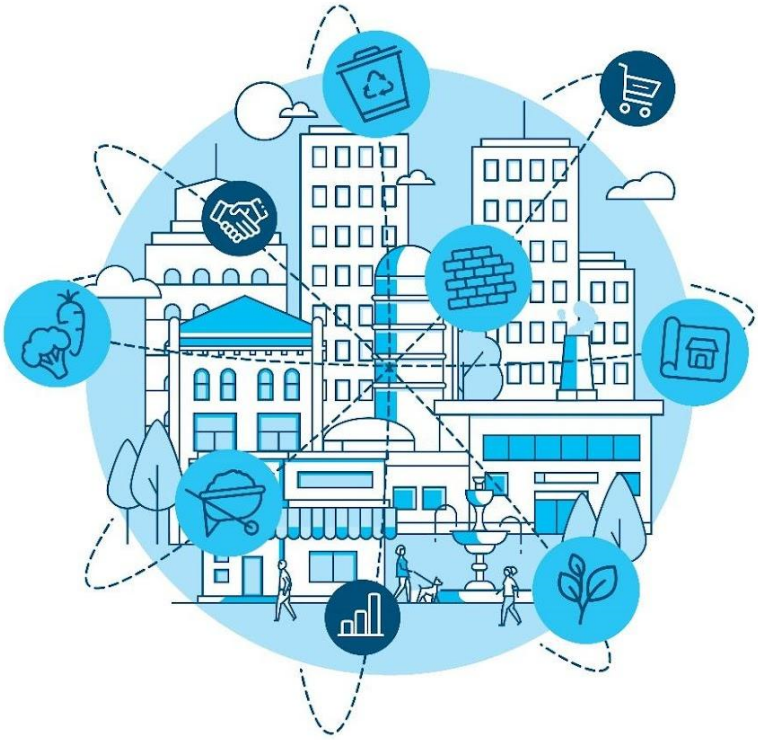
CIRCULAR CDW IN BODØ

Demonstration Report

Bodø Municipality, Norway



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Abstract	Bodø's demonstration actions involved embedding guidelines for circular material management processes linked to the demolition of the military airport of the city, involving stakeholders and citizens in city development as a practice and embed circular strategies in the planning of the new city district. This report describes activities, results and lessons learned from these actions.
Keywords	Demolition, Circular economy, Digital Twin, Construction and Demolition Waste, collaboration, materials, intermediate storage facilities, city planning, strategy.
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Contents

1. Executive summary

In Bodø, three demonstration actions have been carried out. These demonstration actions aim to

- Embed circular material management processes of in the demolition of Bodø's military airport.
- Establish a practice of stakeholder and citizen involvement in city development.
- Embed circular strategies in the planning of the new city district.

The background for these actions is the huge city development projects going on in Bodø, with focus on one, namely the project where a military airport is relocated, a new part of the city and a new airport is to be constructed. CityLoops tools are also demonstrated on other projects, like a road renovation project and the demolishing of a school.

To carry out the demonstration actions, a set of tools, methods and actions have been practised, including:

- Using 3D technology to visualize data related to materials, emission, soil, traffic, BIM-models, and reusable buildings on demonstration site. The rationale for this is that complex data is easier to understand if it is visualised, and correlations between different factor are easier identifiable. This enables decision makers to do informed decisions for a sustainable development of the city.
- Stakeholder involvement arrangements aimed at businesses, academia, public sector, and inhabitants.
- Implementation of sustainable and circular procurement, including data gathering on tenders, workshops, establishment of new procurement strategy
- Developing, using, and implementing the use of innovative technology for sustainability, like development of a contaminated soil-dashboard, the use of

Material Mapper, and other data management programs to help the municipality get insight on materials & masses and its reusability.

- Establishing a mass handling strategy in an overall environmental program for the city development projects, committing the municipality to treat masses and materials to the highest circularity degree possible.
- Preparation of proposals that sets requirements to circularity on all building applications that is treated by the municipality.
- Setting circularity requirements to architects and city developers as criteria in a mission competition.
- Mapping masses and materials in the city and establishing collaboration with local waste company to develop a marketplace for reused materials.
- Creating a sector-wide and urban circularity assessment in Bodø.
- Creating business cases on treatment of soil and materials that takes into account not only financial values but also environmental and social factors.

To support these actions a selection of tools developed in the Cityloops consortium are used:

- 3D GIS-based visualisation tools for monitoring and planning
- CityLab (ByLab) stakeholder engagement platform at Bodø town hall
- Life Cycle Assessment for demolition and renovated sites
- Screening procedures and tool for selective demolition
- Wellbeing monitoring tool
- Databank and digital marketplace for recovered materials.
- Instrument for predicting future excavated soil production.

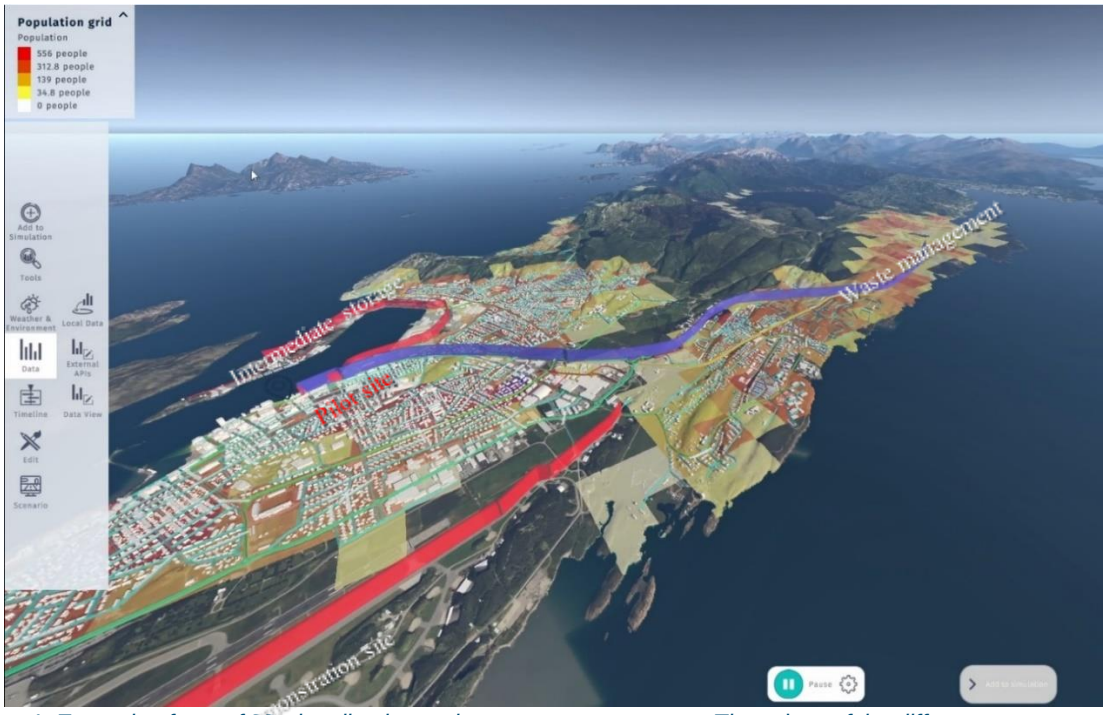


Figure 1. Example of use of 3D visualization tool: mass transport routes. The colour of the different areas represents density of population. The red stripe on the left represents the distance from the pilot site to the intermediate storage facility while the blue one represents the distance from it to the waste management facility.

In the project, employees in Bodø municipality from different departments have been involved, mainly from business & society, building & property, public procurement, technical sector, and IT. Furthermore, contributions from external actors like Avinor (airport owner), Norconsult (consultant), Augment City (software developers), Nord (University), Circulus (research project) have been crucial in the project.

Project progress and execution

The CityLoops project's demonstration site is located at the airport area where the new airport and the new part of the city will be constructed:

The timing of the project has enabled CityLoops to be involved in planning the execution of the project and has been crucial in preparing and manifesting strategies that commit the city's development project to a sustainable and circular handling of construction and demolition waste (CDW).

Figure 2. Demonstration area

Physical testing of CityLoops tools have done in pilot projects in Bodø, including a road renovation project in Sjøgata where 10 000 – 15 000 tonnes of masses of different quality needs to be treated. The different mass treatment options are what the project's business case is based on. Furthermore, tools for registering reusable materials and preparing selective demolition, have been used on a school in Bodø that is to be demolished. Such pilot actions enable us to demonstrate and test CityLoops tools before they are used in the New Airport New City project.

In addition to influencing how these projects are carried out, CityLoops in Bodø has also had a city-wide focus in terms of influencing how masses are treated, procurements are carried out, emission is reduced, and stakeholders are in involved in city development projects. To evaluate the effect of CityLoops activities, indicator data is gathered to measure whether or not Bodø's circular and sustainable practice is increased.

In the process of increasing circular treatment of materials in the city, social and financial factors are also taken into consideration meaning that data related to these is also gathered and interpreted.

2. City context

2.1 Basic characteristics

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

The population of Bodø was 52,560 in 2021. Over the last 35 years, it has increased significantly, namely by 46.8%, where there were only 35,792 inhabitants in 1986. On average, the municipality grew by 471 people each year over the last 10 years. The population density of Bodø is quite low with 40 inhabitants per km² of land area (2020). The population density of the rest of the region is much lower, and Bodø is the capital of Nordland County. There are long distances to nearby cities, and Bodø can in many ways be seen as a closed system, with a good overview of business activities and social phenomenon.

Bodø

- 52,560
- 1,395 km²

Nordland

- 240,559
- 38,155 km²

Nord-Norge

- 482,839
- 112,975 km²

Norway

- 5,398,804
- 385,207 km²

Figure 3. Size and population of different areas.

Bodø city is expected to grow in the coming years, and city planning for circular and green solutions for the expansion in the city development planning. With plans to move

the military part of Bodø airport to another region of Norway and moving the commercial part of the airport further out on the peninsula, new central areas will open for city development.

