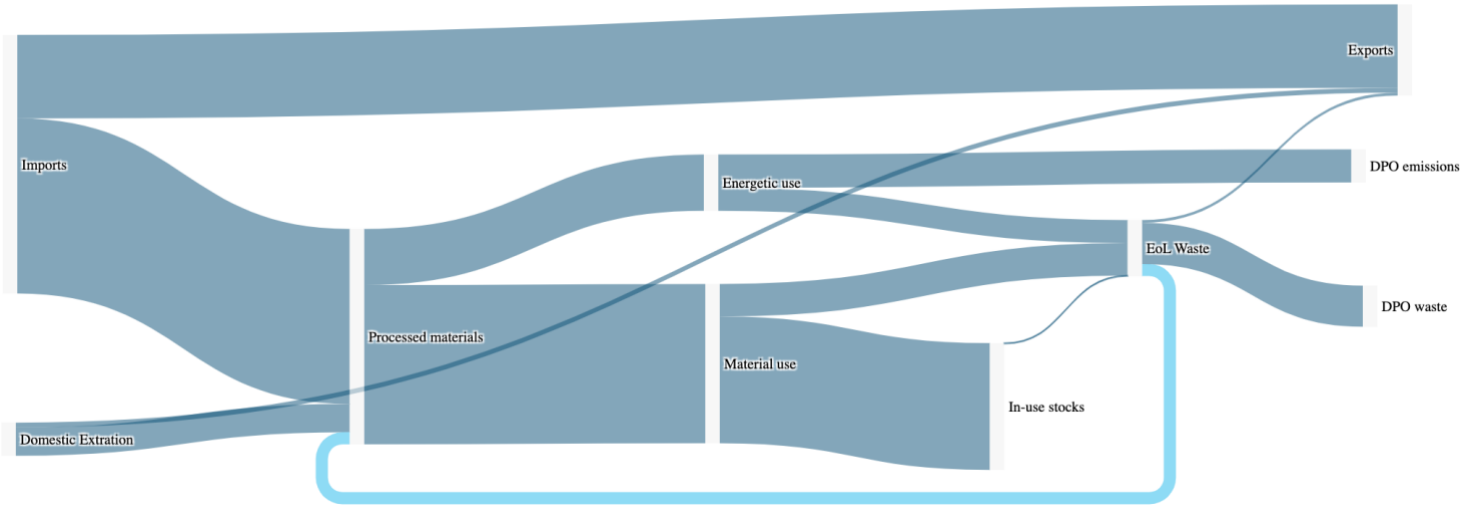
URBAN CIRCULARITY ASSESSMENT BODØ

Deliverable 7.6

Metabolism of Cities



Version	1.0
WP	7
Deliverable	7.6
Date	November 28, 2022
Dissemination level	Public
Deliverable lead	Metabolism of Cities (MoC), info@metabolismofcities.org
Authors	Carolin Bellstedt, Metabolism of Cities Gerardo Ezequiel Martín Carreño, Metabolism of Cities Aristide Athanassiadis, Metabolism of Cities Deniz Çelik, Metabolism of Cities Tiffany Nicoli, Metabolism of Cities
Contributors	Eirik Lerum Vigerust (Bodø Municipality) Ingrid Schistad Berg (Iris Produksjon AS)
Abstract	This report on the Urban Circularity Assessment for Bodø presents the gathered information and main findings on the material flows of the local economy for 2015 and 2020, as well as the building stock accounting. It provides contextual information of the city and the local economy under study and then illustrates the quantities of flows in the single parts of the supply chain, summarised by a Sankey diagram, followed by a map of the material stock. Both of the accounted materials are evaluated in the form of circularity indicators and their data quality. Finally, the results are analysed and interpreted to determine a status quo, taking into account limitations of the data used, before recommendations are offered on how to achieve greater material circularity in the municipality of Bodø.
Keywords	Urban circularity assessment; Material flow accounting; Building stock; Circularity indicators; Urban metabolism; Circular city;
License	

Contents

Summary

The Urban Circularity Assessment (UCA) was carried out for the municipality of Bodø in 2022 for the years 2015 and 2020. The municipality of Bodø is located just north of the Arctic Circle and the town of Bodø is the second largest town in North Norway (Gulliksen Tømmerbakke 2019). This Northern city functions as a regional capital of Nordland county (Nikel 2022) and It is also part of the traditional region of Salten.

Bodø has a population of 52,803 people, which are spread over an area of 1,396 km2. Currently, its local economy is mainly based on “Health & Social Work activities” (26.2%), “Wholesale and retail trade” (12.8%), and “Education” (10.13%) in terms of employees.

By applying the developed method, it is possible to illustrate that Bodø is a linear and carbon-rich city (90% linear), processing yearly approximately 360 kt of materials, adding 211 kt in the building stock and reinjecting just 20 kt of secondary materials in their economy. From these numbers, the magnitude of the efforts becomes visible. In addition, the “weight” of Bodø can be illustrated through its building stock which amounts to 4,500 kt (or 86 tonnes per capita), which requires continuous flows for both its operation and construction.

Given the land use of Bodø and its local activities, this provides a considerable opportunity to develop a circular bioeconomy. For instance, a significant share of GHG emissions associated with food consumption of Bodø could be reduced by covering animal proteins with local production of food (especially proteins coming from fish). Fish waste could be used for fertilisers or for creating new products. In addition, a part of this biomass (wood) could be used for energetic use reducing the demand of imports and partly GHG emissions. In addition, given the demand for new construction materials needed for the future urban development, local hubs for storing materials for reuse from the construction sector could significantly reduce the use of virgin materials as well as reduce construction and demolition waste generation. Finally, local materials (rammed earth, biomass insulation, timber, etc.) could be used to drastically reduce the amount of concrete (which is carbon intensive) for future urban developments. In addition, the production of local and low carbon construction materials, could develop new jobs and attract the development of new production activities.

Numerous datasets were collected and processed for the UCA, which are nested in several spreadsheets that are connected with each other. People with an interest in understanding the data or replicating the process are encouraged to reach out to Metabolism of Cities (info@metabolismofcities.org). It is also suggested to browse the online version of the UCA report where charts, Sankey diagram and the material stock map can be interacted with: https://cityloops.metabolismofcities.org/city/bodo/uca-report/

1. Introduction

The EU Horizon 2020 funded CityLoops project focuses on closing the material loops of cities in terms of material flows, societal needs and employment. Cities, depending on their magnitude and types of economic activities, possess considerable opportunities and various levers to transform their metabolism and economy towards a more environmentally sustainable and circular state.

Within this project, seven European cities, amongst those also the city of Bodø are (planning to) implement demonstration actions to kickstart their circularity journey. To better understand what the current circularity status quo is, as well as the impact of these actions, and the efforts needed to transform their cities, an Urban Circularity Assessment (UCA) method was developed. The method consists of urban material flow and stock accounting that paired with system-wide indicators assesses the material circularity of a city.

The material flows are accounted economy-wide for two separate years, applying a city-level adjusted Mayer et al. (2019) framework, which in itself builds on the EW-MFA method, including a wide material scope (specified below), while optimised for a circular economy assessment. The material stock accounting is limited to the buildings of the municipality, with the exact material scope depending on data availability in each city. Finally, the mass-based, "circularity" indicators cover the entire system and enable the assessment of a city's circularity. As such, a balance between comprehensiveness and scientific rigour on the one hand, and operability by urban policy makers and practitioners on the other is sought by the UCA method.

The material scope of the flow accounting aims to cover the entire local economy and is divided into a total of six material groups. These material groups are depicted as icons here and were studied each with more specific materials in sub-categories and along the supply chain of domestic extraction, imports & exports, domestic material consumption and waste. When studying these materials and the entire supply chain, together, these elements help to set a solid knowledge and analytical foundation to develop future circularity roadmaps and action plans.

Within the CityLoops project, the Urban Circularity Assessment was carried out by three of the seven cities (Mikkeli, Porto and Sevilla) themselves after having previously successfully completed their Sector-wide Circularity Assessments and Reports. They could build on extensive training that they had received in the form of courses on data collection for the

construction and biomass sectors and data processing. The cities were accompanied and supported in their work by the Metabolism of Cities team, who conducted the UCA for two further cities (Apeldoorn and Bodø). Numerous additional insights can be found in the individual Data Hubs of each city.

This current Urban Circularity Assessment report presents the gathered information in seven sections:

- *Urban Context*
- *Economic Context of Bodø*
- *Material Flows in Bodø*
- *Material Stock in Bodø*
- *Analysis of Flows and Stocks: Measuring Indicators*
- *Data Quality Assessment*
- *Analysis of Data and Indicators: Assessing Circularity*

It provides contextual information of the city and the local economy under study. It then illustrates the quantities of flows in the single parts of the supply chain, summarised by a Sankey diagram, followed by a map of the material stock. Both of the accounted materials are evaluated in the form of circularity indicators and their data quality. Finally, the results are analysed and interpreted to determine a status quo, taking into account limitations of the data used, before recommendations are offered on how to achieve greater material circularity in the municipality of Bodø.

(The italic texts in this report were written by Metabolism of Cities' Aristide Athanassiadis and Carolin Bellstedt. They provide relevant general information and serve as connecting elements of the single report parts.)*

2. Urban Context

To contextualise the results of the Urban Circularity Assessment, this section provides population and land use information data for Bodø. In addition, population numbers and area size of the city under study, as well as its corresponding NUTS3, NUTS2 and country were included, as can be seen to the right of the Bodø map. Data for these scales were added to better understand how relevant and important the approximations are when downscaling data from these scales to the city level.

Bodø
52,560
1,395 km²

Nordland
241,235
38,155 km²

Nord-Norge
484,547
112,975 km²

Norway
5,367,580
385,207 km²

2.1. Population of Bodø

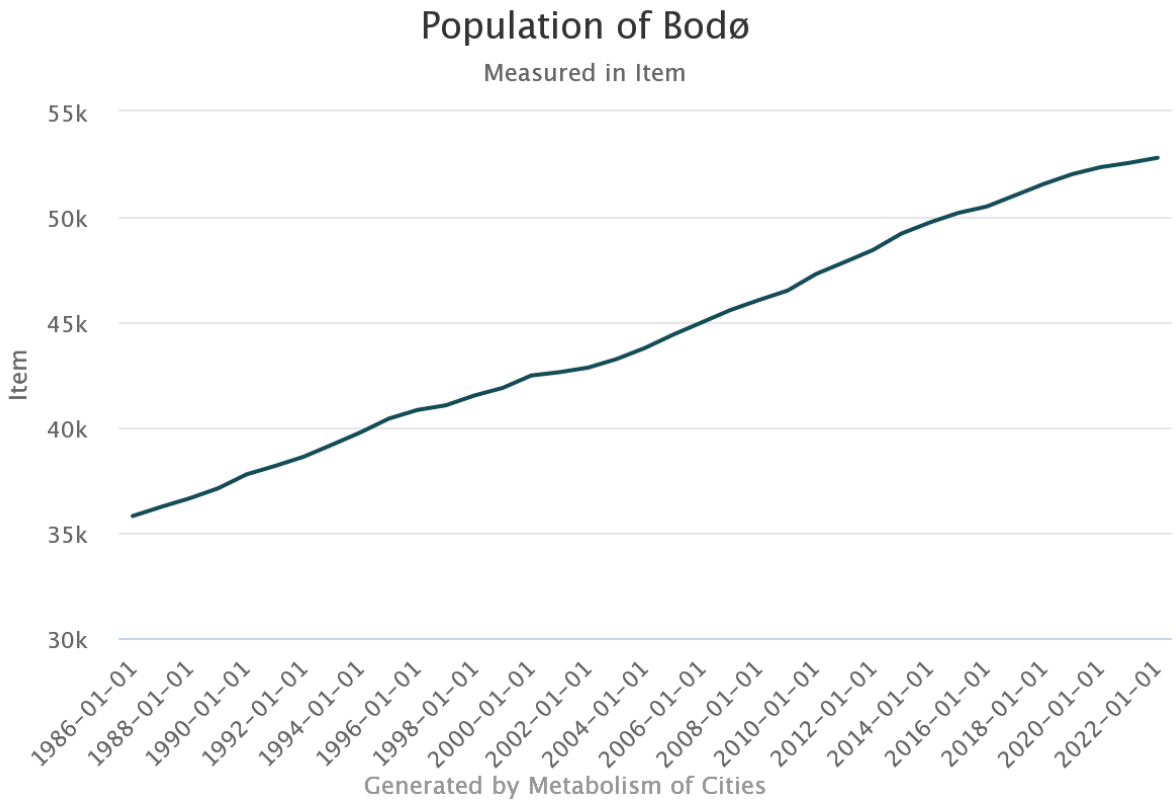


Figure 1 - Population of Bodø (interactive chart)

Bodø is the most central municipality in Nordland, a county in the mid-north of Norway. In 2022, Bodø had a **population of 52,803 people** (Statistik sentrabyra - Statistics Norway 2022b). Over the last 35 years, the population has been increasing significantly (by 47.5%), where there were only 35,792 inhabitants in 1986. Despite this, population growth in the last two years has been the second lowest in the 2000s because of lower birth rates, lower immigration, and lower domestic migration. Yet, compared to the population development in the Nordland municipalities, Bodø is an exception. This city gained 4,468 more inhabitants from 2011 to

2020 (Østerdal et al. 2020). It has experienced the highest percentage growth over the last ten years, preventing low population numbers that are one of the biggest challenges for the finances of municipalities (Bullvåg et al. 2022).

Bodø has a population density of 38 inhabitants per km2 of land area (2020). This is quite high compared to Nordland, which only has six inhabitants and also Norway with 14 inhabitants per km2. Yet, it can be explained by its denser character due to the partially more urban environment.

Between 2015 and 2020, the two reference years of this study, the number of inhabitants in the municipality of Bodø has increased by 2,375 persons, from 50,185 in 2015 to 52,560 in 2020 (Statistik sentrabyra - Statistics Norway 2022a). Currently, according to the age distribution, as can be seen in the graphic, around 22.50% of Bodø's population is between the ages of 0 and 19, while 17.25% is above the age of 65. The majority of the population is between the ages of 20 and 65, accounting for 60.25% of the total population (Statistik sentrabyra - Statistics Norway 2022j). The population is comparatively young with 51% of them being younger than 40 years.

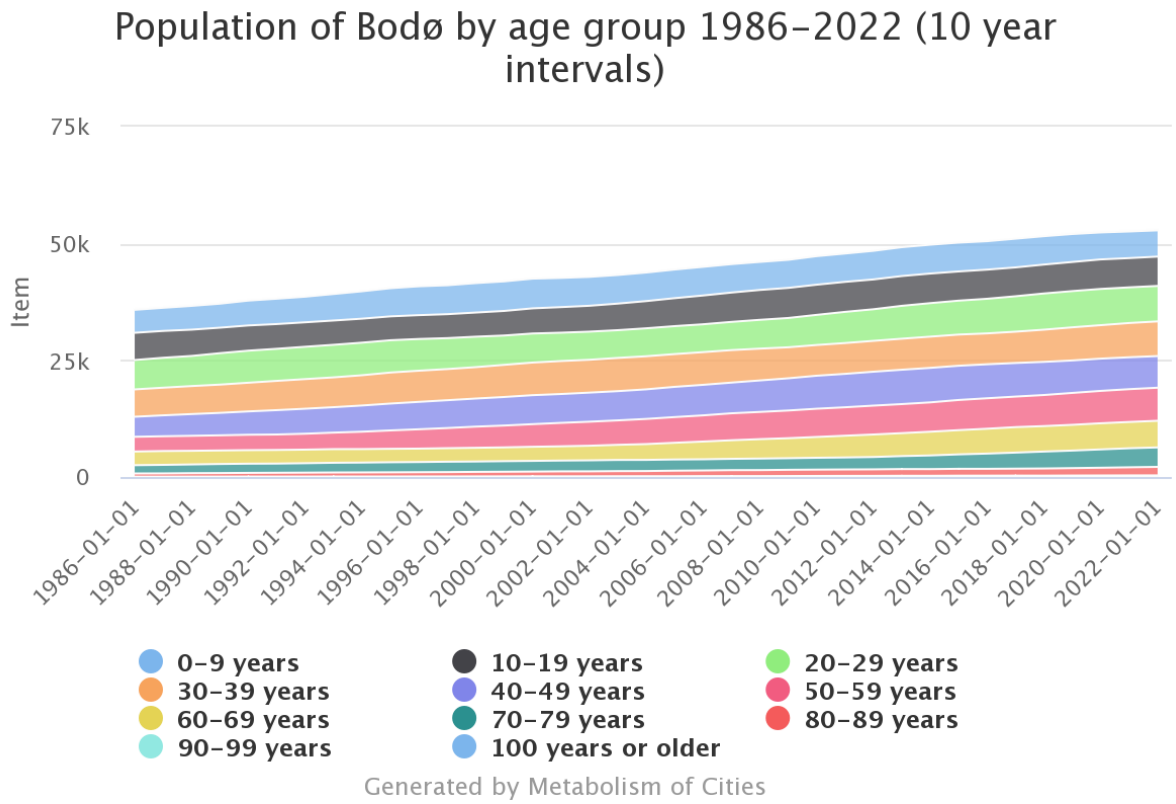


Figure 2 - Population of Bodø by age group 1986-2022 (10 year intervals) (interactive chart)

2.2. Land Use

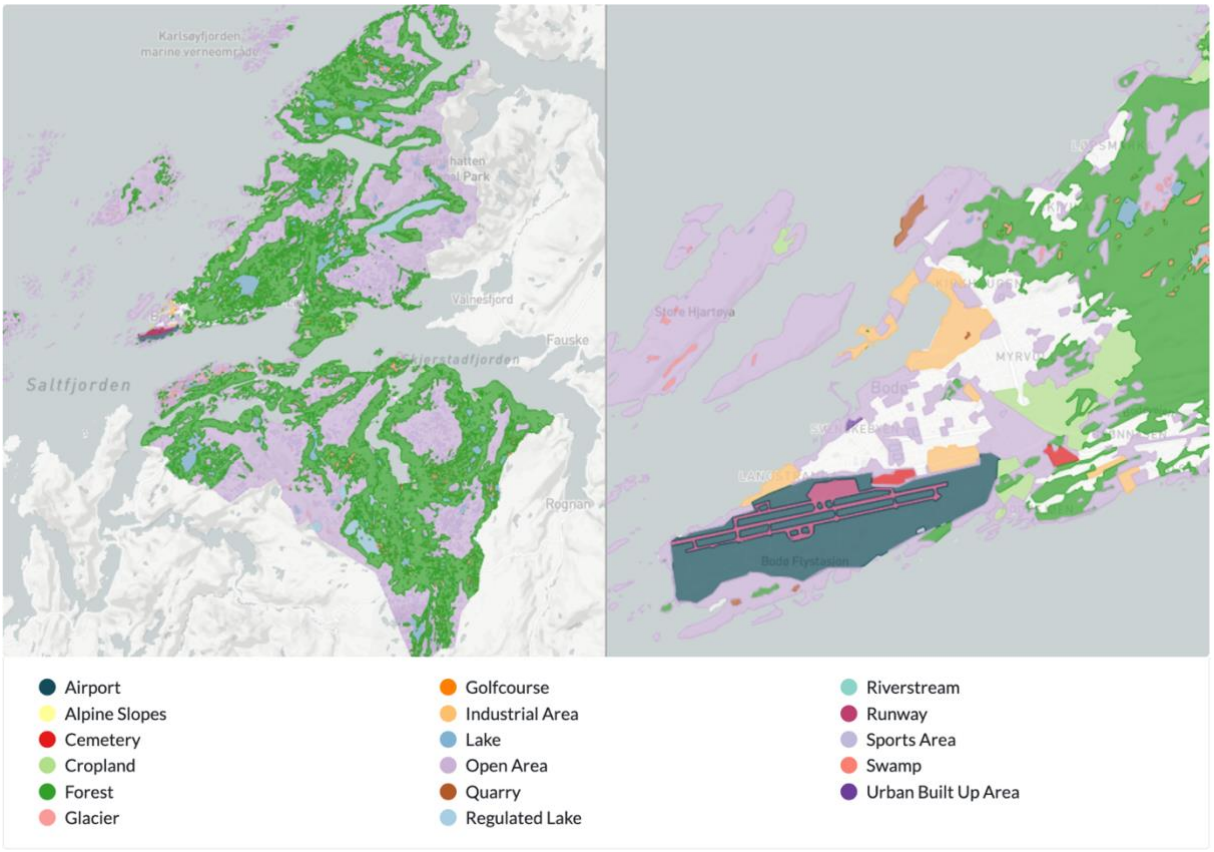


Figure 3 - Land use map (interactive graphic)

Bodø is a town and a port located on the tip of a peninsula in the traditional region of Salten, north of the arctic circle, in Nordland County, Norway. It also consists of several small islands off the peninsular coastline. Due to its strategic location and its popularity as a trading port, it was established as a town around 200 years ago.

The total area of the municipality of Bodø encompasses 1,395.33 km2. Its landscape was historically dominated by natural birch vegetation, but over the past 4,500 years, it has developed into an open and mostly treeless landscape (Moe 2003). This is evident even today as the dominant land use in Bodø with its total area of 1,395 km2 are Open Area (~47%) and Forests (40%) corresponding to approximately 650 km2 and 560 km2 respectively. The urban built up area, in contrast, is merely 5 km2 (0.35%) of which the airport comprises 3.5 km2 (0.25%), industrial area comprises 1.4 km2 (0.1%) and residential areas comprise 0.02 km2.

