisten. Online via: http://www.urbanisten.nl/wp/?portfolio=waterplein-benthemplein

Amsterdam Rainproof. Online via: https://www.rainproof.nl/

Resource Hubs - Gemeente Amsterdam. (2016). “Uitvoeringsplan Afval: Grondstoffen uit Amsterdam”.

Biopolus. Online via: http://www.biopolus.net/technology/#Bio-Processors

Stadsgas & GroenCollect Online via: http://www.stadsgas.nl/

# APPENDIX

## Selection of sectors

The selected priority areas from Phase 1 were taken as an input for the material flow analysis. In order understand the relevant activities in each of the three priotity sectors, the NACE industrial classification was used. The three selections include:

Priority sectors

**Construction sector**
*(NACE Classification F 41-43)*
Construction activities include the construction of buildings, civil engineering, and specialised construction activities

**Households**
*NACE Classification not applicable*
Households are a typically a category to express the "final consumption" of goods in an economy.

**Utilities (Waste & wastewater management)**
*(NACE Classification E 37-38)*
Activities involving the collection, treatment, disposal, and recovery of residual streams, of both waste and wastewater. The 'energy' segment of the Utilities sector is considered through the lens of energy consumption in each of the three priority setors

## Data sources and processing

The data sources that were used to construct the material flow analysis diagrams are provided in the Annex of this document, and additional remarks are provided on how (if at all) data were combined and processed to arrive at a final figure. The main types of data sources include:

- Literature, studies, and policy documents to further develop an understanding of the resources in the country and city, including the Raw Materials Policy of the Czech Republic(1), Evaluation of complex management systems in the city of Prague(2), Report on water management in the Czech Republic(3) and Construction and demolition waste management in the Czech Republic(4).
- National Input-Output Database - EXIObase - to form the basis of the analysis. EXIObase records the national input and output of physical goods in the Czech Republic, classified by NACE sector, and household.
- City and national statistics are used to provide the most recent and detailed data, and further refine EXIObase data wherever possible. Key sources include, CZSO(5), Prague Statistics Office(6), and the VISOH database(7).

# Material flow analysis

## Material categories and products

The material flow analysis illustrates resource flows through a sector, or household. The material flows are categorised by energy, water, biomass, minerals & chemicals, metals, and emissions. These resource flows include raw materials as well as (finished) products. They depict annual material use and waste production. The material flow categories include:

**Energy**
The energy flows include both fuels for direct use and fuels for electricity generation.

**Biomass**
The biomass flows include vegetable and animal products originating from agriculture and forestry, as well as prepared meals and food products.

**Water**
The water flows include both water withdrawn directly from the environment and tap water. In some cases, such as in the waste management energy recovery sub-sector, a share of the water is not consumed up. Rather, it is used for cooling and can thus be re-entered in the production process.

**Minerals & Chemicals**
The minerals & chemicals flows on the one hand include solid materials that are present in nature and products thereof, such as clay and bricks. On the other hand, they include chemical compositions and oil-based products such as plastics and rubber.

**Metals**
The metals flows include raw and processed metals and products thereof, varying from iron ores to paper clips.

**Emissions**
The emissions flows include only greenhouse gas emissions, the overwhelming majority of which consists of $CO_2$.

## Waste treatment

Waste treatment is detailed per sector, and expressed according to five scenarios: reuse, recycling, energy recovery, land application, landfill, and incineration - where reuse and landfill are respectively the most and least desirable options. Waste treatment numbers, too, are given in amounts per year, based on the most recent available data.

**Reuse**
Products are reused, maintaining their original shape and characteristics. Often, this requires the reparation or replacement of parts of the product. Reuse is the most desirable treatment method, for it guarantees the highest level of value retention.

**Recycling**
Products are processed in order for its source materials to be reused. Throughout the recycling process, value is lost, rendering recycling a suboptimal choice of waste treatment method.

**Energy recovery**
Resources are burned in order to generate heat or other energy. Whereas a small fraction of the product's value is captured, most value is lost.

**Land application**
Resources are directly applied on, and provide value to, the land. Common examples include backfilling of materials to reclaim land or landscaping, use on agricultural land in a similar manner to fertiliser.

**Incineration**
Resources are incinerated and converted into emissions. No heat or energy is captured and resources thus lose all value.

**Landfill**
Resources are diverted to a landfill site, or discharged in surface water. Not only is all value lost, landfilling waste causes high levels of environmental pressure.

# **APPENDIX II:** APPROACH & METHODOLOGY PHASE 2: CIRCULAR OPPORTUNITIES & POTENTIAL STRATEGIES


## IDENTIFICATION OF CIRCULAR OPPORTUNITIES & POTENTIAL STRATEGIES

In order to identify circular strategies that would be most relevant for the city of Prague, two directions were followed: (i) we identified impact areas from the material flow analysis, and (ii) we hosted roundtable discussions with local industry stakeholders to understand what strategies and initiatives are already running on the ground in Prague.

**(i) Impact areas and materials:**

Through the results of the material flow analysis of Prague's three priority sectors, priority material flows and significant impact areas were identified. These priority material flows relate either to a large magnitude, or associated negative impact(s), and, as such, have the greatest transformative potential in a circular economy.