National market conditions

A national strategy for a green circular economy is manifested in 2021 [Link], which may strengthen the national conditions for CE-business cases. Furthermore, regulations, taxes and guidelines evolving in a direction that might lead to an increase of circular economic practise (TEK17 building regulations, EU taxonomy, mass treatment regulations). This increased practice of circular economy might be an opportunity to explore how circular business cases can be built.

There might also be barriers regarding circular treatment of CDW. National regulations states that all materials that is part of a demolition process, shall be treated at a waste management facility [Link]. This might complicate the process of directly reusing masses and materials at nearby projects. However, regulations state that if the quality of the resources is satisfying, and nearby projects are already planned (and not planned because of the freed resources), they can be reused directly.

In CityLoops in Bodø several stakeholder involvement activities have been arranged. In these arrangements it has been asked what the stakeholders believes is necessary to establish a digital and physical market for reused materials. Findings from these workshops suggest that there is a market for reused resources, but that the market has insecurities and risk aversion related to e.g., pricing, insurance, and quality of the materials.

2.2 Construction sector and -waste

In Bodø, the building stock is fairly distributed between residential and non-residential buildings. 47% of the buildings are residential (source), of which 4% are municipally managed housing (source) and remaining 43% are private housing. 53% of buildings

are non-residential (source). Figure 4 shows the number of the different building types in Bodø.

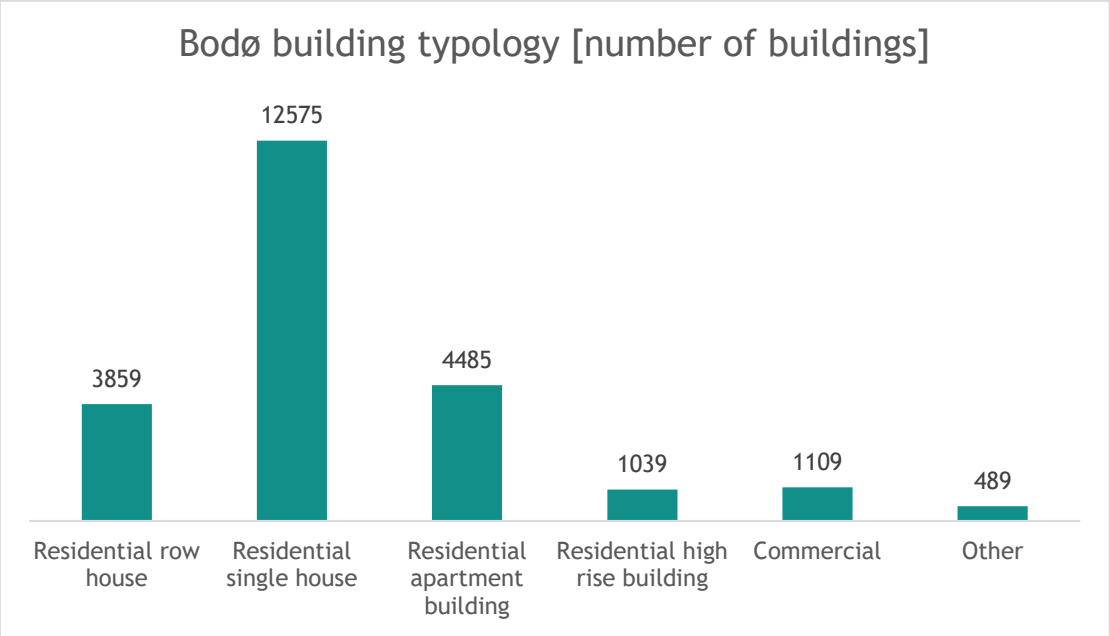


Figure 4 Number of buildings in Bodø by typology (Source: Metabolism of Cities, UCA Bodø)

The construction companies in Bodø are mainly clustered and close to the city. The actors are construction companies, contractors, entrepreneurs, and construction consultants. The construction sector employs 8% of employees in Bodø.

There is no extraction of building raw materials currently being done in Bodø. Manufacturing of construction materials and products in Bodø spans asphalt, concrete, glass, and insulation materials, along with products such as prefabricated concrete pipes and re-safety doors.

The waste composition excluding clean soil and slightly contaminated soil is shown in Figure 5. Currently most of the demolished concrete is crushed and used as a substitute for backfilling. This has been a positive change during the last years least years, where companies have started to see the value of concrete instead of landfilling.

Recently the local concrete factory has also invested in equipment to use crushed concrete as aggregate substitute in new concrete production.

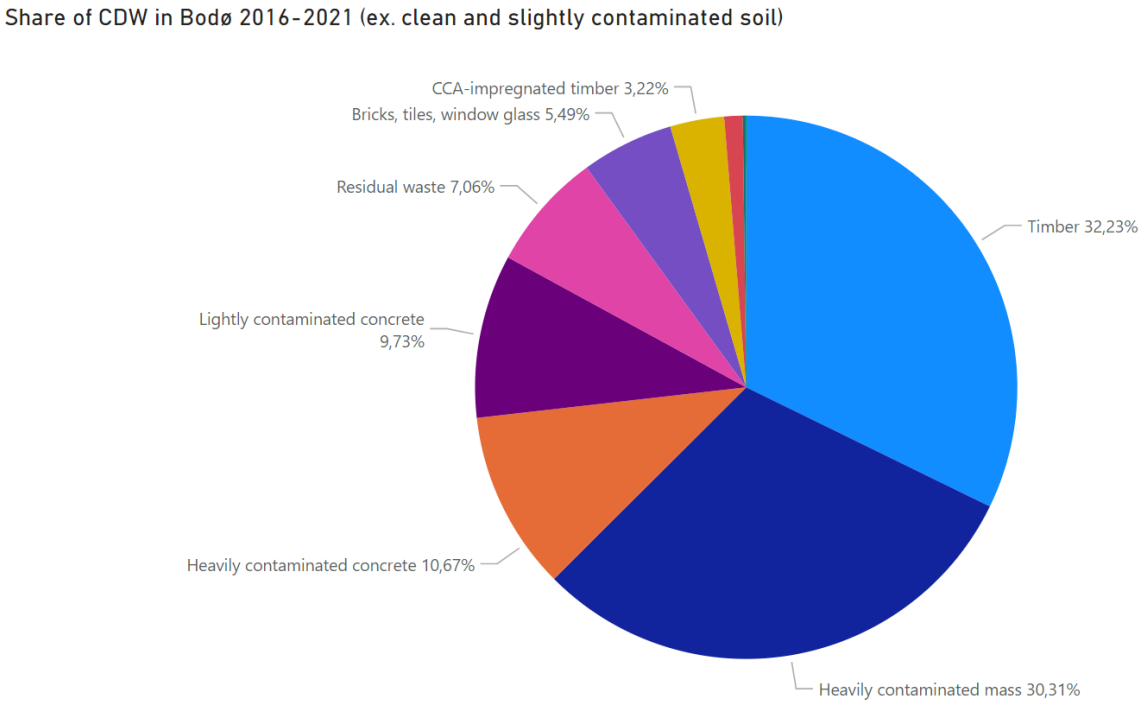


Figure 5 Shares of waste types delivered to waste companies in Bodø between 2016 and 2021. Not including soil.

In Bodø there is no good overview of the reuse of soil. There are however lacking systems for temporal storage and marketplaces for reuse between projects, and we know that much soil is landfilled, much end up in unregulated deposit sites (with good or poor use of the soil) and soil reuse between projects and actors is minimal. In 2023 there are initiatives to facilitate more reuse, where the CityLoops project has been actively involved.

The new airport and city district in Bodø has high ambitions for circularity, low emissions and clean energy, and new solutions for reuse and recycling are needed to meet the ambitions.

2.3 Relevant strategies, action plans, or targets

The large-scale urban development project of moving the airport and building a new city district is called ‘New Airport / New City’. Bodø is influencing the material and mass handling of the process: Less waste, more reuse and repurposing of structures.

The 5 000 000 m2 (500 ha) land currently occupied by the air force has to be cleaned up regarding soil, CDW and other infrastructure. CityLoops has been a part of the process of deciding how all masses and materials on that site are to be treated in a circular manner.

The plans for the project have been postponed from the initial plans when the CityLoops project were started. The new timeline for the project is to start demolishing the military airport in 2024 and move the current airport in 2029.

CityLoops is involved in a crucial time for the huge city development project in Bodø as environmental policies are being set and politically manifested now. In relation to that, a politically approved overall environmental program is prepared. This program is divided into four categories: nature conservation, mass handling, circular treatment of materials, and energy efficiency. CityLoops has been a driver of the work to prepare the mass handling-category but has also been a substantial contributor in the circular treatment of materials-category.

The manifested mass treatment policy consists of these elements:

General

The development of the new airport and the new district of Hernes will lead to the release and movement of mass that must be handled in an efficient and smart way. Mass handling typically entails a lot of transport, construction work and consequently emission of greenhouse gases, particles, and other environmentally hazardous substances. How masses are treated, how masses should be transported, and which type of mass is to be used for different purposes, will thus have a major impact on

energy consumption and greenhouse gas emissions in the construction phase and the need to use new resources.

In order to minimize the need for transport and achieve a high degree of reuse and recycling of masses, emphasis must be placed on to utilize as much as possible of existing masses locally in the urban development area. To handle masses of circular economic way, could result in less extraction on virgin resources. It is an ambition that masses must be able to be classified as resources rather than waste.

Circular treatment of buildings

Buildings are assessed for reusability, and all buildings shall be reused rather than demolished if not necessary because of the construction of the new airport. The buildings that need to be demolished shall be demolished in a way that ensures reuse of the elements in the building, supported by CityLoops methods like selective demolition.

Use of CityLoops instruments

- 3D GIS-based visualisation tools for monitoring and planning
- CityLab (ByLap) stakeholder engagement platform at Bodø town hall
- Life Cycle Assessment for demolition and renovated sites
- Screening procedures and tool for selective demolition
- Wellbeing monitoring tool
- Databank and digital marketplace for recovered materials.
- Instrument for predicting future excavated soil production.