3. Economic Context of Bodø

This section puts into perspective the economic context of the city under study. It describes its significance in terms of GDP or GVA and provides information on the number of people employed, as well as the main economic activities. Main actors that play a significant importance may also be highlighted.

	GDP (MONETARY VALUE, IN NOK)	EMPLOYEES (2020)
Bodø		29,876
Nordland	125,607,019,060	121,693
Nord-Norge	256,722,405,829	
Norway	3,563,628,707,445	2,832,959

In 2021, all of Nordland province experienced stronger economic development than Norway. The recent increase in employment availability and increase in population growth in Nordland can be attributed to a post-COVID-19 economic recovery. Rising export prices for metals, artificial fertilisers, salmon, and other seafood can be expected as the driving forces behind this growth. In 2021, seafood was the most profitable sector in the region (Bullvåg et al. 2022a). In addition, in recent years the municipality of Bodø invested heavily in transport and urban redevelopment: in a new airport, a whole new city district, hydrogen and electric ferries, and port development (Bullvåg et al. 2022a). Overall, the accumulated Gross Value Added (GVA) for Nordland was 104.9 billion Krone (10.3 billion Euro) in 2015 (Middleton et al. 2018).

In 2020, Bodø had **29,876 employees** in total (Statistik sentrabyra - Statistics Norway 2022g). The industries with the highest number of employees were “Health & Social Work activities” (26.2%), “Wholesale and retail trade” (12.8%), and “Education” (10.13%), as can be seen in the graphic. To put this into perspective with the national economy, it can be confirmed that Norway does have a similar distribution of economic activities with a significant number of employees in the health, retail, and education industries (Statistik sentrabyra - Statistics Norway 2022g). The two largest companies by employees were Bodø Municipality (6,323 employees) and the hospital Nordlandssykehuset Hf (6,261 employees).

The majority of employees are in the private sector (51.8%), followed by the government (21%), local government (18.8%), and the municipal government (3.6%), while public-owned companies have the least employees (4.7%) (Statistik sentrabyra - Statistics Norway 2022g).

It is worth stating that Northern Norway's employment growth (2015-2016) was higher than the rest of the country. This may be explained by the fact that the North’s economy has been less impacted by the 2014-2016 oil crisis and the resulting job losses in other regions of Norway. Major investments have also been made in Northern Norway, creating more jobs in the construction industry (Middleton et al. 2018).

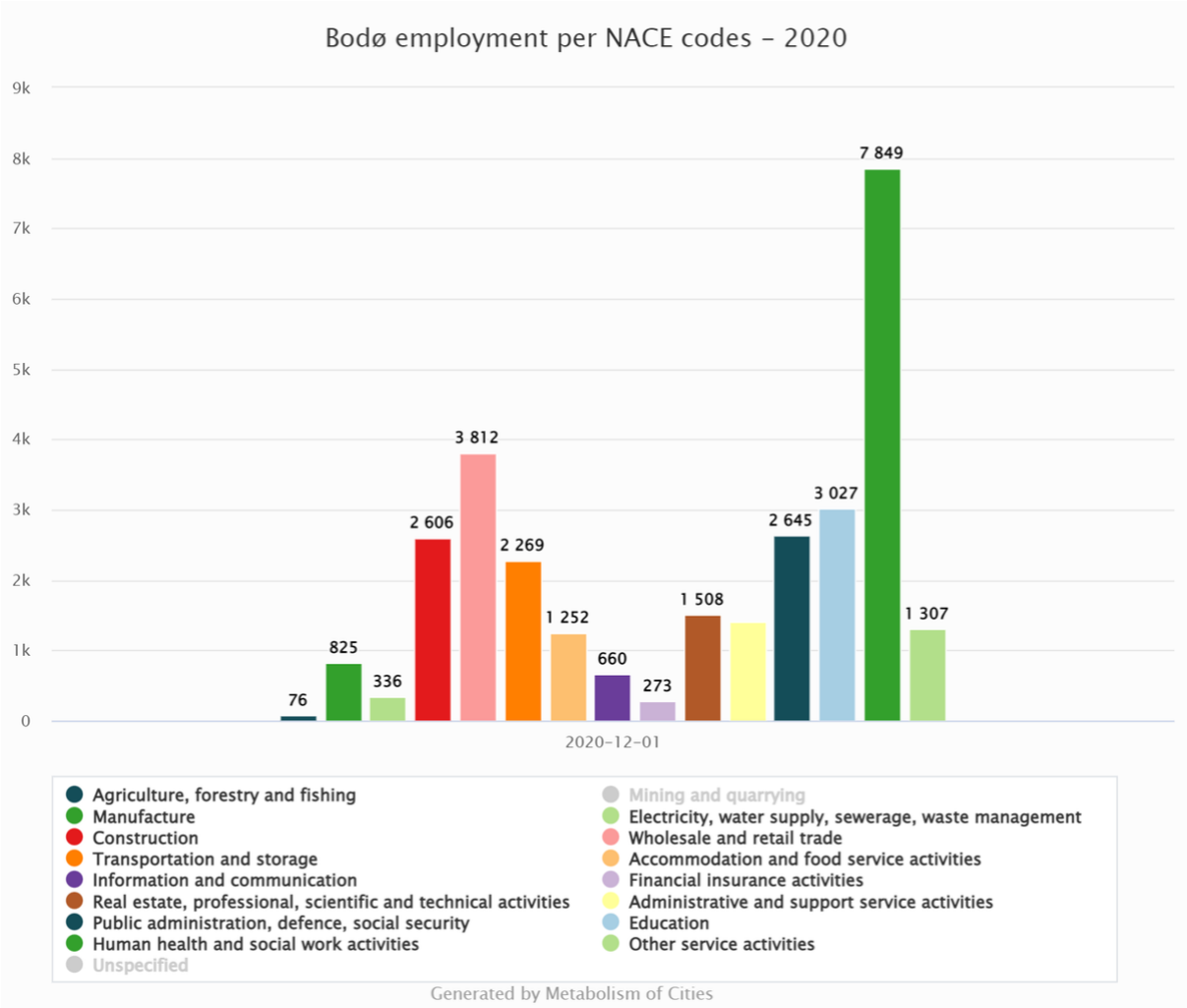


Figure 4 - Bodø employment numbers (interactive chart)

Both public and private spheres in Bodø have recently been dedicated to promoting the region as a place of residence and work (K. Eliassen og Trine Bernhoft 2017). According to Proff, a service page with up-to-date in-depth information about Norwegian companies, Bodø has a total of 9,134 companies registered (Proff 2022a). In 2015, there were 346 creations of new companies in Bodø, while in 2020 that number increased to 615 (Proff 2022a). However, this list includes self-acclaimed personal companies, member organisations as well as some companies with zero employees or zero operating income.

SSB does not report on companies, but classifies them as enterprises and establishments. “Establishment is defined as a locally delimited functional unit which mainly operates within a particular industry group (Standard Industrial Classification)” (Statistik sentrabyra - Statistics Norway 2022i) and an enterprise is defined as the smallest combination of legal units which produces goods or services, and which has a certain degree of decision-making autonomy.” (Statistik sentrabyra - Statistics Norway 2022h). Due to this distinction, the number of establishments is higher than that of enterprises, an example could be a coffee chain (enterprise), that has five cafés (establishments).

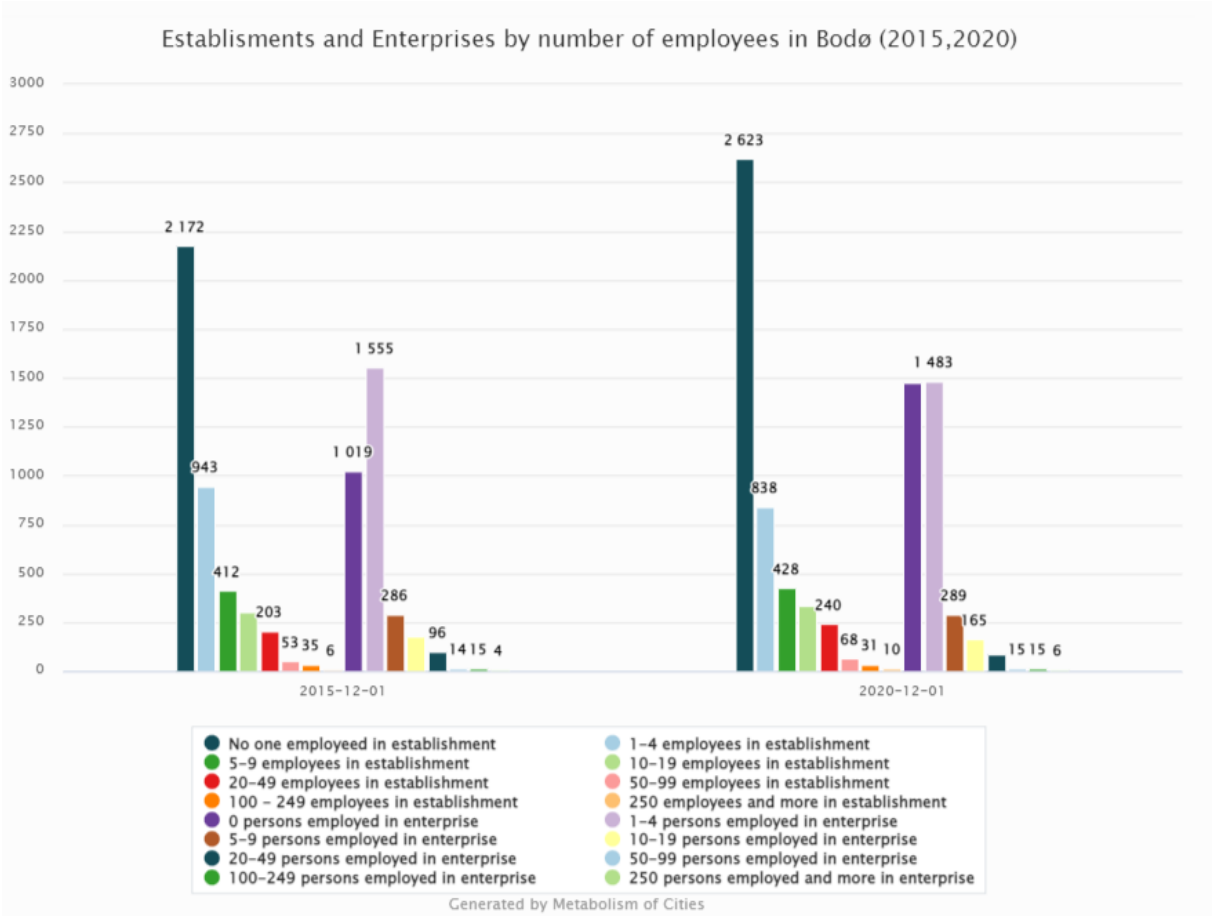


Figure 5 - Establishments and Enterprises by number of employees in Bodø (2015, 2020) (interactive chart)

In total, most of the enterprises deal with “real estate activities" (541) and “human health activities” (347). A total of 7% of enterprises are involved in “agriculture, forestry, and fisheries" with a concentration on “crop and animal production, hunting and related service activities” and “fishing and aquaculture”. There are none in mining coal, lignite, metal ores and extraction in petroleum and natural gas. The real estate and health services sectors seem to be on the rise, while retail trade appears to be on the decline when comparing the values from 2015 to 2020.

In monetary terms, despite enquiring with SSB and the economic department of the municipality of Bodø, the Gross Domestic Product of Bodø is unknown. At a regional level, the GDP totalled 125,607 mio. NOK (2019), contributing to 3.52% of the Norwegian economy (3,563,628 mio. NOK (2019)).

Construction industry

In total, there were 2,384 employees working in the construction sector in 2020. This number includes “construction of buildings", “civil engineering”, and “specialised construction activities" industries, with 603, 273, and 1,525 employees, respectively. The “specialised construction activities" industry had the 5th most employees among all sectors in 2020 (Statistik sentrabyra - Statistics Norway 2022c). According to Proff, there are 312 companies working with services associated with construction in Bodø (Proff 2021z). To get an idea of the sector, the top five

companies by highest operating income and employee number operating in Bodø (Proff 2021z) are presented:

- Nordasfalt AS operates in the production and sale of ravel, shingle and crushed stone and delivers approx. 200,000 tonnes of asphalt for public and private projects annually (Nordasfalt 2022). The number of employees in 2021 was 193. Nordasfalt had a 458,411,000 NOK operating income in 2020 and a profit before tax of 30,380,000 NOK in 2020 that increased to 534,654,000 in 2021 (Proff 2021p).
- Gunvald Johansen Bygg AS is the largest locally owned construction contractor company in Nordland and according to their company website also the biggest one in Bodø (Gunvald Johansen 2022). In 2021, it registered 300 employees and a total operating income of 640,820,000 NOK in 2020 and of 650,716,000 NOK in 2021. In addition, the profit before tax was 3,551,000 NOK in 2020 (Proff 2021i).
- Frost Kraftentreprenør AS is a total supplier of power contractor services within development, operation, maintenance and emergency preparedness of electrical infrastructure, fibre and electrical safety throughout Norway (Frost Kraftentreprenør AS 2022). They are Northern Norway's largest power contractor. Their head office is in Bodø and in 2021 the company registered 155 employees. In 2020, they had a total operating income of 387,606,000 NOK and of 308,132,000 NOK in 2021. In addition, the profit before tax was 10,338,000 NOK in 2020 (Proff 2021f).
- Consto Anlegg Nord AS is one of Norway's leading groups in construction (Consto 2022). In Bodø, according to Proff website, there were 35 employees in 2021. In 2020, Consto Anlegg Nord AS had a total operating income of 291,020,000 NOK and of 331,827,000 NOK in 2021. The profit before tax was -30,548,000 NOK in 2020 (Proff 2021c).
- [Nordland Betong, with concrete stations located in Bodø, Fauske and Meløy, is one of the region's largest players in concrete production (Nordland Betong 2022). In 2021, it registered 25 employees and a total operating income of 130,371,000 NOK in 2020 and 163,268,000 NOK in 2021. In addition, the profit before tax was 19,833,000 NOK in 2020 (Proff 2021q).

Fisheries and aquaculture

The Nordic fish industry has historically supplied raw materials for traditional food processing and exported unprocessed raw materials to other countries (Ottesen et al. 2016). Within this scope, northern Norway has some of Europe's richest fisheries. Fish farming in Norway started during the 1970s, and since then, salmon-based aquaculture has evolved to become the country's second largest business, behind the oil and gas industry. Most of the Norwegian coast now has aquaculture in place. The northern region of Norway, particularly the area surrounding Bodø, plays a significant role, since many of the leading companies in the sector have regional or global headquarters in Bodø and some conduct their fisheries and aquaculture operations here.

In total, there were 143 employees working in the fisheries and aquaculture sector in 2015 compared to 177 in 2020 (Statistik sentrabyra - Statistics Norway 2022c). According to Proff, there are 373 companies working with services associated with sea- and coastal-based aquaculture in Bodø (Proff 2022c). However, this list includes self-acclaimed personal companies, member organisations as well as some companies with zero employees or zero operating income.

According to the "*Bodøs 300 storste selskaper"* magazine (Nu Publishing 2021a), which carried out a survey of Bodø's 300 largest companies in the year 2021 and ranked them by operating income, the following companies in the aquaculture sector can be highlighted:

- The Salten Aqua group comprises Salten Aqua AS with subsidiaries and owner companies (Salten Aqua 2022b), as described below:
  - Salten Aqua AS handles local salmon production and further processing as well as selling salmon to customers in the local area and internationally (Salten Aqua 2022a).
  - Salten Stamfisk AS has salmon production in Skjerstadfjorden, with headquarters in Fauske Municipality. The company produces farmed salmon for human consumption and broodstock which are sold on to roe producers (Salten Aqua 2022a).
  - Salten Smolt occupies 94th place on the list of the biggest Bodo's companies and supplies smolt to breeders in Nordland (Salten Aqua 2022b). The company has two company's branches. One is Department Rognan which is located in Vik in Saltdal Municipality. It takes care of hatchery and starter feeding and produces fry up to 5 - 10 grams in size. And the other one, is the juvenile fish plant at Abdeling Breivik, which is located in Breivik in Bodø Municipality (Salten Aqua 2022a). This company, which was previously called "Salten Havbruk AS", had a total of around 22 employees in 2021, with a 38,144,000 NOK operating income (Nu Publishing 2021a). Salten Smolt performed a negative value of -12,126,000 NOK for profit before tax in 2020 and increased it to 3,626,000 NOK in 2021 (Proff 2021x).
  - Salten N950 This slaughterhouse is located at the south-west of the Bodø Peninsula. Its salmon abattoir is on Søarnøy in Gildeskål Municipality and is equipped with its own waiting cages (Salten Aqua 2022a).
  - Salten Salmon AS, in the 66th position of the top 300 companies in Bodø, produces a range of different salmon products, fresh and frozen. They are a local processor and have their own fillet factory at Rønvikleira in Bodø that also houses Saltenlaks AS (Salten Aqua 2022a). This company has 115 employees with a 51,637,000 NOK operating income (Nu Publishing 2021). Their profit before tax corresponded to -9,408,000 NOK in 2020 and increased to 3,927,000 in 2021 (Proff 2021y).

- Saltenlaks sells finished products, and specialises in its own smoked salmon (Salten Aqua 2022a).
- Polar Quality is an international seafood company (Polar Quality 2022), that sells and exports approximately 20,000 tonnes of gutted salmon annually (Salten Aqua 2022a) and coordinates transport to customers from Polar Quality's offices in Bodø (Fish Choice 2020). They are one of the largest companies according to '*Bodøs 300 storste selskaper*' magazine, not only in the aquaculture sector, but also in the general ranking of companies, in the **3rd** position. They have 11 employees and a 1,452,294,000 NOK operating income (Nu Publishing 2021). Their profit before tax corresponded to -24,022,000 NOK in 2020 and increased to 16,992,000 in 2021 (Proff 2021u).

- Fram Seafood is operating in the aquaculture sector, in **6th** position in the general top 300 companies ranking (Nu Publishing 2021a). The company is a Norwegian trader of farmed Atlantic salmon, rainbow trout and a wide range of wild caught seafood. This company manages daily contact with farmers in the arctic area and customers around the globe. It has a total of seven employees at the facility in Bodø, which is the main office (Fram Seafood 2022a), with a 694,603,000 NOK operating income and 6,632,000 NOK of profit before tax in 2020 and 8,202,000 in 2021 (Proff 2021e). There are three production-related locations (Fram Seafood 2022b), all in the arctic area:
  - Ellingsen Seafood AS: 94 employees and a production of 11,500 tonnes
  - Kvarøy Fiskeoppdrett AS: 26 employees and a production of 7,000 tonnes
  - Salaks AS: 63 employees and a production of 10,000 tonnes
- Dahl Fiskeri AS is on the **20th** position of the list. The Dahl group consists of two parent companies, Dahl Fiskeri AS (DF) and BHDahl Eiendom AS (BHDE). Dahl Fiskeri AS owns and manages two seine vessels, MS Kvannøy and MS Senior, which fish for pelagic fish (Dahl Fiskeri 2022). Dahl Fiskeri AS had a total of around 40 employees in 2021, with a 206,533,000 NOK operating income (Nu Publishing 2021a), 19,648,000 NOK profit before tax in 2020 and 148,240,000 NOK in 2021 (Proff 2021d).
- Andreassens Rederi AS is in **101th** position. Officially the Andreassens Rederi AS, fishes for herring, mackerel and capelin in the Norwegian Sea. This company is based at Nordfiskbrygga on Nyholmen in Bodø(BRUS - Bodøregionens Utviklingsselskap n.d.). It has a 36,464,000 NOK operating income (Nu Publishing 2021). Their profit before tax corresponded to 17,080,000 NOK in 2020 and decreased to 5,478,000 in 2021(Proff 2021a)
- Bofisk AS occupies **119th** place on the list. The company has existed since 2001 and has local fishing boats in Bodø. Their whitefish production is mainly exported to Europe, but much is also sold on the domestic market and a good part of the turnover comes from fish shops in Torvgata, in the centre of Bodø (Bokisk 2022). They have 22

employees with a 30,243,000 NOK operating income (Nu Publishing 2021a). However, their profit before tax went down to -517,000 NOK in 2021 from -14,000 NOK in 2020 (Proff 2021b).

Other relevant companies that have high operating income according to Proff (Proff 2022c), but are not on the top 300 list:

- Pelagia AS produces pelagic fish products for human consumption and supplies ingredients for all kinds of fish- and animal feed, such as fish meal and fish oil, as well as hydrolyzate and fish protein concentrates. It has one of its feed facilities, Pelagia Bodø Sildoljefabrikk, in Bodø (Pelagia 2022).It has a total of around 27 employees, with a 6,732,263,000 NOK operating income in 2020. Pelagia had a value of 664,892,000 NOK for profit before tax in 2020 and 381,889,000 NOK in 2021 (Proff 2021t).
- Gigante Havbruk AS is a farming group that works both with hatchery and food fish, and has its head office in Bodø. It is the largest owner (61%) of 'Gigante Salmon AS' and concentrates its business in Salten and Helgeland (Gigante Salmon 2022). This company has around 2 employees, with a 698,000 NOK operating income.Their profit before tax corresponded to 33,518,000 NOK in 2020 and decreased to 22,808,000 in 2021 (Proff 2021g).
- Polarfeed AS works with feed production for fish and has a department in Bodø (Polarfeed 2022). According to Proff, Polarfeed has 1 employee in the branch office of the municipality, with a 233,509,000 NOK operating income in 2020. Their profit before tax corresponded to -9,620,000 NOK in 2020 and to -13,399,000 in 2021 (Proff 2021v).

