

CIRCULAR GLASGOW

A vision and action plan for the city of Glasgow

GLASGOW
CHAMBER OF COMMERCE



CIRCLE
ECONOMY

Executive summary

The circular economy means 'enough for everyone forever', a direct challenge to the 'take, make, waste' mentality of the linear economy. The benefits of a circular economy for companies are endless: reducing dependency on scarce natural resources; increasing their competitive advantage; and realising significant financial savings.

Glasgow pioneers circularity

This report is the result of a pioneering collaboration between Glasgow Chamber of Commerce and Circle Economy, with support from Zero Waste Scotland and Glasgow City Council. The report addresses the essential question:

Where do we start in order to make a city more circular?

Glasgow is committed to growing a greener economy in its transformation into a more sustainable, smart and resilient city. A circular economy fits well within this ambition. The project has enabled Glasgow Chamber of Commerce to identify areas of circularity, determine how it can support local business, and become the pioneering champion of circular economy in Glasgow.

Circle City Scan of Glasgow

The *Circle City Scan* was delivered in four stages:

1. Local agenda - Assess economic and political will

Based on economic profile and political agenda, initial findings from the *Circle City Scan* of Glasgow identified three key sectors of economic importance to Glasgow: education, manufacturing and health. Combined, these three sectors provide over 117,500 jobs and over a quarter of Glasgow's economic value.

2. Material flows - Maps out the current state of the environmental impacts of the economic sectors

With strong stakeholder links to the private business sectors, coupled with an economic value of circa £329.7 million, Manufacturing was identified as having the greatest circularity potential, particularly within the food and beverage sector.

For cities, the circular economy has the potential to improve the quality of life for its citizens by creating jobs and spurring innovation, and reducing the demand on rare resources.

This project shows businesses and citizens how the circular economy can be implemented in Glasgow through practical and scalable strategies.

3. Circular innovations - Identifies tangible circular strategies

Nine potential circular strategies within the following three food and beverage sub-sectors were established: Bakery, Meat & Fish and Beer & Spirit. Post further stakeholders discussions, it was agreed that a focus should be placed on four of the nine circular strategies:

Heat Recovery – Bakery

Heat from bakery ovens can be recovered and redirected to the boilers by using heat exchangers, saving 15% – 30% of the energy currently used in the baking process.

Aquaponics – Meat & Fish

A promising technology in which the growing of fish is combined with the growing of soilless crop production, leading to substantial savings in water use (90%) in comparison to traditional farming.

Bread to Beer – Beer & Spirit

Utilises bread waste in the beer brewing process, saving 1/3 of the resources utilised in the brewing process. Food waste is also reduced.

High Value Cascading – Beer & Spirit

Residual streams from brewing (spent grain) can be used to replace up to 50% of the flour needed to produce bread in the baking industry.

4. Action plan - Implementation

Following the completion of the *Circle City Scan* and resultant identification of the above four circular strategies, the next phase of this project will be to focus on the implementation of the pilot projects. These selected case studies will act as a starting point to illustrate how the circular economy can be implemented through practical and scalable strategies, how businesses will benefit, and what positive effects it will have on the citizens of Glasgow.



Introduction

“Scotland is already recognised globally as a front-runner in putting the circular economy into practice.”

- Iain Gulland, Chief Executive, Zero Waste Scotland

CIRCLE CITIES
From scan to action in four steps

Life in our growing cities is a defining characteristic of humanity

More than 50% of the world's population inhabit our cities, with urban areas responsible for over two thirds of the world's energy consumption, more than 70% of greenhouse gas emissions and generating 1.3 billion tonnes of waste per year. As the global population grows beyond nine billion people by 2050, the demand and cost of scarce resources will continue to rise. This increasing demand, combined with a finite supply, will lead to shortages that will have a profound impact on economic development. It will restrict the homes that can be built, the people we can feed, and the water left to drink.

Circularity in cities

The circular economy is a radical solution that advocates a fundamental change in our current economic system, reducing the environmental burden on the planet. For cities, the circular economy is a way to improve the quality of life for citizens by creating jobs and spurring innovation, while reducing the resources needs. A circular economy makes business sense by using new and emerging technology to create opportunities for innovation and the development of new products and production techniques.

A new direction for Glasgow

Glasgow is a city renowned for its pioneering spirit in the sphere of trade and commerce. While Glasgow topped the list of UK cities making a successful recovery from the economic recession, it still faces challenges in increasing employment, productivity and economic output. In moving towards the circular economy, Glasgow has an opportunity to increase productivity by changing the way it uses resources and improving the city's economic output. Ultimately, this will lead to the sustainable wealth and wellbeing of its citizens. Sustainability is at the heart of Glasgow's policy agenda and embracing the circular economy is a pioneering step in increasing productivity and strengthening the city's economy.

Scotland as a world-leader

Scotland is one of the pioneering nations in the field of circular economy. The collaboration of policy-makers and businesses aims to accelerate the transition. Iain Gulland, Chief Executive, Zero Waste Scotland, said: *“We recently became one of the first countries in the world to have a government strategy, called Making Things Last, which aims to accelerate the circular economy and lead the way with practical projects, pilots and business support”*. Zero Waste Scotland has launched an investment fund to support local businesses, and welcomes the ambitions of the Scottish Government's new circular economy with Making Things Last and its commitment to reducing food waste to 25% of current levels by 2025.

“Glasgow is committed to growing a circular economy as part of our transformation into a more sustainable, smart and resilient city.”

- Kevin Rush,
Head of Economic
Development,
Glasgow City Council

As a leader in the implementation of a circular economy, Scotland is seeking new sustainable opportunities. Here Scotland's businesses will play a critical role in the transition to a circular economy, recognising that our cities are hotspots of innovation, creativity and entrepreneurship.

A starting point for a circular strategy

A unique collaboration between Glasgow Chamber of Commerce and Circle Economy, a social enterprise, based in the Netherlands, has been able to build a programme to accelerate the adoption of the circular economy. With support from Zero Waste Scotland and Glasgow City Council, this pioneering project has addressed two essential questions: Where do we start in order to make a city more circular? How can we translate the vision of a circular economy for Glasgow into practical and especially scalable solutions? Iain Gulland, Chief Executive, Zero Waste Scotland, said: *"This new partnership with Glasgow Chamber of Commerce is an important step towards engaging the business community and helping them to achieve more circular ways of working – for both the benefit of the individual business and Scotland's economy"*.

“ This project has enabled the Chamber to identify real areas of circularity in Glasgow.

- Alison McRae,
Senior Director,
Glasgow, Chamber
of Commerce

Businesses at the forefront of transition

A growing world population, combined with the finite supply of resources, will lead to scarcity and strong price fluctuations. More and more companies are, therefore, opting for the transition to a circular economy, which offers opportunities for innovation, export of new production techniques and business models, while reducing dependency on imports. Glasgow Chamber of Commerce can play a crucial role in bringing companies together to form collaborative and unique relationships. Alison McRae, Senior Director, Glasgow Chamber of Commerce, said: *"Circular economy becomes an important element of the overall economy in the city. It is clear that cities need to embrace the circular economy to maintain or*

improve its competitive advantage. Working closely with our partners in the city, we intend to explore these emerging opportunities with vigour."

The longer term benefits for business

The circular economy will shape smarter business models leading to better collaboration, fresh market opportunities and increased profits, while reducing overall environmental impacts. Glasgow Chamber of Commerce is actively involved in fostering new opportunities. Alison McRae, Senior Director, Glasgow Chamber of Commerce, said: *"Given the benefits of a circular economy for Glasgow and its businesses, the Chamber is keen to ensure that businesses are fully engaged with the concept and benefits of circularity to drive economic growth in the city."*

“ The Circle City Scan has brought into focus how we can support local businesses, and become a champion for the circular economy in the city.

- Alison McRae, Senior Director, Glasgow Chamber of Commerce

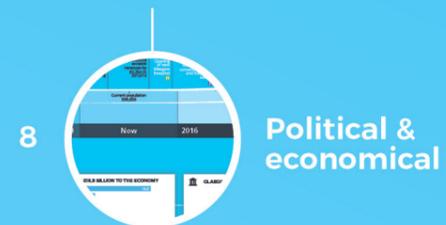


Reading guide

The reading guide describes the **four steps** that have been taken in the *Circle City Scan* of Glasgow. Throughout this project we have been primarily working with visuals that explain many of the complex aspects of a circular economy. Hereunder is a reading guide which takes you through the process as well as an illustration of the visuals that have been used.

1. Local agenda

Assesses the strongest economic sectors within the city, which have a strong political will to create rapid change towards a circular economy.



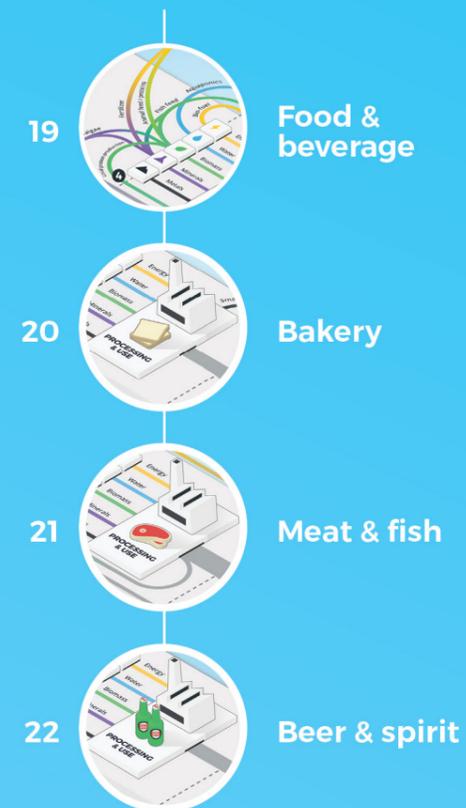
2. Material flows

Maps out the economic and the environmental impacts.



3. Circular innovations

Outlines selected circular tangible strategies.



4. Action plan

Demonstrates what first pilot companies can implement circular strategies, the (financial) benefits and requirements.





1 | Local agenda

CIRCLE CITIES
From scan to action in four steps

Where do you start in building a circular economy?

Creating a circular city is a complex journey involving many organisations, companies, technologies and resources. A range of stakeholders need to be initiated in the transition towards a circular economy. Both Glasgow and Scotland have rolled out several sustainability policies and environmental programmes, setting strong policy targets to provide support. However, the critical question for Glasgow was: **which areas within the city are ripe and relevant to begin the transition towards a circular economy?** In order to become a circular economy, it is vital to identify and initiate change in areas where there is strong political and economic support.

Strengthening the economy

To understand Glasgow's political and economic agenda, the ten most dominant sectors were examined for their potential to adopt the circular economy. By addressing these issues the likelihood of successful implementation of circular strategies increases.