3. Implementation

Bodø is going through a large-scale city development, both with the demolition and relocation of the airport, planning of the new city district and the transition in the current practices to meet ambitions for circularity in the future city.

Bodø municipality is taking part of the CityLoops project to improve circular city planning, circular construction practice and stakeholder involvement in the city planning. The goal of the participation is to develop tools and methodologies and demonstrate in projects to influence the material and mass handling by reducing construction waste and landfilling (soil and CDW) and reuse and repurpose buildings, infrastructure, and structures at the airport.

Initial plans for airport demolition and the new city district were more directly relevant with the CityLoops timeframe. Postponement of the projects have led to less direct impact on the demolition of the airport and implementation of solutions into the new city district, but the objectives of the project has still been fulfilled within the planning processes and with relevant pilot projects.

3.1 Demonstration action 1: Circular material management processes of Bodø military airport

In the large-scale demolition project of the military airport large amounts of materials and structures need 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 practices in the demolishing strategy in the New Airport / New City project.

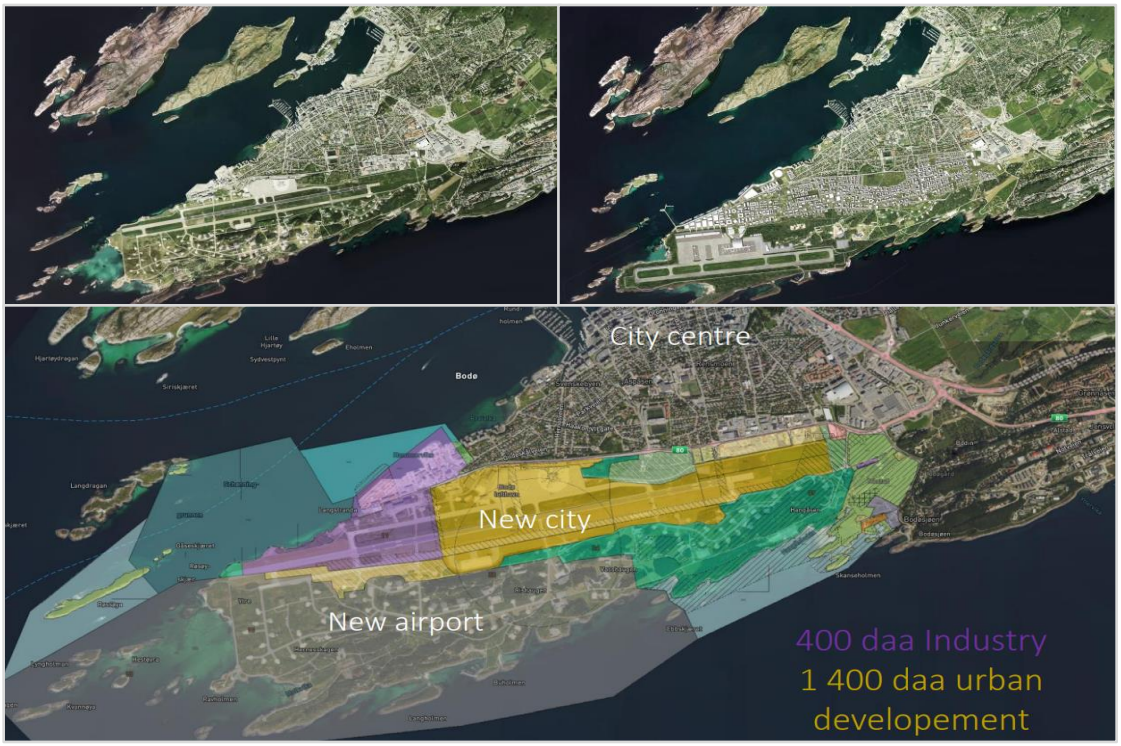


Figure 6 City today (up left); City after relocation and new city district (up right); illustration of area is to be regulated to a civil airport, and which is to be regulated to a new part of the city.

The figure 7 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 has developed, tested, and implemented tools and methods that are supporting the goal of doing this in the most circular and sustainable possible manner.

3.1.1 Activities

Reuse of existing airport terminal building

When the new airport is ready, the ownership of large areas at the current airport will be moved to Bodø municipality. Bodø municipality has ambitions to reuse as many as possible of the existing buildings and make them a useful part of the new city district. The current airport terminal building lies within the first area to be developed and is planned to be a geographic center for the development within this area.

The terminal is a large and architecturally beautiful building of approximately 17 500 m^2 divided over four floors. The facade of the building is protected due to its architectural and cultural-historical value. The building is known for its unique curved shape and its distinctive concrete cladding. In 2014, the building was listed as a protected monument by the Norwegian Directorate for Cultural Heritage, which means that the facade of the building must be preserved in its original state and cannot be altered or rebuilt without approval from the Directorate.

Figure 7. Bodø Airport terminal building

The building is large with a lot of open space, as well as some office areas. To find possibilities for reuse of the building it will be important to consider the desired and possible functions of the building. As a part of this, CityLoops has together with Apeldoorn and Saxion University initiated a building challenge for architectural

engineering students at Saxion university, with mentor students from circular economy at Nord University International Business school in Bodø.

Four groups of five Saxion students were teamed with two Bodø mentor students to evaluate possible use cases for the building and suggest realistic solutions for use of the space, technical aspects, energy efficiency and use of reused materials.

The challenge was done in May 2023.

Airport mapping

- The airport consists of about 4200 concrete plates and 20 shelters. Total amount approximately of 72,000 m3 / 173,000 t.
- 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 and recycled for aggregates in new concrete or recovered for unbound surface layers.
- Some of the shelters will be demolished, while some can be reused for other purposes.
- 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 was done by Saxion university students in 2023.

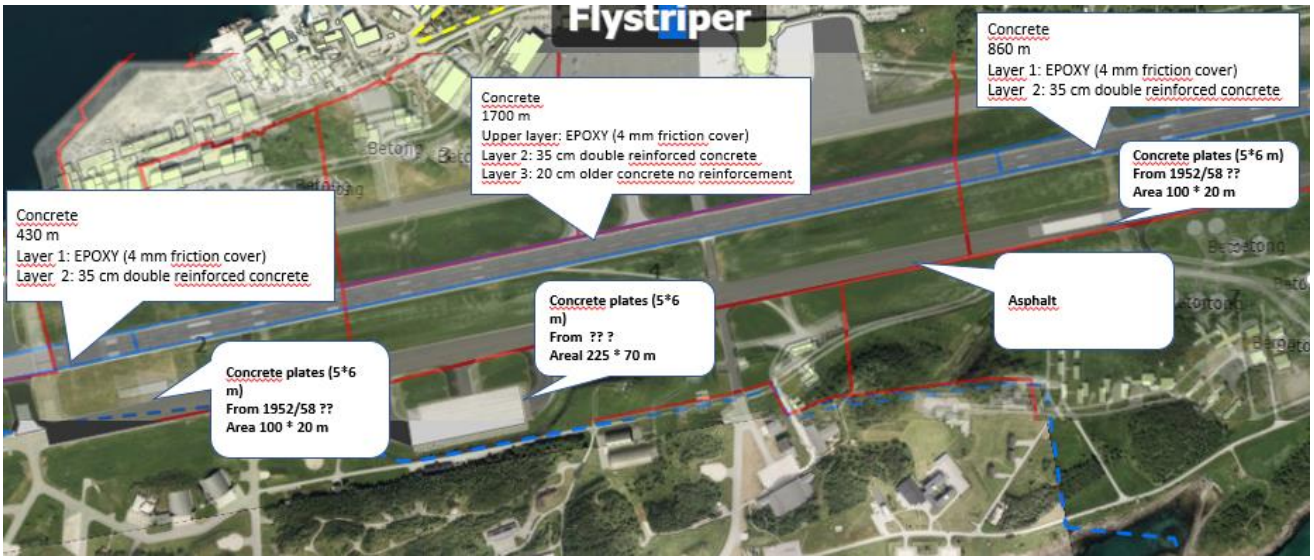


Figure 8. Example of material mapping

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.

Recycled concrete flows from demolition to new construction.

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

Many of the structures at the airport will be dismantled in the transformation of the airport. In collaboration with the CIRCULUS research project, amounts of concrete to be demolished from shelters and other concrete constructions at the airport have been mapped. Two scenarios for use of the concrete were analyzed, described below.

After measuring the amount of concrete on the demonstration site, calculations are made to measure CO2 emission and fuel use on two different scenarios on how concrete could be used and the level of emissions that they would make based on repurposing, recycling, and demolishing, as well as the energy consumption that those might require. Scenario 1 evaluates the option of landfilling all dismantled concrete. Scenario 2 evaluates the option of dismantling and demolition for recycling and use for other purposes, where reuse is done at the airport construction area, while recycling is done at the local concrete factory. Transport is included in both scenarios.

See in the table below the raw data from these scenarios and then the same data visualized into the digital twin in colored bars (where red is demolishing, green recycle and light green repurposing).

	Scenario 1	Scenario 2				
	Demolition (m3)	Demolition (m3)		Dismantle (m3)		Reuse (m3)
		Recycle	Loss	Repurpose	Loss	
Material Quantity (m3)	72349	33243	3929	4168	129	30880
Energy Use (GJ)	13415	6607		190		879
Fuel Use (kL)	373	184		9		45
CO2 Footprint (Ton CO2-eq.)	995	491		23		119
Material Lost	100%		6%			
Material Recovered	0%	46%		6%		43%

Figure 9. Scenarios with raw data

Converting this table to visual data does not only simplify data for city planners, but also enables the data to be communicated in an understandable way to stakeholders. In the figure below we can see the potential emissions from different scenarios and their emissions in case of demolition, repurpose, recycle, etc.