Some trends in the circular economy can be identified in the region of Bodø, where fishing gear recycling is a relatively young industry. Nofir AS is a company which specialises in recycling fishing gear including ropes and nets. Another circular economy practice in Bodø (one that diminishes the production of waste) is the use of entire fish, including instances from both aquaculture and the wild fish processing industry. In these cases, byproducts like the guts and bones are utilised as the basis for oil and meal products (Centre for the Ocean and the Arctic 2019). Pelagia AS states it contributes to less food waste by using 100% of the fish and providing a longer shelf-life after processing (Pelagia AS 2021). The daily production capacity is 1,400 tonnes.

Due to the importance of the fish industries (especially in Bodo's exports), it can be easily assumed that significant transport activities are associated, including airfreight of seafood to Asia and North America, are involved to facilitate the operations of this industry. In the material flows section, the impact of this industry and the rest of the local economy will be further elaborated.

Waste sector

As waste is an essential component of the Urban Circularity Assessment, waste companies are presented in more detail, to highlight the situation around and readiness to deal with

outflows in Bodø. In total, there were 141 employees working in the waste sector (waste activities, materials recovery) in 2015 versus 176 in 2020 (Statistik sentrabyra - Statistics Norway 2022c). Waste in Bodø is largely handled by two companies, Iris Salten IKS (and its subsidiaries), and Østbø AS, while a total of 12 establishments were registered in the municipality (Statistik sentrabyra - Statistics Norway 2022c) and 15 companies on Proff.no. While Bodø municipality is a local waste authority and has the formal responsibility for waste disposal in the municipality, it rents services from Iris Salten.

- Iris Salten IKS is an inter-municipal waste management company with its head office in Vikan, outside the city of Bodø. It serves the nine municipalities in Salten, which also own the company. The company's main activity is the collection and treatment of both household and corporate waste, through five subsidiaries that have been established to perform this service: Iris Service AS, Iris Produksjon AS, Retura Iris AS, Mivanor AS, Nofir AS. However, the final waste treatments are left to their partners.
- Iris Service AS was founded in 2001, focuses on household renovation and operation of the environmental squares. It has the biggest share of employees in this sector with 123 employees, and had 115,935,000 NOK of operating income in 2021. However their profit before tax went down to -1,056,000 NOK in 2021 from 926,000 NOK in 2020 (Proff 2021n). Iris Service AS is responsible for collecting household waste in every Salten municipality and operating all twelve environmental squares, from Oppeid north to Halsa south.
- Iris Produksjon AS handles all waste that comes through the Iris Group and operates Salten's only landfill. At this location, they also prepare waste for the local district heating plant, for energy recovery. Iris Produksjon has the aim to be Northern Norway's leading production company for recycling waste. The company has 35 employees with a 121,344,000 NOK operating income and 20,847,000 NOK of profit before tax in 2021. In 2020, their profit before tax was relatively low (3,848,000 NOK) (Proff 2021m).
- Retura Iris AS is a wholly owned subsidiary of the Iris Salten IKS Group, a part of the national franchise chain called Retura Norway, a waste management company. The company offers waste solutions to companies and institutions. They have 28 employees with a 70,033,000 NOK operating income and 3,856,000 NOK profit before tax in 2021 (Proff 2021w). It offers complete waste solutions, from waste planning to collection and treatment of the waste throughout the Salten region. It offers rental services for waste containers for different types of waste streams such as industrial, hazardous and construction & demolition waste. It also provides courses and sorting guides to corporations.
- Nofir AS, formerly known as Norsk Fiskeriretur AS, is responsible for collection, recycling and retail of discarded equipment from the farming and fishing industry with a head office in Bodø. Nofir also has a separate company in Lithuania where all dismantling takes place, in addition to branch offices in Poland and Turkey. Currently there are three employees in Bodø with a 29,148,000 NOK of operating income and

826,000 NOK of profit before tax in 2021 (formerly it was 2,322,000 NOK in 2020) (Proff 2021o). Nofir also does dismantling of nets, trawls, farming rings and other farming equipment, and collects all equipment that can be recycled to be sent to recycling. The company is owned by Iris Produksjon (40.45%), Egersund Group (34.17%), Lofoten Avfallsselskap (19.00%) and Sørheim Holding (6.38%).

- Iris Miljøtorg Vikan is responsible for collecting non-hazardous waste and is one of the collection spots registered as a company under Iris Salten, 2.25 km from the centre of Bodø, adjacent to Iris's landfill and compost facility. This service area has 63 employees, with 111,948,000 NOK operating income and 926,000 NOK profit before tax in 2020 (Proff 2021l).
- Østbø AS, which is part of the Saltens Gruppen AS, that supplies passenger traffic, logistics services and environmental services in Northern Norway, is Nord-Norge's largest commercial waste and environmental company with its headquarters in Bodø. It offers total waste services throughout northern Norway and provides the following services: Business renovation, household renovation, industrial service, environmental mapping and environmental remediation, transportation, transport of dangerous goods, consultancy, car wreck reception in Bodø and Fauske, and solutions for the oil and gas industry as well. The waste categories they deal with are hazardous waste, iron and metals, and electronic waste. Østbø employs 202 people, but since it operates in all of Northern Norway, not atll of them are in Bodø. The company has the highest operating income in Bodø among the waste companies which operate in Bodø, with 355,579,000 NOK and 23,572,000 NOK of profit before tax in 2021 (Proff 2022b).

Aside from these two large companies, there are four smaller players dealing with waste and various levels of activity:

- Haftor AS is a non-hazardous waste collection company with a 40,000 NOK operating income. However, their employee information is not disclosed and they do not have a profit before tax (Proff 2021j).
- Nordland Metall AS is a non-hazardous waste collection company established in 2013. They currently do not have any employees, nor operating income or profit (Proff 2021r)
- Green Environmental Products AS is responsible for the wholesale of waste and scrap in Bodø, established in 2011. Their employee and operating income is not disclosed, but their profit before tax was zero for 2021 (Proff 2021h).
- Helligvær Brøyteservice AS is a company that collects non-hazardous waste with an operating income of 642,000 NOK and had a profit before tax of 382,000 NOK in 2021 (Proff 2021k).

In addition, there is another company that is known in the waste sector with many facilities throughout Norway, but does not seem to operate in Bodø anymore: Norsk Gjenvinning Metall AS avd Bodø is branch of Norsk Gjenvinning service company including waste management, metal recycling, industrial services, hazardous waste, downstream solutions, household

renovation, demolition, environmental cleanup and safety shredding. Norsk Gjenvinning is Norway's largest supplier of recycling and environmental services. Their operating income is the highest among the waste companies with 1,326,969,000 NOK and their profit before tax is 19,311,000 NOK (Proff 2021s). These values are for the head office in Lysaker. However, the Bodø branch which was registered in 1995 is currently closed permanently (according to their main website) and only their cooperation partner Iris Salten operates the Vikan landfill.

Lastly, Bodø Energi Varme AS is a subsidiary company of the Bodø Energi group. The company is headquartered in Bodø and 100% owned by Bodø Municipality. Bodø Energy Varme AS supplies heat from the Keiseren Bio plant at Rønvikjordet to the district heating system in the municipality that has been in place since 2015 (Bodø Energi n.d.). The biomass heating plant uses locally recycled wood (pallets, demolition wood, kitchen fittings, etc.) as feed, which it receives in about equal parts from the two waste management companies, Retura Iris and Østbø. After four years of operation, by 2019, 96% of Bodø's energy needs in 2019 (i.e. 53,859 MWh of energy) were met by bioenergy.

4. Material Flows in Bodø

Measuring material flows and circularity is a data heavy exercise. Numerous datasets were collected and visualised throughout the Urban Circularity Assessment process. To synthesise these findings, a Sankey diagram illustrates how material flows of the local economy of Bodø are circulating from one lifecycle stage to another. The height of each line is proportional to the weight of the flow. This diagram therefore helps to quickly have an overview of all the materials flows that compose the economy and their respective shares. The flows that are coloured in light blue in the Sankey diagram, are return flows. This means that they flow in the opposite direction of the lifecycle stages and are subjected to reuse, redistribution, or remanufacturing. Their size relative to the others is a good indication for a materials' circularity.

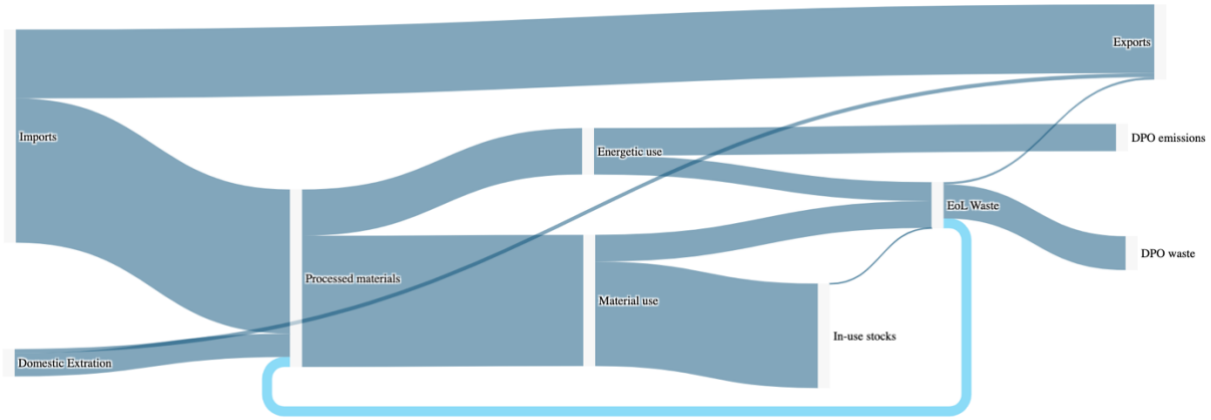


Figure 6 - Bodø Sankey diagram (interactive diagram in online report)

4.1. Domestic Extraction

Domestic Extraction (DE) of biomass, minerals (metallic and non-metallic), as well as fossil fuels plays a minor role in Bodø compared to its imports, as can be observed in the Sankey diagram. Local extraction is limited to biomass materials (91%) and two non-metallic minerals (9%). While fossil fuel extraction represents a dominant share in the Norwegian economy, it is non-existent in Bodø. Likewise, the extraction of metal ores plays a subdued role in Norway, where mostly iron is mined, however, no mining activity for metal ores is carried out in Bodø.

In terms of **non-metallic minerals** there is some salt and sand & gravel extraction. The salt company is a small producer and only harvests 1.5 tonnes yearly, exporting 83% of it. Sand and gravel extraction have historically had a larger and more significant presence in Bodø, although it has been greatly reduced over the years and 4,700 tonnes are still extracted yearly.

The **biomass** extracted locally represented 50,531 tonnes in 2020 and 74,561 tonnes in 2015, underlining a decrease of 32%. Overall, fodder crops and fish extraction, either in the form of wild fish catch or aquaculture were the most extracted materials in 2015 and while the quantities of fodder crops remained constant in 2020, the quantities of fish extraction decreased significantly. Fodder crops (36,231 tonnes in 2020) were consumed by livestock composed of 27,627 animals (Landbruksdirektoratet 2021) in Bodø (2020). In total, livestock consumed about 73% (40,572 tonnes) of the biomass in 2020 (51% in 2015) in the form of fodder crops and grazed biomass.

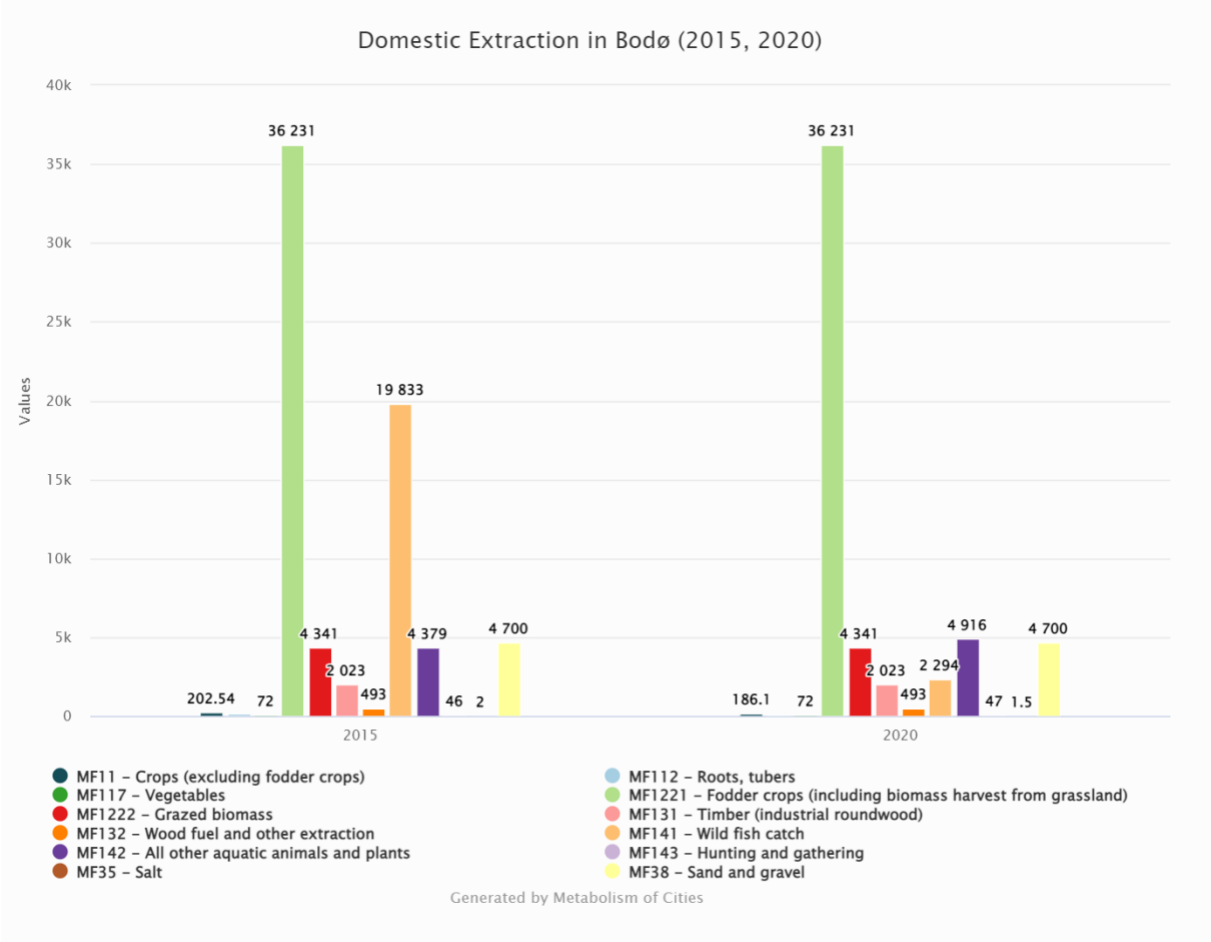


Figure 7 - Domestic Extraction in Bodø (interactive chart)

The rest of the extracted biomass plays a more significant economic role and is connected to the fisheries industry, representing a total of 7,210 tonnes or 13% in 2020 and 24,211 tonnes (31% of all domestic extraction) in 2015. These values are made up of wild fish and aquaculture catchment. While aquaculture remained relatively stable between 4,379-4,916 tonnes, there was a sharp drop of 88% for wild fish harvested from 2015 to 2020 (19,833 to 2,294 tonnes). This decrease can most likely be attributed to the closing of landing ports, where fishery reception takes place.

After fish extraction, roundwood removal, albeit in lesser quantities, is also extracted in Bodø. From 475,500 decares (47,550 ha) of productive and unproductive forest (Statistik sentrabyra - Statistics Norway 2022d), a total of 2,516 tonnes of timber and fuel wood were harvested, making up 4.6% of the domestic extraction.

Compared to the forest area, which together with "firm ground" makes up 83% of all land (Statistik sentrabyra - Statistics Norway 2022d), agricultural land covers 3.26% of Bodø's surface. Even though 75.5% of agricultural land (25,292 decares) were actively in use, only 186 tonnes (0.3% of DE) were harvested in the form of roots and tubers, and vegetables. Lastly, 281 moose were shot in 2020, representing 47 tonnes.

4.2. Imports & Exports

Imports & exports account for a very large share of the flows entering and exiting Bodø's economy (much larger than the domestic extraction), as visible in the Sankey diagram. However, these values are considerably less reliable than the DE ones (as will be discussed in the data quality part) as they can be very difficult to obtain at a city level. In the case of Bodø, only a handful of measured data were found for imports and exports flows for a few non-metallic minerals, bunkered fuels and waste. Other data found for the analysis were national data on imports & exports which were in turn downscaled with employee numbers.

Imports

The total amount of materials imported to Bodø were 449,856 tonnes in 2015 and **439,227 tonnes in 2020**. While there has been a very slight decrease of 2% between these two years in Bodø, the absolute numbers on a national level tell a different story for 2020, as the imports actually increased by 15%. Therefore, it could be deduced that the employee proxy used to downscale information may not adequately represent the actual changes in imports and exports (more information is available in the data quality part).

The distribution of the imported material groups found in the graphs shows that non-metallic minerals made up the main share of imports with 57% and 59%, with fossil fuels following at 22%, and biomass, metals, other products and waste together made up 21% in 2015 and 19% in 2020. In both years, the imported non-metallic minerals amounted to 242,500 tonnes of sand and gravel, 14,000 tonnes of cement and 500 tonnes of lime for the local production of concrete and asphalt. It is worth mentioning that while it is surprising that the amount of non-metallic materials imported is the same for both years, the data was provided by a local company. The weight of imported fuels was 87,749 tonnes and those of other products 50,552 tonnes.

As mentioned earlier, bottom-up data was obtained for the two largest categories non-metallic minerals and fuels, providing a reliable picture of Bodø's imports. The imported fossil fuels are fuels that were imported mainly for transport (land, water, air). They are distributed through ST1 Norge Depot Vestervika terminal and account for 99% of liquid imported fuels in Bodø. These fuels totalled 91,745 tonnes in 2015 and 87,749 tonnes in 2020, representing 20% of the imports. In 2020, the majority of it (96%) was transported over more than 2,000 km and

came from Gothenburg (Sweden) and Southwold (UK). For 2020, the remaining 3,589 tonnes came from Mongstad (Norway), while in 2015 the amount imported from there had been threefold (ca. 10,000 tonnes). In addition, it is important to underline that heating is predominantly delivered through electricity in Norway reducing the imports of more fossil fuels.

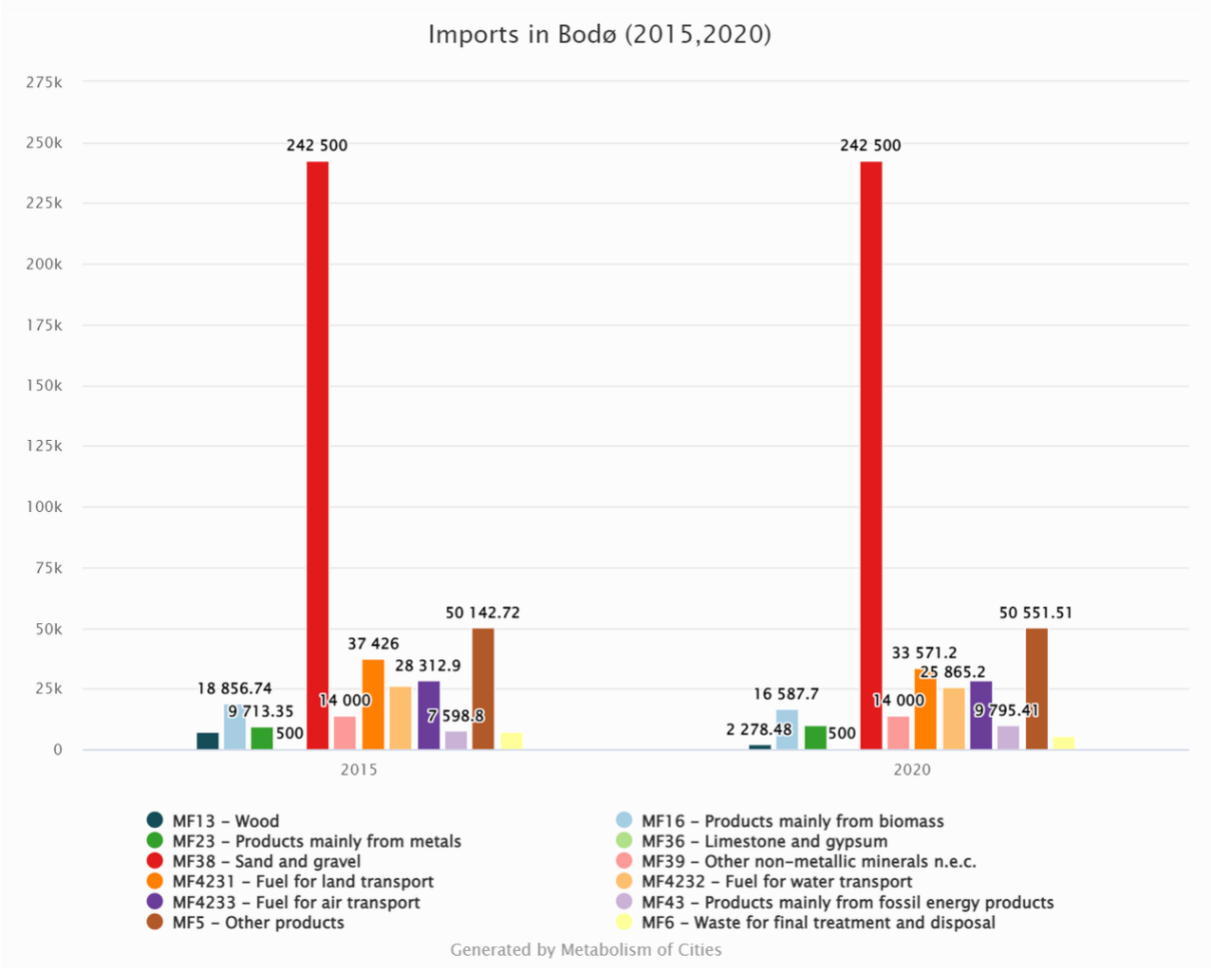


Figure 8 - Imports to Bodø 2015 and 2020 (interactive chart)

From the author's experience and in relation to those two groups, the import of biomass should be considerably higher to satisfy the food needs of the population (more details to improve the quality of this data point is provided in the data quality part).