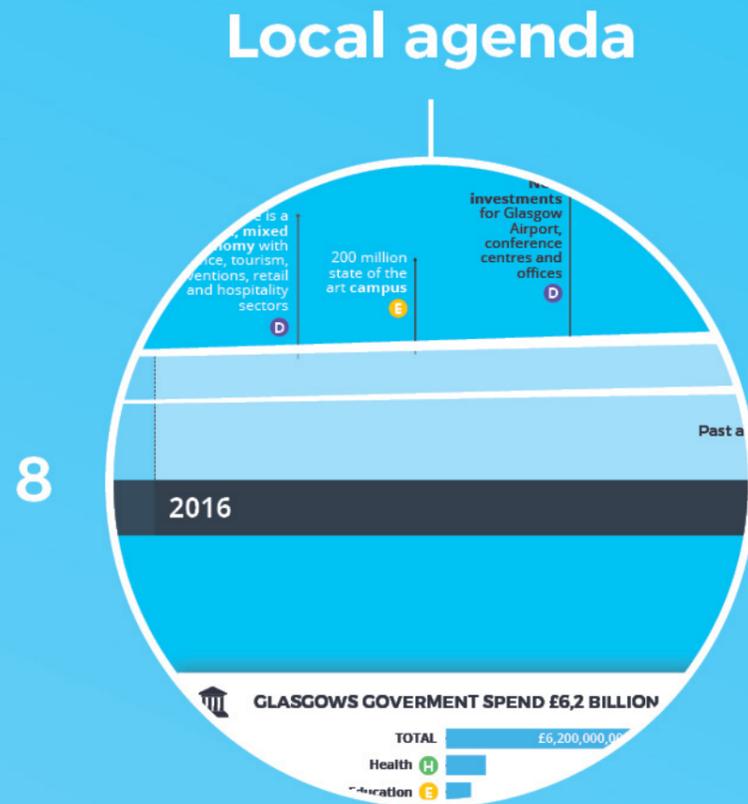
Providing jobs and adding economic value

The analysis showed clearly that the healthcare, education and manufacturing sectors are the three most significant sectors, both economically and politically. These combined sectors provide over 117,500 jobs, almost 30% of Glasgow's workforce and have an economic value of over £5.5bn (27% of Glasgow's total economy).

The healthcare, education and manufacturing sectors are the three most significant sectors for Glasgow.

Description of visuals

Political & economical analysis



The political and economic ambitions for each sector in Glasgow is summarised in a visual, presented on the following page. The political agenda of both Scotland and Glasgow and their supporting environmental targets are highlighted above the graph, while the current economic state of the city of Glasgow is illustrated below.

The graph highlights significant historic events, current priorities and future trends that have or will affect Glasgow's gross value added and population levels. This visual is a result of an analysis of numerous documents pertaining to Glasgow's political and economic status both currently and historically.

Political & economical analysis

Key city facts

Glasgow is Scotland's largest city with a population of almost **600,000**

£18 Billion in gross value added to the Scottish economy each year

Over 130,000 students from 135 countries

A skilled and adaptable labour pool of over **400,000**

Services

- Professional, scientific & technical** (P) A major centre for low carbon development
- Business services** (B) Glasgow is the fifth most entrepreneurial UK city
- Financial services** (F) The most important UK financial centre outside of London

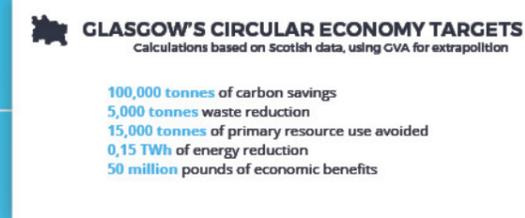
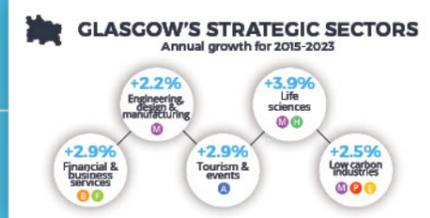
Public

- Education** (E) Five higher education institutions and three super colleges
- Health** (H) Queen Elizabeth hospital is one of the largest hospitals in Europe

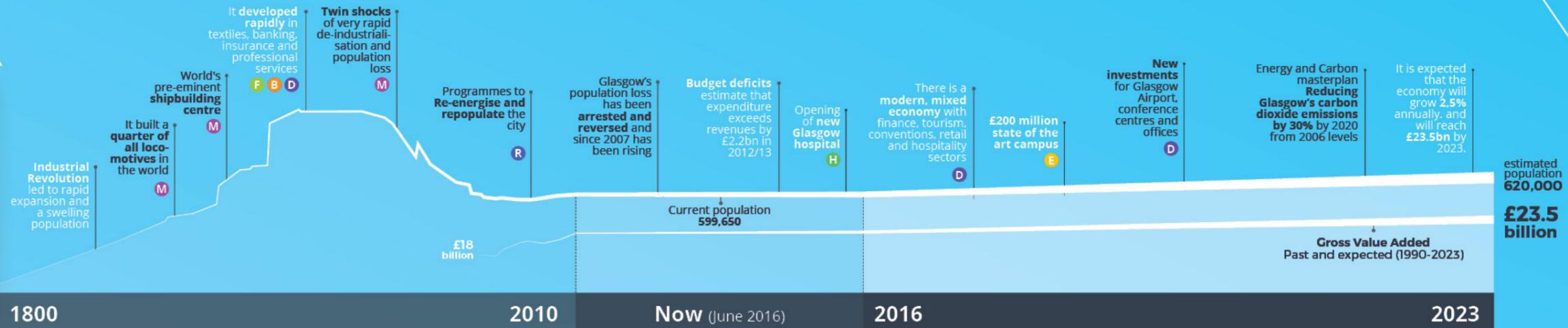
Commercial/production

- Accommodation & food** (A) Glasgow has the capacity to host more conferences than all six Scottish cities combined
- Real estate** (R) Third largest UK office market and largest office market 27m ft²
- Distribution and transport** (D) Glasgow Airport serves over 7 million passengers each year to 90 destinations
- Manufacturing** (M) Glasgow makes the single biggest contribution to Scotland's manufacturing economy
- Wholesale & retail** (W) Glasgow is the number 2 retail destination in the UK after London

POLITICAL



POPULATION & GVA

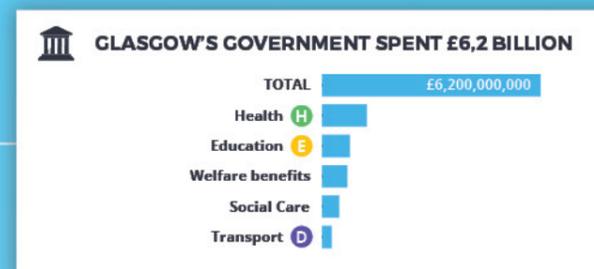
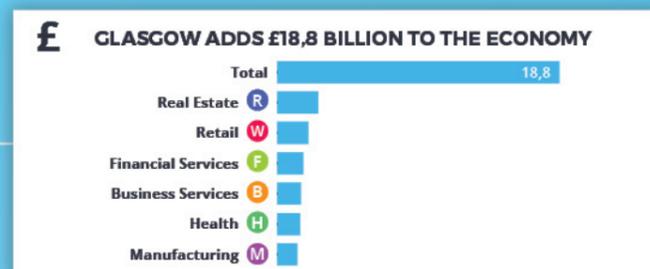


GLASGOW'S CIRCULAR ECONOMY

FOCUS SECTORS



ECONOMY





2 | Material flows

Identify the most pressing environmental issues

The study looked at the environmental impact of the healthcare, education and manufacturing sectors to identify the most pressing issues. It began by charting **how energy, biomass, minerals, water and metals are being consumed, processed and disposed of**. From this, a refined state of each sector was developed. This pinpointed the resource flows through Glasgow. The flow map identifies the most significant starting points for circular innovations.

Glasgow's food and beverage industry has an economic value of £330 million, and employs over 5,000 people. Due to its significance, the project team, consisting of the consortium of Glasgow Chamber of Commerce, Zero Waste Scotland, Glasgow City Council and other representatives of the city of Glasgow, selected food and beverage.

Food and beverage, a sub-sector of manufacturing, was selected as the first sector where circular innovations can be explored and initiated.

Description of visuals

Material flows

Material flows



The material flow maps track the five major resources used in process and production:

- Energy
- Water
- Biomass
- Chemicals and Minerals
- Metals

Each resource is represented by an icon and a line links the resource being used to the industry. The line thickness indicates the extent of usage, highlighting the areas where significant resources are used. A sector's total emissions and amount of waste produced is noted.

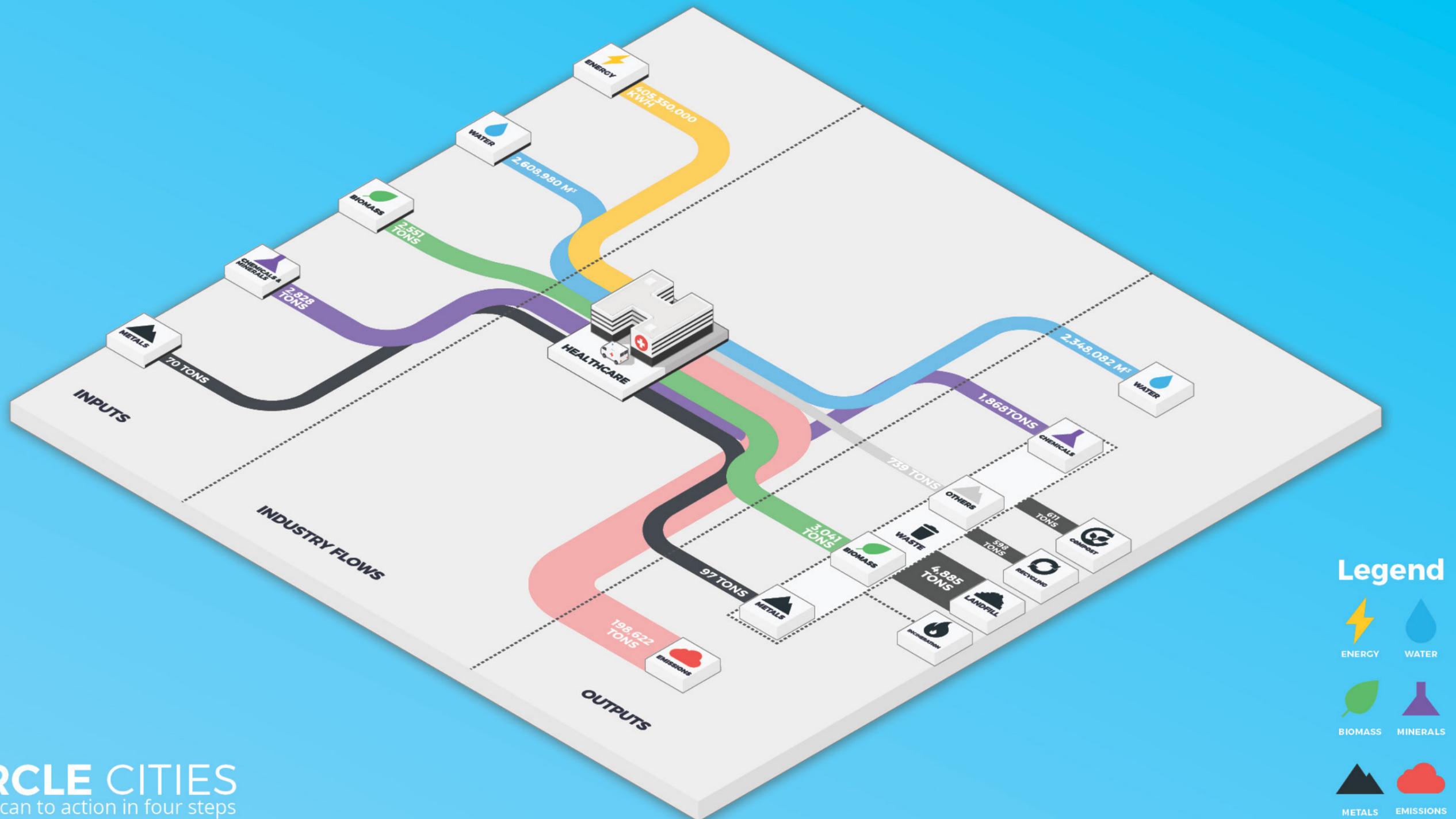
The waste disposal methods are indicated to show if it is composted, recycled, sent to landfill or incinerated. The 'Fact' section (above the main diagram) translates the resource measurements into comparable units between sectors.

