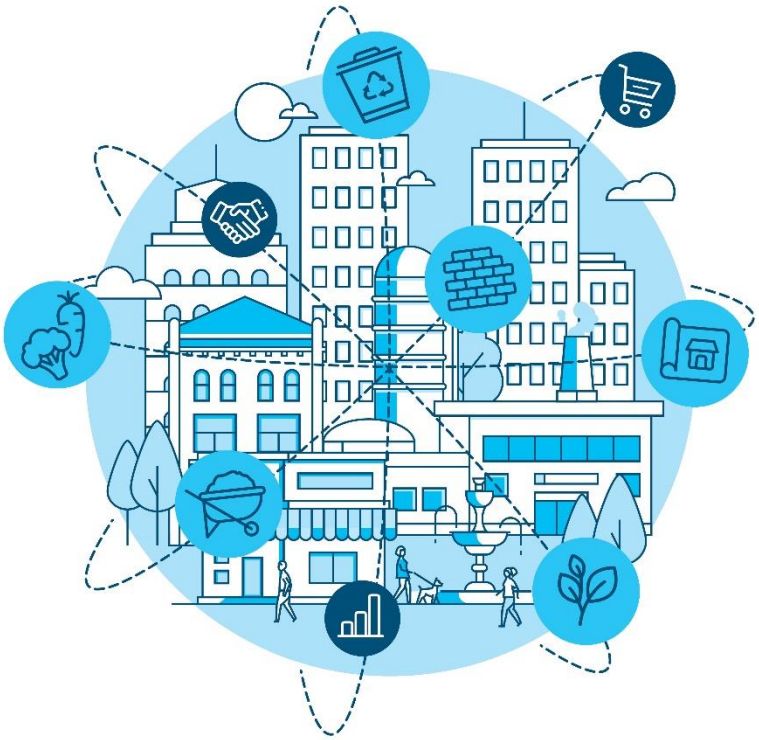
Data and material passport in Bodø

Extract from the Demonstration Report

Bodø, Norway



Contents

This text describes Bodø's experience in gathering and digitalizing data in the Circular material management processes of Bodø military airport and in the planning of the new city district. The sections come from Bodø's CityLoops demonstration report available here.

Summary

Soil and mass management

Soil strategy

Soil and mass management is a significant concern matter in Bodø, due to the limited availability and lengthy transport distances of quality masses, as well as the high volumes of traffic and direct CO2 emissions from mass handling in construction projects. Little is reused today due to lack of systems in public procurements and logistics systems for reuse between projects.

Bodø municipality is working on a mass handling management strategy document and mapping of predicted future masses and mass needs. The CityLoops Instrument for predicting soil production is used to predict soil amounts. The sustainable soil management roadmap is in combination with other Norwegian guidelines used for the mass strategy.

Logistics system

Another Norwegian municipality, Bærum Municipality, has been working to design a logistics tool to connect all stakeholders in mass management. Bodø municipality is in close contact with the project management and discussed testing the system in 2023 for Bodø's internal infrastructure projects.

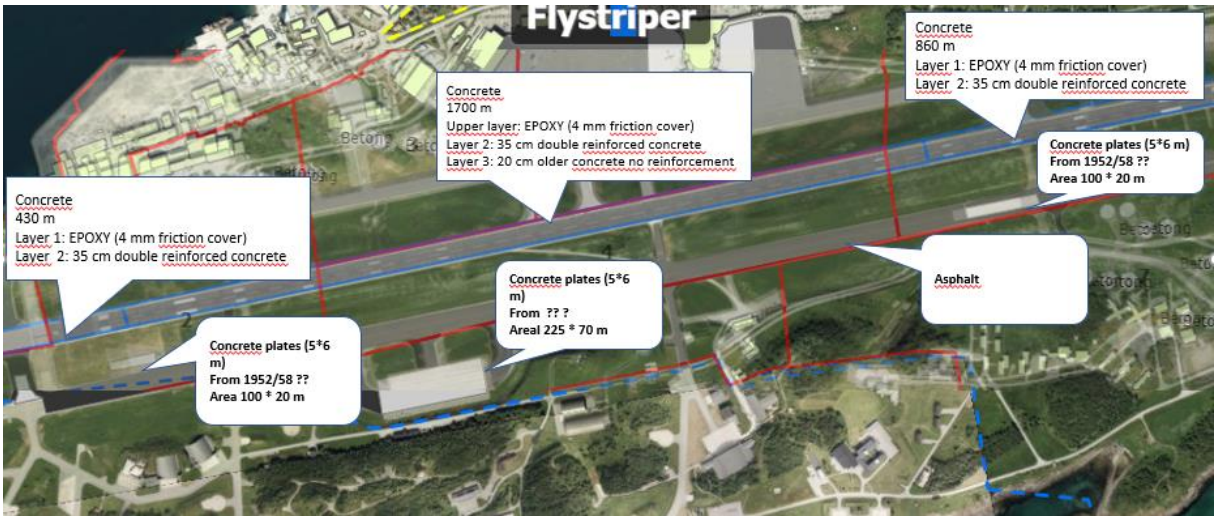
Intermediate storage facility:

- Need for intermediate storage and sorting space for soil and masses to allow their reutilization within and between projects.
- Existence of an area close to Bodø city center that can potentially be used for four to five years before it will be regulated for industrial use (soil is still setting)
- Applied for concession to manage and store masses without heavy contamination (up to Norwegian contamination classification 3)
    - Accepted by municipality and environmental authorities in 2022.
- Included rights to use the storage area in application for road renovation project in city center (Sjøgata). The project will run 2023-2025

- All respondents on the project proposal (Sjøgata) wanted to use the intermediate storage area for improved soil and gravel reuse.

Airport material mapping

- The airport consists of about 4200 concrete plates and 20 shelters.
- Some of the plates may be reused in the new airport, some can be useful for new purposes where they are already located, some can be demolished and reused as elements of other construction projects, and some can be crushed.
- Some of the shelters will be demolished, while some can be repurposed for other uses.
- The consulting company Norconsult was hired to evaluate reuse potential of airport shelters.
- Cooperation with the research project CIRCULUS to evaluate reuse potential of concrete at airport area – testing strength, contamination, and mapping reinforcement.
- Mapping the material amounts, state and potential for demolishing, repurposing, and recycling.
- Evaluation of reuse potential of terminal building of old airport will be done in 2022.



Other reuse mapping

- Bodø municipality has conducted few reuse mappings.
- Ambitions to conduct reuse mapping of all coming demolishing projects.
- In dialogue with CityLoops Mikkeli for testing their demolishing tool
- Barriers such as lack of storage facility and a system for facilitating reuse have been identified.
- A few of the mapped materials have been reused.
- CityLoops helps establish routines for reuse mappings and is working to find a system for a reuse market.

Reuse market

- Evaluating best solution for establishment of reuse material marketplace in Bodø
- A marketplace operated by the municipality is not a good option – due to regulations hindering municipalities from providing competitive advantages. Operating as a subsidized marketplace in competition with material retailers is troublesome.
- The waste company of the Bodø region, Iris Produksjon, is a commercial company (with municipalities as their shareholders) have established a physical marketplace. CityLoops is involved and will help design a system and set up the pilot (if timespan allows).
- Iris is applying for financial support for a three-year project to establish a marketplace for materials.
- During stakeholder communication (workshop by Bodø municipality among others) pilot building projects have been identified for piloting the marketplace
- Iris and Bodø municipality have been in contact with national networks and competence to learn from them and design the establishment process.
- Dialogue with multiple digital platforms to evaluate the best digital options.

- Evaluating possible municipal (and other) locations for setting up a temporary intermediate storage for building materials

Demonstration action: Circular material management processes of Bodø military airport

In the large-scale the demolition project of the military airport presents large amounts of materials and structures needed to be managed. With such large scale and complexity, it's important to have general requirements for selective demolition, establish a central recycling plant and logistics facility to prepare the CDW to be delivered to new constructions and establish a marketplace for reused and recycled materials. The goal of demonstration action one in Bodø is to reduce demolitions and waste as much as possible by renovating and repurposing buildings, integrating circular thinking into procurement and embed circular and sustainable practice in the demolishing strategy in the New Airport / New City project.

The illustration below shows an overview of the city today, the planned city after relocation of airport and construction of the new city district and a description of the plans. Bodø Municipality will be the owner of the land, structures, soil, and other resources that are freed in the process. CityLoops in Bodø is developing, testing, and implementing tools and methods that support the objective of achieving this in the most circular and sustainable manner.