Aside from fuels, waste is also imported to Bodø, for treatment. While the waste import through Østbø is unknown, Iris Salten imports at least 5,300-7,300 tonnes yearly. From the neighbouring municipality Fauske, Iris imported polluted soil 327 tonnes in 2021, 2,006 tonnes of residual waste came from households in the other municipalities in Salten, and 3,000 tonnes of food waste originating from households in other municipalities in Salten, as well as other regions.

Exports

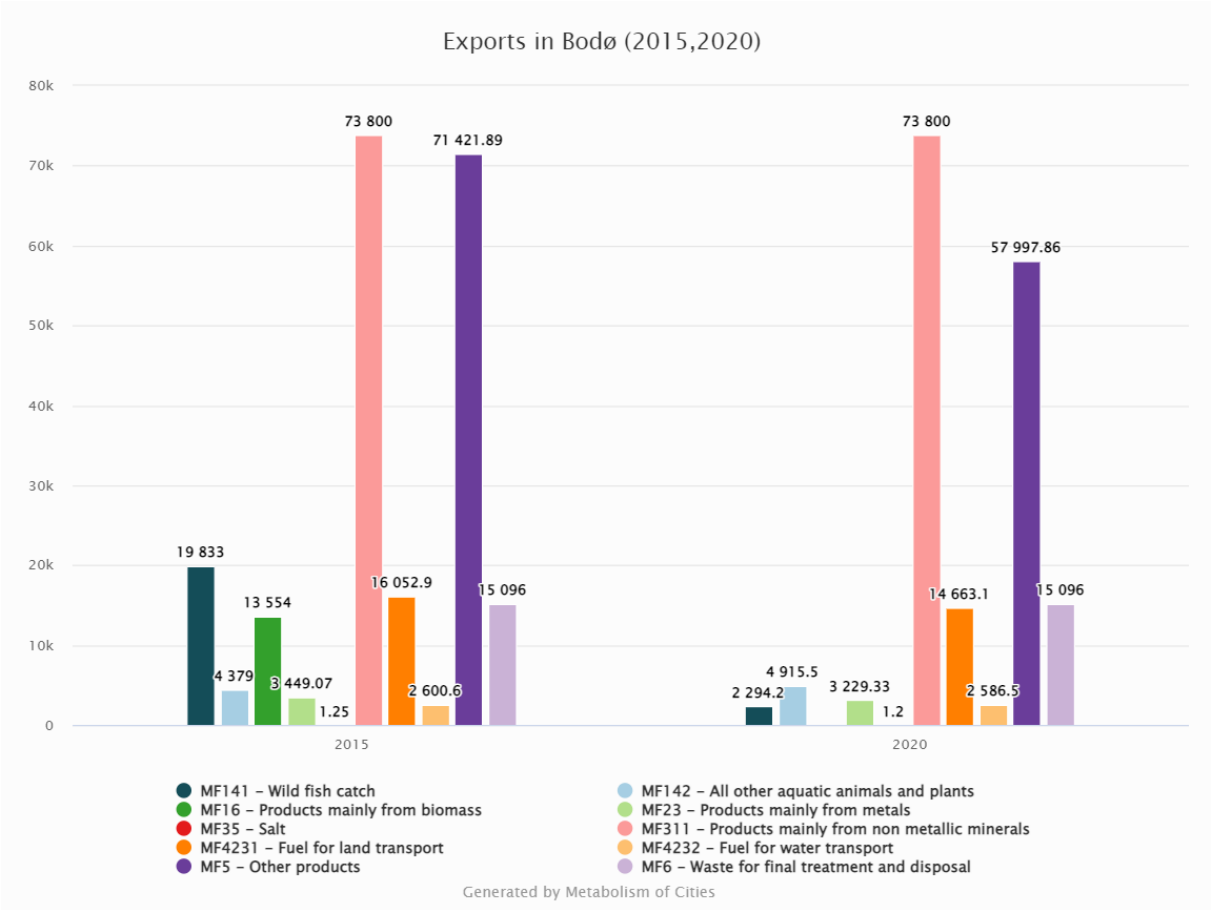


Figure 9 - Exports from Bodø (interactive chart)

The total amounts exported from Bodø were 220,104 tonnes in 2015 and **174,584 tonnes in 2020**. Unlike imports, a sharp decrease of 21% can be observed. More specifically, the export of wild fish decreased by 88% and other products by 19%. Again, the national trend does not follow this development. On the contrary, exports were 7% higher in 2020 compared to 2015.

As for the single years, the distribution of the exported material groups is reflected in the graphs. It can be seen that non-metallic minerals make up the main share of exports with 34% and 42%, followed by other products with 32 and 33%, respectively. These figures are not too surprising as they reflect on the major economic activities present in Bodø. However, an interpretation of these values needs to be done with great care, as the data cannot be considered reliable: A number of downscaled values for export were left out, as they made the DMC negative, as is explained in the data quality part.

The data on the largest quantity exported comes from the local concrete and asphalt producers, who are exporting their products (73,800 tonnes). In both years, they estimated that 45,000 tonnes of asphalt and 28,800 tonnes of concrete were exported, where the latter

represents an assumption that 30% of their production was used outside of Bodø's municipal boundaries.

To reflect on the domestic extraction and exports of the fisheries and aquaculture industry that was mentioned earlier, the values that were not downscaled, but could be obtained from the local production, it was assumed that all of the harvested fish, 24,211 tonnes in 2015 and 7,210 tonnes in 2020, were exported. The decrease of 70% that was experienced in the extraction, therefore carries onto the export as well. The distribution of exports to the national and international markets is unknown.

As for the large quantity of imported fuels, only a little is further exported as 100% of the aviation fuel and 90% of the gas oil for marine transport are used locally. Only 17,250 tonnes were exported in 2020, most of it fuels for road transport.

A total of 15,096 tonnes of waste was also exported. Though the amounts for Iris are unknown, it is certain that Østbø ships metal and tire waste outside of Bodø. Østbø has its department for metal recycling at Finneid, just outside the centre of Fauske, the neighbouring municipality. From there, they export over 15,000 tonnes of metal by boat, train and car every year. In addition, they dispose of 8,000 tires (96 tonnes) annually, 200 km to the North, in the cement factory of Norcem in Kjøpsvik. There, together with other waste-based fuel from Østbø, based on sorted and ground residual waste, it replaces coal and fuels the cement factory. Closing the loop, the cement from Kjøpsvik goes, among other things, to Nordland Betong in Bodø (Nu Publishing 2021b).

4.3. Domestic Material Consumption

The domestic material consumption (DMC) is calculated by adding the domestic extraction with imports and subtracting exports. It represents the quantities that are consumed in the municipality and totalled **334,249 tonnes in 2020**. This amount, added up with 24,857 tonnes of secondary materials forms the input flow to the processed materials (359,106 tonnes in 2020), which was split up 26% vs. 74% in energetic and material use, 93,628 tonnes and 265,478 tonnes, respectively.

The energetic use powers the local economy and results in emissions to air (DPOemissions with 55,276 tonnes), as well as to land, in the form of solid & liquid wastes - 93,489 tonnes that ended up at the end-of-life (EoL) waste. A part of the energetic use is made up of the fossil fuels that have been imported to Bodø. Most of them are used for transport and as its nature would have it, its users are moving consumers. Although the fuels are shipped to Bodø and bunkered there, ships and planes are filled in Bodø and use the fuel to get to many parts of Norway and the world. The same goes for road transport and other mobile combustion, where the fuel is sold to gas stations in Bodø from where it is distributed to cars and machines. It is therefore not necessarily consumed in Bodø.

A part of the material use, with 211,281 tonnes, found its permanent destination as gross additions to stock at the "societal in-use stocks", such as infrastructure and goods that stay in

the city for more than one year. Throughput materials are the second stream that leave the material use and were 54,196 tonnes of used materials that ended up at EoL waste.

4.4. Waste

The last component of the material flow accounting for the UCA, found on the right side of the Sankey diagram, is the waste output of Bodø. As it will be explained in the data quality part, mostly household waste and some commercial waste could be included in the accounting, as no information was available from industrial waste. These totalled at **186,183 tonnes in 2021**, an increase of 22% from 2017 (152,471 tonnes). The largest fraction was mineral and solidified wastes with about 46% in 2021 and 62% in 2017 of the total waste and soils as their largest waste type (77-92 kt), as can be seen in the waste composition graph. Thereafter, the dominating waste fractions are “household waste and similar waste” (21,163 tonnes in 2021), which is the residual waste that is not separated, and wood waste (15,833 tonnes). The recyclable waste, namely metals, glass, paper & cardboard, rubber, plastic, wood and textile, totaled at 41,729 tonnes (2021) with wood and paper & cardboard waste as two largest fractions.

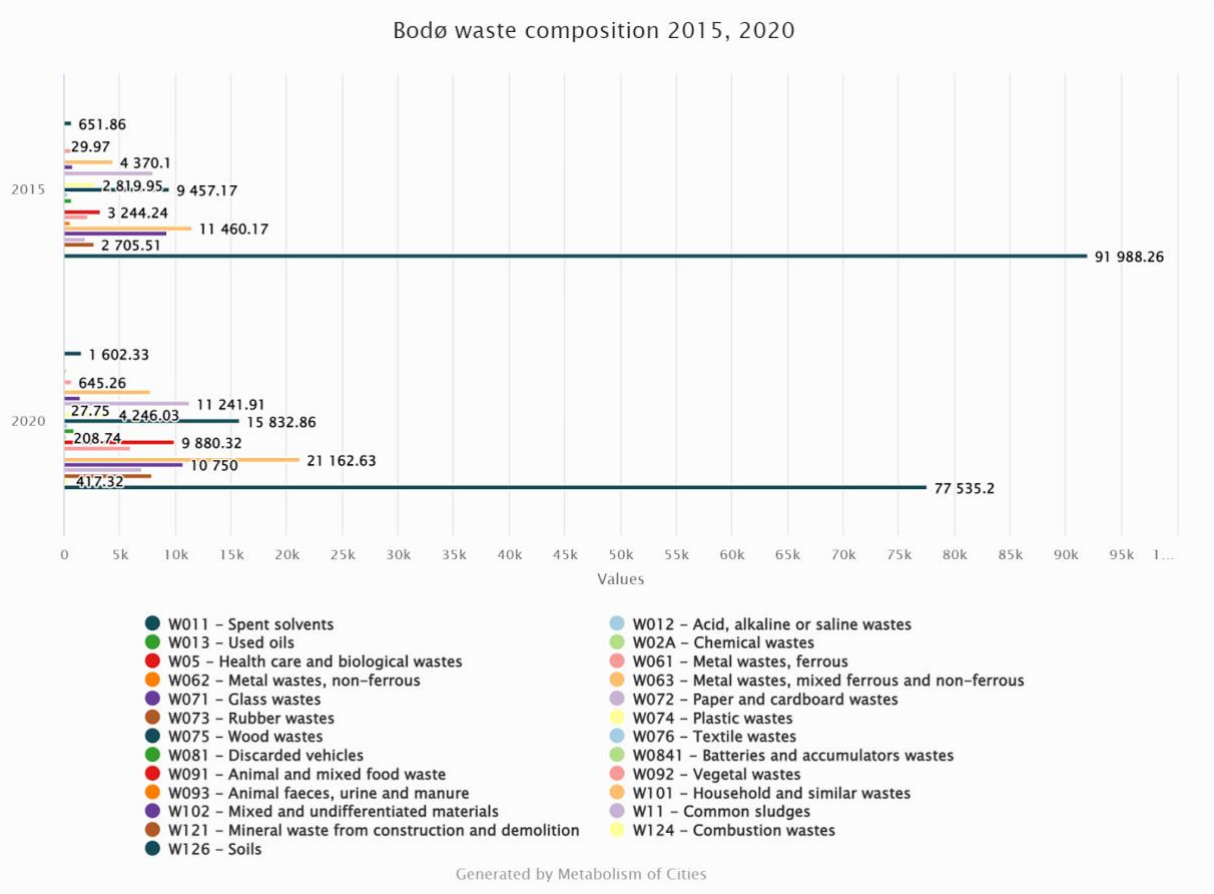


Figure 10 - Waste composition (interactive chart)

Considering only the household waste, the per capita generated value was 468 kg in 2020 and 433.7 kg in 2015 (Statistik sentrabyra - Statistics Norway 2022f). This number and development mirrors that of the region: For Nordland, in 2020, each inhabitant generated an average of 481 kg of household waste, 79 kg more than in 2015 and 33 kilograms more than the national average. At the same time, the amount of waste delivered for recycling remained relatively unchanged between 2015 and 2020. Each Nordlander provided an average of 84.2 kg for recycling in 2020. It was around 1 kilogram less than the previous year but quite a bit more than in 2016. Also, Nordland residents recycle more than the national average. It increased by about 2 kg in 2020 (Bullvåg et al. 2022b).

The total end-of-life waste in 2020, however, was 93,489 tonnes. This encompasses the total waste (reported), both energetic and material use, as well as the total waste (non-reported). In the Sankey diagram, EoL waste splits up as DPO waste, the material left after recycling or not subjected to it in the first place, which was 68,632 tonnes in 2020, as well as secondary materials. The latter equalled 24,857 tonnes in 2020 and consists of materials from recycling and for backfilling, where 81% (20,176 tonnes) made it back to processed materials and 19% were exported.

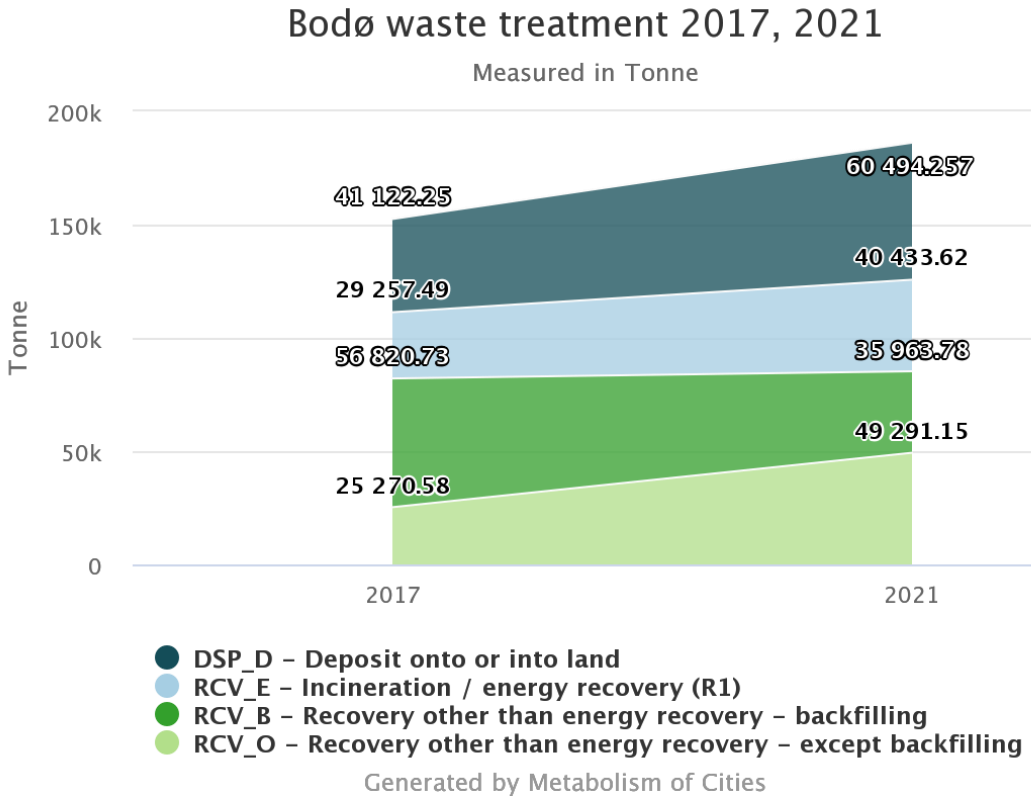


Figure 11 - Waste treatment distribution (interactive chart)

With regards to waste treatment, the waste from Bodø is subjected to recycling, incineration, backfilling and disposal to landfill. It is unknown what happens to the industrial and parts of commercial waste, for which there was no data i.e. whether and how it is treated locally or exported for treatment.

Recycling in the UCA method bundles into one group various operations that take place within Bodø such as sorting or separation, composting (aerobic), transhipment / bulking. Therefore, it cannot be further distinguished what exactly happens to the various waste fractions. Taking this into account, it still is relevant to mention that recovery (other than energy recovery) predominated waste treatment operations in 2017 (54%) and 2021 (46%). In 2017, the majority of this recovery was due to 56,821 tonnes of backfilled soils (37% of total waste), while in 2021 this amount decreased as there was 37% less soil available for backfilling.

Recycling, other than backfilling (RCV_O in the chart), almost doubled from 2017 to 2021 (49,291 tonnes). This was mostly due to animal and vegetal waste recycling which tripled to 15,954 tonnes and the grouped recyclable waste of 29,354 tonnes that had increased by 72%. The strongest leap was in the wood waste, which rose from 2 to 3,600 tonnes.

Despite the positive development in recycling, incineration still plays a large role in Bodø too. In 2017, 29,257 tonnes were incinerated with energy recovery, while it was 38% more (40,434 tonnes) in 2020. As for the least desirable waste treatment, disposal to land, that is still made use of for Bodø too, where 27% of the remaining waste was landfilled in 2017, while in 2021 it had increased to 32% (60,494 tonnes).

5. Material stock in Bodø

Determining and analysing the material stock of a city can, similarly to the material flow accounting, also be a data intensive endeavour. The intensity depends on the scope and the data availability. For the Urban Circularity Assessment, the scope includes all residential and non-residential buildings in the municipality. Unlike for the material flow quantification, the analysis is not done for one or several specific reference years, but considers all buildings that have been constructed and still exist, up until and including 2022 (year of study). The aim is to quantify the materials that every single building contains and represent them spatially on a map. Depending on the data availability around building typologies, age cohorts, building height and material intensities, different, specific quantifications and investigations can be made.

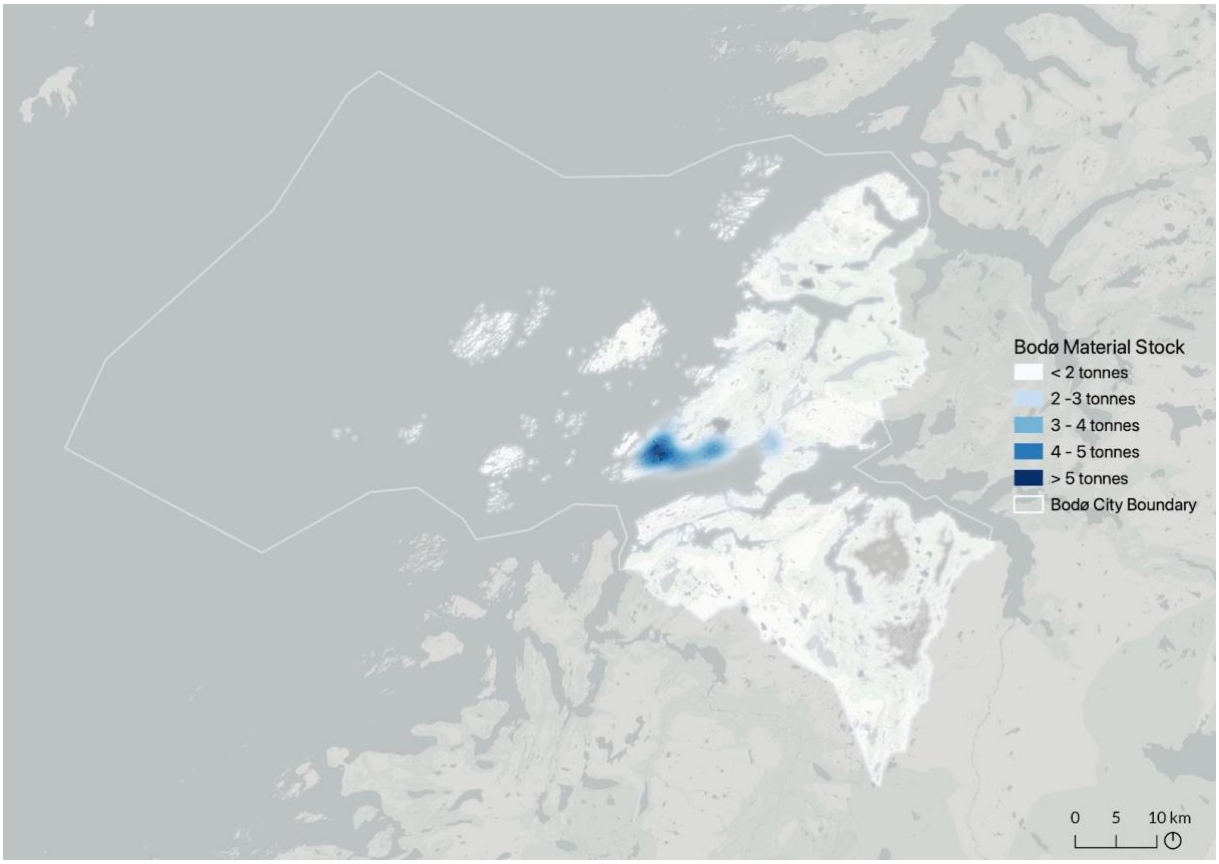


Figure 12 - Map of Building Material Stock in Bodø expressed in tonnes and with an overlaid heatmap to facilitate its compression. (interactive map – explore it!)