Material flow

Healthcare sector

- The healthcare sector **provides jobs** for over **67,700 people**
- The healthcare sector **consumes electricity** equal to **40,000 households** per year
- The yearly **water use** of the healthcare sector is equal to the volume of **1000 olympic swimming pools**
- The healthcare sector uses **biomass** equal to what **5,000 people** consume in a year
- The healthcare sector **generates waste** equivalent to the carrying capacity of **800 waste trucks**

- The healthcare sector emits **greenhouse gases** equal to annual emissions of **38,000 cars**
- Most of the **waste** streams in healthcare consist of **biomass** (3 kilo tonnes)
- The **large majority** of the waste from the healthcare sector is currently being **landfilled**
- **Paper waste** accounts for **over 35% of the waste streams** in the healthcare sector
- The healthcare sector **recycles 600 tonnes** of materials per year



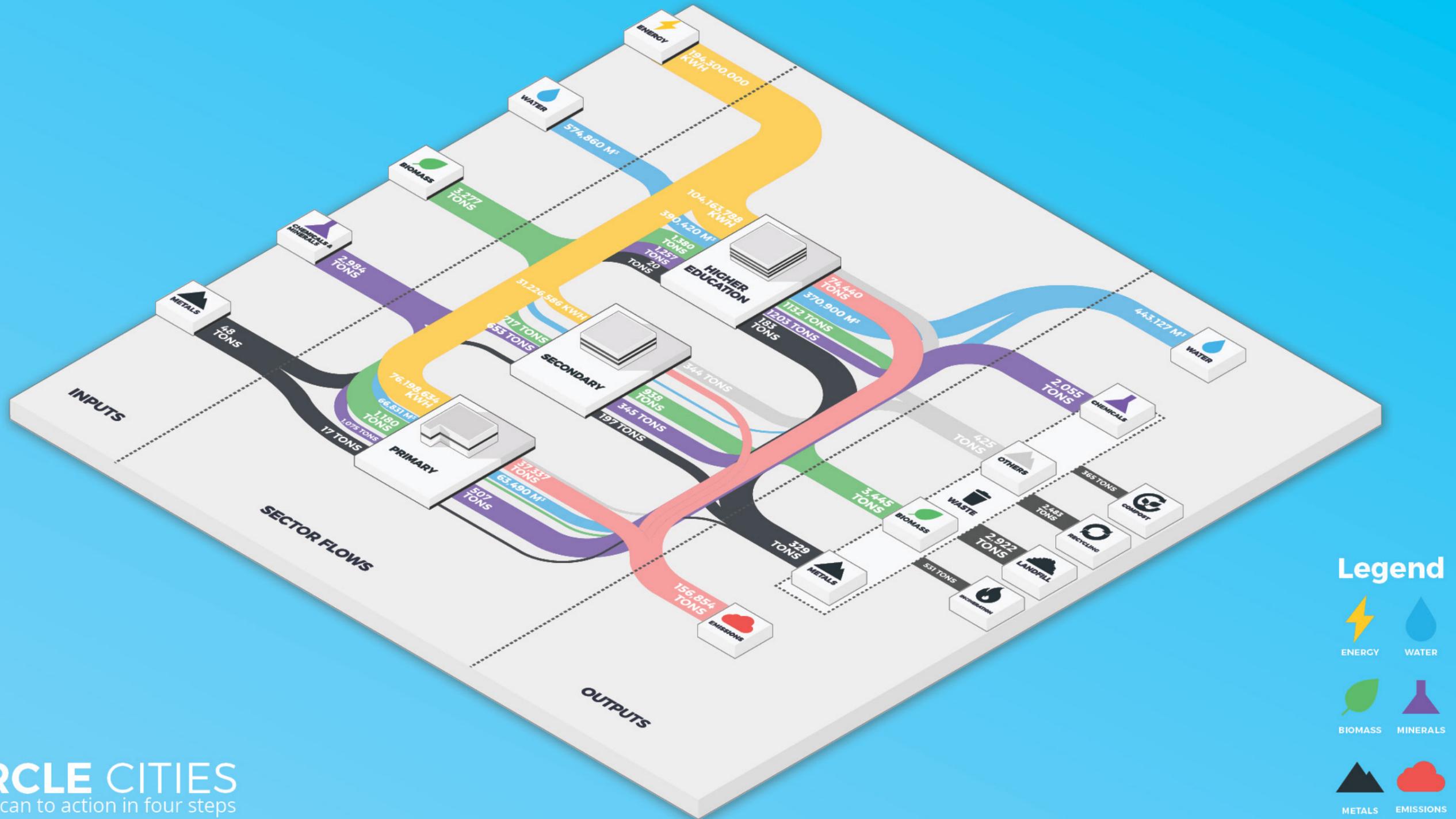
Material flow

Education sector

Primary / Secondary / Higher

- The education sector **provides jobs** for over **30,000 people**
- The education sector **uses electricity** equal to **20,000 households** per year
- The yearly **water use** of the education sector is equal to the volume of **230 olympic swimming pools**
- There are over **107,000 students**, of which 45,000 are in higher education, 23,000 in secondary and 39,000 in primary education
- The education sector has a **governmental budget** of over **£800 million** per year

- The education sector **uses biomass** equal to what **7,000 people** consume in a year
- The education sector **generates waste** equivalent to the carrying capacity of **1,200 waste trucks**
- The education sector **emits greenhouse gases** equal to annual emissions of **30,000 cars**
- **Food waste** accounts for **over 30%** of the waste streams, of which almost 30% is cooked food
- **80% of the total** waste streams from the education sector are still **landfilled**
- Higher education **uses 50% of the energy** in the education sector
- Most waste is coming from education, and **mainly from food waste**



Material flow

Manufacturing sector

- The manufacturing sector **provides jobs** for over **18,000 people**
- The manufacturing sector **uses electricity** equal to **112,000 households** per year
- The yearly **water use** is equal to the volume of **700 olympic swimming pools**
- The biggest users of **metals** is the **shipyard** and others industry
- The biggest user of **biomass** is the **food and beverage** industry
- The manufacturing sector **adds £1.3 billion** to economy annually
- **Over one third of the water** (558,000 m³) is consumed by the wood industry

- The manufacturing sector **generates waste** equivalent to the carrying capacity of **3,400 waste trucks**
- The education sector **emits green house gases** equal to annual emissions of **110,000 cars**
- **Over 6 kilo tonnes** of **minerals and chemicals** are consumed by the chemical industry
- Almost **60% (18 kilo tonnes)** of the **total waste** stream is coming from the food and beverage industry
- Almost **50%** of the **total waste** stream consists of minerals and chemicals



Description of visuals

Spatial map

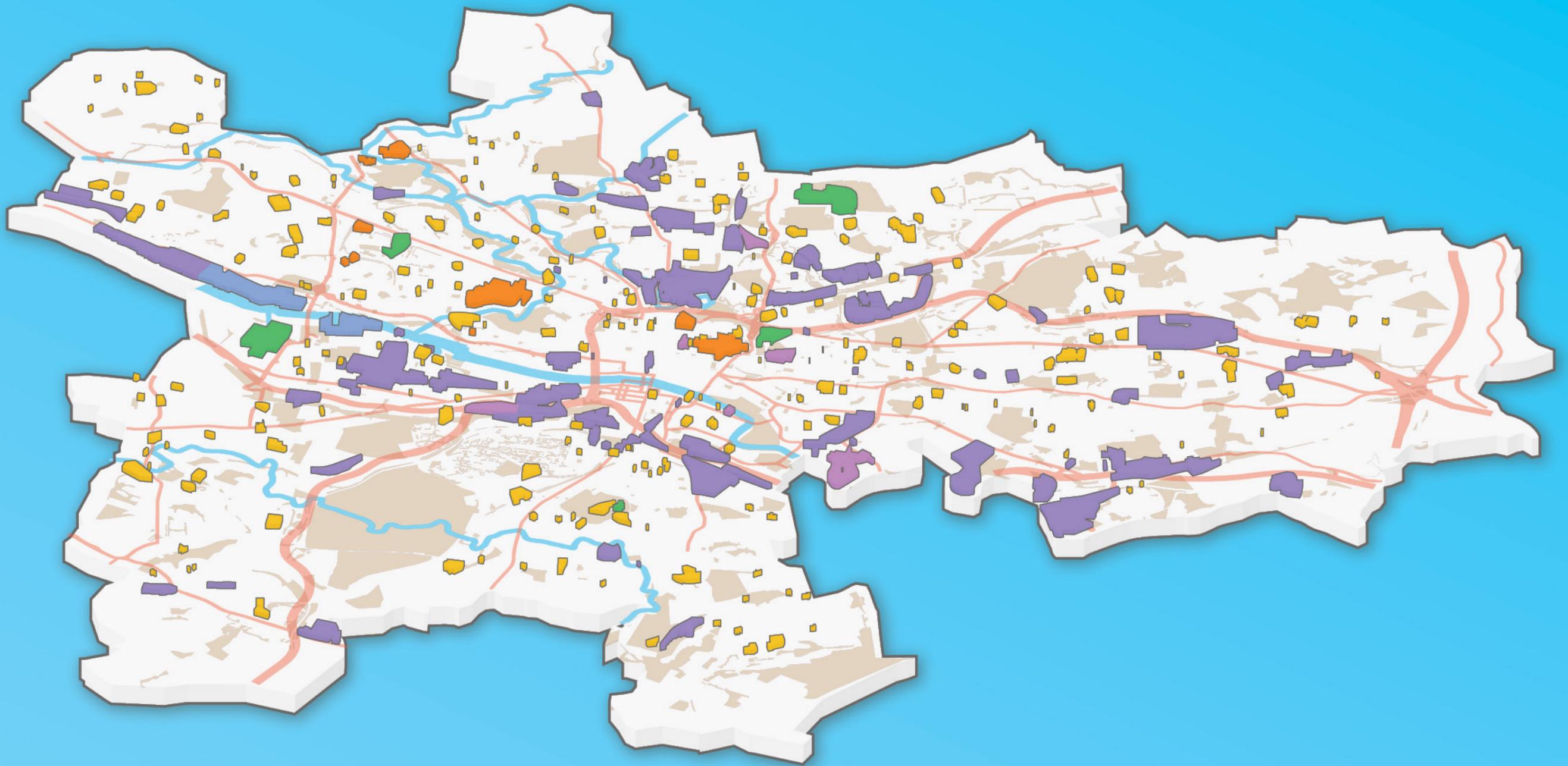
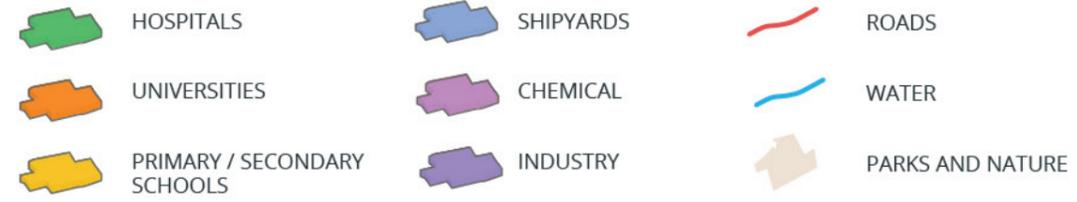


To broaden the understanding of where the sectors operate within Glasgow, a spatial analysis was conducted. This helped identify clusters of key players within each sector and their locations within the city. This has given a clearer understanding of:

- The best locations for the implementation of circular innovations;
- The opportunities of local co-operation and sharing of resources;
- The potential for scaling up pilot projects in the future.