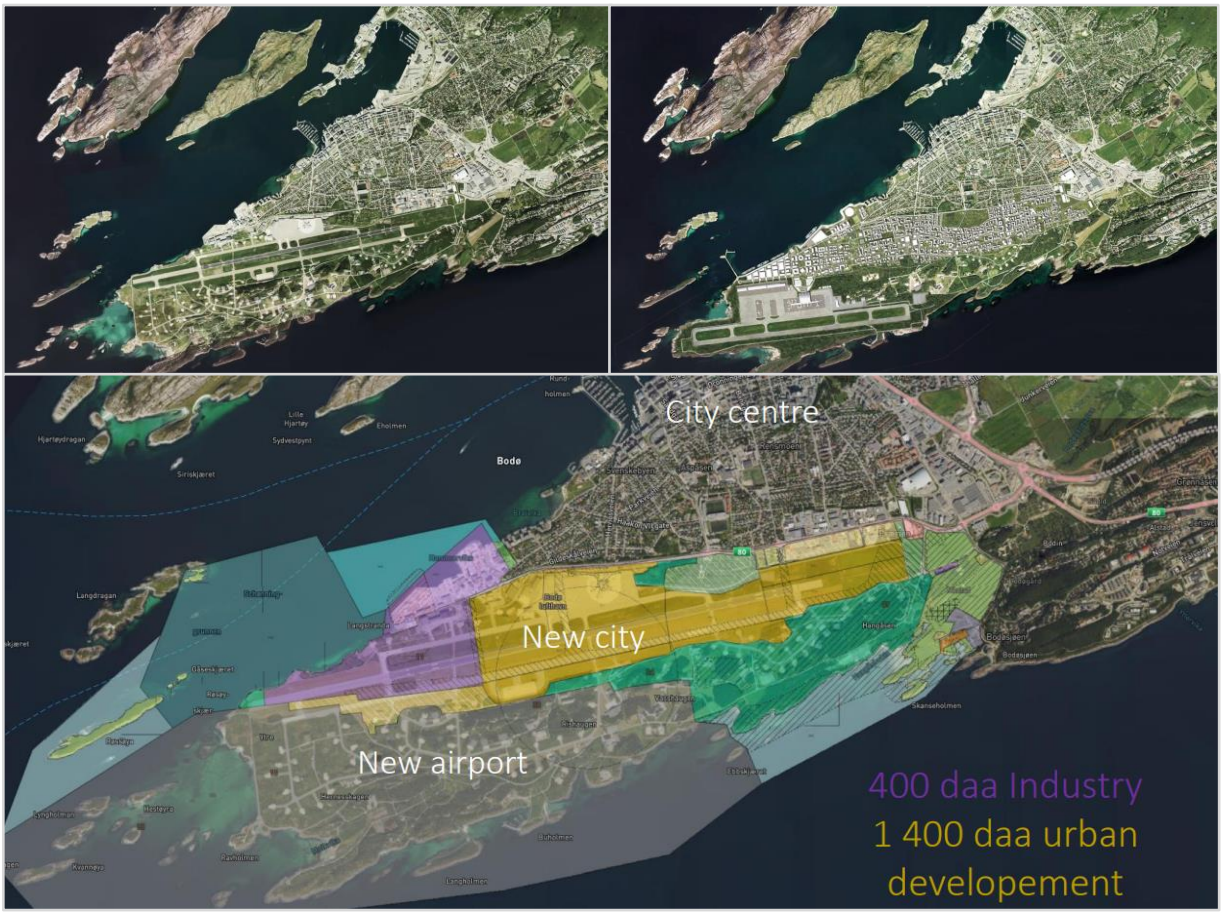


Figure 3 City today (up left); City after relocation and new city district (up right); illustration of area is to be regulated to a civil airport, and which is to be regulated to a new part of the city.

Tools and activities

Tendering and procurement - incl new buildings/ Procurement Handbook

- Evaluation of the circularity of tenders and procurements in the municipality
    - This was done through master thesis early and late in the project period.
- Circularity in tender for design of new city district
    - A tender for three parallel missions for design in the new city district was released with criteria that the city should be as circular as possible.
- Development of procurement strategy and guidelines
    - Municipal procurement strategy has been developed.
- Embedding circular principles in demolition procurement

- Because of delays in the airport demolition timeline the demolition will happen after the CityLoops project is finalized. Circular criteria have instead been tested and used in pilot projects for the airport.

Preparation and selective demolition – incl CO2 calculation

- Mapping structures and masses and assessing quality and pollution.
  - Mapping of structures and masses for reuse, and visualizing it in 3D model
- Evaluation of reuse potential of buildings/structures for other purposes without demolition
  - Assessing the potential for repurposing the buildings and structures through stakeholder involvement, such as student challenge to repurpose current terminal building at the airport and citizen involvement in reuse ideas for airport shelters.

Instruments for circular soil handling – incl CO2 calculation

- Mapping soil pollution and quality
  - Visualized in 3D model and Power BI
  - Used LCA calculator to visualize emission from transport.

Gathering and digitalizing data for reuse or recycling + use as material passports + marketplace

- Testing CityLoops pre-screening tool for digitalization of reuse materials and material passport
- Tender of marketplace and digitalization software (start-up company Material Mapper) to predict future soil, digitalization of reuse mappings and marketplace for soil and construction materials.
- Agreement to test material bank for soil transfer between projects
  - National software under development. Bodø to be pilot city.

Recycled concrete flows from demolition to new construction.

- Flow of crushed concrete from airport to recycling, reuse or landfill visualized in 3D-model.

Handling / Physical material banks

- Establishment of intermediate storage and logistics
    - Intermediate storage for masses established near city center and at current landfill site.
    - Marketplace for building materials under development. Iris waste company responsible for establishment and Bodø municipality involved with pilot building, reusable materials, pre-screening tool, and competence.

Demonstration action: Embed circular strategies in the planning of the new city district.

This demonstration action focuses on the internal processes and plans within Bodø municipality for circular city planning – addressing questions such as: *How is the new city part going to look, and how can it be built in a circular way? What plans, tools and procedures do we need in the municipality to enable the development?* CityLoops is a part of the planning of the new city development project. Establishing circular procurement policies in the municipality is one of the initiatives from CityLoops. Furthermore, the tools and concepts developed in CityLoops will be used in the project.

Use of 3D visualization tool

Mass quality data from demonstration site

Instrument description: The observations of mass quality are mapped on a GIS-tool and the values are compared to a limit value (that classifies the soil's degree of pollution). When new observations are made, data will be plotted in the source document (Illustration 3), and the dashboard will automatically update. Visualization of

such data might be beneficial in terms of getting an overview of the soil in the relevant area. This will assist the dashboard user in city planning processes. In a CityLoops context, we use this dashboard to assist us in deciding which masses are ready for reuse, which need to be cleaned, and what needs to be treated as polluted and/or dangerous soil – and its whereabouts.

- **Method**: Sampling from the whole demonstration area, including from masses underneath the surface. What masses consist of its degree of pollution and its reuse potential is identified.
- **Collaborator(s)**: Norwegian Geotechnical Institute
- **Tool**s **used for visualisation**: PowerBI, Augment City Digital Twin
- **Usage**: Used for mass treatment planning. Necessary analysis has been done to evaluate if masses should be sent to facility for cleaning or disposal. Heavily polluted and dangerous masses are identified, and this information is crucial for city planning purposes in the demonstration area. A dashboard is created and can be used as a tool for decision makers on how masses should be treated, transported, and reused.
- **Example:**

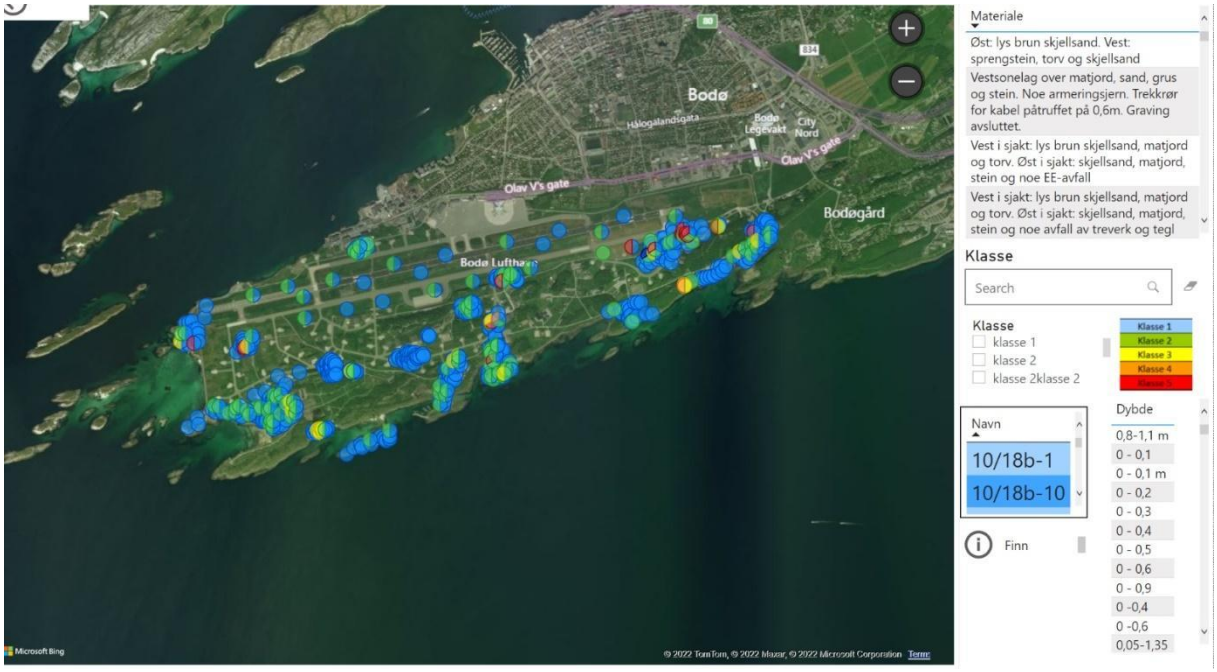


Illustration 5: Excerpt from PowerBI Dashboard

Functions:

- Qualitative description of soil masses
- Classification of degree of pollution
- Depth information
- Link to detailed information about technical qualities

Replication potential: It is not necessary to be in possession of PowerBI to use the dashboard. It can be presented by ex. an internet browser. To further develop it, or change its functionality, a free version of PowerBI can be used. It is however recommended to use a paid version of PowerBI. Many organizations have that in their Office 365-license. PowerBI typically relates to data formats that's available for most organizations (.xls, .csv, .txt, databases (like azure, sql, aws)). Basic data management skills are recommended.