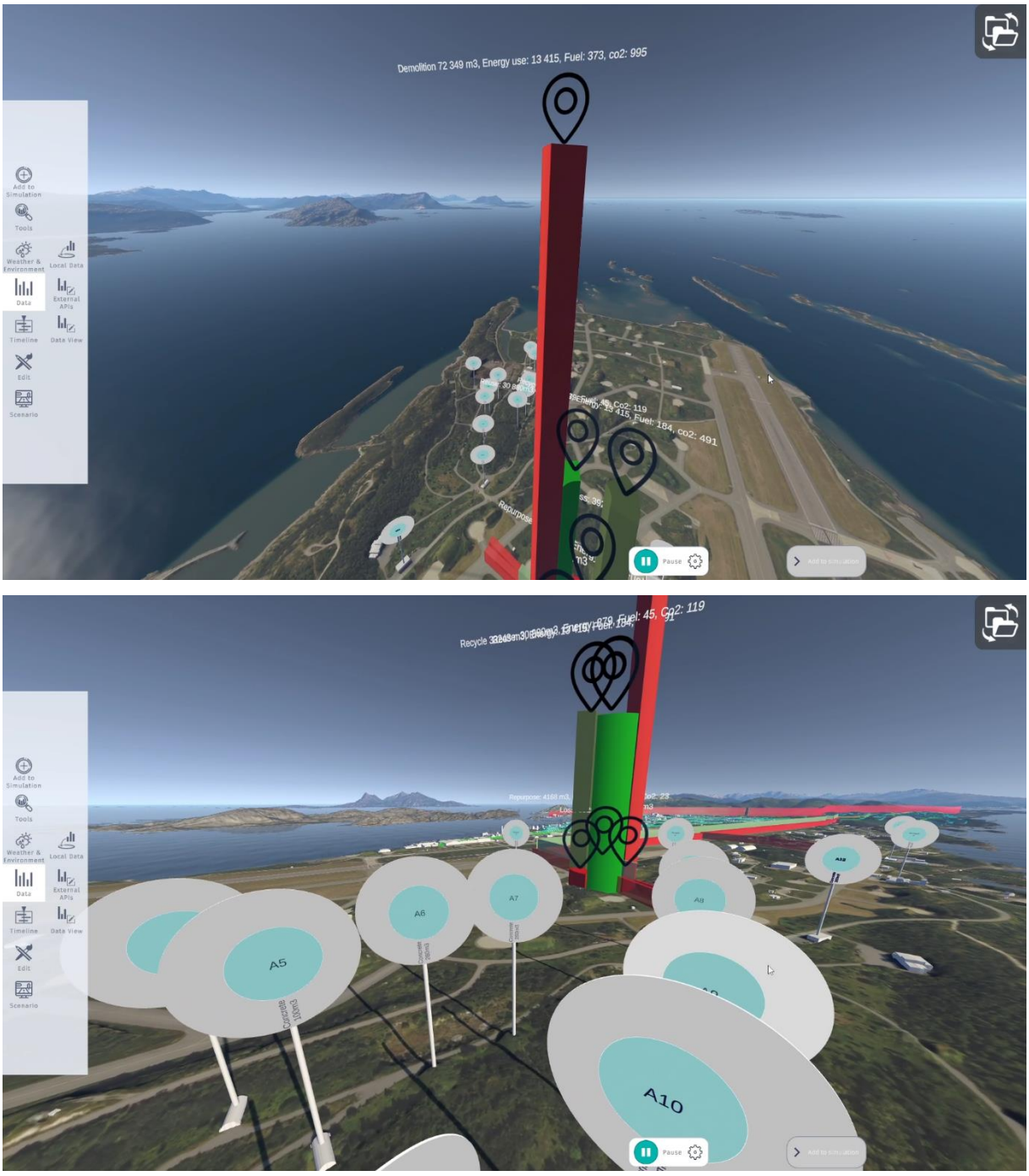


Figure 10. Scenarios with data visualisation in the digital twin, the circle etiquettes show the amount of concrete of each building in cubic meters while the towers show the CO2 emission amounts from different options for a building, like its demolition, recycle, reuse, etc.

3.1.2 Instruments and tools

Use of visualization tool

Digital twin

Bodø has developed the tool no. 11 3D GIS-Based visualisation tool for monitoring and planning, a digital city twin. A digital city twin refers to a computer-generated virtual representation or digital counterpart of an actual city that employs cutting-edge information to create a dynamic and interactive simulation of the city's infrastructure, buildings, and services. A digital model of a city's assets, systems, and processes is utilized by city managers, planners, and stakeholders is used to examine data visually and analytically in order to make informed decisions regarding urban planning, development, and management.

The creation of a digital city twin involves the integration of diverse data sources, including but not limited to geographic information systems (GIS), sensors, traffic cameras, weather data, and social media feeds, into a unified platform. The platform employs advanced analytics and machine learning algorithms to analyse the data and construct a comprehensive model of the physical and social systems of the city.

The digital twin can provide real-time data regarding a city's traffic flow, energy consumption, air quality, and other parameters, allowing city administrators to monitor and optimize urban systems for efficiency and sustainability. It can also be used for urban planning and design, enabling stakeholders to simulate various scenarios and visualize the impact of urban development initiatives prior to their implementation.

The concept of digital city twins is acquiring popularity among city planners and technology companies, as it provides a potent tool for the creation of smart and sustainable cities. By providing a comprehensive view of a city's systems and processes, digital city twins can aid in optimizing resource use, carbon emissions, and enhancing the quality of life for citizens.

Sources:

- “Digital Twins for Smart Cities” by Carlo Ratti and Matthew Claudel, Scientific American, 2017.
- “Digital Twin Cities: What are they and how can they help us?” by Future Cities Catapult, 2021.
- “What is a Digital Twin City?” by IOTA Foundation, 2021.

Power BI

Microsoft's Power BI is a service for business analytics that enables users to integrate, analyse, and visualize data from multiple sources. It offers a variety of tools for transforming raw data into insightful observations, reports, and interactive dashboards.

Users can import data from diverse sources, including spreadsheets, databases, cloud services, and web APIs, using Power BI. Power Query, a data modelling tool that facilitates data cleansing, filtering, merging, and aggregation, can be used to transform the data once it has been imported.

Using Power BI's integrated visualization tools, such as charts, tables, maps, and gauges, users can then construct interactive visuals. These visuals can be combined and customized to generate informative and dynamic dashboards.

Power BI also offers a variety of collaboration and sharing features. Users can collaborate with team members by sharing dashboards and reports, as well as by developing content packs that can be distributed throughout the organization. Additionally, they can share dashboards and reports with external stakeholders via secure URLs or by embedding them on websites or SharePoint pages.

Power BI is a champion in the business intelligence and analytics platform market, according to a report by Gartner, with a strong emphasis on usability and an intuitive interface. It has been extensively adopted by organizations of all sizes and in all industries, including Fortune 500 firms, governments, and non-profit organizations.

Sources:

- Microsoft Power BI: https://Power BI.microsoft.com/en-us/what-is-power-bi/

- Gartner Magic Quadrant for Analytics and Business Intelligence Platforms, February 2021: https://www.gartner.com/en/documents/3992463/magic-quadrant-for-analytics-and-business-intelligence-pla

Archicad

ARCHICAD is a building information modelling (BIM) software developed by the Hungarian software company GRAPHISOFT. It is a powerful tool for architects, engineers, and designers that enables them to create detailed 3D models of buildings and structures, as well as to manage the design, construction, and maintenance process.

ARCHICAD allows users to create a virtual building model in 3D, which can be viewed and edited from different angles and perspectives. The software offers a wide range of design tools, including parametric objects, building materials, and textures, as well as advanced modelling features such as morphs, shells, and beams.

One of the key features of ARCHICAD is its ability to generate detailed construction documentation directly from the 3D model. This includes plans, elevations, sections, and schedules, as well as detailed quantity and cost estimates. The software also supports collaborative work with other members of the design team, enabling multiple users to work on the same project simultaneously.

ARCHICAD has been widely adopted by architects and designers around the world and is recognized for its innovative features and ease of use. In a review by Capterra, ARCHICAD was rated 4.5 out of 5 stars, with users praising its powerful design tools and advanced BIM capabilities.

References:

- GRAPHISOFT ARCHICAD: https://www.graphisoft.com/archicad/
- ARCHICAD by Capterra: https://www.capterra.com/p/155338/ARCHICAD/
- “ARCHICAD 25: The Next Generation of BIM” by BIM+, 2021: https://www.bimplus.co.uk/news/archicad-25-next-generation-bim/

ArcGIS

ArcGIS is a geographic information system (GIS) software developed by Esri; a software company based in California. It is a powerful tool for managing and analysing spatial data, enabling users to create, edit, and analyse maps, as well as to share and publish them online.

ArcGIS provides a wide range of tools for working with geospatial data, including data management, visualization, and analysis. It supports a variety of data formats, including shapefiles, geodatabases, and web services, and allows users to combine data from multiple sources to create custom maps and spatial analyses.

One of the key features of ArcGIS is its ability to perform advanced spatial analyses, including spatial statistics, network analysis, and 3D modelling. The software also includes a range of mapping tools, including base maps, symbology, labelling, and annotation, that enable users to create professional-quality maps.

ArcGIS also includes a range of tools for collaboration and sharing, enabling users to share maps and data online through web applications, mobile apps, and social media. The software supports integration with other Esri products, as well as with third-party applications and systems.

ArcGIS is widely used by organizations and individuals around the world for a variety of purposes, including urban planning, natural resource management, environmental monitoring, and emergency response. According to Esri, ArcGIS is used by over one million organizations in more than 200 countries.

References:

- Esri ArcGIS: https://www.esri.com/en-us/arcgis/products/arcgis-online/overview
- “What is ArcGIS?” by GIS Geography, 2021: https://gisgeography.com/what-is-arcgis/
- “ArcGIS Desktop Review” by G2, 2021: https://www.g2.com/products/arcgis-desktop/reviews

Technical and physical requirements

In order to replicate Bodø's activities in CityLoops, Task 2.7 Tool 11, it is not necessary to be in possession of the tools described above, however, it is necessary to use tools that can geographically place data. In extension of this, the replicator should be in possession of a software that can manage data, like Microsoft Excel.