Spatial map

Education / health / manufacturing



CIRCLE CITIES
From scan to action in four steps

3

Circular innovations

Identifying a starting point for circular innovations

The food and beverage industry, a sub-sector of manufacturing, was found to be one of the biggest consumers of resources and one of the largest waste producers. The food and beverage industry uses over 51% of the total resources consumed by all three sectors - healthcare, education and manufacturing, combined. For this reason, food and beverage was selected ahead of ship-yards, chemicals and wood products, for deeper analysis.

The food and beverage industry uses over 51% of the total resources consumed by all three sectors

Developing a future vision

A future vision was developed to identify the practical and scalable strategies that could spark a transition towards a circular economy. As secondary industries, the meat and fish and baking industries generate over half of the £60 million the food industry contributes to Glasgow's economy annually and the beer and spirits industry generates over two thirds of the economic value added by Glasgow's beverage industry.

The vision for the food and beverage sector includes nine practical and scalable circular economy strategies designed to optimise the flow of resources throughout the industry. It highlighted specific inputs, processes and outputs within companies in each category mentioned above. Special attention has been given to cross-company benefits, collaborative working and the potential for a significant impact.

Identifying scalable and practical strategies

The project team narrowed the initial list of nine to four, based on the potential for success and the ability to deliver innovation in Glasgow. This allowed the creation of four pilot projects. The team chose easy-to-implement strategies that were understandable to a broader audience with the ability to show positive results in a short period of time. A focus was also placed on the pilot projects ability to inspire and motivate others to initiate innovative, circular projects.

The four selected projects were: Heat Recovery, Aquaponics, Bread to Beer, and High Value Cascading (Beer to Bread). Each has the potential to strengthen the local economy by creating lower demand on resources and higher levels of resilience and sustainability.

Sector focus: Food & beverage

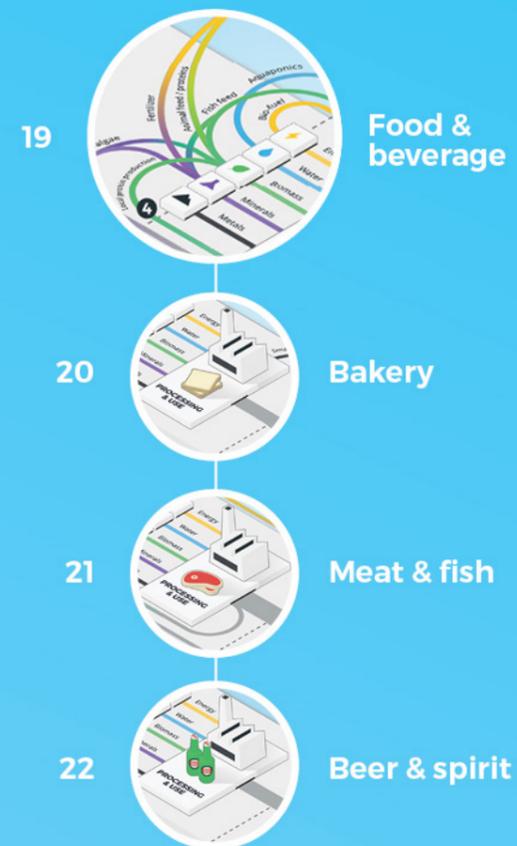
- The food and beverage sector **adds £330 million** to the economy annually
- The food and beverage sector **provides jobs** for over **5,000 people**
- There are **over 100 enterprises** in the food and beverage sector
- The food and beverage sector **uses electricity** equal to **17,000 households** per year
- The food and beverage sector **uses almost 34 kilo tonnes of biomass** every year
- The food and beverage sector **generates waste** equivalent to the carrying capacity of **2,000 waste trucks**

- The food and beverage sector **emits greenhouse gases** equal to annual emissions of **17,000 cars**
- The total **waste stream** coming from the food and beverage sector is **18 kilo tonnes**
- Over **70% of the waste** streams from the food and beverage sector are **landfilled**



Description of visuals

Circular innovations



Each individual strategy includes the icons to illustrate the potential impact of each resource flow. Additionally, three more icons have been added to identify:

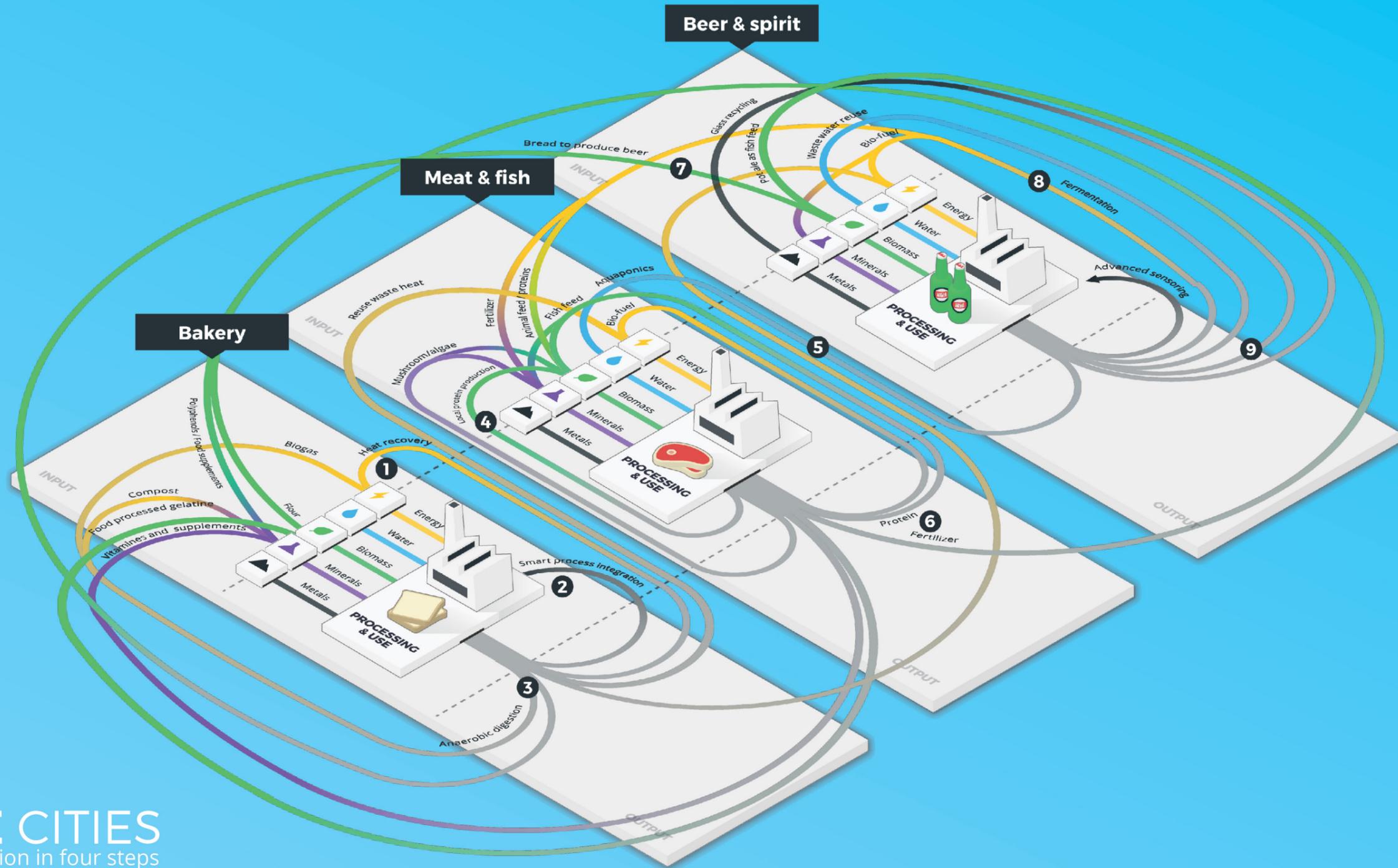
- Ease of implementation;
- Potential to add economic value;
- Ability to create jobs.

A description of each strategy is included to identify potential implementation partners and highlight examples of how similar strategies have been successfully implemented elsewhere in the world.

Circular vision

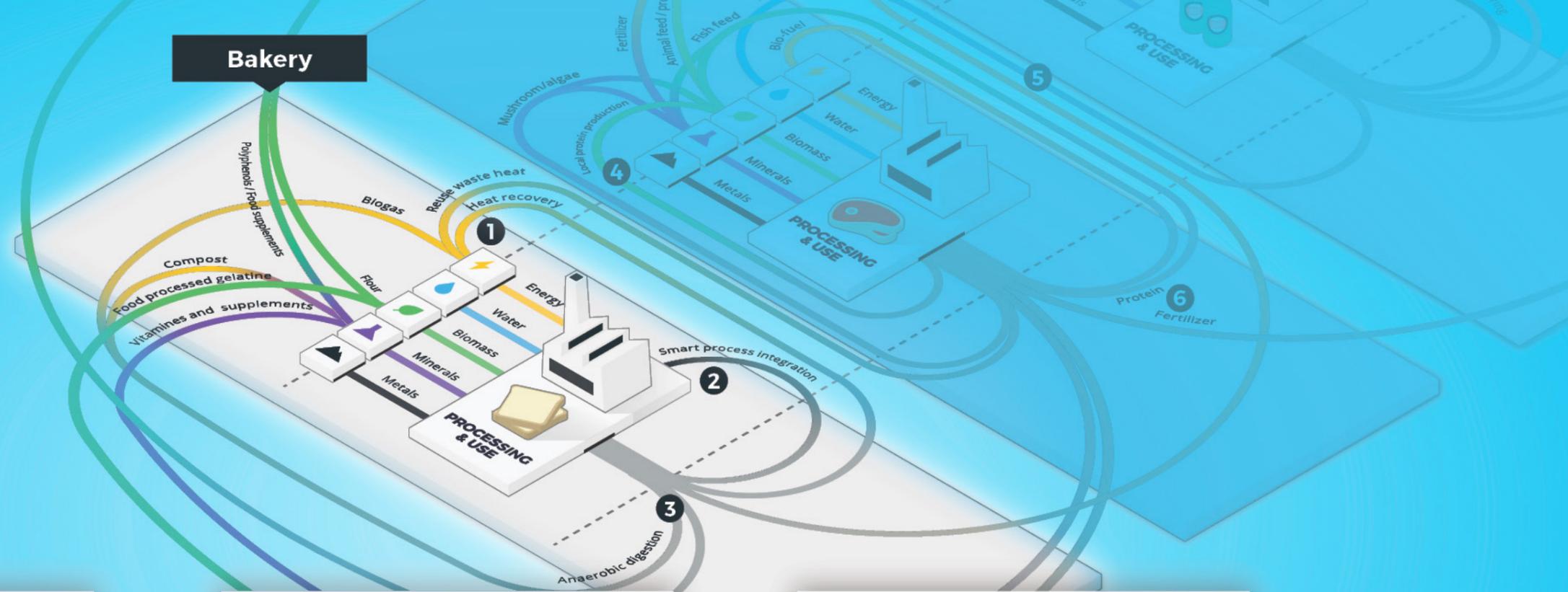
Food & beverage
9 circular strategies

- 1 Heat recovery
- 2 Smart process integration
- 3 Anaerobic digestion
- 4 Local protein production
- 5 Aquaponics
- 6 Nutrient recovery
- 7 Bread to beer
- 8 Fermentation
- 9 High value cascading