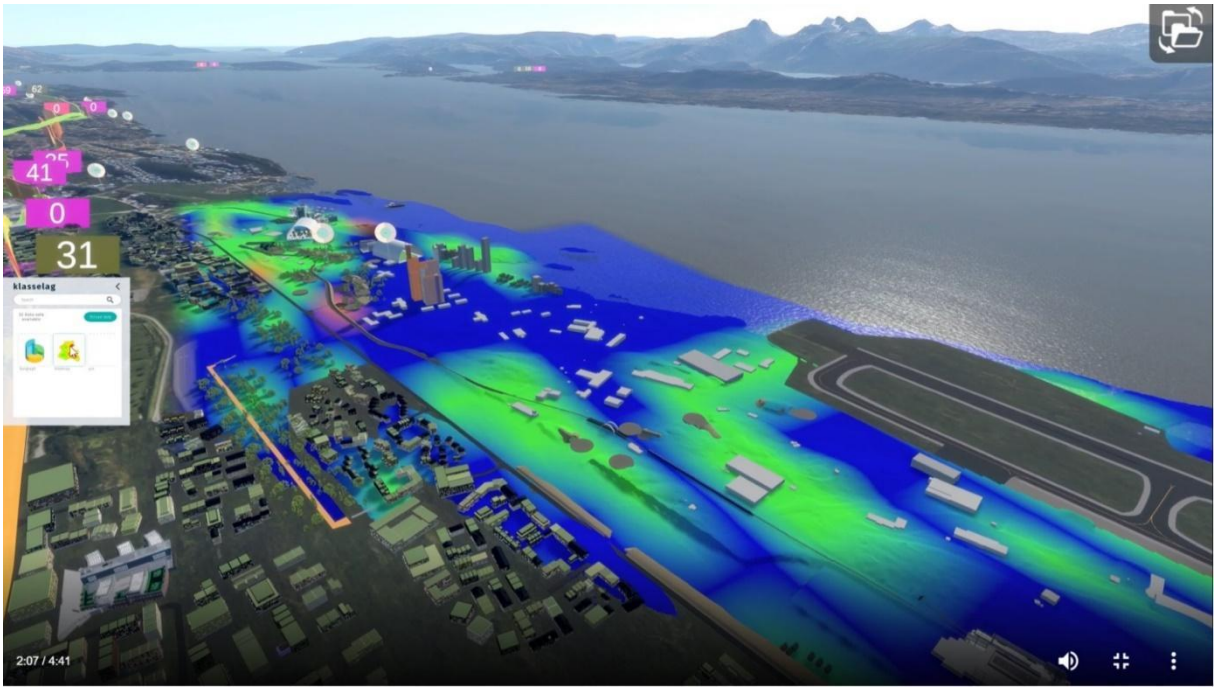


Illustration 6: Same data visualized in digital twin.

Technical guidelines

Material data from buildings on demonstration sites and pilot buildings

- **Method**: Scanning of building and their materials, assessment of quality, pollution, reusability. Testing of Tool 8) Databank and digital marketplace for recovered materials. Visualization of data from “sister” project CIRCULUS.
- **Tools used for visualization**: Power BI, Augment City Digital Twin
- **Usage**: Used to get an overview of buildings that need to be demolished, and buildings where that’s not necessary, what materials they consist of, their quality, and reuse potential. Data gathered is presented in detail in the 3D visualization tool. Presenting e.g., the amount of concrete on demonstration sites assists city planners in planning of reuse of the concrete.
- **Example**:

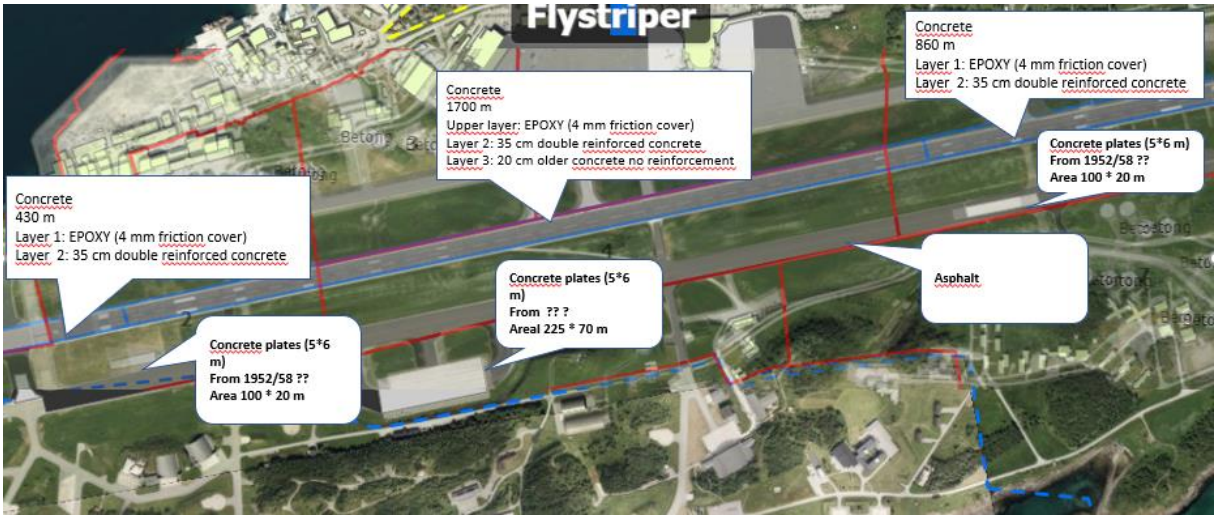


Illustration 7: Excerpt of data before visualization in digital twin

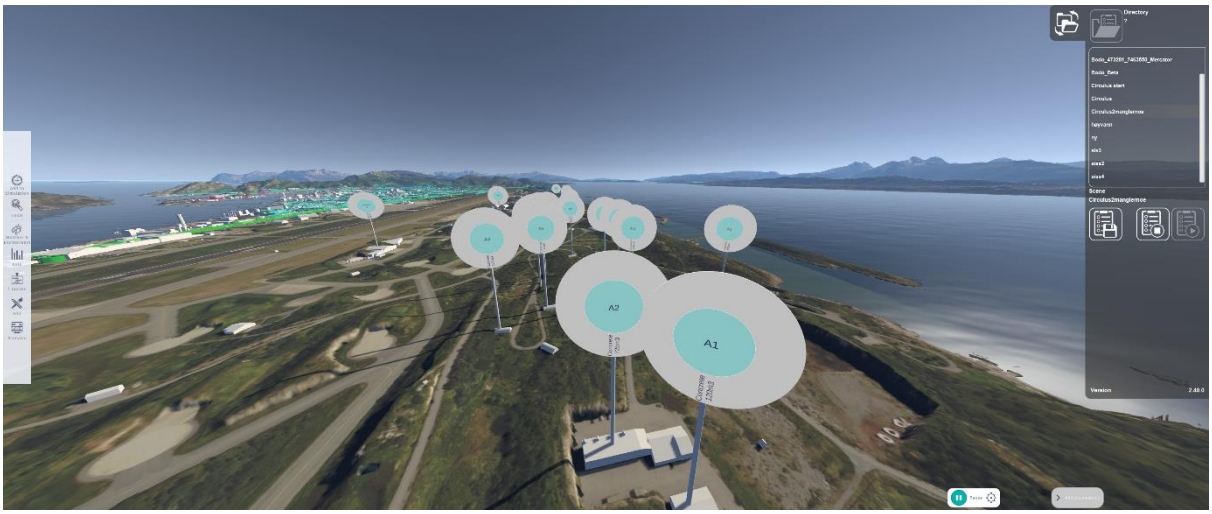


Illustration 8: Visualization in digital twin of how many m3 of concrete different buildings contain.

Illustration 9: visual representation of co2 emission from different scenarios on treatment of concrete on demonstration site.

Visualization of transport, infrastructure, and emission data

Method: Traffic data is gathered through an API-connection to the National Road Authority's traffic sensors. In that way, we get information about the amount of traffic circulating on the different streets of Bodø. This information is combined with *Tool 1) Life Cycle Assessment for demolition and renovated sites* to quantify the amount of emission on different sites in the city. This is visualized in the digital twin, and the height of the bars on the roads represents the amount of emission correlated with traffic on different times of the day.

Furthermore, hypothetical data about mass transport is populated in the digital twin. An estimation of the volume of masses from the demonstration project, and pilot project is done. This volume of masses needs to be transported to either waste management facilities or intermediate storage facility (ref business case). To evaluate which route for mass transport is best, visualization of this data is done. This enables us to see how mass transport interferes with traffic, housing, infrastructure, tear on asphalt, and its emission (LCA-tool).

Tools used for visualization: Digital twin, LCA-tool.

Usage: Scenario-building for mass transport. Communication to decision makers – to influence where masses shall be transported, stored, and treated.