The embedded map allows to explore the building stock of Bodø and interact with the different scales and buildings by zooming in and out, and clicking on the buildings to discover more about typologies and quantity of building materials. The widgets on the right can be used to account for certain information, e.g. the number of buildings in an area, or to filter for specific construction years, which in combination with the average useful life of buildings can be used

to calculate the potential urban mine. Furthermore, an analysis can also be performed by using the lasso tool and drawing an area (a block, a neighbourhood or an urban area) to be analysed.

5.1. Building typologies in Bodø

An essential part of stock material analysis is the definition of typologies. Through a correct creation of typologies, the typologies can be linked to the material intensities, in order to obtain the mass of the building stock. To define the typologies, the cadastral information is used to inform their geometry, but in this case, they were designed using the cadastral information and its geospatial attributes. As such, six typologies were defined:

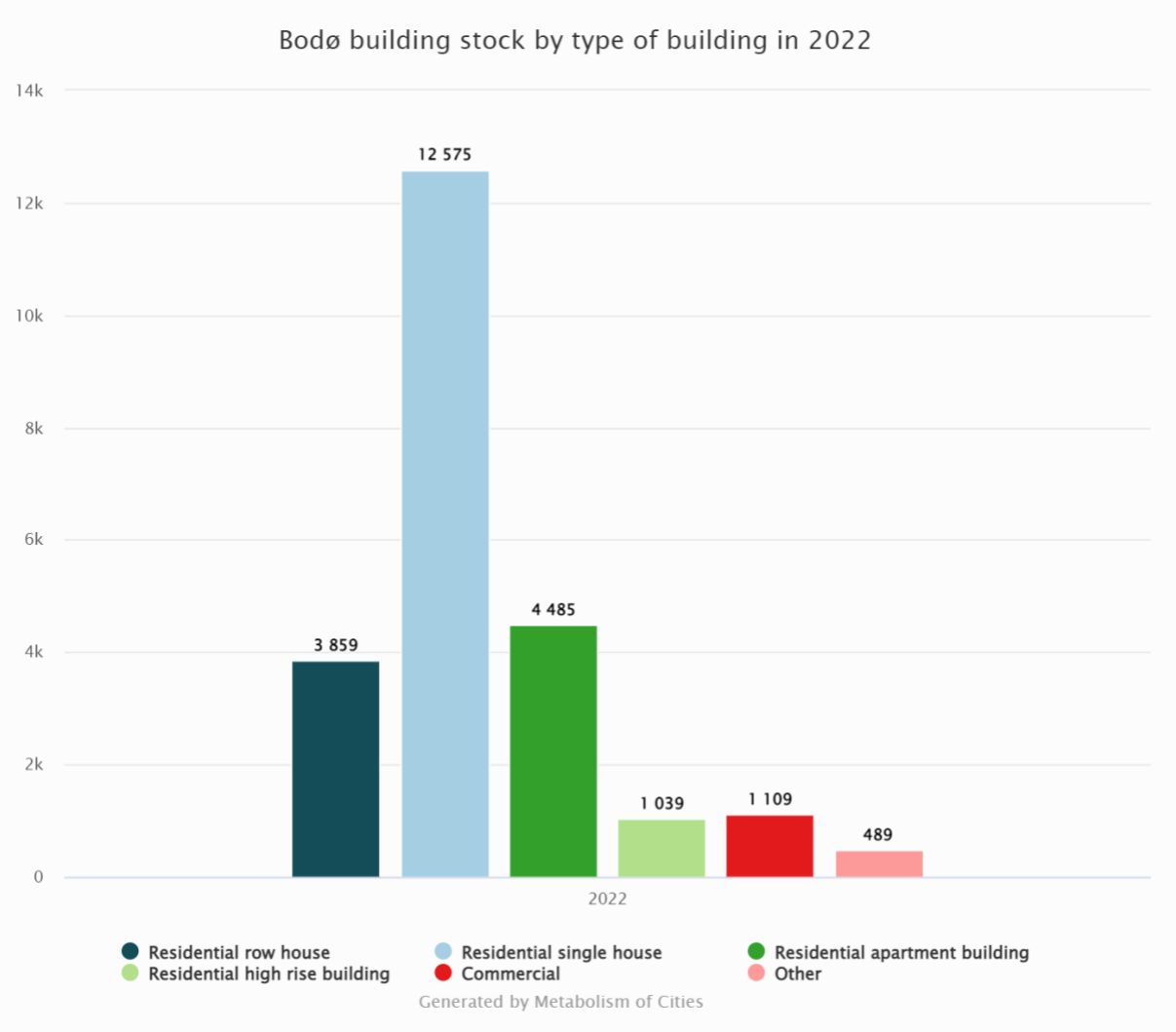


Figure 13 – Bodø building stock by type of building (interactive chart)

- Residential Single: When the building is residential, not adjacent to another building, the number of floors is less than 3 and the number of dwellings is 1.

- Residential Row House: When the building is residential, adjacent to another building, the number of floors is less than 3 and the number of dwellings greater than 1.
- Residential Apartment: When the building is residential, not adjacent to another building, the number of floors is less than 3 and the number of dwellings greater than 1.
- Residential High Rise: When the building is residential, not adjacent to another building, the number of floors is equal or more than 3.
- Commercial: Defined with matching cadastre typologies.
- Other: Defined with matching cadastre typologies.

In total, **23,556 buildings have been analysed in the municipality of Bodø.** The chart here illustrates the share of each typology in the total building stock. As visible, the majority of the buildings (53.4%) are residential single houses, followed by residential apartment buildings (19%) and residential row houses (16.4%), commercial (4.7%), residential high-rise buildings (4.4%) and others (2.1%).

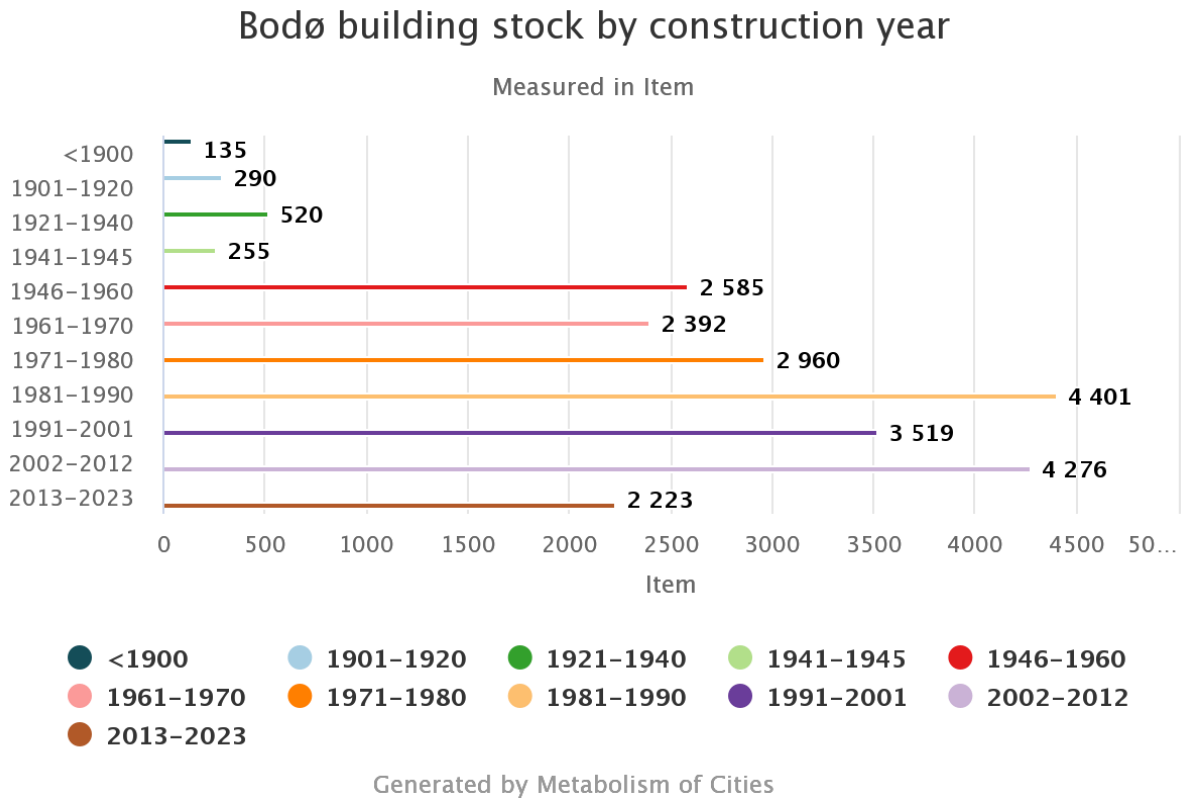


Figure 14 - Bodø building stock by construction year (interactive chart)

As for the year of construction distribution, it can be seen that the buildings constructed in the cohort of 1981-1990 have the largest share (18.7%), followed by the ones of 2002-2012 (18.2%) and those between 1991-2001 (14.9%), resulting to a relatively recent building stock.

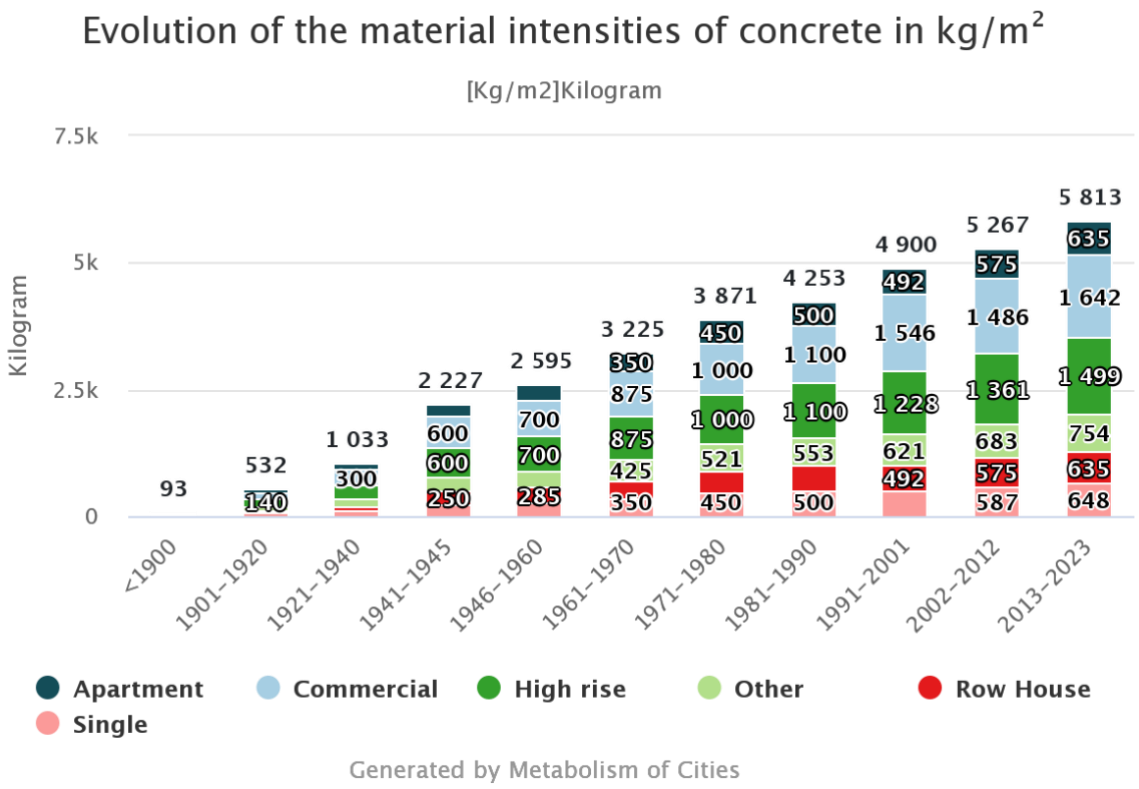


Figure 15 - Evolution of the material intensities of concrete in kg/m2 (interactive chart)

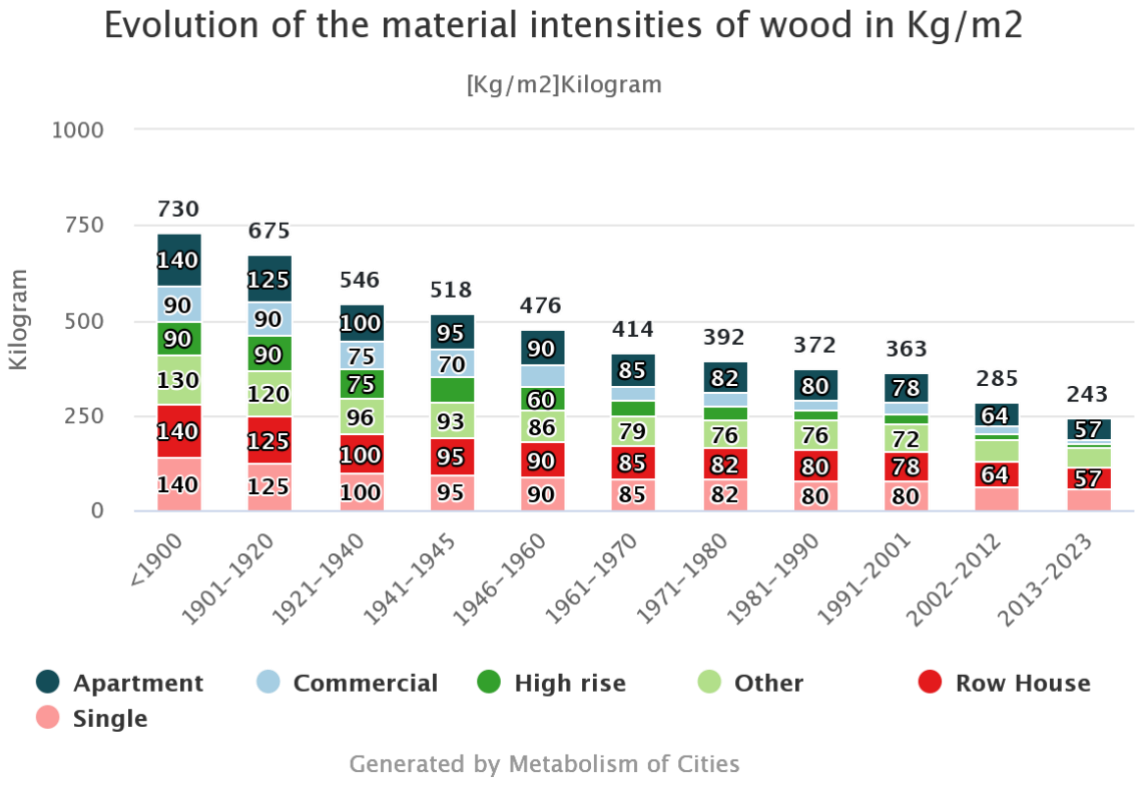


Figure 16 - Evolution of the material intensities of wood in kg/m2 (interactive chart)

Once the typologies are defined, the material intensities per age cohort and housing typology can be linked to calculate the material building stock per building. Of the material typologies in Norway, the following pattern is noteworthy and evident in the material intensity figures. It can be seen that while the material intensities of concrete have been increasing over time, the material intensities of wood have decreased considerably. It can be deducted that older buildings still have more wood in their construction, unless they have been renovated, while the more recent buildings are primarily constructed with concrete.

5.2. Analysis of Material Stock

In the previous chapter, building typologies were developed and material intensities were gathered from the National Cadastre and the National Building Map Database of Norway, as well as an academic paper (Bergsdal et al. 2007) to measure the building material stock of Bodø. To obtain it, the gross floor area of each building was multiplied by its associated material intensity, which depended on the typology of that building.

Thanks to the spatial explicitness of the material stock, it is possible to map the material stored within the city and identify different zones, for example those with higher material intensity (higher density of buildings or high-rise buildings). Overall, it is estimated that Bodø's **quantified building stock weighs approximately 4,225,599 tonnes, with 3,907,096 tonnes of concrete and 318,503 tonnes of wood.**

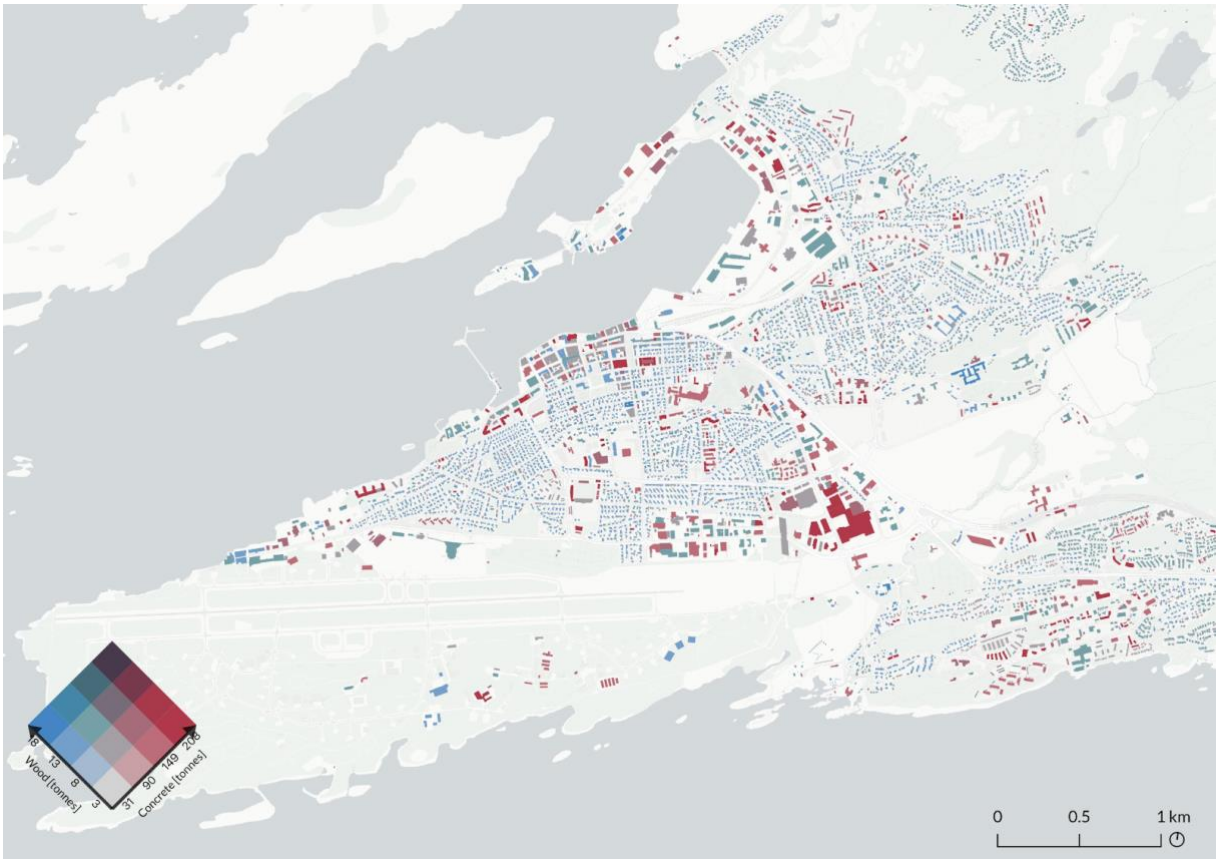


Figure 17 - Bivariate map of Bodø's building material stock of wood and concrete in tonnes

As can be seen in the map at the beginning of the chapter, despite the large surface area that Bodø has, most of the building material stock is located at the end of a peninsula projecting into the Norwegian Sea. In addition, as can be observed in the bivariate map showing both concrete and wood stock, the areas with the highest concentration of wood (buildings coloured in blue) are equivalent to those areas with single buildings, apartments and row houses, which are also the oldest buildings. Those areas, where there is a higher concentration of concrete, are located in the port area and in emblematic buildings such as the town hall and the cathedral, as well as the Scandic Havet hotel, coinciding with high rise and commercial buildings.