CIRCLE CITIES
From scan to action in four steps

Bakery



1. Heat recovery

⚡ High	⬇️ Low	£ High
💧 Low	⬇️ Low	⚙️ High
🌿 Low	☁️ Med	👤 Low

A typical industrial bakery has energy costs around £390,000 and £770,000 per year. The most important energy source used in an industrial bakery is natural gas for heating, 70-80% of which is used by the bakery's ovens. On average, 10% of the energy consumed by baking ovens is wasted heat, which can easily be recovered and reused through heat exchangers and heat pumps. This heat can be used for area heating, heating process water, or even for the production of low pressure steam. In addition, steam produced by steam boilers in bakeries can be recovered via economisers, saving an additional 5-10% in natural gas consumption. The waste heat can also be used by other industries, such as the beer and whisky industry for the drying of residual streams.

Potential partners:
Bakeries, natural gas and energy companies, equipment installers and ESCOs

Case study

Bakery Bolton in Germany made significant investments in heat recovery systems in their operations. The company partnered with MIWE to deliver a complete combined heating system concept via their eco:nova heat recovery system. The company saved nearly 490kWh of energy per day, saving thousands of pounds per year.



2. Smart process integration

⚡ Med	⬇️ Low	£ Low
💧 Low	⬇️ Low	⚙️ Med
🌿 Med	☁️ Low	👤 Med

Efficiency in production in the food processing industry tends to be lower in comparison to other industries. Improving productivity with smart IT solutions and automation technologies can reduce energy consumption, thereby increasing efficiency. Additionally the introduction of new processes has enabled more preventative maintenance by identifying equipment that is close to failure thus preventing loss of production. Innovations such as the Internet of Things, artificial intelligence and state-of-the-art robotics can enable the industry to deliver faster, flexible and more complex production processes. Technologies, such as robots, have already been proven to increase quality and decrease waste in the baking industry.

Potential partners:
Bakeries, smart sensing technology companies, IT companies and universities

Case study

Warburton's Tyne Bakery is the first bakery in the UK to use sensors to improve the efficiency of their processes. For example, when too much dough is poured into the baking tray, a failure in the process occurs. To solve this, a detection system was designed using sensors that sound an alarm or stop production if the baking tray is too full.



3. Anaerobic digestion

⚡ High	⬇️ Med	£ Med
💧 Low	⬇️ Med	⚙️ Med
🌿 Low	☁️ High	👤 Med

Over 80% of baked goods are thrown away because they are not consumed prior to their best-before date or because they are judged to a specific standard. Old bread that cannot be reused in other products can be collected and processed in an anaerobic digestion plant to produce heat, compost and green gas. An anaerobic digestion plant consists of a series of biological processes in which micro-organisms break down biodegradable material in the absence of oxygen. The anaerobic digestion process works well with old bread because of its high caloric content. The compost from the anaerobic digester can be used as a fertilizer for growing wheat and the green gas can be used as biofuel to drive cars, or to provide heating for bakery ovens. Anaerobic digestion is usually done in a central treatment plant, there are also low-scale, decentralised, refinery technologies coming to the market.

Potential partners:
Bakeries, waste treatment companies, logistics, technology companies and farmers

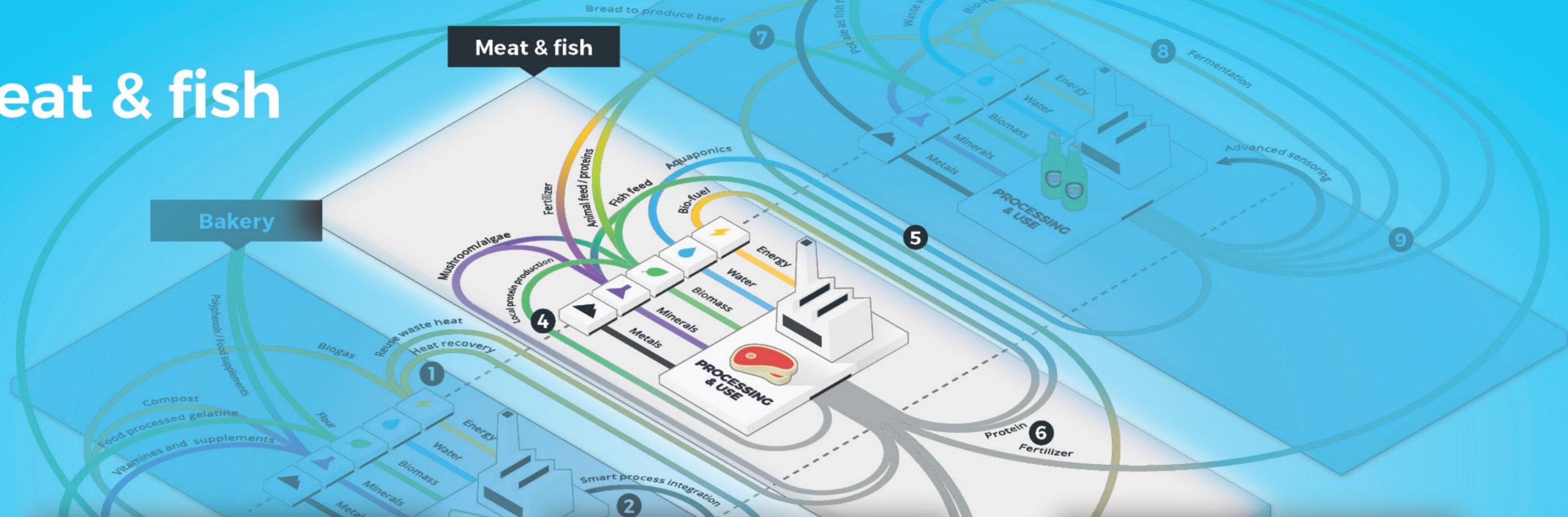
Case study

A waste company in the Netherlands, Meerlanden, is using old bread from a large hotel chain as input in their anaerobic digester. The old bread is collected and put through the anaerobic digestion process to generate green gas, compost and heat. The green gas produced is used to fuel the trucks that collect the old bread.

Legend

- ENERGY
- WATER
- BIOMASS
- MINERALS
- WASTE
- EMISSIONS
- ECONOMIC VALUE
- EASE OF IMPLEMENTATION
- JOBS

Meat & fish



4. Local protein production

⚡ High	⚙️ High	£ High
💧 Low	🌱 Low	⚙️ Low
🌿 Low	👤 High	👤 High

A major negative impact on the environment is the use of soybeans as a source of protein for fish feed in the fish and meat industry due in part to the distance the beans must travel when being imported from abroad. An alternative source of protein are field beans which can easily be grown in Scotland and are a net contributor to nitrogen in the soil. This enables savings in minerals use, and reduces CO₂-emissions. Additionally, the starch-rich fraction of the field bean can be used to replace main inputs (wheat and soya) in pig and poultry feeds, as well as certain consumer food processes such as brewing. Lastly, the crop residues can be used to create biogas, thereby reducing the energy needs of the sector.

Potential partners

Aquaculture companies (for example salmon), farmers, pig and poultry industry

Case study

Beans4feed is a research programme in Scotland that is researching the potential to use locally grown protein for fish feed. The collaborative research program, led by the James Hutton Institute, estimated that about 8% of the farmable land in Scotland is needed to supply all protein needed by the Scottish aquaculture sector, thereby creating a sustainable alternative to soy imports.



5. Aquaponics

⚡ Low	⚙️ Min	£ Med
💧 High	🌱 High	⚙️ Med
🌿 High	👤 Low	👤 Med

Aquaponics is the integration of aquaculture and hydroponics, a soilless system for crop production. In the system, fish are raised in tanks that are connected to plant beds containing edible crops. Water from the fish tank, containing ammonia from fish waste, is circulated underneath the plant beds and bacteria in the plantbeds break the ammonia down into nitrates, which then fertilise the crops. Water from the plant beds, containing nutrients for the fish, is recirculated back to the fish tank, thus closing the cycle. This system uses a mere 10% of the amount of water used in traditional soil systems, uses no chemical fertilisers, pesticides or herbicides, and produces nearly zero waste. Today, commercial aquaponics production exists in greenhouses or outdoor locations with favorable climates, using methods and equipment that draw from both the hydroponics and aquaculture industries.

Potential partners

Aquaponics companies, commercial fisheries, commercial farmers and entrepreneurs

Case study

In the United States, Pentair worked with Urban Organics to develop the Recirculating Aquaculture System. The system enables the farming of 6,000 Tilapia and produces an acre's worth of crops in 2,400 square meters. In 2014, Urban Organics harvested 450,000 kg of lettuce and herbs, and produced 23,000 kg of fish.



6. Nutrient recovery

⚡ Low	⚙️ High	£ Med
💧 Low	🌱 Med	⚙️ High
🌿 Med	👤 Low	👤 High

Compared to the meat industry, the fish industry has a relatively high volume of residual streams during the production process. The process waste is about 1/4 of the inputs and is high in protein and nutrients creating a range of alternative uses for fish waste, fish skins and fish frames. The protein can be used to make protein based products through the process of protein hydrolysis. These products can be used as input for the fish feeding industry to reduce the need for additional protein feed. Furthermore, the fish waste has been used as a natural fertiliser as it provides a range of agricultural opportunities due to its high nitrogen content. Other applications include the use of residual waste streams in the beer and spirit industry.