Example:

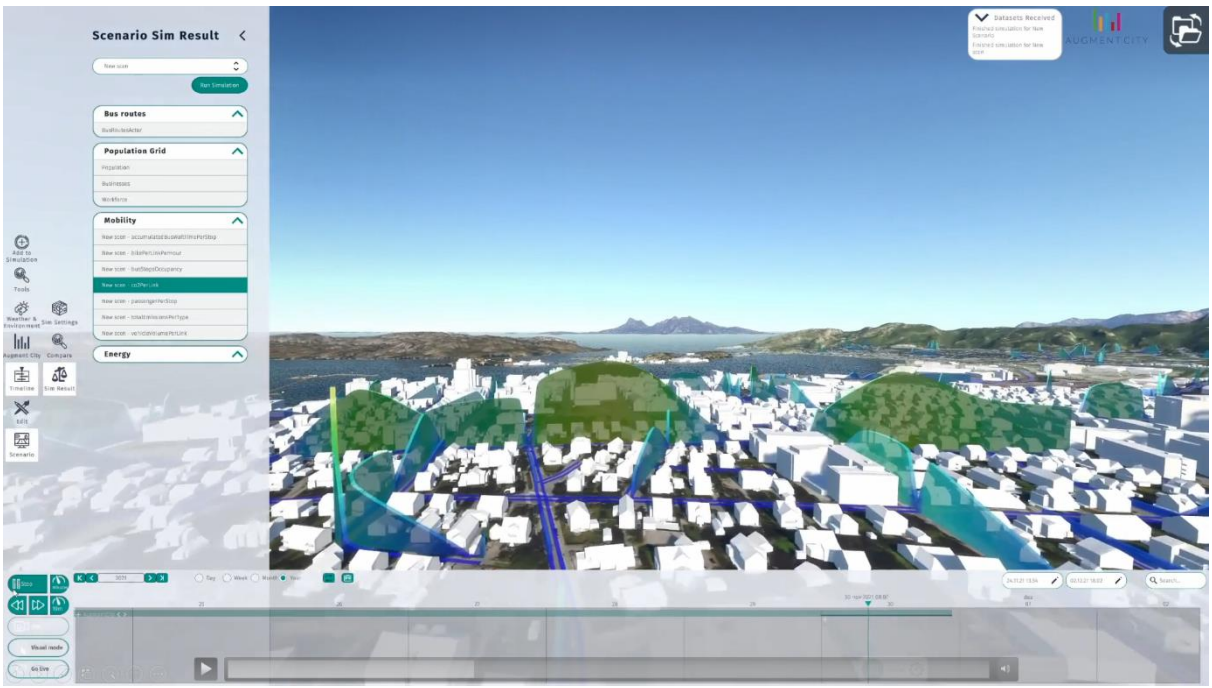


Illustration 9: Size of the bars represents CO2-emission (correlated with traffic) on pilot project for demonstration project. LCA-tool used.

This helps us identify which routes are best for mass transport, compare distances, emissions, busy traffic hours, etc.

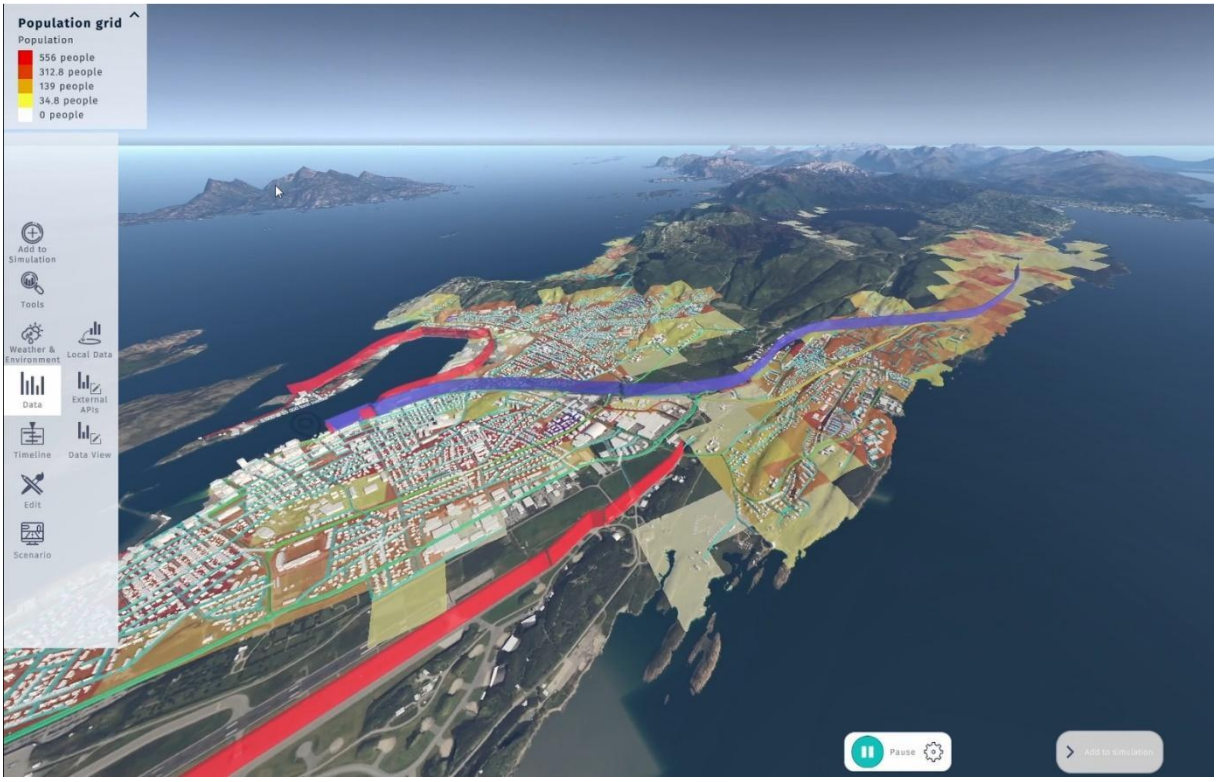


illustration 10: Mass transport routes. The color on the heatmap represents the density of population in different areas.

Identification of loose sediments and potential sea level rise at demonstration site

Identification of loose sediments and potential sea level rise (based on statistics) is done on demonstration site.

Method: Sampling on demonstration site, statistics on how sea level rise will develop. These values are particularly interesting as the demonstration site is situated near the sea.

Tools used for visualization: Digital twin.

Usage: Due to safety it is necessary to identify loose sediments as areas where this is identified might not be safe to be built on. Visualizing areas with these observations help city planners and decision makers to plan where construction work can and cannot be done and might be guiding on how these masses can be treated. Potential sea level

rise scenarios are also subject for visualization, as it is necessary to plan long term in building the new part of the city and the new airport.

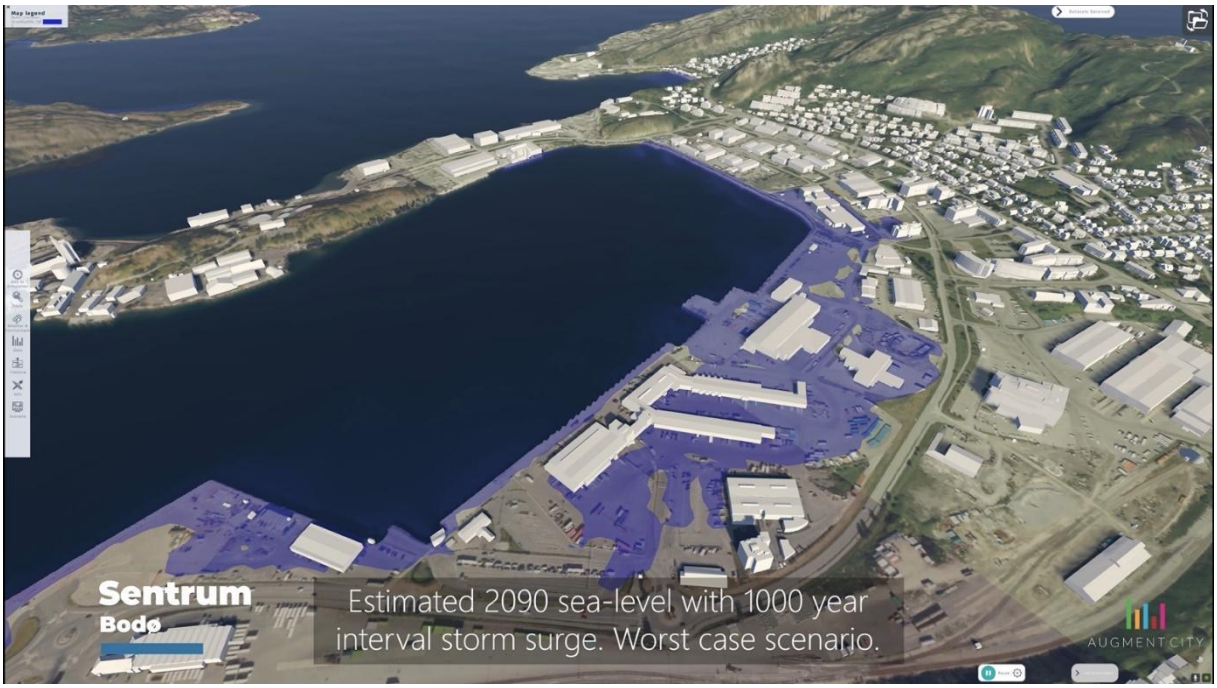


Illustration 11: Visualization of sea level rise, estimate based on statistics.

Social values

In the demonstration project, the triple bottom line is taken into consideration. The United Nations' triple bottom line refers to a framework for sustainable development that considers three dimensions: economic, social, and environmental.

In order to evaluate social values in the project, socio-demographic values have been gathered.