Equipment

To run complex data analysis and processing tasks, it is often necessary to have a computer with sufficient processing power, memory, and storage capacity.

For instance, software applications like ArcGIS or Power BI can require a quite capable computer to handle large datasets and perform complex analyses. To run ArcGIS, Esri recommends a computer with a 64-bit operating system, a multi-core processor, at least 8 GB of RAM, and a dedicated graphics card for 3D modelling and visualization. Similarly, for running Power BI, Microsoft recommends a computer with at least an Intel Core i5 processor, 8 GB of RAM, and a dedicated graphics card for optimal performance.

Other software applications, such as ARCHICAD, may also require a capable computer for running advanced 3D modelling and visualization tasks. In general, the specific system requirements for a given software application will depend on the complexity of the analyses being performed and the size of the datasets being used.

The provider of the digital twin recommends a computer with at least an Intel Core i7 or equivalent processor, 16 GB of RAM, and a dedicated graphics card for optimal performance.

References:

- ArcGIS System Requirements: https://pro.arcgis.com/en/pro-app/get-started/arcgis-pro-system-requirements.htm
- Power BI System Requirements: https://docs.microsoft.com/en-us/power-bi/fundamentals/desktop-system-requirements

- ARCHICAD System Requirements: https://www.graphisoft.com/support/system_requirements/archicad-25/

Technical architecture digital twin

The architecture of the digital twin is represented in the illustrations under. In addition to the data sources presented in this model, other “ad hoc” data sources are used, like research data (e.g., CIRCULUS project), data from building consultants (BIM), sample data (NGI), architectural concept data (ref. architect competition).

In ArcGIS, Shapefiles (.shp) is generated and distributed to the digital twin. Shapefiles have been used to visualize noise zones from the demonstration project:

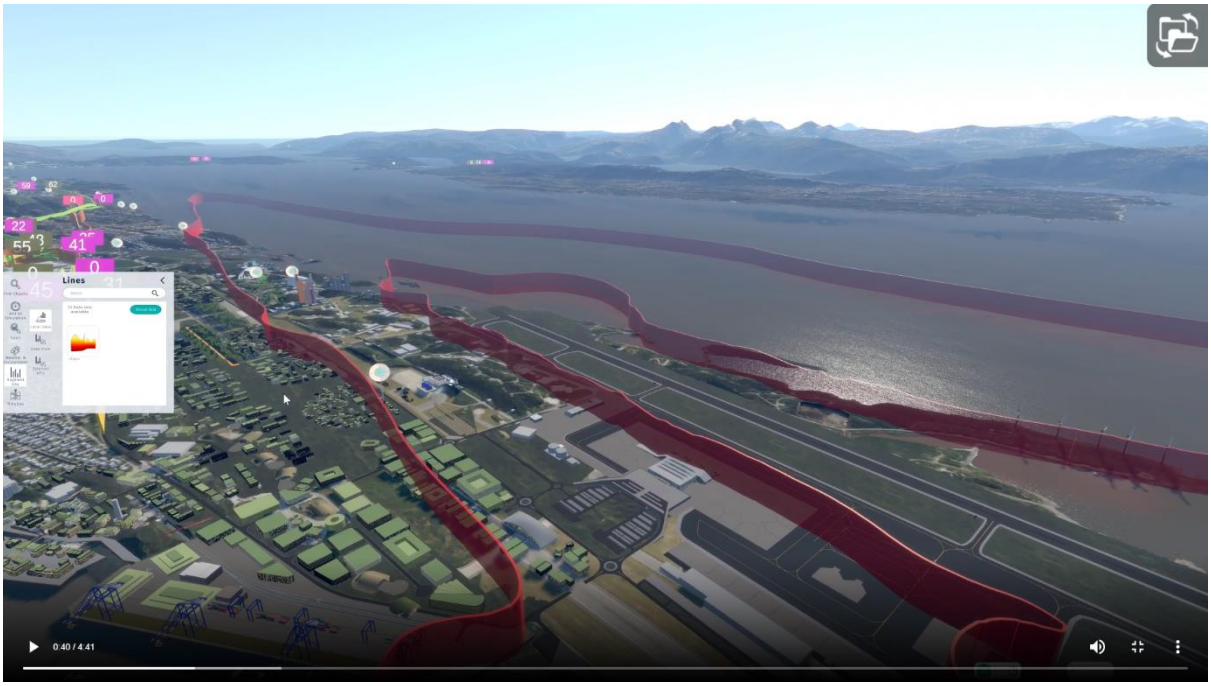


Figure 11. Noise zones visualized over a 3D-model of the future airport.

Furthermore, shapefiles are used to create hypothetical roads from demonstration site and pilot sites to evaluate how they would affect existing infrastructure, traffic, emission, dust, and noise:

Figure 12. Shapefiles that illustrate different mass transport alternatives from pilot site.

Architecture digital twin

The technical architecture of a digital city twin typically involves a variety of hardware and software components working together to collect and process data about the physical city and create a digital representation of it. In our specific case the architecture is illustrated in these models:

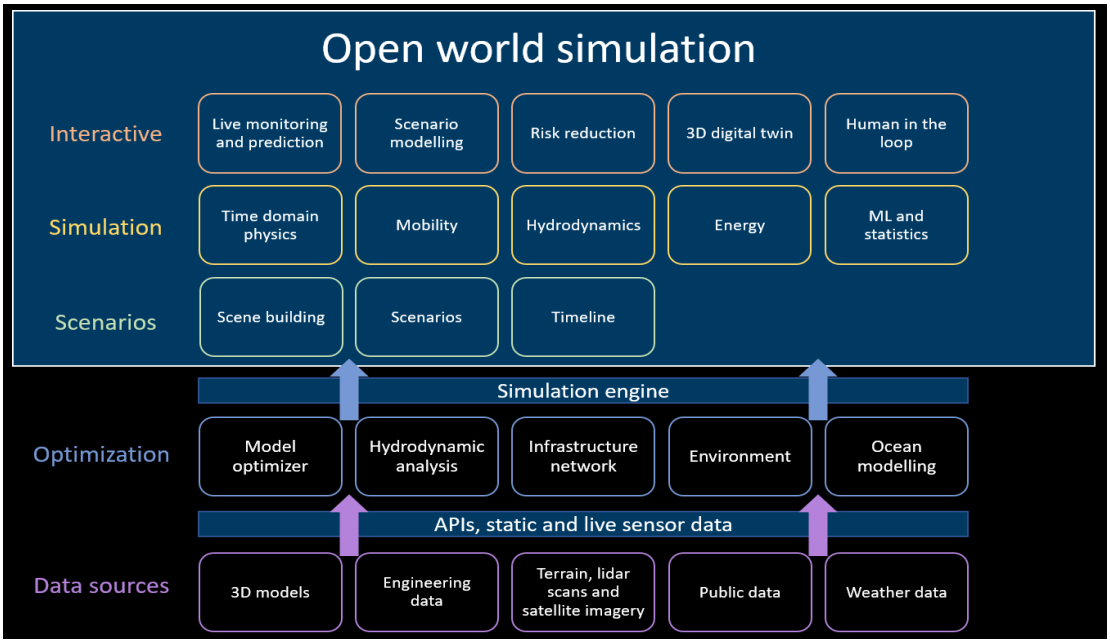


Figure 13. General architecture

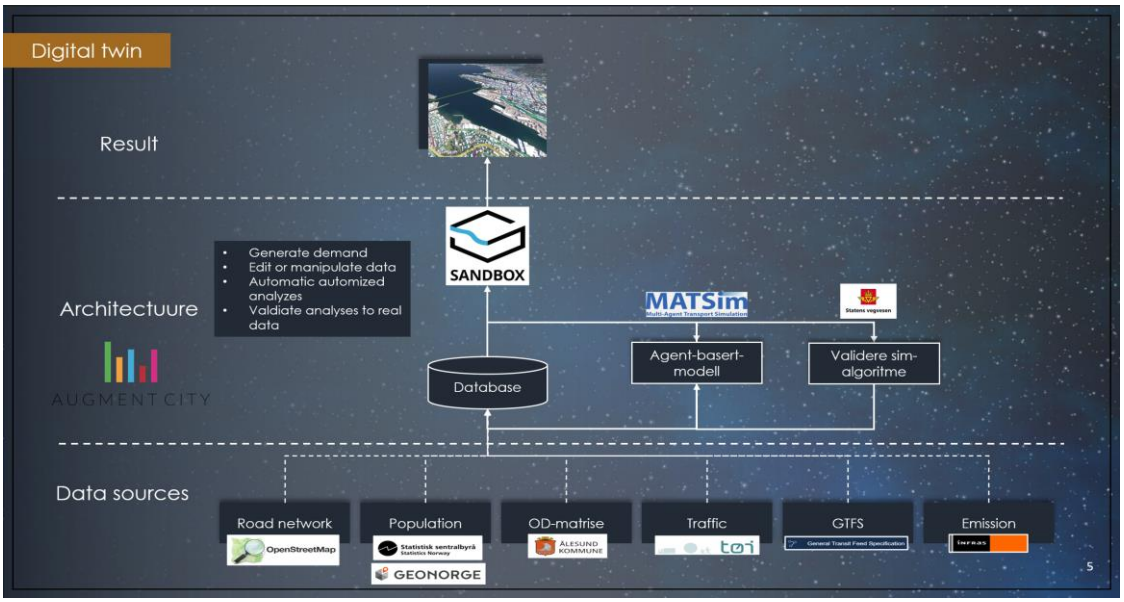


Figure 14. Architecture digital twin

Data gathering

Data for visualization has been gathered from different sources, including these:

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 (figure 15), and the dashboard will automatically update. Visualisation 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.