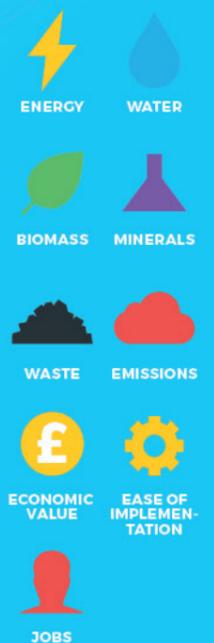
Potential partners

Fish industry, farmers and technology companies

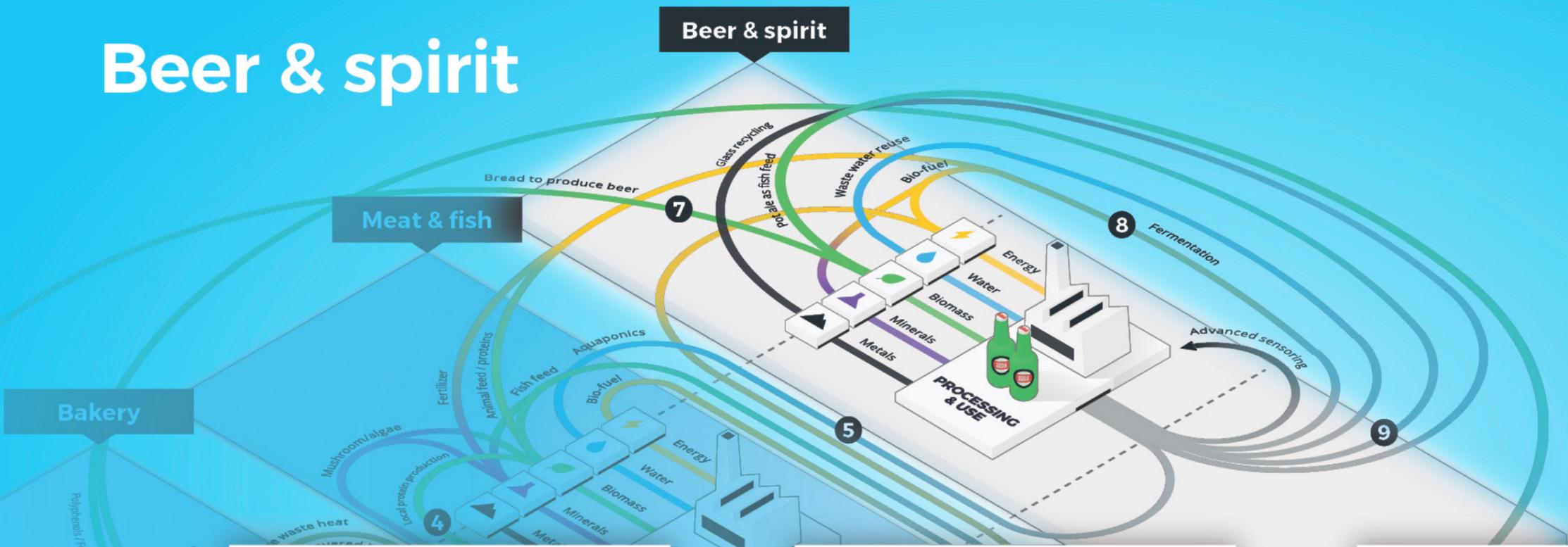
Case study

In Norway the process of protein hydrolysis is a prevalent technology. Several case studies have shown that protein hydrolysis is a cost-effective and feasible alternative fish feed. In Scotland this is done by Rossyew Ltd which produces proteins from Scottish salmon by-products and is used as an alternative to normal sources of protein for fish.

Legend



Beer & spirit



7. Bread to beer

⚡ Med	⚙ Low	£ Med
💧 Low	🏔 Med	⚙ High
🌿 High	🔴 Low	👤 Med

Typically, beer is made from a simple mixture of water, yeast, hops and barley (or another similar grain). However, brewing with bread is actually a millennia-old process and some beer academics speculate that beer was originally a by-product of early bread-making, when accidental fermentation of damp grains, during the malting or mashing process, resulted in a foamy, drinkable liquid. Nearly 30% of food produced globally, including bread, is discarded, and the production of barley requires significant energy and resource inputs. By using one and a half slices of bread per bottle, a brewery can produce a beer that reduces barley usage by nearly 30%. This change in recipe can contribute to tackling the issue of global food waste and the negative environmental and energy impacts of the agriculture industry.

Potential partners
Beer companies, bakeries, supermarkets, breweries and logistics companies.

Case study

A small Brussels-based brewery, the Brussels Beer Project, teamed up with Atelier Groot Eiland, to collect leftover bread from local supermarkets to be processed into meal suitable for beer-making.



8. Fermentation

⚡ High	⚙ Med	£ Med
💧 Low	🏔 High	⚙ High
🌿 Med	🔴 Low	👤 Med

The amount of waste due to whisky production is relatively high compared to the inputs used. Main waste residue is pot ale, a nutrient rich co-product, of which is left in pot still after the distillation process. About 10 litres of pot ale are produced per litre of pure malt whisky. Through a fermentation (and hydrolysis) process the pot ale can be used to produce high quality bio-based fuels as well as chemical and animal feeds. Fermentation is a metabolic process that converts sugar into acids, gases or alcohol. The processes are both applicable to the spent grains from beer and to the pot ale from whisky production. High value products such as glutamic acid, as well as transport fuels such as butanol and ethanol can be produced during the fermentation process. Residual waste that is not used for high value purposes but contains high nutrient levels can be used as animal feed in the fish and meat industry.

Potential partners
Whiskey distilleries, technology companies, fish & meat industries and transportation companies.

Case study

Celtic Renewables is a Scottish company that produces bio-based fuels and chemicals from industry waste products. The technology can be applied to whiskey by-products and spent grains from breweries. The company has demonstrated its technology in a pilot project in Belgium.



9. High value cascading

⚡ Low	⚙ High	£ High
💧 Low	🏔 High	⚙ High
🌿 Low	🔴 Low	👤 High

In the beer brewing process, about 100 to 200 grams of leftover "spent" grain is produced per litre of beer. With the millions of litres of beer that are being produced in Glasgow, the residual streams of spent grains are high. However, they are suitable for a range of high value purposes. Products that can be made from spent grain include human food supplements, antioxidants, fragrances, and bio-chemicals. Additionally there is the potential to use the spent grains for waste water treatment. Specifically interesting for the chosen sectors is the ability to make high protein fibre flour which can be used as a replacement for wheat flour in various bakery products. Another application is Polyphenols which are a type of antioxidant that can be extracted from liquid wastes or materials such as the brewer's spent grains. Polyphenols are used in food and drink products, pharmaceutical applications and increasingly as a preservative in bio-based products.

Potential partners
Bakeries, breweries and bio-chemical industries.

Case study

A Dublin based company is in the process of developing a technology for the extraction of high-value polyphenol compounds from process waste in brewing, distilling and related sectors. FDT consulting estimated that the value of polyphenols from malt and grain by products is worth over £50 million per year.

Legend

- ENERGY
- WATER
- BIOMASS
- MINERALS
- WASTE
- EMISSIONS
- ECONOMIC VALUE
- EASE OF IMPLEMENTATION
- JOBS



4 | Action plan

Benefits for businesses in a circular economy

An action plan for Glasgow has been developed to drive forward the positive environmental and economic impact for the city and local businesses.

Developing new business models

Business owners and managers need to adopt new business models to capture the benefits of a circular economy. Circular strategies will require investment in new technologies, innovations or learning to operate in a new and more complex environment. Businesses must fully understand how their own companies can adopt strategies that fit the circular economy.

Solid preparation is needed in order to support the transition from ideating circular innovations to implementing action plans with sustainable results. Companies have the ability to play a part in bringing the strategies selected to fruition. With this forefront of mind, organisations will need to be identified and convinced of the benefits of participating in initial pilot projects.

The benefits of a circular economy for companies are limitless; from reducing a dependency on scarce natural resources, cutting production costs, increasing competitive advantage, improving efficiency and customer retention, to delivering new streams of profits.

Description of visuals

Circular strategies

Action plan



The action plan for the selected strategies is set out. As each has the potential to have a significant impact on Glasgow's environment and economy, the total is calculated and described further in each action plan.

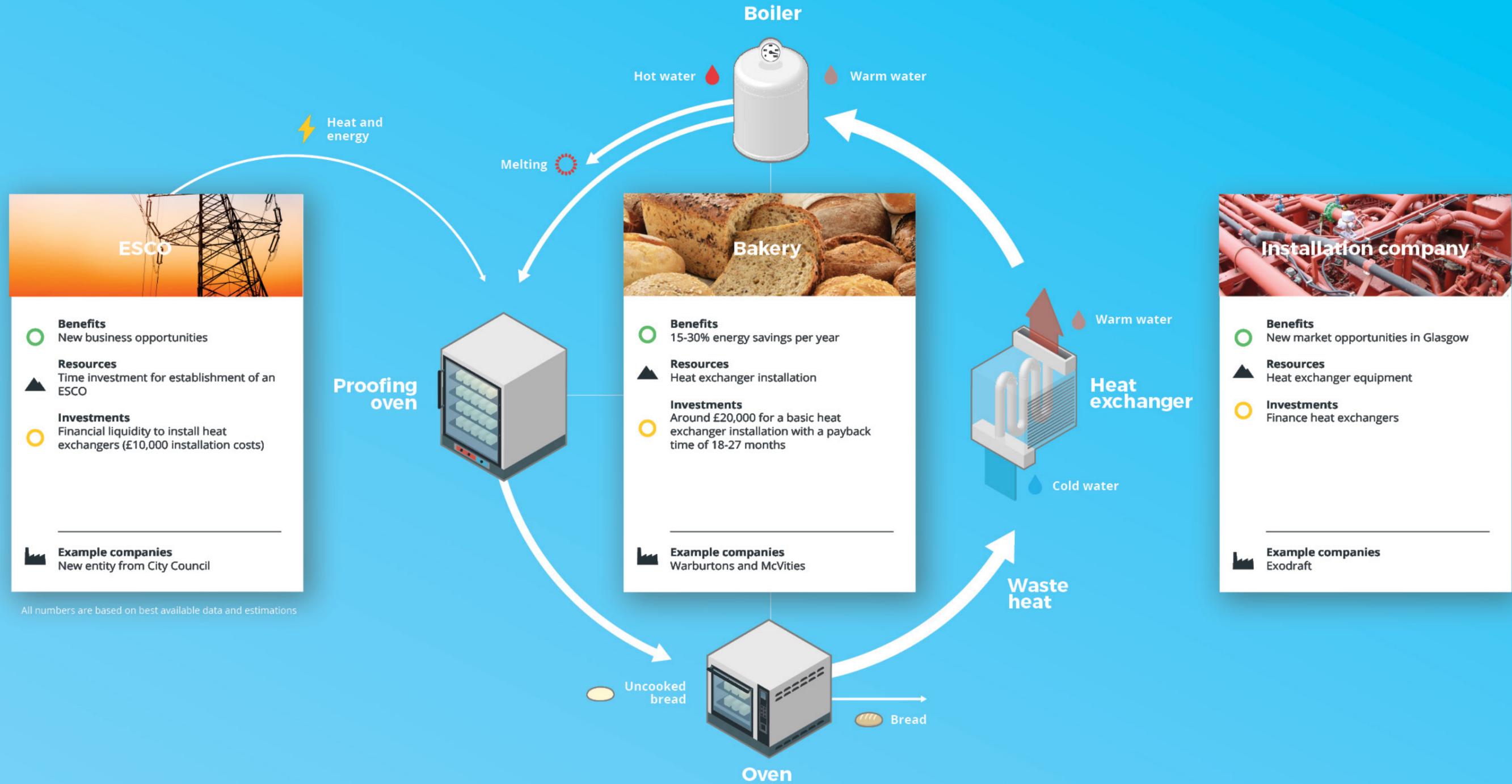
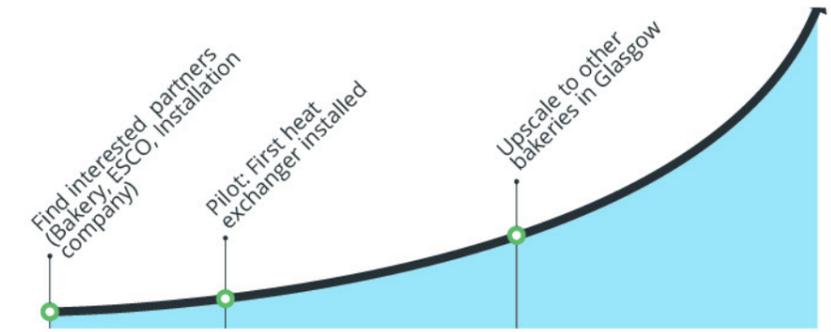
The next step is setting achievable goals for the first year of implementation. This is the series of four pilot projects that will identify the key participants required to build a working circular economy model.