Method: Get public data from Statistics Norway. Data gathered is income, fortune, level of education, and age distribution. These values are divided into 176 neighborhoods in Bodø Municipality. The tool created in Bodø is inspired by the CityLoops tool 15) Wellbeing monitoring tool.

Furthermore, residential areas are mapped to evaluate how the inhabitants QoL in Bodø are affected by mass transportation on nearby roads. Factors related to heavy mass transport that might affect QoL are dust, noise, emission, safety, traffic.

Tools used for visualization: Power BI, digital twin.

Usage: Tool is used to map sociodemographic values in the city. This information is then used to plan how the city can be developed in terms of e.g., nursing homes, kindergartens, facilities for refugees, youth facilities. Sociodemographic information gives insight into the city's current status, but this can also be used to estimate future values. For example, if we know how many people from 64-85 that live in the different neighborhoods in the city, we can estimate how many people over 85 years old that live in the city in 10-20 years. Supported by statistics on death rates, home service capacity, experience on how many over 85 that needs municipal support, we can use the data gathered to be proactive in city planning. Being in possession of social data also enables us to identify correlations between increased practice of circular economy and decrease of emission. Having identified a need in the city can help us decide which purpose a refurbished building from demonstration site can serve, and this can even be used as an argument for keeping buildings rather than demolishing them.

Examples:

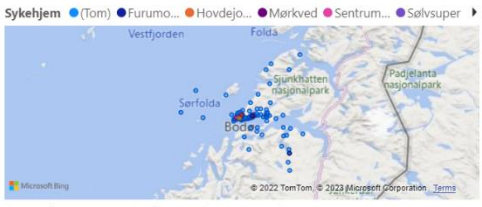
In the illustration underneath it is counted how many people from 65 to 84 years old live in Bodø in the city's 176 neighborhoods. It is also counted how many people over 85 years old live in the city. Findings: it will likely be more people over 85 years old in Bodø in 10 – 20 years. This information might be used to plan how the buildings in demonstration site can be used to serve elderly inhabitants in Bodø.

Sum på Alder 65-74 år	Sum på Alder 75-84 år	Sum på Alder 85 år og over
4968	2865	1001

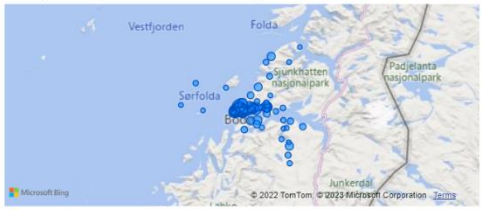
Sum på Alder 55-64 år	Sum på Alder 65-74 år	Sum på Alder 75-84 år	Sum på Alder 85 år og over	Grunnkrets
128	126	108	68	Reinsletta
49	69	57	59	Stadion
51	40	52	45	Zefyrhaugen
69	60	48	34	Jordbruket
20	27	22	32	Mørkved sentrum 2
80	70	42	31	Tverlandsbyen sentrum
93	90	80	26	Moloen
49	64	66	23	Østre Skolepark
39	50	75	23	Rønvikleira 2
58	28	28	20	Einmoen 1
106	100	52	20	Lagården
40	46	32	19	Misvær
24	24	42	17	Småtindveien
40	46	29	17	Solslett
89	101	51	15	Årnessletta
33	28	25	15	Domkirken
78	46	28	15	Symrahaugen
123	58	57	14	Alstad 1
19	29	34	14	Solparken
76	52	34	14	Vollen 2
46	50	35	13	Hunstadlia 1
52	37	38	13	Olahaugen
26	17	15	12	Stille Dal
33	47	24	11	Kjerringøy
76	41	22	11	Rensmoen
101	77	26	11	Roald Amundsens vei
52	57	21	10	Knaplund
125	94	40	9	Bertnes
66	35	15	9	Gjerdet
6275	**4968**	**2865**	**1001**	

Sykehjem	Kapasitet sykehjem
Furumoen sykehjem	20
Hovdejordet	41
Mørkved	50
Sentrum sykehjem	54
Sølvsuper	80
Stadiontunet	56
Vollsletta	24

Sykehjem, XCoord og YCoord



Sum på Alder 65-74 år av XCoord og YCoord



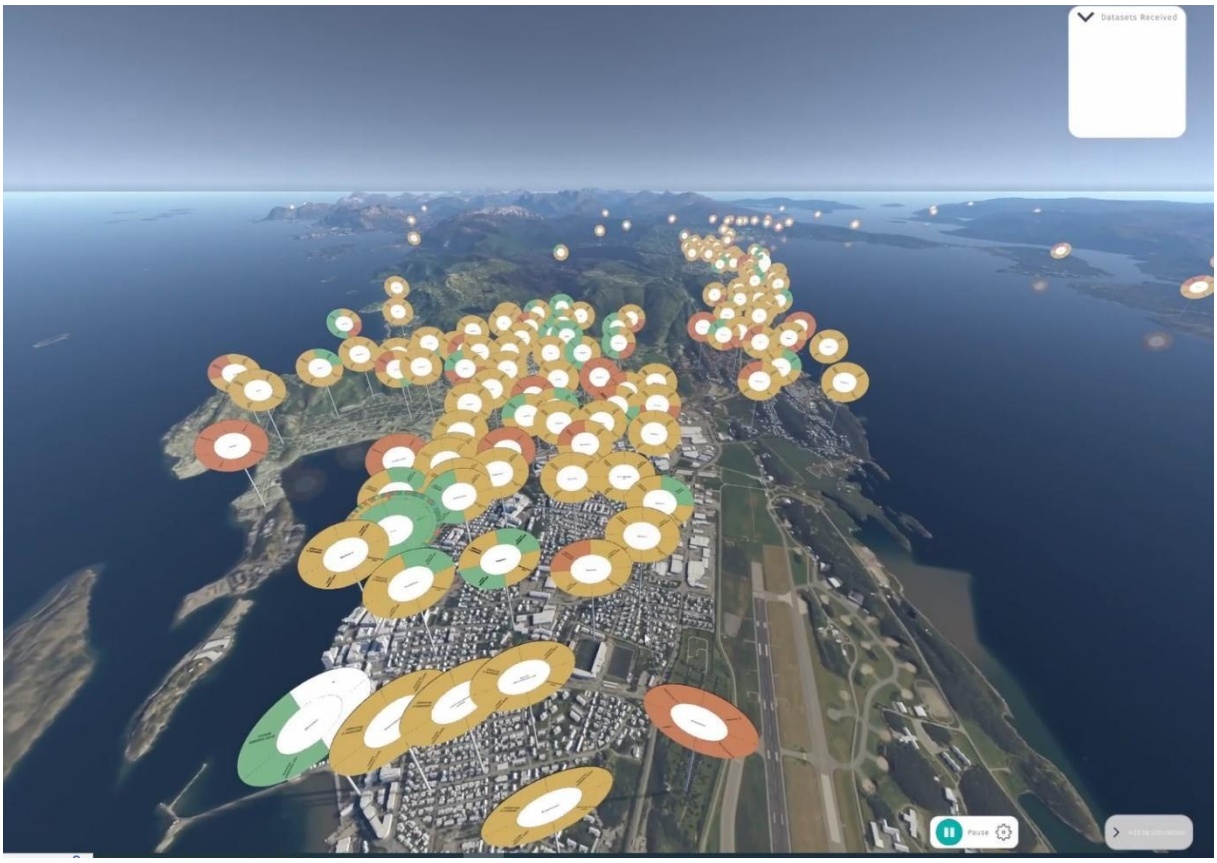


Illustration 12: Visual representation of how different neighborhoods' average income, net worth, level of education and age are placed in comparison to a city average.

Illustration 14: Visualization of architect made concept using digital twin. Source: local newspaper.

Soil databank/marketplace

For the actual soil management in projects the construction companies are the ones responsible for soil management in each project. They are commonly working from project to project and are not well connected or informed about parallel projects. Most soil is therefore deposited in the landfill outside of Bodø city (IRIS). This drives the cost of projects up, but lack of systems for reuse and increased risk makes landfilling the most used method.

One of the large barriers for reuse is the lack of knowledge of options. Bodø therefore has evaluated options for establishment of databanks or marketplaces to match surplus and need for soil.

Goal for databank: To give overview of future and present available surplus soil and locations with need for soil, to enable a market for transfer of soil between projects.

Identified requirements for databank:

- Estimated for surplus soil, with location, volume, quality, contamination, and timeframe for availability.
- Estimated need for soil, with location, volume, quality, timeframe, and permission to receive soil.
- Contact information between projects (or chat function etc.)
- System for tracking soil transfer between projects (to avoid illegal reception)
- It should be designed to allow establishment of a market for the soil (with prices and logistics)

There are currently no available market systems meeting all the requirements (in Norway), but a few databases software options meeting some. There is also one system under development by another Norwegian municipality, under an initiative called Bærum Ressursbank. This is an initiative to create a network for best practice for soil management. Their soil market system is being developed to meet all the above requirements. It will be available for testing from mid-2023.

Bodø municipality has been working to establish close contact with Bærum Ressursbank to be one of the pilot cities to test the market system. Through meetings, discussions, and active involvement in the competence network, Bodø has been able to establish a close connection. It has also resulted in the establishment of a local soil

competence network in Bodø, which will also work to include private actors to use the market system.

Bærum Ressursbank has worked to design the market system since 2019 to make sure to include all the stakeholders in the value chain and work within all relevant regulation. A description of the system can be seen in the illustration below, created by Bærum Ressursbank. CityLoops has not been involved in the system but has facilitated for Bodø municipality to test in our projects. Bærum Ressursbank is working to make the marketplace available nationwide, and Bodø wish to assist in the ambitions.