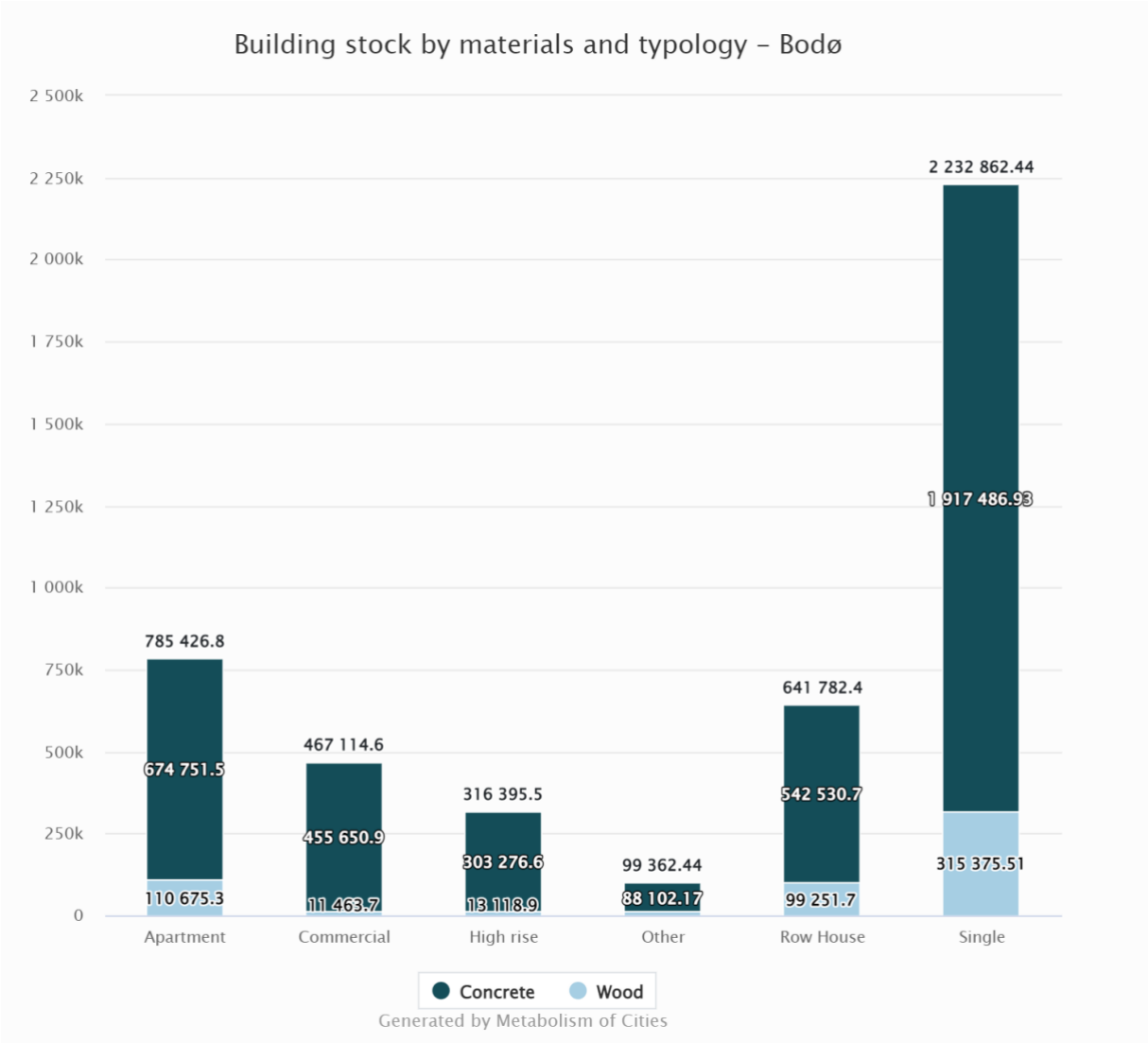


Figure 18 - Building stock by building typologies and materials (interactive chart)

By analysing the building material stock by typology, it can be seen that the dominant typology in Bodø is single residential buildings with 2,332,862 tonnes, followed by flats with 785,426 tonnes and row houses with 641,782 tonnes.

Development of Bodø's Material Building Stock

In order to understand Bodø's material stock, it is important to understand not only how much of it is embedded in the building, but also to try to elucidate how it has been shaped over time, where it is located and why.

The Foundation of the City

Bodø was founded in 1816 as a trading town for northern Norwegian fishermen, which until then relied on Bergen (Beaudoin and Marthinsen 2017). In the first 50 years, nothing stuck, and the town was nearly abandoned until fishing brought wealth and a permanent urban population. The small town was laid out in a square grid and was dependent on fishing and trade. It was a compact little town made of brightly coloured wooden houses in a narrow street grid, with larger structures like warehouses along Sjgata, the hospital, the prominent church, schools, and commercial buildings (Beaudoin and Marthinsen 2017).

Due to a series of events that will be explained below, very few of the buildings built during this period remain in the municipality of Bodo. Today, the building stock that was constructed before 1940 only makes up 3.8% of the total number of buildings analysed and their material composition was and is different from the buildings constructed today. As can be seen in the graph of material composition of those buildings, 92% of the building materials are wood and only 8% are concrete.

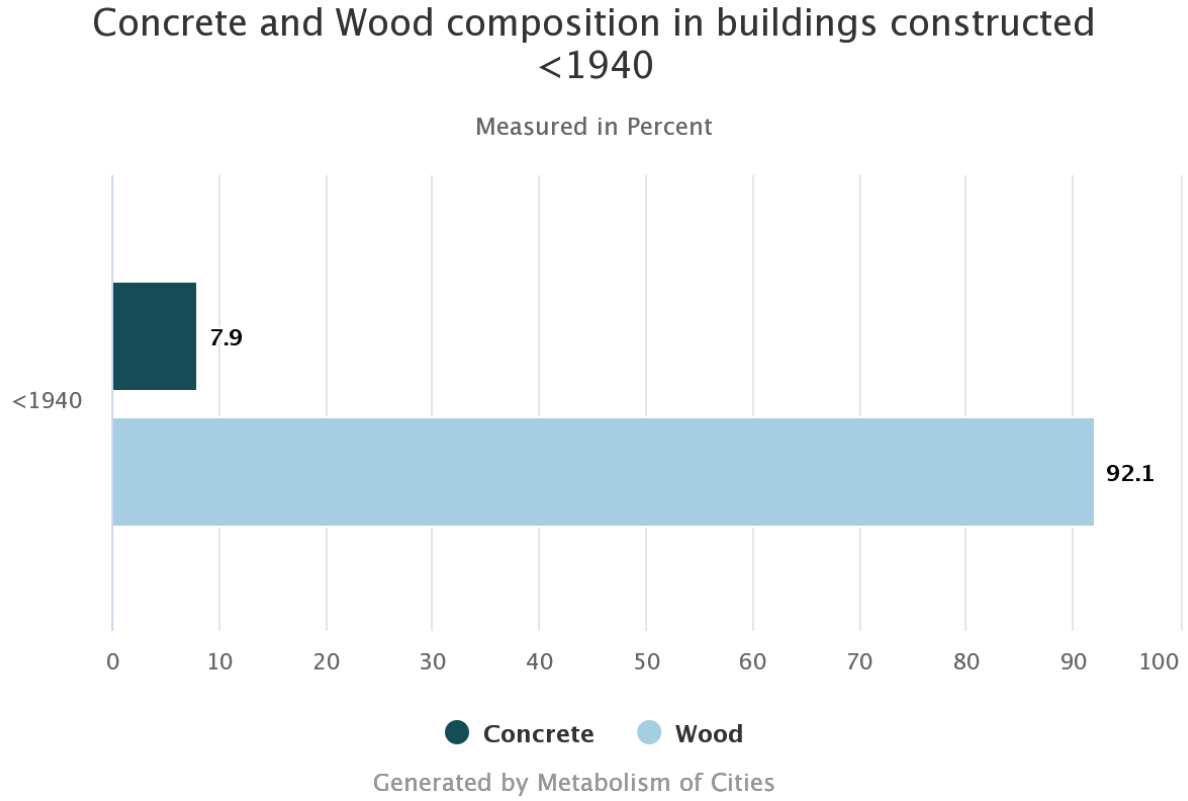


Figure 19 - Concrete and wood composition in buildings constructed prior to 1940 (interactive chart)

From the Middle Ages until the Ålesund fire in 1904, wood was the main building material in most Norwegian towns. Even though towns were often burned, architects were reluctant to change styles. Cities were rebuilt as before until new laws banned wood in urban areas and introduced a new architectural style. When post-war town modernisation began, the old wooden areas had been neglected for years. The building stock could not meet new demands for more volume and efficiency (Kittang 2016). This event explains why the buildings in the centre of Bodø started to move away from the use of the abundant wood in the territory to the use of concrete.

The War: Destruction and Renovation of the Building Stock

Bodø had 6,000 residents when the German bombers destroyed 80% of the town's structures in 1943, during World War II. This becomes evident in the building stock chart by material and age cohort, where it can be seen that the 1,200 buildings built prior to 1945 contribute very little with just a 7.26% share of the total tonnage of material stock in Bodø.

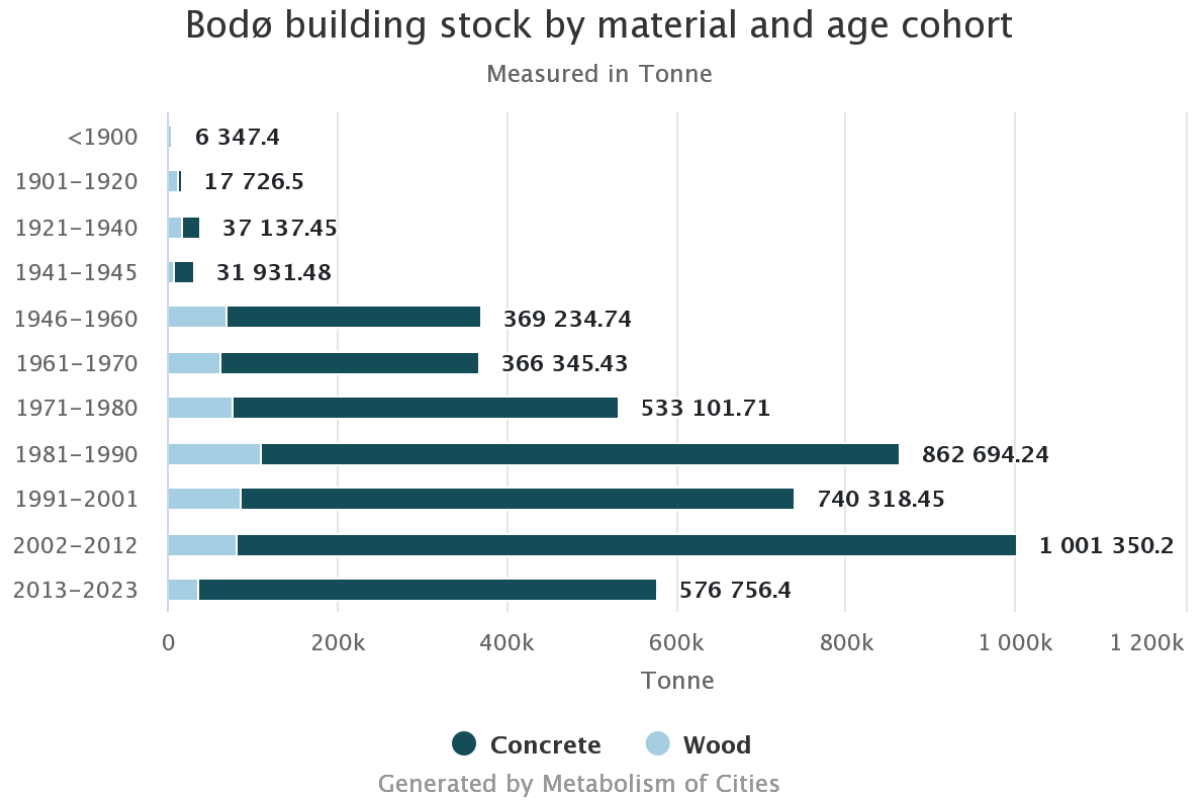


Figure 20 - Building stock by age cohort and materials (interactive chart)

At the end of the war, housing was desperately needed in Bodø and 20 other Norwegian cities. National planners began Burned Places Regulations (BSR), or regulation of burned places. The BSR town plan widened the blocks by 20%, moved the main streets, and opened vistas to the surrounding mountains. The plan called for adding one floor to the most central buildings, for a total of 3 stories. The plan allowed for gradual growth and increased commercial floor space by 40% (Beaudoin and Marthinsen 2017). The urban centre was to be built with non-flammable materials, while the outer districts allowed wooden row houses and single-family

homes. The housing association built mostly multi-family units for a growing population. The typical urban building had retail on the ground floor, offices or apartments on the first, and more apartments on the second. The typical reconstruction building had clean, plastered volumes with few ornaments and details. Many important buildings such as the town hall, cathedral, the post and telegraph building, the bank, Grand Hotel, etc. were built during reconstruction. In the 1960s, town leaders declared reconstruction complete (Beaudoin and Marthinsen 2017). Naturally, this post-war renewal demanded a lot of construction materials to be used, which can be observed in the form of a quantitative leap in the chart from the 1946s onwards.

Growing in Height and Spreading

The NATO airbase took up much of the peninsula and plans to expand the harbour in the northeast left limited area for growth. Planners believed the town was "full" and sought fresh expansion regions. Sea, farms, mountains, and airport limits constrained possibilities. Bodø amalgamated with neighbouring municipalities and grew east and north. As most homes were built along the East and North corridors, the town centre was a commercial hub. Most retail was in the centre, and the shorelines had fishing and maritime industries (Beaudoin and Marthinsen 2017).

In 2008, zoning allowed three new high-rises, changing the townscape. The inner centre was opened to new residential constructions. Since 2014, around 1,000 new apartments were built or proposed, which could double the inner-city population. In 2012, Bodø was told the airbase would be moved to Trondheim. A proposal was established to re-establish the airport 900 metres to the south, in the former air force base area, and to start a new urban development on the former airport land, which is on the periphery of the existing town centre (Beaudoin and Marthinsen 2017). Although 1981-1990 was the age cohort in which most buildings were constructed (4,401 buildings) the 2002-2012 age cohort is the one where most of the building material stock is concentrated with 1,001,350 tonnes, due to the intensive use of concrete in this period. This growth in height and expansion has had a clear impact on the building stock and as can be seen in the graph above, in addition to the quantitative leap after the war, another important leap occurred in the 1980s, a decade when the building stock doubled compared to the buildings constructed in the 1960s.

Present and Future

Today Bodø, although having experienced considerable growth, still preserves the character of a northern coastal town, albeit with several unique high-rise buildings lining the shoreline and a myriad of residential blocks consisting of single houses, apartments and row houses. More recently, buildings in Bodø are being built with more and more concrete. As can be seen in the figure below, 94% of the composition of the materials present in the buildings constructed in 2020 was concrete, thus increasing the external dependence on materials, since the majority of sand and gravel has to be imported. When analysing the amount of domestic timber extraction in Bodø, it could be argued that the quantities gained from roundwood removal are sufficient to meet the material needs to construct buildings of mostly wood.

Bodø will experience the most growth over the next two decades in Northern Norway (Bodø Kommune 2014). With the new city - new airport development plan and the intention to reach 70,000 inhabitants by 2030, it will be a major challenge for Bodø if it is to grow in a sustainable and circular way. In order to do so, it can make use of several strategies to achieve a higher degree of circularity in the material stock. First and foremost, it can encourage the reuse and recycling of concrete, for which there is a big source: Based on a 100-year lifespan for buildings in Norway (Sartori et al. 2008), the building material stock (excluding building renovation) in Bodø, referred to as a potential urban mine, contains 158,248 tonnes of concrete.

For wood, the urban mine amounts to about 357,881 tonnes, which can also be reclaimed and recycled. Wood as a bio-based, renewable resource is also available from domestic timber extraction, which in 2020 was 2,023 tonnes. Therefore, it should also be strived to reintegrate locally sourced wood in the construction of new buildings and embrace the traditional vernacular architecture.

Figure 21 - Concrete and wood composition in buildings constructed in 2020 (interactive chart)

Comparison with other case studies

Figure 22 compares the material stock per capita of a number of global cities (Athanassiadis et al. 2017) to the one of Bodø. Compared with other cities, Bodø is situated at the lower end. However, it should be noted that in Bodø's analysis only concrete and wood material intensities were calculated and considered for material stock (per capita), while other cities have broader material scopes. Bodø's concrete and wood material stock accounts for approximately 86.43 t/cap and 3,256.6 t/km2. Additionally, it should be taken into consideration that the results from

different studies also have a number of assumptions and were not carried out during the same year (2008, 2011 Beijing; 2022 Bodø; 2015 Melbourne; 2012, 2015 Brussels; 2003 Geneva; 2013 Paris; 2013 Vienna; 2006 Orléans).

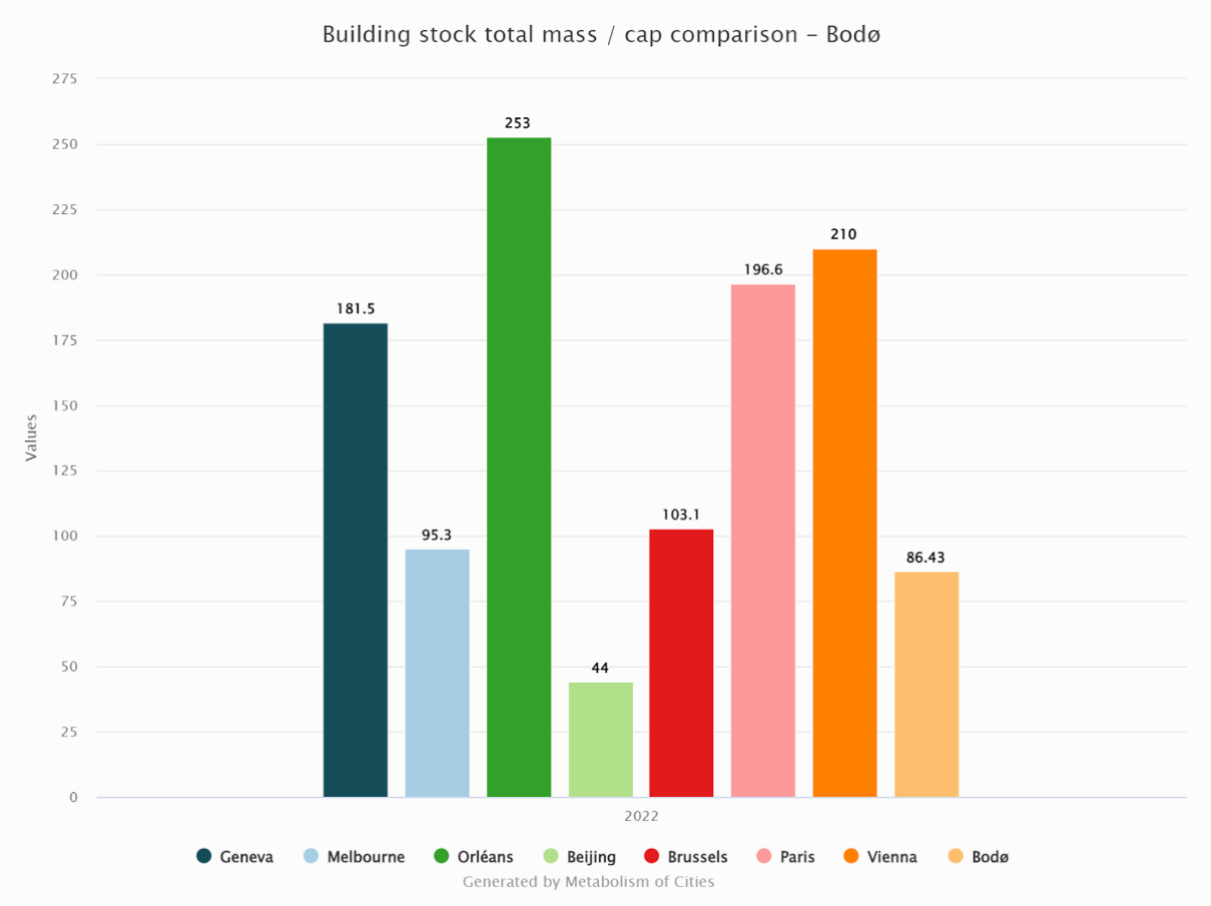


Figure 22 - Material stock in total mass (in tonnes) per capita for major cities and Bodø (interactive chart)

6. Analysis of Flows and Stocks: Measuring Indicators

To monitor the progress of the local economy towards circularity, a number of indicators were proposed and measured. Altogether, these indicators depict several facets of circularity of the sector. As such, they need to be considered in combination rather than in isolation when assessing circularity. In addition, these indicators can be compared to other cities or spatial scales (such as the country level). However, this has to be done with great care and use of the contextual elements in the previous sections of the report. Finally, the value measured from these indicators can be traced over time to track the city's progress towards circularity. The below table provides the value for two reference years, where possible, and the percentage change between the two.

Indicator table

Indicator	2015	2020	Unit	Change from 2015 to 2020(%)
Input Socioeconomic Cycling Rates (ISCr)	4.4%	6.9%	%	55.9%
Output Socioeconomic Cycling Rate (OSCr)	13.8%	16.7%	%	21.0%
Input Ecological Cycling Rate Potential (IECrp)	12.4%	16.4%	%	32.6%
Output Ecological Cycling Rate Potential (OECrp)	45.9%	48.0%	%	4.5%
Input Non-circularity Rate (INCr)	10.2%	9.9%	%	-3.1%
Output Non-circularity Rate (ONCr)	31.6%	23.8%	%	-24.8%
Remaining non-renewable primary resources	73.0%	66.8%	%	-8.5%
Remaining interim outputs	8.7%	11.6%	%	32.6%
Material recovery	26.4%	26.6%	%	0.7%
Direct Material Input (DMI)	502,470.3	486,226.5	tonnes / year	-3.2%
Domestic Processed Output (DPO)	91,578.7	123,908.8	tonnes / year	35.3%
Domestic Material Consumption (DMC)	315,645.4	334,248.6	tonnes / year	5.9%
Domestic Material Consumption Corrected (DMCcorr)	290,157.8	306,310.1	tonnes / year	5.6%
Local and Exported Processed Output (LEPO)	106,674.7	123,908.8	tonnes / year	16.2%
Processed Material (PM)	330,312.4	359,105.5	tonnes / year	8.7%

Interim Outputs (IntOut)	106,245.7	148,765.7	tonnes / year	40.0%
Secondary Material (SM)	14,667.0	24,856.9	tonnes / year	69.5%
Net Addition to Stock (NAS)	224,066.8	210,339.8	tonnes / year	-6.1%
Physical Trade Balance (PTB)	229,751.5	264,643.4	tonnes / year	15.2%

Indicators that were chosen and their development over time

In 2020, 41% of processed materials (PM) (148,765 tonnes) were converted into interim outputs (IntOut), increasing by 40% from 2015. The remaining 59% of the PM were added to in-use stocks of buildings, infrastructure, and durable goods, which in 2020 were **210,340 tonnes as net addition to stock** (NAS). Nearly **26.59% of the total End-of-Life (EoL) waste was recovered in 2020** and used as secondary resources, while in 2015, it was marginally lower at 26.41%. The Output Socioeconomic Cycling Rate (OSCr), which expresses the contribution of secondary materials to IntOut remained relatively low, at only 13.8%, while it had already been increasing by 21% from 2015.