Initially, small in scale to make this practical and able to implement in a short period of time. After this, there is potential to scale up the pilot projects enabling a cascade into other sectors.

Circular strategy

Heat recovery

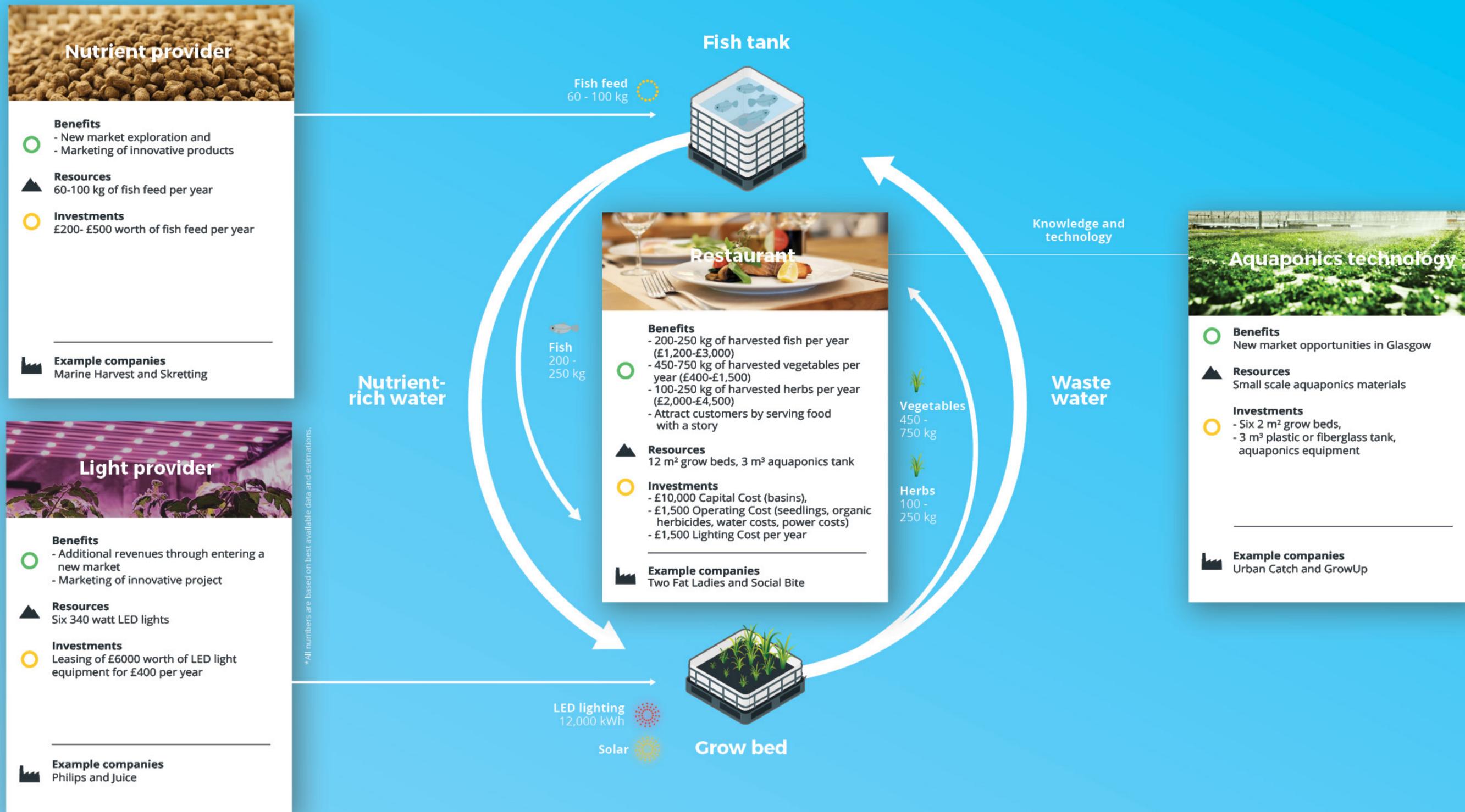
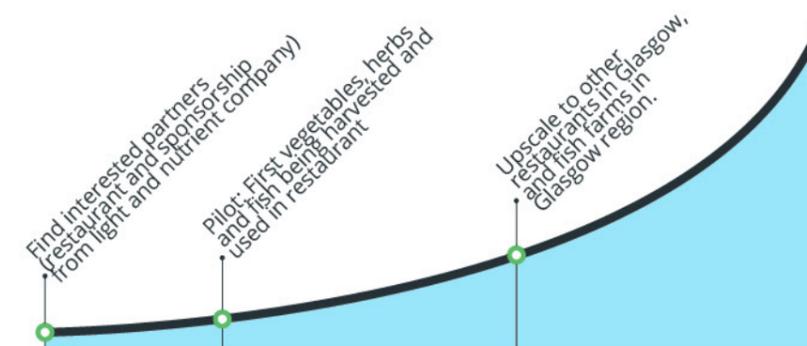
In a bakery, nearly 20% of the total energy consumption is from the boilers to heat process water and produce steam. This water and steam is used for: area heating, washing, and proofing the bread before it is baked. Heat from bakery ovens can be recovered and redirected to the boilers by using heat exchangers saving 15% to 30% of the energy currently used in the baking process. The payback period for such an investment is typically 18-27 months. The potential energy savings in Glasgow could total up to £300,000 in energy costs per year, an equivalent of 700 tonnes of CO₂ per year. One of the bottlenecks is the initial investment costs, which can be resolved via an Energy Service Company (ESCO). With an ESCO, an external company funds the initial investment and the investment is paid back through energy savings.



All numbers are based on best available data and estimations

Circular strategy Aquaponics

Aquaponics is a very promising technology in which the growing of fish is combined with the growing of biomass, leading to substantial savings in water use (90%) in comparison to traditional farming. The pilot project would include a small scale system (15m²) managed by a local restaurant. The restaurant would benefit from the production of locally grown and sustainable fish (+/- 250kg), vegetables (+/- 600kg) and herbs (+/- 150kg) per year. This project will serve as inspiration for fish farms in the Glasgow region that could experience the additional benefits of food farming. Aquaponics can be done on vacant land (1,000 square metres), or in empty buildings (hundreds of square metres). Thereby making it possible to upscale the pilot to hundreds of tons of locally grown food.

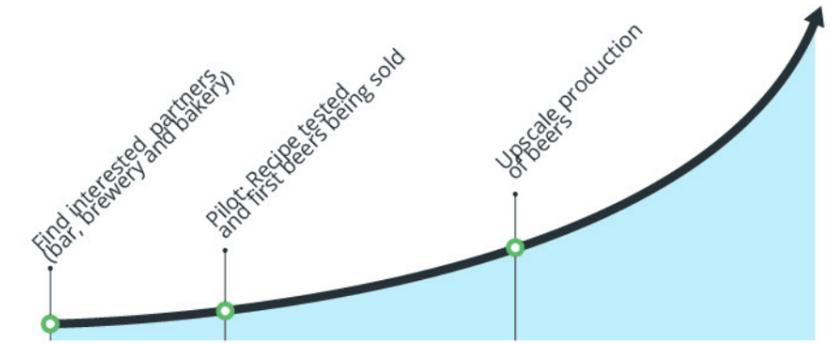


*All numbers are based on best available data and estimations.

Circular strategy

Bread to beer

Bread to beer is an innovative technology which utilises bread waste in the beer brewing process. Over 200,000 slices of bread are wasted every day in Glasgow, And at the same time hundreds of tons of barley is being used for brewing beer. By using this bread to beer technology, over one third of the resources utilised in the brewing process can be saved while also reducing food waste, by using the wasted bread in the beer brewing process. A pilot would require 500 kg (13,000 slices) of unsold bread to be used in the production of 4,000 litres of beer. When piloted successfully, this technology has the potential to use 70 million slices of wasted bread, produce 20 million litres of beer and save over 200 tonnes of biomass annually in Glasgow.



Bakery

Benefits

- Saving waste management costs of £45 per 500 kg in the pilot
- Marketing value

Resources

- 500 kg of bread
- Machine to slice the bread and oven to dry the bread in

Investments

- Time investment

Example companies
Warburtons and McVities



Brewery

Benefits

- Using fewer brewing ingredients (600 kg Barley, 0.5 kg yeast, and 1 kg Hops) Replacing 1/3 of the barley, thereby saving £30 per 50 kg of flour (per pilot of brewing 4,000 l).
- Beer with a story (Marketing)
- Premium for circular craft beer

Resources

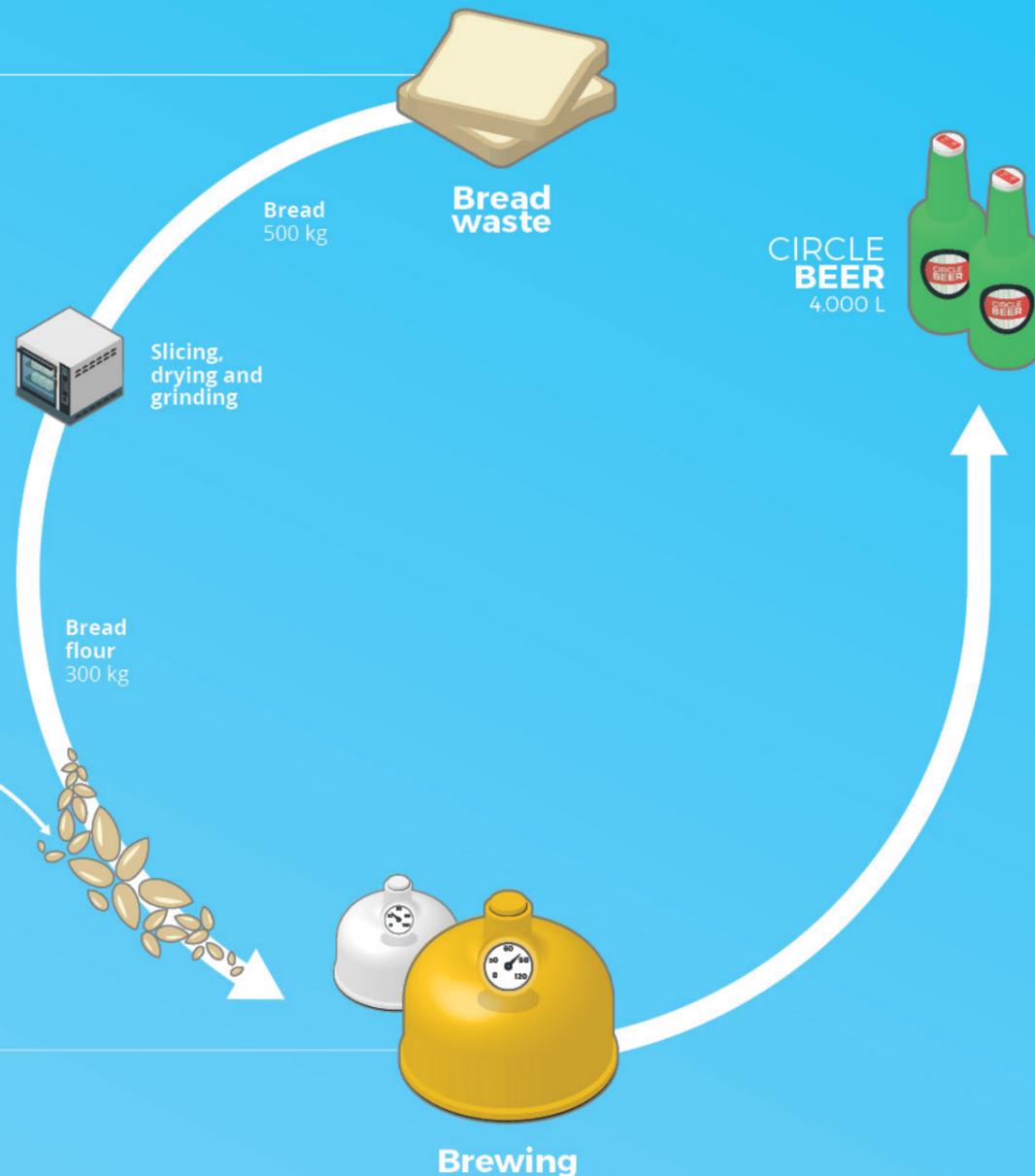
- Transportation of flour, one brewing cycle