**(ii) Industry roundtable discussions**

In November 2019, roundtable discussions were held in Prague that brought together relevant stakeholders from the city's priority sectors. Through these roundtable discussions, insights were developed for the key priorities of the sector in the city, identifying local strengths, existing initiatives and potential opportunities and challenges for the circular economy.

## EVALUATION OF CIRCULAR STRATEGIES

In order to bring greater depth to each of the potential circular strategies identified, an impact analysis was carried out that investigated three overarching categories as presented below; environment, economic and feasibility. For each of the evaluation categories, more detailed indicators were used (the full list of which is provided in the Appendix IV):

**Environmental impact potential:** The environmental impact potential explores the environmental benefits that each direction could generate. It is important to note that this evaluation is only completed to the extent that information was available, and was not intended to offer a quantitative assessment. Indicators include; waste reduction potential, emissions reduction potential, and raw material consumption reduction potential.

**Economic potential:** The economic potential for each direction was explored further to give insight into the approximate costs and economic benefits that could be expected from each direction. Indicators include; jobs creation potential, investment costs, and return on investment.

**Technical feasibility:** It is important to understanding the overall feasibility to practically implement a pilot project of the circular strategy in Prague. This information is critical in identifying strategies that are likely to succeed in the near future. Indicators include; technology readiness level, legal barriers and institutional barriers.

## INDUSTRY WORKSHOP

On 28th November 2018, the results of material flow analysis, circular opportunities and potential circular strategies were presented to stakeholders from local business and municipal departments. During the workshop, participants selected two of the most promising circular strategies for each priority sector and further developed business models for each. A final vote was held to decide which single circular strategy for each priority sector held the greatest transformative potential for the city of Prague, and should be taken into Phase 3 to further develop action plans.

# SELECTION OF CIRCULAR STRATEGIES TO PILOT

Phase 3 of the Scan began following the industry workshop on 28th November in which local businesses and representatives from the municipal departments of Prague selected one circular strategy for each of the city's three priority areas. The three circular strategies are listed below:

## CONSTRUCTION

**Circular tendering criteria in construction projects**

A potential pilot for this circular strategy involves the development of a set of relevant and impactful circular criteria that could be incorporated in the tendering process of a municipal construction project.

## HOUSEHOLDS

**Circular ReUse Hubs**

A network of decentralised circular 'Hubs' throughout the city can focus on-site, value activities to utilise residual streams from households, such as offering reused materials and products, as well as recycling and upcycling, and repair activities.

## UTILITIES

**Waste Biomass to BioCNG**

Anaerobic digestion systems can covert residual biomass into biogas, which can subsequently be upgraded into bioCNG. Tangibly, this circular source of energy can be used to power vehicles, such as municipal bus, or waste collection fleets.

# LITERATURE REVIEW OF INTERNATIONAL BEST PRACTICES

For each of the circular strategies selected to lead the practical transition towards circularity in Prague, an extensive literature review was undertaken. This literature included project documentation from international best practices as well as synthesis reports that compiled learnings, best practices and recommendations for the implementation of each circular strategy. From this review of relevant literature, 'key ingredients for success' were aggregated for each strategy; including stakeholders, actions, resources, regulations etc.

# INDUSTRY ROUNDTABLES

These 'key ingredients' and international best practices were taken to a local industrial roundtable specialising on the circular strategy in question. Over the weeks of 25th Febrauary to 8th March, three industrial roundtables took place, one for each priority area of the Scan. At each of the roundtables were relevant local businesses and representatives from municipal departments. During the industry roundtables, the synthesised insights were presented and the circular strategy was co-created for the specific content of Prague, identifying potential pilot projects.

# CREATION OF ACTION PLANS

From the input of both external literature and local stakeholders from the industrial roundtables, each of the circular strategies was further developed to include the following elements:

1. A short overview of the circular strategy and resulting pilot project. The description of each project provides the following information:

- A project description further details how the project will work, reflecting the notes and insights generated from the stakeholders at the industry workshop.
- A handful of Key Performance Indicators (KPIs) are proposed such that project stakeholders can monitor the impact that the project is having in relation to the city's larger vision for a circular economy.
- Best practice examples of relevant projects in other cities are included to provide both inspiration and good "blueprints" for previously successful projects in each domain.

2. A business model canvas details the activities, benefits, investments and resources for each stakeholder within each pilot project. Specific organisations are named here as possible partners in Basel. The business model is visualised in a single, easy-to-read diagram such that each stakeholder can clearly understand their role within the overall concept.

3. A proposed action plan details the tangible steps needed to get the project started and how it could scale over time. Particular stakeholders are allocated to each action step, and insights into a scale-up strategy are also provided.

# APPENDIX IV: EVALUATION OF POTENTIAL CIRCULAR STRATEGIES

## ENVIRONMENTAL IMPACT POTENTIAL:

**The environmental impact potential explores the environmental benefits that each direction could generate. It is important to note that this evaluation is only completed to the extent that information was available, and was not intended to offer a quantitative assessment. Indicators include; waste reduction potential, emissions reduction potential, and raw material consumption reduction potential.**

## ECONOMIC POTENTIAL:

The economic potential for each direction was explored further to give insight into the approximate costs and economic benefits that could be expected from each direction. Indicators include; jobs creation potential, investment costs, and return on investment.