The high significance of fossil energy carriers in the Bodø primary energy supply, flows that cannot be recycled or reused, led to an **Input Non-Circularity rate (INCr) of 9.9%,** a decrease of 3.1% from 2015. Moreover, it resulted in an **Output Non-circularity rate (ONCr) of 23.8%** that grew considerably (24.8%) from 2015. Ecological cycling, although indicated only as theoretical potential, was comparatively high: the Input Ecological Cycling Rate Potential (IECrp), indicating the maximum share of Processed Materials (PM) that qualifies for ecological cycling, was 16.4% in 2020 and had increased substantially by 32.6% from 2015; the Output Ecological Cycling Rate Potential (OECrp) which measures the contribution of Domestic Processed Output (DPO) from biomass in IntOut was even higher, at 48%, and had increased slightly from 2015 a 4.5%.

A slight **increase in Domestic Material Consumption (DMC) of 19,442 tonnes** from 315,645.4 tonnes between 2015 and 2020 was found. The relatively stable flow of secondary materials resulted in a noticeable increase of 55.9% in Input Socioeconomic Cycling Rates, which measures the recycled and downcycled materials reprocessed as secondary material inputs into the domestic economy, reflecting a move towards replacing virgin materials. Of all these recycled materials, 63.7% (15,836 tonnes) are materials from biomass, as can be seen in the chart. For the year 2020 alone, 3,600 tonnes of wood were recovered, indicating a low degree of wood recovery, considering that 12,233 tonnes were incinerated. Furthermore, from the values it can be seen that of the construction materials, only 676 tonnes (2.7%) were recovered. Moreover, from the analysis of material stock, a potential urban mine of 158,248 tonnes of concrete was revealed. Therefore, there is still a great potential for recycling and reuse of these materials. Bodø, as a participant in the CIRCULUS project, is already striving to move in that direction. The project, which commenced in 2019 and runs until 2023, aims to achieve 75% of reuse and recycling of concrete structures and 75% of reduced energy consumption.

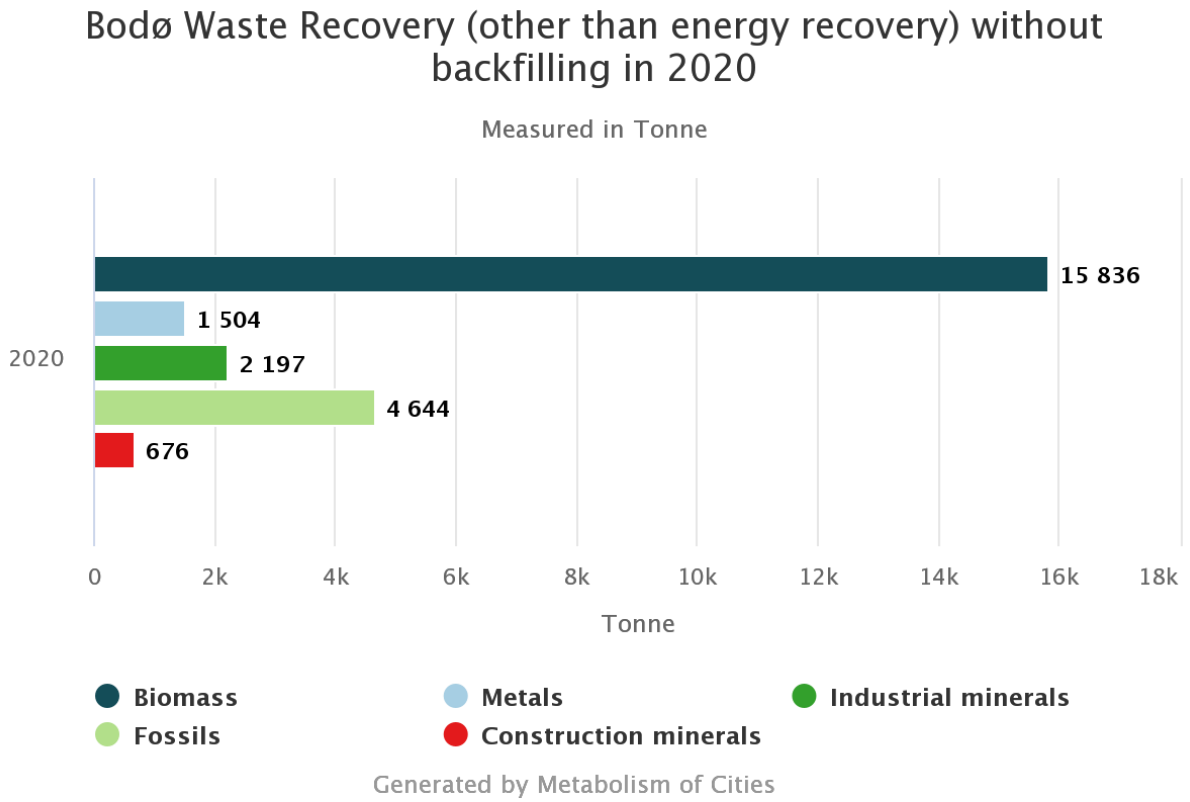


Figure 23 - Waste recovery in Bodø in 2020 (interactive chart)

Of all the indicators proposed for the UCA method, the DMCcorr and LEPO were not calculated due to the low quality of the waste imports and exports data, which would make the indicators unreliable, while the material productivity and material intensity indicators could not be determined due to the absence of GDP data at the municipal level.

7. Data Quality Assessment

Numerous datasets were collected and considered in the Urban Circularity Assessment and this section qualitatively assesses how reliable the data used is. In some cases, datasets were not available for some materials or for some lifecycle stages for the city. Therefore, estimations needed to be done by looking at data at higher spatial scales (region or country) and downscaling it with proxies, described in the part on data gaps and assumptions.

The overall data quality is considered as well and depicted in the data quality matrix below. It is expressed through four data quality dimensions: reliability, completeness, temporal correlation, and spatial correlation. Each dimension has its own criteria for the ranking of high (green), medium (yellow) and low (red), which is based on this Pedigree report and shown in the table here. There may be additional explanations in some cells, as supporting information.

Rating	Reliability	Completeness	Temporal correlation	Spatial correlation
high	Reviewed or measured data	Data exists for all of the single sub-material groups and/or materials	1 data less than 3 years difference to the time period of the data set	City-level data
medium	Estimated data	Data exists for most of the single sub-material groups and/or materials	2 data less than 6 years difference to the time period of the data set	Regional-level data (NUTS 3)
low	Provisional data	Data exists for the main material group only	3 data less than 10 years difference to the time period of the data set	NUTS 2 and country-level data

Data quality matrix

Lifecycle stage	Reliability	Completeness	Temporal correlation	Spatial correlation
Domestic extraction				
MF1 - Biomass	Municipal and SSB data.	All materials are known.		
MF3 - Non-metallic minerals	From the local companies.	All materials are known.	Data only for 2020.	
Imports & Exports				
MF1 - Biomass	Downscaled data.			National data.
MF2 - Metal ores (gross ores)	Downscaled data.			National data.
MF3 - Non-metallic minerals			Data only for 2020.	
MF4 - Fossil energy materials/carriers			2020 and 2016.	
MF5 - Other products	Downscaled data.			National data.
MF6 - Waste for final treatment and disposal				

Waste	From the local waste companies.			
Material stock				

7.1. Data Quality

The data gathered for this report is a combination of public, company, and municipal data. Most of the data has been modelled and/or downscaled from higher spatial scales and therefore the accuracy is somewhat compromised.

As can be seen in the data quality matrix above, the overall quality of the data is medium to good for most lifecycle stages (LCS) and material groups:

- The reliability of the data is acceptable, since much from it comes from municipal sources. The data were gathered and measured with a bottom-up approach using resources from the municipality and Statistics Norway for domestic extraction. Waste data was collected from the companies directly and building material stock was calculated using relevant resources. Imports & exports were partially estimated or provisional.
- The completeness of the data scores are fairly medium for imports & exports, while again domestic extraction, waste, and material stock score high and are as complete as possible.
- The temporal correlation is very good for all lifecycle stages, as the data was almost always from the reference years (2015 and 2020). The employee data for Bodø was used for 2016 and 2020, since 2015 data did not have detailed breakdown of industries for employees. Additionally, the building stock data included up until 2022 and data gathered from companies mostly included 2020 information, except for the waste companies that provided data for 2017 and 2021.
- The spatial correlation overall is medium. Domestic extraction, waste and the material stock data on building is excellent (although national material intensity data were used). However, it does suffer for imports & exports where mostly national data was employed.

7.2. Data Gaps and Assumptions

Domestic Extraction

To determine whether materials were extracted locally, several sources were considered. First, a top down approach was followed, considering the Economy-Wide Material Flow Analysis data from Eurostat for Norway over the last 10 years. It was determined if the materials had been extracted over the last 10 years nationally and if this was not the case, they were excluded from analysis for Bodø too.

Based on insights from the first step, a bottom-up approach was followed, where the information from staff at the municipality was considered as the main source to identify if these materials do exist at the city level. According to them, Bodø does not extract metal ores or fossil fuels. Non-metallic minerals are extracted in the form of salt and sand & gravel (for concrete and asphalt). The data for the latter were received from Nordasfalt and Nordland Betong, the respective extracting and producing companies that provided the information for 2020 and estimated that it is the same for 2015.

To measure biomass domestic extraction of crops in Bodø, SSB and municipality data were used:

- Roots, tubers, fodder crops, wild fish catch and other aquatic animals and plants information were obtained from the municipality for 2020. They stated that there are some small variations from year to year, but over time all the data has been quite stable, so that similar amounts for 2015 as 2020 should be acceptable.
- Statistical data from SSB had the agricultural area of crops at the city level. To calculate the tonnage, yields of various crops data from SSB for the respective years were multiplied with arable land area values.
- For MF 13 Wood, commercial removals of industrial roundwood and fuelwood removals (roundwood), by wood-group datasets were used from SSB. To calculate the weight, wood densities of various species were employed by multiplying with the removed volume (m3).
- The most common animals were researched to calculate hunting and gathering activities. Based on the SSB information, the types and quantities of moose and calf were determined. Estimated carcass weights were calculated from SSB (Statistik sentrabyra - Statistics Norway 2022e) and academic papers (Aitken et al. 2012), taking into account the age and sex of the animals.

Imports & Exports

To the report authors' knowledge, imports and exports data at the city level does not exist. Eurostat provides national data for Imports & Exports, which were downscaled using employment by Industries and matching classes with relevant material codes. This method of downscaling imports and exports from national level using economic activities is a normal practice in similar assessments.

In this case, values were estimated from provisional data by downscaling imports and exports using employee information with detailed NACE classification from SSB (Statistics Norway) at national and city level to calculate the proxy ratio to be used for specific MF codes. To do so, first NACE codes were matched to CPA, and CPA to MF since the correspondence from NACE to MF does not exist. After matching MF values by adding up the respective NACE classes that related with MF classification, the final proxy ratios to be used to downscale national values were calculated. Although there were four-digit NACE codes available, some employees could belong to different MF classes at the same time. Consequently, this method includes double

counting in the matching process between NACE, CPA, and MF, leading to some employees being counted multiple times in some instances. While not desirable, it was necessary to do so in order to match with the Mayer et al. framework that requires more detail than the MF 1-digit level information. The results were driven using this methodology.

In total, ten downscaled values were obtained with national and local employee data from 2020K4 and 2016K4 (K4, being the final quarter of the year), because 2015 was not available. There were some downscaled values that proved problematic, because they produced a negative DMC. This means that the sum of domestically extracted and imported materials are less than the exported materials. This is unlikely, unless there is some stock in the area, which means that materials have been previously stored in a previous year. To avoid this, which would be reflected in the indicators too, and to remove uncertainty since the exact quantity was unknown, the values were reduced to zero and marked as “unknown”, even though there probably is export of these materials. This practice was done for:

- MF13 - Wood that had a downscaled value of 5,433 tonnes (2020).
- MF16 - Products mainly from biomass: 16,588 tonnes imported and 21,118 tonnes exported in 2020. Since Bodø extracts so little biomass, it is unlikely that the exported amount is so high. In fact, this amount is triple the mass of extracted fish, which is the largest extracted biomass item.
- MF43 - Products mainly from fossil energy products had a downscaled amount of 10,178 tonnes for export. While the amount reflects the Norwegian economy, which is dominated by fossil fuels, this is unlikely for Bodø as there is neither local extraction of these materials, nor an industry of fossil fuels processing.

Finally, the values for MF23 - Products mainly from metals did not produce a negative DMC, but were still questioned because they seemed unlikely, because there is no DE of metals. However, since the imported amount of metals is unknown or not validated either, it cannot be excluded that metals products were exported.

This shows that data from local production companies on imports and exports are necessary to obtain results accurately at the city level. For example, MF42 - Liquid and gaseous energy materials/carriers had a downscaled amount of zero tonnes, but could be replaced with bottom up data from the oil and gas company ST1 that is responsible for the import of 99% of the fuels (MF423 - Fuels bunkered) in Bodø through the ST1 Norge Depot Vestervika. Other examples are that of local data on the fish and aquaculture industry exported goods, amounts of imported non-metallic minerals for asphalt & concrete and their exports, as well as the estimate of waste in- and outflows that aided in making the data and therefore the results more accurate and useful.

The results of this downscaling still provide some surprising results, as it implies that a very small quantity of MF3 - Non-metallic minerals are imported and few are extracted. This is highly unrealistic as construction flows often account for 1/4 to 1/3 of the flows entering an economy) and a more detailed analysis on the construction sector should be carried out separately.

A final way to estimate imports and exports would have been to estimate the consumption and production levels of Bodø and their associated imports and exports flows. It is important to note that household expenditure datasets do not include the breakdown of consumables (e.g. food), but rather a general overview of household expenditures. In such a case, only the general groups of materials (MF1 digit information) is accounted for, making it incompatible with Mayer et al. framework which requires more detail. Moreover, despite being the most accurate method, measuring production and consumption patterns was not possible due to time constraints.

Domestic Material Consumption

As DMC is a measured indicator (DMC = DE+IMP-EXP) no extra assumptions were made, neither data collected to calculate this indicator. However, it inherits all assumptions and uncertainties from the two previous sections.

Waste

After reviewing the main possible sources, information from the municipality and data from the two local leading waste collection and treatment companies, Iris Salten and Østbø, were obtained. Iris Salten provided the exact amounts of waste that they are receiving at their facility (including waste that originates from other municipalities than Bodø) for 2017 and 2021. In their system they would need to consider each customer's location to determine the origin of waste, a task that was too time consuming at the point of enquiry, but one that would ensure certainty around the amounts from the municipality. An estimate of imported waste of the largest waste stream was also provided. Older data than 2017 was not accessible to the person from Iris providing the data, but could be retrieved in the future. They also assigned the waste to their treatments which they distinguish between landfilling, energy recycling, material recycling and reuse.

Østbø provided an approximate proportion of 65% of their waste in Bodø and did so for 2017 and 2021 as well. In addition, data on their exported metal and tire waste was found in an article.

Between both companies, most of the types of waste materials were covered, including chemical waste, medical waste, recyclable waste, equipment waste, animal and vegetal waste, municipal solid waste (including household and similar waste), sludge, as well as mineral and solidified wastes. However, it cannot be certain if all sources are included. While Iris handles all of the household and some company waste, Østbø deals with commercial waste. Therefore, it is not certain which share of the companies are covered, nor what the quantities of industrial waste are.

Material Stock

For the calculation of Bodø's material stock, data from two national databases, National Cadastre and National Building Map Database, including information on building typologies, gross floor area, year of construction, number of dwellings and number of floors.

Initially, there were 69,907 observations, of which many appeared to be duplicated observations. After processing the data, 27,724 duplicated observations were identified and removed. In addition, after analysing the buildings' years of construction, it was observed that 3,997 buildings had a year of construction equal to 0 or 1, which were also removed resulting in 23,727 observations.

To calculate the heights of buildings, the "antalletas" field of the provided dataset was used, which is equivalent to the number of floors. However, it was only available for 5,859 observations. For a correct calculation of the heights and consequent definition of the typologies, heights were calculated by dividing gross floor area by floor area and multiplying by the average height of ceilings, which is 3 m. With the previously existing field, 'antalletas', the assumption was validated. The extreme values were corrected, and the heights were validated by photo interpretation with Google Street View photos for the extreme values in 30 randomly selected buildings. Out of these 30 buildings, 7 buildings had to be corrected and the rest validated the authors' assumption. Finally, after eliminating buildings with a gross floor area of zero, a total of 23,545 buildings remained to be analysed.

In parallel to the cadastral information used to develop building typologies, the material intensities developed by Bergsdal et al. (Bergsdal et al. 2007) were used to calculate Bodø's material stock. This paper provides material intensities for five housing typologies (Single, Row House, Apartment, High rise, Commercial and Other) for 9 age cohorts ranging from before 1900 to 2001. The material intensities are provided only for concrete and wood in (kg/m2). After studying the material intensities per age cohorts, it appears they follow a linear trend i.e. the use of concrete increased linearly over time and, in turn, the use of wood has decreased linearly over time. As material intensities are missing for recent years a linear regression was used using past information.

To link the typologies of our building dataset with the one provided with material intensities studies, a limited set of typologies and sub-typologies were defined. For the design of the typologies for which the stock would be assessed (Residential, Commercial and Other) the categories already present in the cadastral dataset were used.

The sub-typologies were defined through their construction attributes. In addition to the heights calculated previously, a "touch" field was created that shows if the buildings (geometries) are adjacent or "touching" each other.

Once the gross floor area, years of construction and typologies were obtained, the material building stock of concrete and wood was calculated by multiplying the corresponding material intensity for each typology and age cohort with the gross floor area of each building. The data are of good quality. However, it should be noted that material intensities were only available for concrete and wood and that the intensities are not recent and had to be projected. In addition, the heights had to be estimated. Given the cadastral information available, it would be highly recommended to define the material intensities of some buildings of Bodø in order to construct a robust dataset which could be used for material matchmaking purposes.

8. Analysis of Data and Indicators: Assessing Circularity

This last section of the UCA report analyses the status quo in terms of material circularity in Bodø. It takes into account the findings visualised in the (Sankey) diagrams and the conclusions from the indicators. The overall results of the Urban Circularity Assessment are discussed and interpreted here, before providing recommendations to accelerate the transition towards a more circular Bodø.

8.1. Insights on Status Quo of Bodø

After assessing the circularity of Bodø, it becomes clear that the city is an open system that throughputs materials, but does not cover its needs, nor reuses sufficiently the materials that it outputs. As most European cities, the import flows far exceed the domestic extraction. In addition, most of the local extraction and production are exported to satisfy consumption from other territories.

Almost 1/3 of the materials processed locally are used for energetic uses whereas the other 2/3 are used for material uses (most of them employed for the urban development and new constructions of buildings). Energetic use is responsible for the vast majority of emissions, which in comparison to imports and exports flows “weigh” less, but are responsible for other related challenges such as climate change.

It is also clear that a very small quantity of waste generated is following a circular economy practice (reuse, recycling, etc.). This quantity represents an even smaller share (8%) of the processed materials.

As such Bodø is clearly a linear and carbon-intense city (90% linear) processing yearly approximately 360 kt, adding 211 kt in the building stock and reinjecting just 20 kt of materials in their economy. From these numbers, the magnitude of the efforts becomes visible. In addition, the “weight” of Bodø can be illustrated through its building stock which amounts to 4,500 kt (or 86 t per capita) which requires continuous flows for both its operation and construction. The study of Bodø’s material stock provides valuable insights about how to reduce the extraction of virgin materials, reduce waste flows going to landfill and increase the reuse and recycling of construction materials. Knowing where and when materials entered Bodø’s urban mine, enables to forecast output flows and where they will emerge. In addition, the insights from measuring the material stock could not only propose circular strategies in the construction sector, but propose where to locate reuse hubs, develop a materials marketplace

and estimate jobs creation (in material handling, logistics, etc.). This would be particularly relevant given the important urban development expected in the next years.

The results provide a unique first insight about the materiality of Bodø's economy. Nevertheless, it also highlights how scarce the knowledge and data about such topics are. When collaborating with the city of Bodø, it becomes very clear how information and datasets are siloed, confidential and sometimes absent. This new type of systemic exercise required to pull together information from national, local and company level. It showcases the difficulty of understanding how cities function in physical, economic and employment terms and therefore how difficult it is to produce systemic policies.