Investments

- Time investment to create a first successful draft

Example companies
West and Tennants

All numbers are based on best available data and estimations



Bar

Benefits

- Beer with a story, that entices consumers to taste it
- Increased sales
- Increased Brand reputation (marketing value)

Resources

- Marketing of the product

Investments

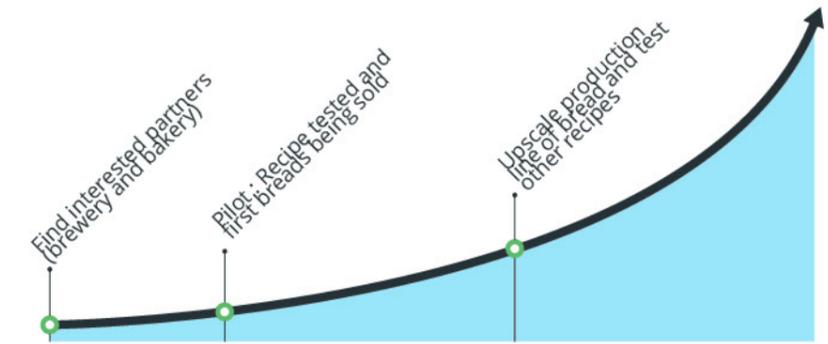
- Time investment

Example companies
The Glad Cafe and Brewdog

Circular strategy

High value cascading

Residual streams from beer brewing (spent grain) can be used to replace up to 50% of the flour needed to produce bread in the baking industry. Over 4,000 tonnes of residual spent grain is produced every year in Glasgow and can be used to make over 12,000,000 loaves of bread, reducing the amount of food waste throughout the city, thus lowering the city's waste treatment costs and resource needs. Additionally, the spent grain can be used in a plethora of other ways including the production of flapjacks, beer snacks, or to grow mushrooms on. After the mushrooms are grown, the mushroom grounds can be deposited into a composter, aiding in the realisation of a circular process.



Brewery

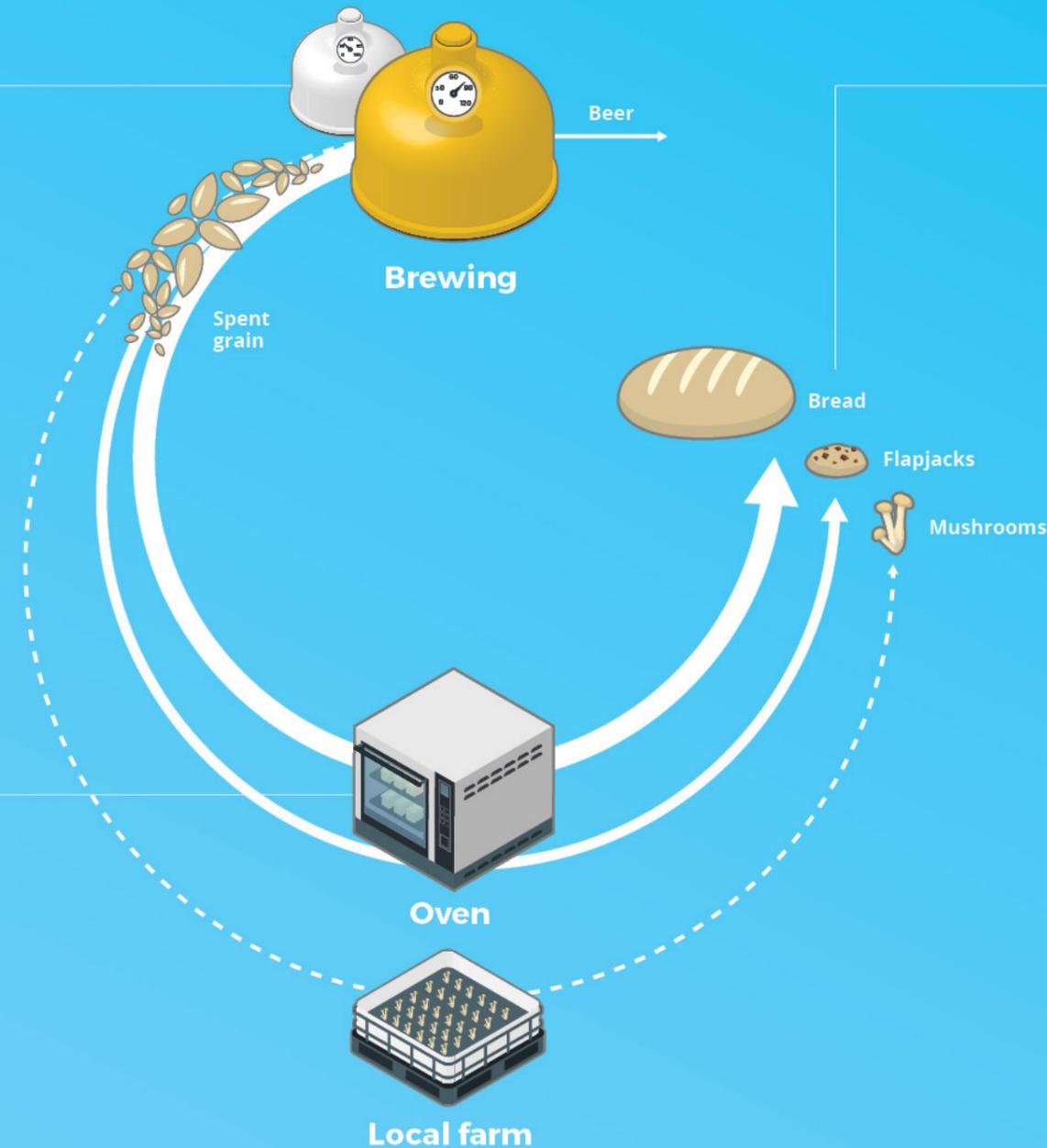
- Benefits**
 - Saving waste management costs (300kg worth £30 for the pilot)
 - Marketing value
 - Resources**
 - Centrifuge or oven to dry the spent grain
 - Investments**
 - Time investment to centrifuge / dry spent grain
- Example companies**
West and Tennants



Bakery

- Benefits**
 - Normal bread ingredients (700kg flour, yeast, water) and 30% reduced flour use (Replacing 300kg of flour worth £30)
 - Increased brand reputation
 - Attracting new customers interested in sustainable and healthy bread
 - Resources**
 - Transporting spent grain from breweries to the bakery
 - Mill machinery
 - Investments**
 - Time investment to test the recipe
- Example companies**
Warburtons and McVities

*All numbers are based on best available data and estimations.



Bar / Restaurant

- Benefits**
 - Craft Bread with a story (Marketing)
 - Sales of a locally produced bread made from beer
 - Revenues through bread sales (£4 per kg of bread)
 - Resources**
 - Transportation of the bread from the bakery to the bar/restaurant
 - Investments**
 - Marketing
- Example companies**
Two Fat Ladies and Social Bite

Closing remarks and next steps

CIRCLE CITIES
From scan to action in four steps

Creating the future: the next steps

The *Circle City Scan* of Glasgow has established a critical starting point to motivate and inspire the city with the limitless possibilities of implementing the circular economy. The support in implementing the scan has shown Glasgow's eagerness to be among the most innovative and progressive cities in the world positioning it at the forefront of a new kind of sustainable economy.

The action plan provides clear direction in how to implement circular business models, and how Glasgow businesses can embrace these pilot projects to bring lower resource costs and new market opportunities. It can be shown that beneficial synergies, established in collaborations between companies who would normally never work together, will strengthen the competitive advantage in Glasgow's food and beverage sector. This, in turn, will show the way for other sectors.

Pilot projects for circular success

The next phase will focus on the implementation of the four pilot projects of the proposed strategies. This crucial step will lead to tangible and inspirational examples of the circular economy in Glasgow and will illustrate how the circular economy can be implemented, how businesses will benefit, and what positive effects it will have on the people of Glasgow.

After the implementation of the pilot projects, a further phase will aim to scale up the projects to build real momentum.

Glasgow seeks to become a European and global showcase and a civic champion for the successful adoption of the circular economy.

In the meantime, it is vital to capture the key lessons from the pilot projects, build collaboration and engagement with local businesses, brands and organisations and throw weight behind this innovative effort.

GLASGOW
CHAMBER OF COMMERCE



CIRCLE
ECONOMY

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Data presented in the material flow maps is gathered through three methods:

- Input output tables from regional or local statistics
- Data provided by utility companies and government bodies
- Assumptions based on closely related data or relevant projects

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Pictures

- p1: Robert Brown, Glasgow Harbour
p6: Lismith, The Lighthouse Staircase, Glasgow
p9: Jessica Spengler, River Clyde West of Glasgow
p16: Robert Brown, Clyde West, Glasgow
P23: Marc, Women's Cycling Roadrace, Glasgow
p29: Truonghien, Wave

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Project teams

Circle Economy

Andy Ridley - CEO
Klaske Kruk - Director of Programmes
Jurn de Winter - Lead Cities
Shyaam Ramkumar - Lead Tools
Kay van 't Hof - Lead Design

Glasgow Chamber of Commerce

Alison McRae - Senior Director
Nick Boyd - Strategic Advisor
Rebecca Ricketts - Senior Projects Manager
Cheryl McCulloch - Projects Manager

Zero Waste Scotland

Maurice Golden - Circular Economy Programme Manager
Cheryl Robb - Project Manager Business Models

Glasgow City Council

Sustainable Glasgow Team

Extended thanks goes to the following organisations for their contribution:

Scottish Institute for Remanufacture
University of Strathclyde Institute for Future Cities

For information and details on participation,
contact Glasgow Chamber of Commerce:

+44 0141 204 2121
circulareconomy@glasgowchamberofcommerce.com

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Nieuwe Herengracht 95
1011 RX Amsterdam
www.circle-economy.com