Figure 9 Description of Bærum Ressursbank marketplace criteria. More information at Bærum Ressursbank webpage.

In addition to Bærum Ressursbank market system, Material Mapper, the software described under section 4.4.2 for soil prediction can also be used as a soil marketplace. Material Mapper has the ability to automatically detect projects and make generic estimates of surplus soil volumes, where all the projects are collected in a map functionality with contact information. It also has a marketplace functionality where

projects can offer soil and give the necessary information about quality, contamination, available volumes and when it will be available, and give climate footprint calculations. It also has chat functionality for communication between projects, order transport and order some documentation.

At the time of the purchase of the marketplace it is however evaluated to not be suited for full scale use, as the systems for documentation of contamination and traceability is not good enough to keep track of poor soil management, contamination, and illegal landfilling. The systems for ordering transportation and some documentation through the system are also not compatible with municipal requirements for public procurements. The system can however be tested on a case-to-case basis.

Bodø municipality will keep working with Material Mapper to improve the functionality for municipal use. The focus will however be on Bærum Ressursbank marketplace, as the system has a more thorough approach and is more likely to become a widely used software across the country.

More information about other functions of the software under chapter 4.5.2 Digital marketplace and construction material tool.

Intermediate storage for soil

Optimally soil should be transported as short distances as possible and only be unloaded once, back in the project it came from or directly reused at another destination project. Supply and need for soil do however often not match in time, making intermediate storage a necessity. Space for intermediate storage is often scares in urban construction projects, making external intermediate storage necessary. In Bodø there are few central areas suitable for soil storage, and it is challenging to find good options.

In the overall municipal area plan (Kommuneplanens arealdel) for Bodø four areas are reserved for intermediate storage for soil. Neither of the options are, however, central, or practically useful without cleaning, and establishment of infrastructure for heavy transport and operation.

There is a need for more central and suitable intermediate storages, as well as more experience with the establishment of new and temporal intermediate storages within the municipality.

At Burøya, close to Bodø city center, an available location was identified as suitable. The area is municipally owned land that is filled out in the sea for establishment of an industrial area. The infilled soil needs to be settled for four to five years before it is

considered stable enough for construction. Until it is settled it has a great location for soil management. The location is shown in the map below.

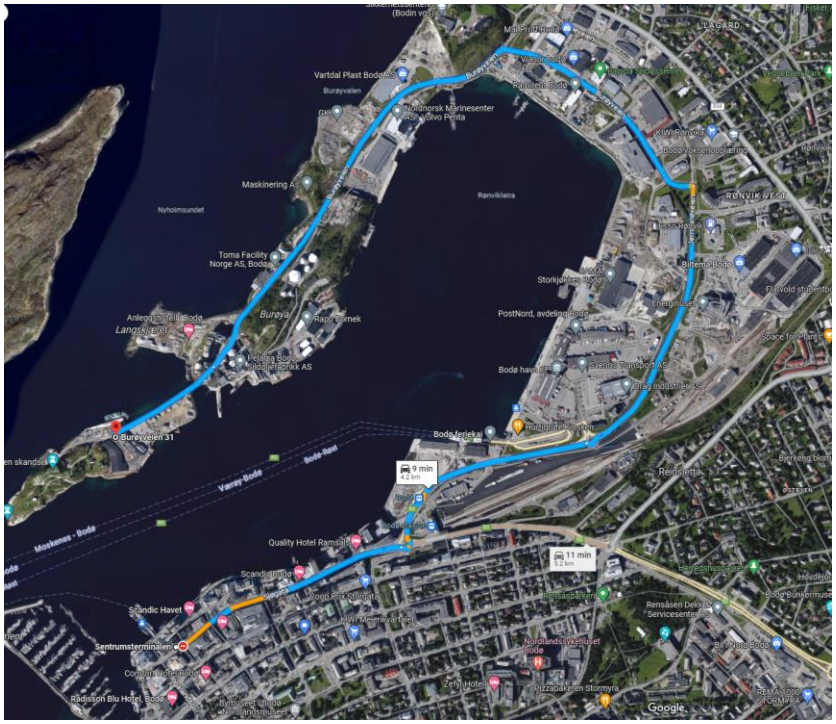


Figure 10 Map showing the location of Burøya intermediate storage. The storage is 3-4 km by road, or less than a kilometer by boat from the road construction project in Sjøgata in Bodø city center.

To use the location for intermediate storage it needed concession from environmental authorities (Statsforvalter). The intended use and operation were described in an application process that was answered and approved within a few months. The area was approved for intermediate storage of clean and slightly contaminated soil (up to grad 3 in the Norwegian system (going from 1-5)). Because of the settling of the soil, an important constriction was added, not allowing to fill more than 1,5 m in height.

The road Sjøgata in Bodø city center has been dedicated as a pilot construction project for the airport and new city district for implementation of circular and low emission measures. In the tender, the intermediate storage at Burøya was made available for construction companies to use, with a general criterion for the project that all reusable soil from the project was to be reused. The project will be going from 2023-2025.

Some barriers turned up when intending to start using the storage, which has postponed the operation. Establishment of construction roads was more challenging than expected because of the ground conditions, making it a large investment for the

construction project. The height restriction of 1,5 m storage piles also makes the operation more area intensive, with consequences for the practical operation of the site. The municipality is currently looking for models to cooperate with the construction company to establish the necessary infrastructure.

As a consequence of not being able to use Burøya, the option of establishing intermediate storage at the local landfill site came up as a good alternative. Priorly this was only used as a landfill site, but operation of an intermediate storage has now been established. The storage is further from the city center than preferred, but it is a good alternative to the prior linear approach. The co-location of landfill and intermediate storage also gives some benefits, as less investment and operational costs are needed because the site is already operational. It is also possible to leave the soil in the intermediate storage while waiting for lab results for contamination, potentially allowing more reuse of soil that would otherwise be landfilled because of uncertainty. Much of the soil in Bodø is contaminated and needs landfilling with today's regulations, and the intermediate storage makes it possible for the transporters to bring soil back to the project when going to the landfill, reducing transport of new soil.

The options for intermediate storage are further described in the CityLoops Bodø Business Case.

Mapping soil pollution and quality

- Visualized in 3D model and Power BI
- Used LCA calculator to visualize emission form transport.

Dashboard with soil information

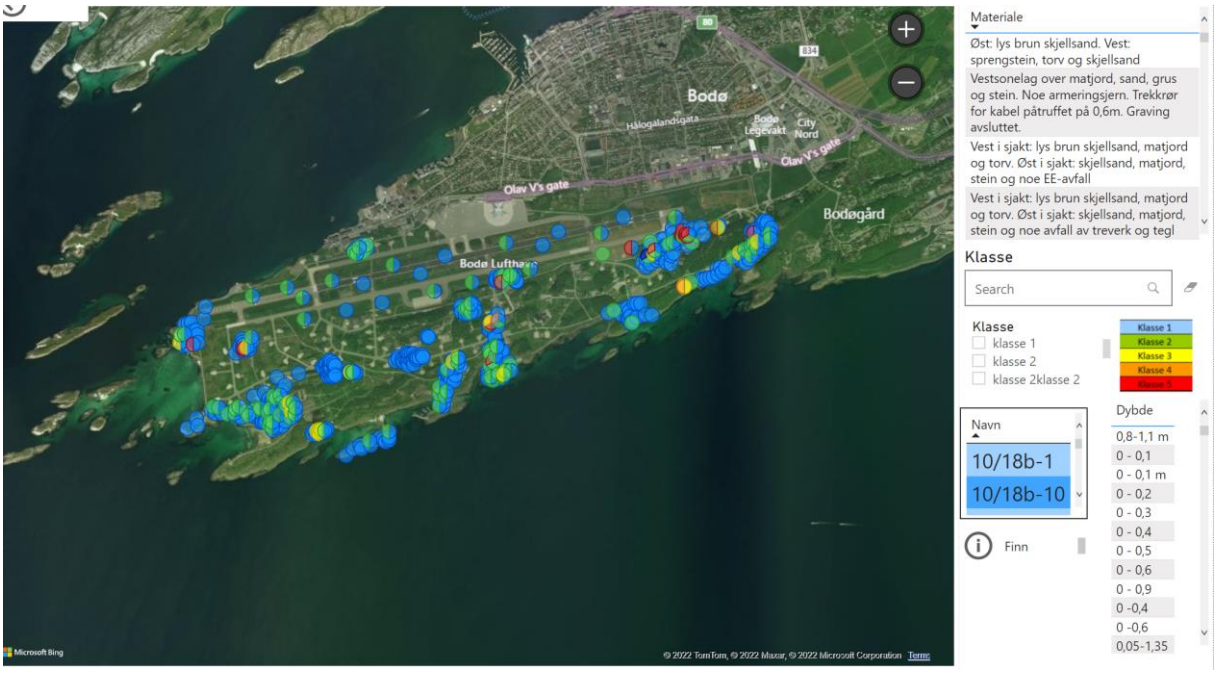
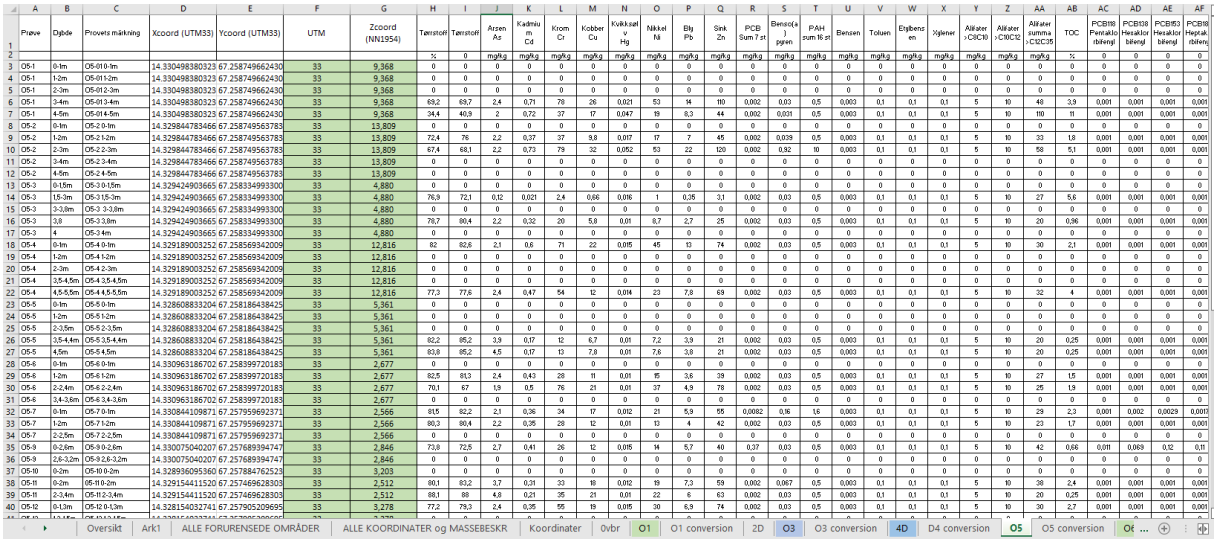