From this first exercise, numerous data sources were scrutinised, analysed and processed to carry out the presented analyses. Admittedly, the data required to carry out this analysis were frequently missing at Bodø's scale, although they could be estimated either through sources from individual companies or they existed at higher spatial levels. This implied that numerous assumptions and calculations needed to be carried out, in order to downscale data at a city level. This compromised the quality of the results, but still provides a solid basis for understanding, using an accounting method that has been validated and used at a national and European context. In the future, further validations by comparing values with other Norwegian cities and the Norwegian economy could be carried out. Further recommendations about how to use the results of this study and how to improve it can be found in the next section.

8.2. Recommendations for Making Bodø More Circular

Several opportunities to make Bodø more circular appeared through the UCA:

- **Develop a bioeconomy**: Given the land use of Bodø as well as the fishing activities happening locally, this provides a considerable opportunity to develop a circular bioeconomy. For instance, a significant share of GHG emissions associated with food consumption of Bodø could be reduced by covering animal proteins with local production of food (especially protein coming from fish). Fish waste could be used for fertilisers or for creating new products.
- **Create reuse opportunities**: Given the space available in Bodø and the demand for new construction materials needed for the future urban development, local hubs for storing materials for reuse from the construction sector could significantly reduce the use of virgin materials as well as reduce construction and demolition waste generation. In line with this, attention should be paid to a good source separation of concrete so as not to contaminate it, as is happening currently, requiring it to be landfilled instead of using it for backfilling or reuse. In addition, local materials (rammed earth, biomass insulation, timber, etc.) could be used to drastically reduce the amount of concrete (which is carbon intensive) for future urban developments. Moreover, the production of

local and low carbon construction materials, could develop new jobs and attract the development of new production activities. Ideally, Bodø should also better regulate new constructions by filling existing vacant buildings instead of constructing new ones. Vacant buildings could also host new productive activities which could use small waste flows (coffee waste, bread waste, composting, etc.) and transform them locally for its inhabitants.

- **Support collaboration**: Bodø could play an active role in all these new actions by developing a circularity roadmap. This could be carried out by elaborating further the actions presented and identifying the stakeholders responsible for implementing these actions as well as budgeting the efforts and money required. By collaborating more closely with extraction, production and waste management companies, it would be possible to also refine the data necessary to assess and monitor the circularity of Bodø. To do so, a number of online tools could be used (or developed). For instance, a circularity roadmap manager which lists the circularity actions to be developed and tracks their progress, a forum and a map showcasing where they take place. Another tool which could be used is a material/space/equipment matchmaking tool such as PlatformU.
- **Collect better data to monitor the situation**: The current analysis provides a first baseline of Bodø's circular assessment. It provides insights about how to make the city more circular. However, it also highlights how important data collection of material flows is essential to propose actions. This exercise showcases where future efforts should be placed to make the analysis more relevant as well as develop internal capacity. More specifically, here are some proposals to enhance the quality of the assessment for future iterations.
    - For imports & exports, it is essential to get more granular and qualitative information of the flows by looking at production flows (a local survey with the productive activities could be a good start) and consumption flows (a local survey with consumption patterns of households and other segments of the population). Getting reports on actual imports and exports from the industry, should also be aspired to. For example, it was insightful to work with the fuel data obtained from ST1. Natural gas (LNG) used for LNG ferries and industry is another important fossil fuel in Bodø, one that is delivered by multiple companies, therefore making it more difficult to collect. Yet, the municipality could attempt to request such data from the industry or a representative organisation.
    - For waste, more detailed information on their treatment (landfill, incineration, energy recovery, recycling, and backfilling) and waste categories (chemical and medical wastes, recyclable wastes, equipment, biomass, mixed, mineral, and metallic wastes) would be needed to get a sense of the circularity practices and how to improve them. As mentioned in the data quality part, only household waste and some commercial waste could be included. This significantly

underestimates the total amounts, misrepresents the situation and fails to unravel opportunities for circular economy activities, since the potential of waste streams remains unknown. A better characterisation of commercial and industrial waste should be done using confidential data internally or through the waste companies.

References

Aitken, Dan, Kenneth Child, Roy Rea, and Olav Hjeljord. 2012. 'Age, Sex and Seasonal Differences of Carcass Weights of Moose from the Central Interior of British Columbia: A Comparative Analysis'. *Alces* 48 (January): 105–42.

Athanassiadis, Aristide, Vincent Augiseau, Fritz Kleemann, André Stephan, and Sabine Barles. 2017. 'Comparing the Material Stock of Seven Cities: Brussels, Melbourne, Paris, Vienna, Geneva, Orleans and Beijing'. In *Proceedings of ISIE 2017*. Chicago, USA. https://www.researchgate.net/publication/325381212_Comparing_the_material_stock_of_seven_cities.

Beaudoin, Mercedes, and Andrea Marthinsen. 2017. 'PLAN Magazine #5: Bodø, Norway - New Airport, New Smart City by ISOCARP | UPAT World Projects'. https://issuu.com/upatworldisocarp/docs/plan_bodo_final_small.

Bergsdal, Håvard, Helge Brattebø, Rolf A. Bohne, and Daniel B. Müller. 2007. 'Dynamic Material Flow Analysis for Norway's Dwelling Stock'. *Building Research & Information* 35 (5): 557–70. https://doi.org/10.1080/09613210701287588.

Bodø Energi. n.d. 'Besøk Fra Saltvern Ungdomsskole Og Glimt På Bioanlegget Keiseren'. Accessed 17 November 2022. https://bodoenergi.no/a/blogg/besoek-fra-saltvern-skole-og-glimt.

Bodø Kommune. 2014. 'Kommuneplan 2014 - 2026: Strategisk Samfunnsdel Bodø 2030'. Bodø: Bodø kommune. https://salten.no/sites/s/salten.no/files/srsak_3417__vedlegg_kommuneplan_bodoe_kommune.pdf.

Bokisk. 2022. 'Bofisk – Din lokale fiskebutikk i Bodø!' BOFISK. 2022. https://www.bofisk.no/.

BRUS - Bodøregionens Utviklingsselskap. n.d. 'Aksjonær Nordfisk'. Accessed 24 November 2022. https://www.bodoregion.no/aksjonaerer-og-samarbeidspartnere-i-brus/aksjonaer-i-brus-nordfisk/.

Bullvåg, Erlend, Sunniva Greger, Carl Erik Nyvold, Sissel Ovesen, Marit Kristin Kvarum, Signe Kilskar, Andreas S. Knutson, and Synnva Eide Etterlid. 2022a. 'Indeks Nordland'. 19. https://indeksnordland.no/wp-content/uploads/2022/03/IndeksNordland2022.pdf.

———. 2022b. 'Indeks Nordland'. 19. https://indeksnordland.no/wp-content/uploads/2022/03/IndeksNordland2022.pdf.

Centre for the Ocean and the Arctic. 2019. 'Sustainable Blue Economy in the Norwegian Arctic'. Centre for the Ocean and the Arctic. https://www.havarktis.no/img/Sustainable-Blue-Economy-in-the-Norwegian-Arctic-Part-1-Status_FINAL.pdf.

Consto. 2022. 'Consto | Consto Anlegg Nord AS'. Consto. 2022. https://consto.no/selskaper/consto-anlegg-nord-as/.

Dahl Fiskeri. 2022. 'Vi Bringer Fisk Til Det Globale Matfatet - Dahl Fiskeri AS - Dahl Fiskeri AS - Vi Bringer Fisk Til Det Globale Matfatet'. 2022. https://www.dahlfiskeri.no/.

Fish Choice. 2020. 'Polar Quality AS'. FishChoice. 2020. https://fishchoice.com/business/polar-quality.

Fram Seafood. 2022a. 'Fram Seafood'. 2022. http://www.framseafood.no/.

———. 2022b. 'Locations - Fram Seafood'. 2022. http://www.framseafood.no/locations.

Frost Kraftentreprenør AS. 2022. 'Frost Kraftentreprenør AS'. 2022. https://www.frostkraft.no/?ac_id=1&ac_parent=1&ao_name=forside.

Gigante Salmon. 2022. 'Gigante Salmon -Landbasert Lakseoppdrett'. 2022. https://gigantesalmon.no/.

Gulliksen Tømmerbakke, Siri. 2019. 'The Town of Bodø Could Be the First Artic European Capital of Culture'. *High North News*, 19 September 2019. https://www.highnorthnews.com/en/town-bodo-could-be-first-arctic-european-capital-culture.
Gunvald Johansen. 2022. 'Nytt fra Gunvald Johansen'. gjintranett.no. 2022. https://gj.no/hjem.
K. Eliassen og Trine Bernhoft, Mallika. 2017. 'Bedriftsetablering: Hvilke Faktorer i Organisasjonen Og Miljøet Rundt Gjør at Bedriften Overlever?' Bodø: Nord Universitet. file:///C:/Users/tiffa/Desktop/EliassenogBernhoft.pdf.
Kittang, Dag. 2016. 'Vernetanken i Byplandiskursen'. *Heimen* 2 (July): 135–47. https://doi.org/10.18261/issn.1894-3195-2016-02-03.
Landbruksdirektoratet. 2021. 'PT-900 Antallstatistikk'. 2021. https://ldir.statistikkdata.no/pt-900_del2_2020_kommuner.html.
Middleton, Alexandra, Anders Hersinger, Andrey Byksenkov, Andrey Mineev, Bjørn Gunnarsson, Elena Dybtsyna, Erlend Bullvåg, Jaako Simonen, and Ossi Pesämaa. 2018. 'Business Index North'. 2. https://businessindexnorth.com/sites/b/businessindexnorth.com/files/0417_bin_long_version_hq_web.pdf.
Moe, Dagfinn. 2003. 'Landscape History and Heathland Development over the Last 4000 Years in the Bodø Area, Northern Norway'. *Norsk Geografisk Tidsskrift - Norwegian Journal of Geography* 57 (4): 194–204. https://doi.org/10.1080/00291950310003070.
Nikel, David. 2022. 'Norway's Bodø Named A European Capital Of Culture For 2024'. *Forbes*, 25 September 2022. https://www.forbes.com/sites/davidnikel/2019/09/25/bod-norways-european-capital-of-culture-for-2024/?sh=14116293caa7.
Nordasfalt. 2022. 'Nordasfalt'. 2022. https://nordasfalt.no/.
Nordland Betong. 2022. 'Nordland Betong | Vi Løser Det!' 2022. https://nordlandbetong.no/.
Nu Publishing. 2021a. 'Bodøs 300 Største Selskaper'. 2021. https://issuu.com/bodonu6/docs/300_st_rste_selskaper_1s_0f390a39a8bfda.
———. 2021b. 'ØSTBØ'. Issuu. 2021. https://issuu.com/bodonu6/docs/bod_s_300_st_rste_selskaper_1s/s/11371253.
Østerdal, Hanne, Liv Bente Kristoffersen, Erlend Bullvåg, Cathrine Stavnes, Svenn Are Jenssen, Daniel Bjarmann-Simonsen, and Monica Ahyee. 2020. 'Indeks Nordland'. 17. https://salten.no/sites/s/salten.no/files/srsak_0220__vedlegg__indeksnordland2020.pdf.
Ottesen, Oddvar, Jón Árnason, Birgir Örn Smárason, Nonna Zhuravleva, and Rannveig Björnsdóttir. 2016. 'Values from Waste/ Hliðarafurðir í Verðmæti'. 15–16. Skýrsluágrip Matís ohf - Iceland Food and Biotech R&D. https://www.matis.is/media/matis/utgafa/15-16-Values-from-waste.pdf.
Pelagia. 2022. 'Pelagia Bodø Sildoljefabrikk | Pelagia'. 2022. https://pelagia.com/cm/facilities/pelagia-bodo-sildoljefabrikk/.
Pelagia AS. 2021. 'We Support the Sustainable Development Goals'. 2021. https://pelagia.com/cm/esg/.
Polar Quality. 2022. 'Polar Quality | Fresh, Quality Seafood, Straight from the Polar Seas.' Polar Quality. 2022. https://www.polarquality.no/.
Polarfeed. 2022. 'Polarfeed | Fôr På Fiskens Premisser'. 2022. https://www.polarfeed.no.
Proff. 2021a. 'Andreassens Rederi AS'. 2021. https://www.proff.no/selskap/andreassens-rederi-as/bod%C3%B8/fiske/IF8FCKP0COV/.
———. 2021b. 'Bofisk AS'. 2021. https://www.proff.no/selskap/bofisk-as/bod%C3%B8/n%C3%A6rings-og-nytelsesmidler-agentur-og-engros/IG9XFC610JV-1/.
———. 2021c. 'Consto Anlegg Nord AS'. 2021. https://www.proff.no/selskap/consto-anlegg-nord-as/bod%C3%B8/bygg-og-anleggsleverand%C3%B8rer/IF65KET0CVG/.

———. 2021d. ‘Dahl Fiskeri AS’. 2021. https://www.proff.no/selskap/dahl-fiskeri-as/bod%C3%B8/fiske/IEJVJFO0COV/.
———. 2021e. ‘Fram Seafood AS’. 2021. https://www.proff.no/selskap/fram-seafood-as/bod%C3%B8/n%C3%A6rings-og-nytelsesmidler-agentur-og-engros/IDKGSUA10JV/.
———. 2021f. ‘Frost Kraftentreprenør AS’. 2021. https://www.proff.no/selskap/frost-kraftentrepren%C3%B8r-as/bod%C3%B8/bygg-og-anleggsleverand%C3%B8rer/IGIJDOC0CVG/.
———. 2021g. ‘Gigante Havbruk AS’. 2021. https://www.proff.no/selskap/gigante-havbruk-as/bod%C3%B8/akvakultur/IFVV4KQ000M/.
———. 2021h. ‘Green Environmental Products AS’. 2021. https://www.proff.no/selskap/green-environmental-products-as/bod%C3%B8/avfall-og-skrap-engros/IGHH6IM10LW/.
———. 2021i. ‘Gunvald Johansen Bygg AS’. 2021. https://www.proff.no/selskap/gunvald-johansen-bygg-as/bod%C3%B8/bygg-og-anleggsleverand%C3%B8rer/IGBZNEN0CVG/.
———. 2021j. ‘Haftor AS’. 2021. https://www.proff.no/selskap/haftor-as/bod%C3%B8/renovasjon/IFBFGR001DV/.
———. 2021k. ‘Helligvær Brøyteservice AS’. 2021. https://www.proff.no/selskap/helligv%C3%A6r-br%C3%B8yteservice-as/helligv%C3%A6r/renovasjon/IGDW74901DV/.
———. 2021l. ‘Iris Miljøtorg Vikan’. 2021. https://www.proff.no/selskap/iris-milj%C3%B8torg-vikan/bod%C3%B8/renovasjon/IG9VO7901DV/.
———. 2021m. ‘Iris Produksjon AS’. 2021. https://www.proff.no/selskap/iris-produksjon-as/bod%C3%B8/renovasjon/IGCS89001DV/.
———. 2021n. ‘Iris Service AS’. 2021. https://www.proff.no/selskap/iris-service-as/bod%C3%B8/renovasjon/IG9UY6701DV/.
———. 2021o. ‘Nofir AS’. 2021. https://www.proff.no/selskap/nofir-as/bod%C3%B8/renovasjon/IGF0WWQ01DV/.
———. 2021p. ‘Nordasfalt AS’. 2021. https://www.proff.no/selskap/nordasfalt-as/bod%C3%B8/asfalt-og-asfaltering/IFPWJMW001X/.
———. 2021q. ‘Nordland Betong AS’. 2021. https://www.proff.no/selskap/nordland-betong-as/bod%C3%B8/produsenter/IF4LFX1016D/.
———. 2021r. ‘Nordland Metall AS’. 2021. https://www.proff.no/selskap/nordland-metall-as/bod%C3%B8/renovasjon/IF3EE2D01DV/.
———. 2021s. ‘Norsk Gjenvinning Metall AS Avd Bodø’. 2021. https://www.proff.no/selskap/norsk-gjenvinning-metall-as-avd-bod%C3%B8/bod%C3%B8/avfallsbehandling-og-gjenvinning/IG526CA002C/.
———. 2021t. ‘Pelagia Bodø Sildoljefabrikk’. 2021. https://www.proff.no/selskap/pelagia-bod%C3%B8-sildoljefabrikk/bod%C3%B8/produsenter/IG2KOMN016D/.
———. 2021u. ‘Polar Quality AS’. 2021. https://www.proff.no/selskap/polar-quality-as/bod%C3%B8/n%C3%A6rings-og-nytelsesmidler-agentur-og-engros/IGA7O1L10JV/.
———. 2021v. ‘Polarfeed AS Avd Bodø’. 2021. https://www.proff.no/selskap/polarfeed-as-avd-bod%C3%B8/bod%C3%B8/akvakultur/IFBIUOP000M/.
———. 2021w. ‘Retura IRIS AS’. 2021. https://www.proff.no/selskap/retura-iris-as/bod%C3%B8/renovasjon/IG9UY6V01DV/.
———. 2021x. ‘Salten Havbruk AS’. 2021. https://www.proff.no/selskap/salten-havbruk-as/breivik-i-salten/akvakultur/IG922F5000M/.
———. 2021y. ‘Salten Salmon AS’. 2021. https://www.proff.no/selskap/salten-salmon-as/bod%C3%B8/produsenter/IF7UQMI016D/.

———. 2021z. ‘Segmenteringsverktøy - Bygg’. 2021. https://www.proff.no/laglister?i=p16684&i=p296&l=Bod%C3%B8&samplerFilter=true.
———. 2022a. ‘Nyetableringer’. 2022. https://www.proff.no/nyetableringer?fromDate=01.01.2015&industryCode=&location=Bod%C3%B8&+locationId=1804&toDate=31.12.2015&industry=&locationId=1804.
———. 2022b. ‘Østbø AS’. 2022. https://www.proff.no/selskap/%C3%B8stb%C3%B8-as/bod%C3%B8/avfallsbehandling-og-gjenvinning/IF81ORO002C/.
———. 2022c. ‘Segmentering- Jordbruk, Skogbruk Og Fiske’. 2022. https://www.proff.no/laglister?i=A&i=p22&i=p47433&i=p47434&l=Bod%C3%B8&samplerFilter=true.
Salten Aqua. 2022a. ‘Produkt’. 2022. https://www.saltenaqua.no/produkt.
———. 2022b. ‘Salten Aqua-Gruppen’. 2022. https://www.saltenaqua.no/om-oss.
Sartori, Igor, Håvard Bergsdal, Daniel B. Müller, and Helge Brattebø. 2008. ‘Towards Modelling of Construction, Renovation and Demolition Activities: Norway’s Dwelling Stock, 1900–2100’. *Building Research & Information* 36 (5): 412–25. https://doi.org/10.1080/09613210802184312.
Statistik sentrabyra - Statistics Norway. 2022a. ‘01222: Population and Changes during the Quarter (M) 1997K4 - 2022K2’. 2022. https://www.ssb.no/en/statbank/table/01222.
———. 2022b. ‘06913: Changes in Municipalities, Counties and the Entire Country’s Population (K) 1951 - 2022’. 2022. https://www.ssb.no/statbank/table/06913/.
———. 2022c. ‘08536: Employed Persons (Aged 15-74), by Industry Division (88 Groups, SIC2007) and Sex. 4th Quarter (M) 2008 - 2021’. 2022. https://www.ssb.no/en/statbank/table/08536.
———. 2022d. ‘10206: Area of Agricultural Properties, by Area Classification (M) 2015 - 2021-PX-Web SSB’. SSB. 2022. https://www.ssb.no/en/system/.
———. 2022e. ‘10817: Estimated Carcass Weight for Moose, by Age and Sex (C) 1998-1999 - 2021-2022-PX-Web SSB’. SSB. 2022. https://www.ssb.no/en/system/.
———. 2022f. ‘12241: Household Waste. Key Figures (M) 2015 - 2021-PX-Web SSB’. SSB. 2022. https://www.ssb.no/en/system/.
———. 2022g. ‘13164: Employees, by Place of Work, Sector and Industry Division (5-Digit Level, SIC2007) (M) 2016K1 - 2022K2’. 2022. https://www.ssb.no/en/statbank/table/13164.
———. 2022h. ‘Enterprises’. SSB. 2022. https://www.ssb.no/en/virksomheter-foretak-og-regnskap/virksomheter-og-foretak/statistikk/foretak.
———. 2022i. ‘Establishments’. SSB. 2022. https://www.ssb.no/en/virksomheter-foretak-og-regnskap/virksomheter-og-foretak/statistikk/virksomheter.
———. 2022j. ‘Kommune: Bodø (Nordland - Nordlánnda)’. 2022. https://www.ssb.no/kommuneareal/bodo.

- Norway
- Nord-Norge
- Nordland

CITYLOOPS

CityLoops is an EU-funded project focusing on construction and demolition waste (CDW), including soil, and organic waste (OW), where seven European cities are piloting solutions to be more circular.

Høje-Taastrup and Roskilde (Denmark), Mikkeli (Finland), Apeldoorn (the Netherlands), Bodø (Norway), Porto (Portugal) and Seville (Spain) are the seven cities implementing a series of demonstration actions on CDW and soil, and OW, and developing and testing over 30 new tools and processes.

Alongside these, a sector-wide circularity assessment and an urban circularity assessment are to be carried out in each of the cities. The former, to optimise the demonstration activities, whereas the latter to enable cities to effectively integrate circularity into planning and decision making. Another two key aspects of CityLoops are stakeholder engagement and circular procurement.

CityLoops started in October 2019 and will run until September 2023.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No. 821033.