- **Method**: Sampling from the whole demonstration area, including from masses underneath the surface. What masses consist of, it's degree of pollution and it's reuse potential is identified.
- **Collaborator(s)**: Norwegian Geotechnical Institute

- **Tools used for visualisation**: Power BI, Augment City Digital Twin
- **Usage**: Used for mass treatment planning. Analysis necessary 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 on 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:**

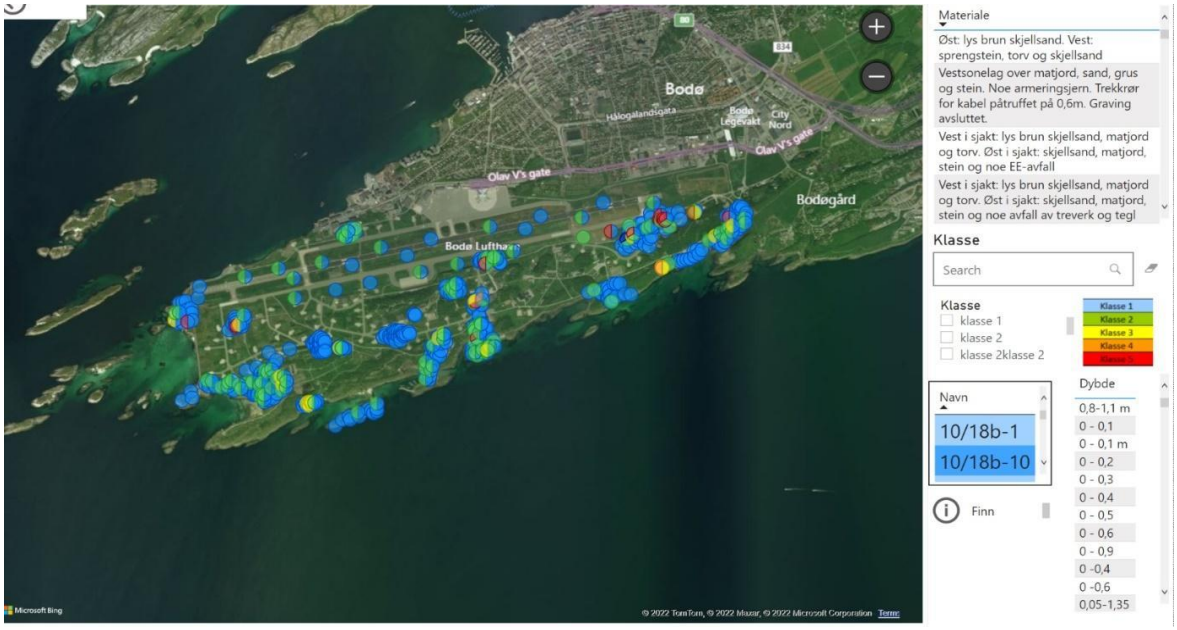


Figure 15. Excerpt from Power BI Dashboard showing levels of polluted soil masses by colour and their location.

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 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 organisations have that in their

Office 365-license. Power BI typically relates to data formats that's available for most organisations (.xls, .csv, .txt, databases (like azure, sql, aws)). Basic data management skills are recommended.

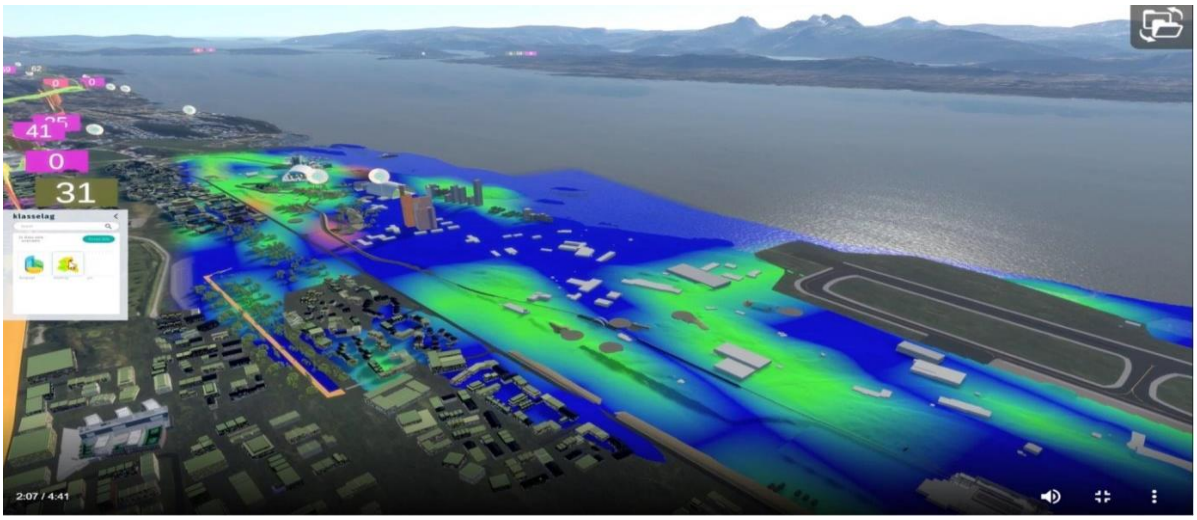


Figure 16. Excerpt from Power BI Dashboard showing levels of polluted soil masses visualized in the digital twin.

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. Visualisation of data from "sister" project CIRCULUS.
- **Tools used for visualisation**: Power BI, Augment City's Digital Twin
- **Usage**: Used to get an overview of buildings that needs to be demolished, and buildings where that's not necessary, what materials they consist of, its quality, and reuse potential. Data gathered is presented in detail in the 3D visualisation tool. Presenting e.g., the amount of concrete on demonstration sites assists city planners in planning of reuse of the concrete.
- **Example**:

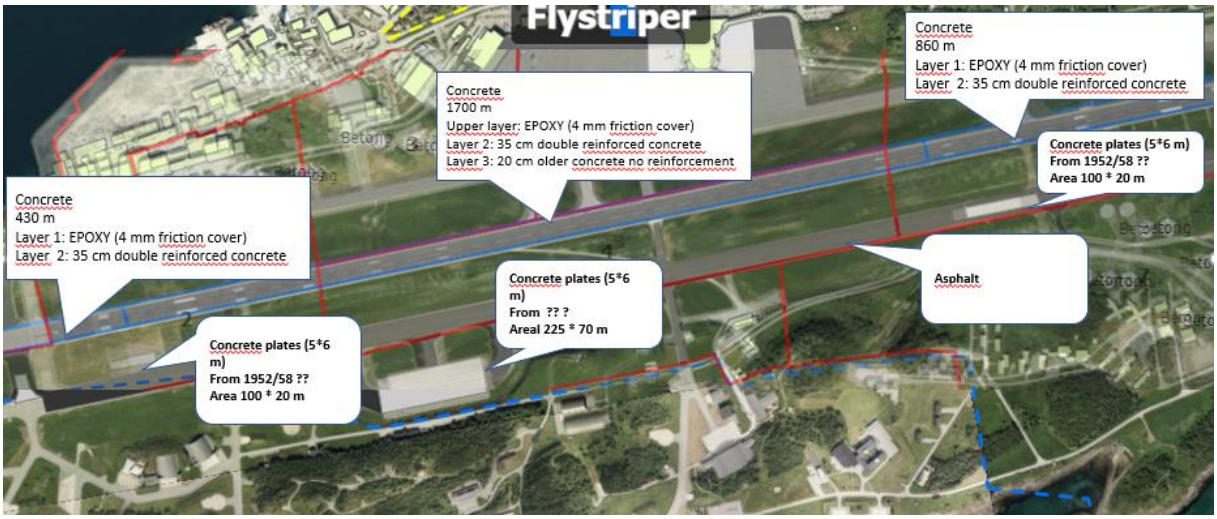


Figure 17. Excerpt of data of materials in airfield runways before visualization in digital twin

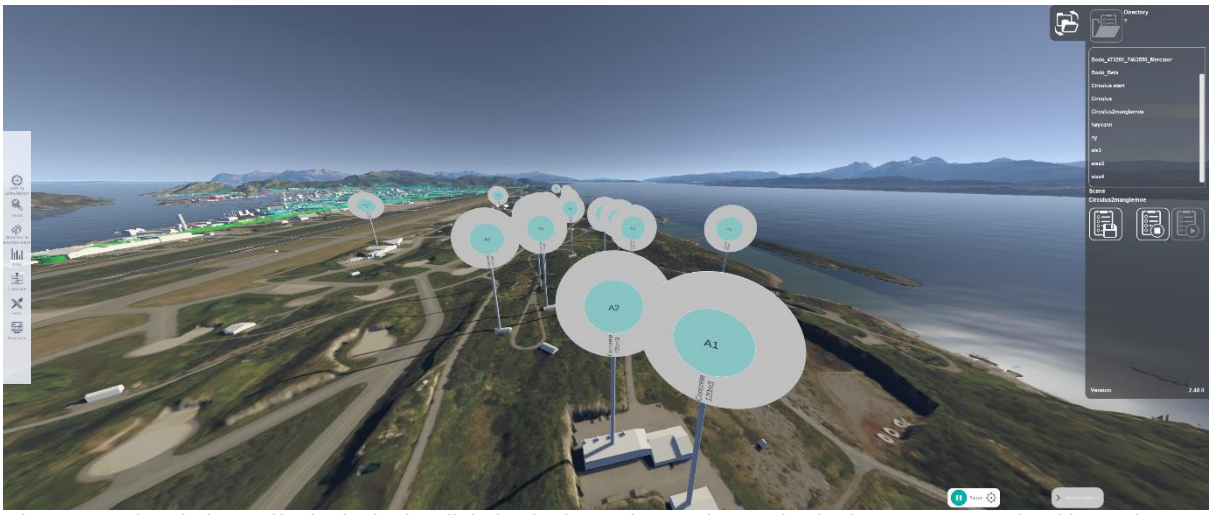


Figure 18. The circle motifs depict in the digital twin the various volumes (m3) of concrete contained by various structures.