Illustration 2: Excerpt from Power BI Dashboard

Functions:

- Qualitative description of soil masses
- Classification of degree of pollution
- Depth information
- Link to detailed information about technical qualities (ex: Illustration 3)



	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V	W	X	Y	Z	AA	AB	AC	AD	AE	AF
1	Prøve	Dybde	Provets märkning	Xcoord (UTM33)	Ycoord (UTM33)	UTM	Zcoord (NN1954)	Tørrstoff	Tørrstoff	Arsen As	Kadmium Cd	Krom Cr	Kobber Cu	Kvikksølv Hg	Nikkel Ni	Bly Pb	Sink Zn	PCB Sum 7 st	Benso(a)pyren	PAH sum 16 st	Benzen	Toluen	Etylbenzen	Xylener	Alifater >C8C10	Alifater >C10C12	Alifater summa >C12C35	TOC	PCB118 Pentaklorbifenyl	PCB138 Heksaklorbifenyl	PCB153 Heksaklorbifenyl	PCB180 Heptaklorbifenyl
2								%	0	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	%	0	0	0	0
3	O5-1	0-1m	O5-01 0-1m	14.330498380323	67.258749662430	33	9,368	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
4	O5-1	1-2m	O5-01 1-2m	14.330498380323	67.258749662430	33	9,368	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
5	O5-1	2-3m	O5-01 2-3m	14.330498380323	67.258749662430	33	9,368	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
6	O5-1	3-4m	O5-01 3-4m	14.330498380323	67.258749662430	33	9,368	69,2	69,7	2,4	0,71	78	26	0,021	53	14	110	0,002	0,03	0,5	0,003	0,1	0,1	0,1	5	10	48	3,9	0,001	0,001	0,001	0,001
7	O5-1	4-5m	O5-01 4-5m	14.330498380323	67.258749662430	33	9,368	34,4	40,9	2	0,72	37	17	0,047	19	8,3	44	0,002	0,031	0,5	0,003	0,1	0,1	0,1	5	10	110	11	0,001	0,001	0,001	0,001
8	O5-2	0-1m	O5-2 0-1m	14.329844783466	67.258749563783	33	13,809	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
9	O5-2	1-2m	O5-2 1-2m	14.329844783466	67.258749563783	33	13,809	72,4	76	2,2	0,37	37	9,8	0,017	17	7	45	0,002	0,039	0,5	0,003	0,1	0,1	0,1	5	10	33	1,8	0,001	0,001	0,001	0,001
10	O5-2	2-3m	O5-2 2-3m	14.329844783466	67.258749563783	33	13,809	67,4	68,1	2,2	0,73	79	32	0,052	53	22	120	0,002	0,82	10	0,003	0,1	0,1	0,1	5	10	58	5,1	0,001	0,001	0,001	0,001
11	O5-2	3-4m	O5-2 3-4m	14.329844783466	67.258749563783	33	13,809	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
12	O5-2	4-5m	O5-2 4-5m	14.329844783466	67.258749563783	33	13,809	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
13	O5-3	0-1,5m	O5-3 0-1,5m	14.329424903665	67.258334993300	33	4,880	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
14	O5-3	1,5-3m	O5-3 1,5-3m	14.329424903665	67.258334993300	33	4,880	76,9	72,1	0,12	0,021	2,4	0,66	0,016	1	0,35	3,1	0,002	0,03	0,5	0,003	0,1	0,1	0,1	5	10	27	5,6	0,001	0,001	0,001	0,001
15	O5-3	3-3,8m	O5-3 3-3,8m	14.329424903665	67.258334993300	33	4,880	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
16	O5-3	3,8	O5-3 3,8m	14.329424903665	67.258334993300	33	4,880	78,7	80,4	2,2	0,32	20	5,8	0,01	6,7	2,7	25	0,002	0,03	0,5	0,003	0,1	0,1	0,1	5	10	20	0,96	0,001	0,001	0,001	0,001
17	O5-3	4	O5-3 4m	14.329424903665	67.258334993300	33	4,880	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
18	O5-4	0-1m	O5-4 0-1m	14.329189003252	67.258569342009	33	12,816	82	82,6	2,1	0,6	71	22	0,015	45	13	74	0,002	0,03	0,5	0,003	0,1	0,1	0,1	5	10	30	2,1	0,001	0,001	0,001	0,001
19	O5-4	1-2m	O5-4 1-2m	14.329189003252	67.258569342009	33	12,816	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
20	O5-4	2-3m	O5-4 2-3m	14.329189003252	67.258569342009	33	12,816	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
21	O5-4	3,5-4,5m	O5-4 3,5-4,5m	14.329189003252	67.258569342009	33	12,816	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
22	O5-4	4,5-5,5m	O5-4 4,5-5,5m	14.329189003252	67.258569342009	33	12,816	77,3	77,6	2,4	0,47	54	12	0,014	23	7,8	69	0,002	0,03	0,5	0,003	0,1	0,1	0,1	5	10	32	4	0,001	0,001	0,001	0,001
23	O5-5	0-1m	O5-5 0-1m	14.328608833204	67.258186438425	33	5,361	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
24	O5-5	1-2m	O5-5 1-2m	14.328608833204	67.258186438425	33	5,361	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
25	O5-5	2-3,5m	O5-5 2-3,5m	14.328608833204	67.258186438425	33	5,361	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
26	O5-5	3,5-4,4m	O5-5 3,5-4,4m	14.328608833204	67.258186438425	33	5,361	82,2	85,2	3,9	0,17	12	6,7	0,01	7,2	3,9	21	0,002	0,03	0,5	0,003	0,1	0,1	0,1	5	10	20	0,25	0,001	0,001	0,001	0,001
27	O5-5	4,5m	O5-5 4,5m	14.328608833204	67.258186438425	33	5,361	83,8	85,2	4,5	0,17	13	7,8	0,01	7,6	3,8	21	0,002	0,03	0,5	0,003	0,1	0,1	0,1	5	10	20	0,25	0,001	0,001	0,001	0,001
28	O5-6	0-1m	O5-6 0-1m	14.330963186702	67.258399720183	33	2,677	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
29	O5-6	1-2m	O5-6 1-2m	14.330963186702	67.258399720183	33	2,677	82,5	81,3	2,4	0,43	28	11	0,01	15	3,6	39	0,002	0,03	0,5	0,003	0,1	0,1	0,1	5	10	27	1,5	0,001	0,001	0,001	0,001
30	O5-6	2-2,4m	O5-6 2-2,4m	14.330963186702	67.258399720183	33	2,677	70,1	67	1,9	0,5	76	21	0,01	37	4,9	78	0,002	0,03	0,5	0,003	0,1	0,1	0,1	5	10	25	1,9	0,001	0,001	0,001	0,001
31	O5-6	2,4-3,6m	O5-6 2,4-3,6m	14.330963186702	67.258399720183	33	2,677	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
32	O5-7	0-1m	O5-7 0-1m	14.330844109871	67.257595692371	33	2,566	81,5	82,2	2,1	0,36	34	17	0,012	21	5,9	55	0,0082	0,16	1,6	0,003	0,1	0,1	0,1	5	10	29	2,3	0,001	0,002	0,0029	0,0013
33	O5-7	1-2m	O5-7 1-2m	14.330844109871	67.257595692371	33	2,566	80,3	80,4	2,2	0,35	28	12	0,01	13	4	42	0,002	0,03	0,5	0,003	0,1	0,1	0,1	5	10	23	1,7	0,001	0,001	0,001	0,001
34	O5-7	2-2,5m	O5-7 2-2,5m	14.330844109871	67.257595692371	33	2,566	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
35	O5-9	0-2,6m	O5-9 0-2,6m	14.330075040207	67.257689394747	33	2,846	73,8	72,5	2,7	0,41	26	12	0,015	14	5,7	40	0,37	0,03	0,5	0,003	0,1	0,1	0,1	5	10	42	0,66	0,011	0,069	0,12	0,11
36	O5-9	2,6-3,2m	O5-9 2,6-3,2m	14.330075040207	67.257689394747	33	2,846	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
37	O5-10	0-2m	O5-10 0-2m	14.328936095360	67.257847625253	33	3,203	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
38	O5-11	0-2m	O5-11 0-2m	14.329154411520	67.257469628303	33	2,512	80,1	83,2	3,7	0,31	33	18	0,012	19	7,3	59	0,002	0,067	0,5	0,003	0,1	0,1	0,1	5	10	38	2,4	0,001	0,001	0,001	0,001
39	O5-11	2-3,4m	O5-11 2-3,4m	14.329154411520	67.257469628303	33	2,512	88,1	88	4,8	0,21	35	21	0,01	22	6	63	0,002	0,03	0,5	0,003	0,1	0,1	0,1	5	10	20	0,25	0,001	0,001	0,001	0,001
40	O5-12	0-1,3m	O5-12 0-1,3m	14.328154032741	67.257905209695	33	3,278	77,2	79,3	2,4	0,35	55	19	0,015	30	6,9	74	0,002	0,03	0,5	0,003	0,1	0,1	0,1	5	10	30	2,7	0,001	0,001	0,001	0,001