## TECHNICAL FEASIBILITY:

Technical feasibility: It is important to understanding the overall feasibility to practically implement a pilot project of the circular strategy in Prague. This information is critical in identifying strategies that are likely to succeed in the near future. Indicators include; technology readiness level, legal barriers and institutional barriers.

| | Environmental potential | | | | | Economic potential | | | | Technical feasibility | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Circular strategy** | Reduce generation of waste | Reduce CO2 emissions | Reduce raw material consumption | Increase secondary materials | Increase climate change adaptation | Job creation | Return of investment | Initial investment costs | Scale up potential | Technology readiness level | Legal barriers | Institutional barriers |
| **Online secondary materials marketplace** | 2 | 2 | 2 | 3 | - | 1 | 3 | 2 | 2 | 3 | 2 | 2 |
| **Cycling sludge into construction material** | 3 | 1 | 2 | 2 | - | 1 | 2 | 1 | 3 | 2 | 2 | 2 |
| **Cycling slag into construction material** | 3 | 1 | 2 | 2 | - | 1 | 2 | 1 | 3 | 3 | 2 | 2 |
| **Recycling excavation materials into construction materials** | 3 | 1 | 2 | 3 | - | 1 | 2 | 1 | 2 | 2 | 2 | 2 |
| **Building stock material database** | 1 | 2 | 2 | 2 | - | 1 | 2 | 1 | 2 | 3 | 3 | 2 |
| **Material passports in construction projects** | 2 | 2 | 2 | 2 | - | 1 | 2 | 1 | 2 | 2 | 2 | 2 |
| **Circular tendering criteria in construction projects** | 2 | 2 | 3 | 3 | 2 | 2 | 2 | 2 | 2 | 3 | 2 | 2 |
| **Circular deconstruction practices** | 3 | 1 | 2 | 3 | - | 2 | 3 | 1 | 2 | 3 | 3 | 2 |

| | Environmental potential | | | | | Economic potential | | | | Technical feasibility | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Circular strategy** | Reduce generation of waste | Reduce CO2 emissions | Increase recycling | Increase awareness | Increase sustainable consuption | Job creation | Return of investment | Initial investment costs | Scale up potential | Technology readiness level | Legal barriers | Institutional barriers |
| **Urban food production strategy** | - | 2 | - | 2 | 2 | 2 | 2 | 2 | 1 | 3 | 2 | 2 |
| **Digital tools for food sharing** | 2 | 2 | - | 2 | 2 | 1 | 2 | 1 | 3 | 3 | 2 | 2 |
| **Circular shopping centre** | 2 | 1 | 1 | 3 | 3 | 3 | 3 | 1 | 3 | 3 | 1 | 1 |
| **Repair 'hubs'** | 2 | 1 | 1 | 3 | 2 | 2 | 2 | 2 | 2 | 3 | 3 | 3 |
| **Community-based reward and recycling platform** | 2 | 1 | 2 | 2 | 1 | 1 | 2 | 2 | 2 | 3 | 2 | 2 |
| **Reverse logistics for E-waste** | 2 | 1 | 2 | 2 | 1 | 1 | 3 | 2 | 3 | 2 | 2 | 2 |

| | Environmental potential | | | | | Economic potential | | | | Technical feasibility | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Circular strategy** | Reduce generation of waste | Reduce CO2 emissions | Reduce raw material consumption | Increase secondary materials | Increase climate change adaptation | Job creation | Return of investment | Initial investment costs | Scale up potential | Technology readiness level | Legal barriers | Institutional barriers |
| **Urban green roof strategy** | - | 2 | 1 | - | 3 | 2 | 2 | 2 | 2 | 3 | 2 | 2 |
| **Decentralised rainwater management** | - | 2 | 1 | - | 3 | 2 | 1 | 1 | 2 | 3 | 2 | 2 |
| **Rainwater management platform** | - | 2 | - | - | 3 | 1 | 1 | 3 | 2 | 3 | 3 | 2 |
| **Decentralised 'circular hubs'** | 3 | 2 | 2 | 3 | - | 3 | 3 | 2 | 3 | 2 | 2 | 1 |
| **'Smart' waste collection infrastructure** | 2 | 2 | - | - | - | 2 | 2 | 1 | 2 | 3 | 2 | 2 |
| **Biomass to biofuels** | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 1 | 2 | 3 | 2 | 2 |
| **Decentralised biomass collection and processing** | 3 | 1 | 1 | 2 | 2 | 1 | 3 | 1 | 2 | 3 | 1 | 2 |

## Legend

- High
- Medium
- Low

# CIRCULAR
# PRAGUE


**Project Team**

**Circle Economy**
Ilektra Kouloumpi, Max Russell,
Jordi Pascual, Alexandru Grigoras

**INCIEN**
Soňa Jonášová and collective



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