Figure 19. visual representation of CO2 emissions from different scenarios on treatment of concrete on demonstration site.

Visualisation 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 how much traffic load it is on the different streets in Bodø. This information is combined with the CityLoops *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, visualisation 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:

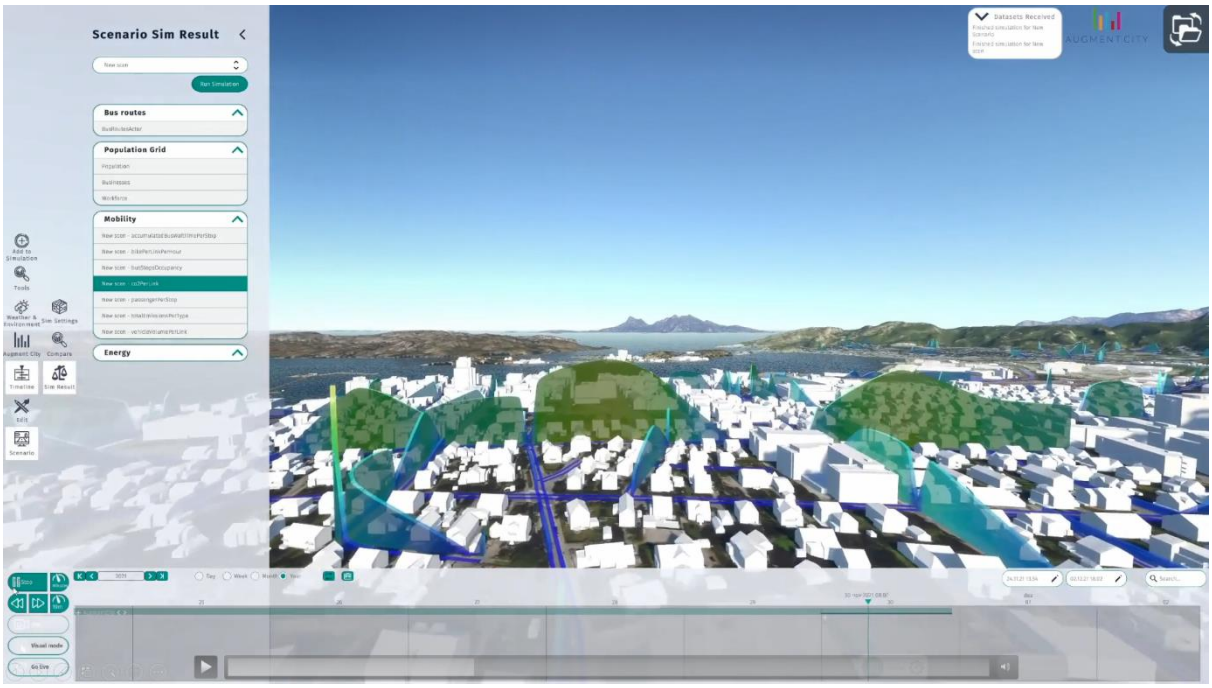


Figure 20. Size of the bars represents CO2-emission (correlated with traffic) on pilot project for demonstration project. LCA-tool used.

This helps us identify which routes are best for mass transport.

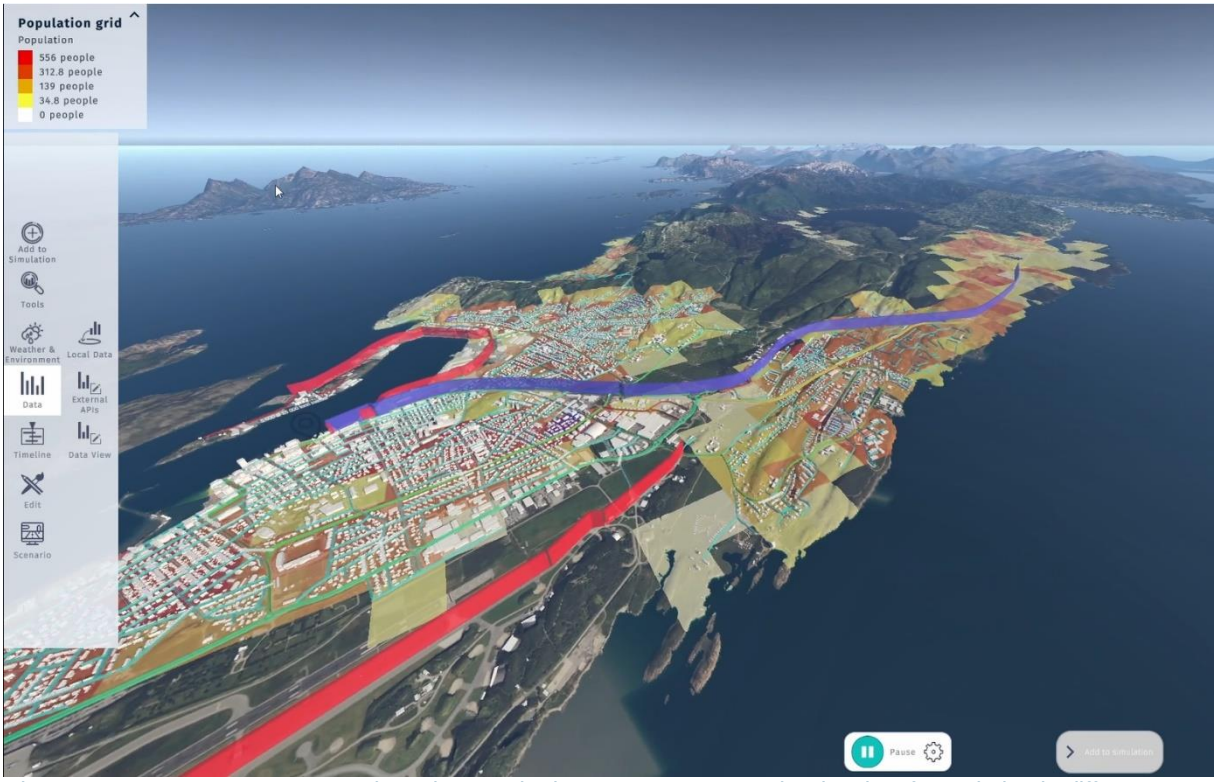


Figure 21.Mass transport routes. The colour on the heatmap represents the density of population in different areas. The red stripe shows the distance between the pilot project and the intermediate storage facility and the blue one a longer distance to the waste management facility.

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 placed nearby 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. Visualising 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 visualisation, as it is necessary to plan long term in building the new part of the city and the new airport.

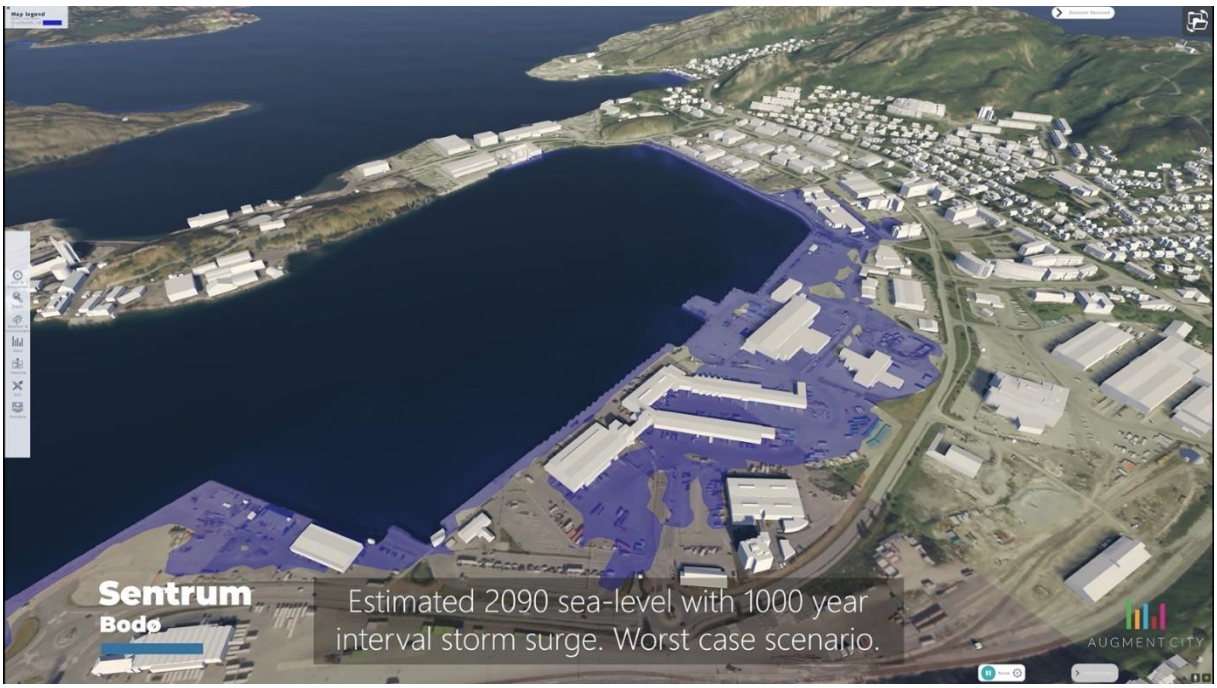


Figure 22. Visualisation of sea level rise, estimate based on statistics.

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.

Instruments for circular soil handling – incl. CO2 calculation

- Mapping soil pollution and quality
    - Visualized in 3D model and Power BI
    - Used CityLoops soil LCA calculator to visualize emission from transport.
- Mapping structures
    - Mapping of structures for use for other purposes, and visualizing it in 3D model

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 centre 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.

Potential assessment of the terminal building

- As we can see this tool can help us to evaluate different scenarios and current data, the terminal building project can be as well supported by the use of this tool to evaluate different structures that have reuse potential, design different scenarios and city plans for the new district, how to incorporate old structures into the new design and follow up of construction projects that provide the best solution for energy efficiency, reuse, repurpose and recycle materials where possible.
- Different 3D visualizations that can as well showcase weather conditions are especially important for city planning as Bodø is located above the polar circle in the arctic region, and therefore highly impacted by weather changes or conditions.