Oversikt | Ark1 | ALLE FORURENSEDE OMRÅDER | ALLE KOORDINATER og MASSEBESKR | Koordinater | 0vbr | O1 | O1 conversion | 2D | O3 | O3 conversion | 4D | D4 conversion | O5 | O5 conversion | O€ ...

Illustration 3: Data source for visualization

Instrument description: This dashboard is based on data from Norwegian Geotechnical Institute's measurements on the demonstration area. The observations are mapped on a GIS-tool and the values are compared to a limit value (that classifies the soil's degree of pollution). When new observations are made, data will be plotted in the source document (Illustration 3), and the dashboard will automatically update. Visualization of such data might be beneficial in terms of getting an overview of the soil in the relevant area. This will assist the dashboard user in city planning processes. In a CityLoops context, we use this dashboard to assist us in deciding which masses are ready for reuse, what needs to be cleaned, and what needs to be treated as polluted and/or dangerous soil – and its whereabouts.

Scalability: It is not necessary to have Power BI to use the dashboard. It can be presented by ex. an internet browser. To further develop it, or change its functionality, a free version of Power BI can be used. It is however recommended to use a paid version of Power BI. Many organizations have that in their Office 365-license. Power BI typically relates to data formats that's available for most organizations (.xls, .csv, .txt, databases (like azure, sql, aws)). A guide to create a similar dashboard in Power BI, and how to automatically feed the dashboard is prepared for the replicators.

Gathering and digitalizing data for reuse or recycling + use as material passports + marketplace

Digital marketplace and construction material tool

Bodø Municipality has started to use the software Material Mapper. The software was intended for use for soil prediction and management but does also have multiple functions for digital overview of materials and waste in upcoming constructions, as well as a marketplace for reuse of materials.

Reuse mappings: The software collects information about upcoming construction projects in Bodø automatically from public documents. Among the documents collected

and digitalized are reuse mappings. As of now reuse mapping is not common practice, but this will be implemented by rule in future projects. This function can give an overview of reusable materials in multiple upcoming projects before they are demolished. The information can be coordinated with construction projects along the same timeline for direct reuse. It can also give an overview of types of available materials on a city level. The functionality requires digitalization of PDF reuse mappings. It is a new function and is yet to be tested.

Material estimation: The software also estimates material use for a new construction project, based on statistical data of material use in historic projects for similar building types. This information can give an interesting overview of material consumption in the city and of the potential for improved circularity. Included in the estimator is also a CO2 calculator.

Waste estimator: Also based on statistical waste data from construction and demolition projects, Material Mapper has implemented a waste generation estimator for the upcoming projects (construction, rehabilitation, and demolition). The estimator has been compared to waste “budgets” required in the planning phase of projects and has proven to be more accurate than the budgets in a majority of cases.

Material marketplace: Materials from the reuse mappings or other reusable materials can be offered to others through an integrated digital marketplace. The marketplace is currently created for soil and masses but is under development for other construction materials. Bodø municipality are interested in testing the marketplace for reuse of municipal furniture to see if it is functional for larger scale use of building materials.

Handling / Physical material banks

At the beginning of the CityLoops project there were no initiatives for reusing construction materials in Bodø, other than unregulated sales by households through Facebook groups and the national marketplace for used items, www.finn.no. There is local production of concrete (with cement produced in Nordland County) and asphalt, and there is a relatively large wood industry in the region. Other than that, close to all construction materials are imported. With large distances to the rest of Norway and Europe, import implies long transport distances and high emissions and costs.

CityLoops in Bodø has worked to understand the status and readiness of the market for new reuse options and facilitate the establishment of a reuse market. In addition, an important work to develop internal procedures for material planning and reuse mapping in the municipality has been important for the work of CityLoops in Bodø.

Reuse market

The work to establish reuse market was done through stakeholder involvement, market analysis for digital and physical options and discussions with relevant stakeholders in an establishment.

- Evaluating best solution for establishment of reuse material marketplace in Bodø
- A marketplace operated by the municipality is not a good option – due to regulations hindering municipalities to cove competitive advantages. Operating as a subsidized marketplace in competition with material retailers is troublesome.
- The waste company of the Bodø region, Iris Produksjon, is a commercial company (with municipalities as their shareholders) have ambitions to establish a marketplace. CityLoops is involved and will help design a system and set up a pilot (if timespan allows).
- Iris is applying for financial support for a three-year project to establish a marketplace for materials.
- During stakeholder communication (workshop by Bodø municipality among others) pilot building projects have been identified for piloting the marketplace
- Iris and Bodø municipality have gotten in contact with national networks and competence while learning from them to design the establishment process.
- Dialogue with multiple digital platforms to evaluate the best digital options.
- Evaluating possible municipal (and other) locations for setting up a temporary intermediate storage for building materials

Early 2023 Iris opened the marketplace for construction materials as a small-scale pilot. To minimize risks and gather experience the marketplace was started together with a small construction project that would use reused products for interior materials, such as doors, indoor windows, wall panels, flooring, roof materials and furniture such as sinks, toilets and such. They also teamed up with donor demolition projects with collaboration agreement to test how the marketplace can work, as well as with demolition and construction companies who can deliver their reusable materials to the marketplace.

Iris rented a small space with possibilities to expand the rental area. The location was strategically chosen close to large retailers for new construction materials – reducing the barrier to stop by the reuse market.

The plan is to slowly scale it up to other projects as well, and they enter into agreements with larger construction projects down the timeline. The plan is to have an operational market where they coordinate materials between projects and receive and sell reusable materials to customers, in addition to a more passive role with rental of intermediate storage space for customers who want to store materials for future reuse.

CityLoops Bodø has participated in the planning process, and Bodø municipality is participating with a test case and donor building in the demolition and construction of Løding school. For the project of Løding school some parts of the interior of the building have already been removed by efforts from Iris Salten and Bodø Municipality as an initiative from CityLoops

Bodø Municipality has spared resources as the financial burden of tearing down materials and removing interior is moved to IRIS. Furthermore, this results in Bodø Municipality not having to allocate resources for handling waste in this project. This initiative also stimulates both Bodø Mun. and IRIS ambitions of increasing the degree of circularity in waste handling. IRIS is donating the materials and interior to Kirkens Bymisjon, a local charity – that also ensures the social sustainability aspect of the project.

Conclusion

When ambitioning the creation of material marketplaces, several aspects such as distances, type of transport, amounts and costs required for the rental or acquisition of a warehouse or terrain that serves as storage, the digital or physical area to offer available materials for reuse, the quality and amount of materials available or readily available, among other aspects should be considered. Ideally to diminish costs, the non-virgin materials should be used as soon as possible in the same or other construction projects.

Legal requirements at national, regional, and municipal levels must be considered, as some materials cannot be reused for certain type of construction projects while others might need to go through a cleaning process for masses or materials to become eligible/suitable for reuse, nevertheless some other materials might not be suitable for reuse, and this also needs to be considered.

Different materials have diverse implications, but prioritizing is a way in which cities can make the biggest impact when aiming to reduce, for example emissions. Evaluating possibilities to reach those goals, for example by using environmentally friendly transport, low emission materials, avoid acquisition of new materials, or using

procurement criteria suitable and designed for example a circular construction project must be evaluated thoroughly and from a case-by-case standpoint.

Planning is important when working with circularity solutions, good planning and scenario building can help to foresee barriers and find ways to overcome them, set a better logistic plan, forecast impacts, both positive and negative, help to map stakeholders or find relevant partners, and set a time for tasks to be completed towards the objectives.

Collaboration. To create possible, informed, and robust solutions we must reach others, these can be consultants, other departments within the same organization, diverse users, external stakeholders, and others that can bring ideas and enrich the problem-solving process, as it is clear that looking at an issue with different eyes and approaches, can help us see opportunities that we could possible not have envisioned before.

Recommendations: Create a team with knowledge and willingness to participate in the project, reach possible stakeholders, consider all aspects including legal requirements, make a map of materials, as well as a plan for them, and forecast different scenarios with the use of those materials.

CITYLOOPS

CityLoops is an EU-funded project focusing on construction and demolition waste (CDW), including soil, and bio-waste, 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 bio-waste, 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.