Testing CityLoops pre-screening tool

CityLoops in Mikkeli has developed the projects pre-screening tool purkukartoitus (image below) for mapping of waste and reusable materials in a building, and Bodø is testing the tool on a school which is to be demolished (Løding skole) before a new kinder garden will be constructed shortly after.

A good reuse mapping with good availability and overview of the reusable materials is an important factor to enable the reuse in practice. The tool was therefore being tested to evaluate its functionality to document the reusable materials, document the necessary information for a material passport for the materials and give overview of reusable materials in the project.

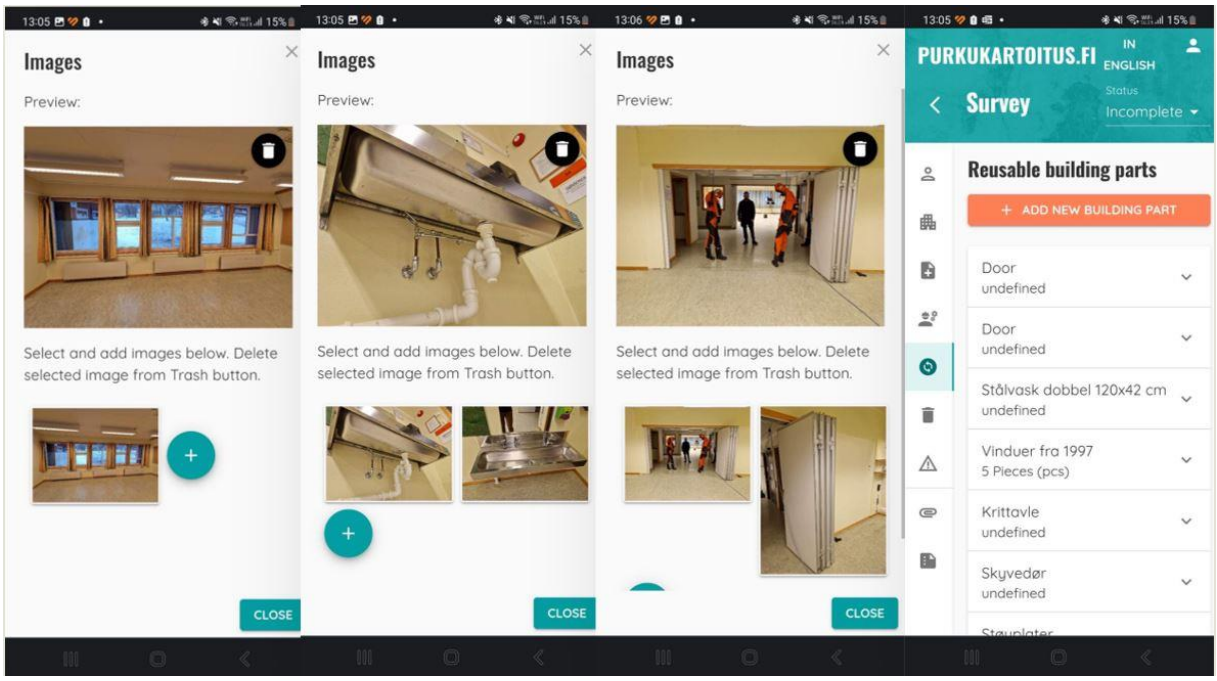


Figure 23. Use of the pre-screening tool Purkukartoitus.

An initial test was done at the school within the CityLoops project, evaluated to be a useful tool. It will however be further tested together with the construction department, the develops the local material use market (Iris). An organization which is interested in using the materials that will not be used by Bodø municipality itself.

Figure 24. From left to right, outside view of the school, inside of a classroom, entrance to a venue, police using the installation as a training facility.

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 for 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 is interested in testing the marketplace for reuse of municipal furniture to see if it is functional for larger scale use of building materials.

3.1.3 Lessons learned.

Shortcomings with digital twin

While the 3D Tool for monitoring and planning is working excellent for scenario building presenting complex data in an understandable way, to identify correlations between several factors and to communicate externally and internally, the system has some shortcomings in making data calculations. Therefore, systems like Power BI and ArcGIS are used in conjunction with the digital twin. This means that in some cases, data management has been done in this order: Data source – data management tool (Power BI) - Digital twin. It would strengthen the tool if the data management could be done directly in the digital twin – this would further enable the tool to be used in analytics tasks.

3.2 Demonstration action 2: Stakeholder and citizen involvement in city development by use of innovative tools

The large “New City / New Airport” project has three main actors: the military, Avinor airport and the municipality. The citizens are a large interest group. Bodø has included the stakeholders in the transformation of the airport and the new city from the beginning. They want the professional stakeholders (e.g. construction consultants, entrepreneurs, architects) to engage in dialogue on practices of screening and selective demolition. Bodø has involved both professional stakeholders and citizens in a dialogue on how to repurpose and prolong the lifetime of existing buildings and materials when designing the new city.

3.2.1 Activities

Stakeholder involvement

Stakeholder / Citizen involvement

- Involve citizens in the development of the new city district.
    - Involvement through events and campaigns to find and design the solutions for the new city in models, 3D-visualization, and Minecraft (computer game)
- Establish internal alliances and strategy between departments of environment, urban planning, and communication in Bodø Municipality
    - Network for circular soil management and working groups for circular procurement and circular construction.
- Convene and facilitate a local circular economy ecosystem of business, industry, civil society organizations, research entities and public actors.

- Conferences, events, and workshops about circular construction with all stakeholders above.

- 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.

- There have been collaboration as different city projects for example “Smarter Transport Bodø” and “New City New Airport” have emphasized that Bodø municipality’s priorities lean towards the environment, circular economy, seeking opportunities for waste materials, recycling of concrete and diminish emissions while at the same time involving stakeholders and using digital tools for better planning.

«The world's» smartest city

A smarter Bodø is all about putting people in the centre of attention. The aim for a smart city and municipality is to improve the quality of life for the inhabitants by utilizing new technology.

But it is also about creating change through involvement. These processes have to be anchored in a sustainability perspective, and Bodø shall have a role in implementing the green shift. The future of Bodø shall be developed in a cooperation between the municipality, the inhabitants, business and industry, institutions and volunteers. The inhabitants shall be involved in order to highlight needs and wishes. In this way, we will encourage creativity, involvement and a sense of community. This will create support and legimitacy to the selected solutions.

In both of the big development projects, «New City – New Airport» and «Smart Bodø», the municipality is working actively together with many national and international partners in order to develop innovative project initiatives. All of the projects share a strong connection and degree of innovation and they are often involved in full scale pilot testing.

The municipality of Bodø is involved in several R & D projects under the Smart Bodø umbrella. These are connected to energy efficiency projects in existing buildings, circular economy and waste as a resource. Examples of this are projects within sustainable renovation in the existing city (temporary storage of waste in pressure containers below ground level) and cleaning and recycling of concrete connected to «New city – new aiport». Bodø municipality is also working on a project on sustainable freight transport in Bodø, which represents an important part in strengthening Bodø's position as an intermodal transport hub also in a low emission society. Bodø airport is already a designated pilot for autonomous plowtrucks and remote operated control towers. In additon to this, a new, modern and smart airport will be built in Bodø during the years 2024 to 2026, and the ambition is to be an exhibition of future oriented technology, logistics and innovation.

Artificial intelligence already plays an important part in Bodø municipality's city planning and the planning processes shall be 100 percent digitalized. Furthermore, artificial intelligence will be relevant in CityLab Bodø – a physical and virtual lab – which will be set up at Stormen library during the spring of 2018. CityLab Bodø shall facilitate the citizens' involvement in the development of a smart city today and in the new city area in the future. For example, CityLab Bodø enables the municipality to involve the inhabitants in the planning process in a totally new way. The inhabitants will for instance have the opportunity to «see» proposed solutions and planning documents by using HoloLens.

Figure 25. Extract from the Smarter Transport Bodø plan from Nordland's County.

Source:https://static1.squarespace.com/static/5b68390de74940b2c83a8101/t/5dcbf5ec37b5697e37471bbe/1573647872659/Smarter_Transport_Bodoe_English_Edition.pdf

Theses

In addition to challenging MSc-students on these themes, CityLoops representatives from Bodø Municipality have held guest lectures at the university. The collaboration with Nord University has had several fruitful results, including: three master theses:

Figure 26. Front pages of theses written in collaboration with the CityLoops project

CityLoops Tool 12 – CityLab (ByLap) Stakeholder engagement platform at Bodø town hall.

The Reuse Lab - Citizen's involvement

The inhabitants of Bodø are important stakeholders in the new city and new airport project. Needs and preferences of the citizens are connected to the outcome rather than the building process. The focus of the citizens involvement is therefore focused on design of solutions in a sustainable new city to be built. They were invited to imagine and build concepts or parts of the new part of the city based on circular principles, for that reason, used household waste and materials were the departing point for them to

generate a physical model their ideas for the use of waste in construction projects such an in the images shown below:

Figure 27 The Reuse Lab were arranged two times. The first time the library served as a CityLab, the second time Folkets hus (The people's house) were the arena for the arrangement.

Process:

There has been a strong collaboration with Nordland research Institute as well as funding application from the Norwegian research council, that founding was used to pay a compare RE Innovasjon, as they gather waste and they plan to reuse it with clean and ready to use materials. The initiative was promoted on social media (Facebook, LinkedIn and Instagram) and two local newspapers Bodø Nu and Avisa Nordland, then they received the concepts and feedbacks from the city lab and presented it to the decision makers in the municipality.

Collaboration: Initiated collaboration with Nordland Research Institute as an academic partner, and Re Innovasjon as an operational partner that contributed with household waste.

Participant engagement: Contacted local newspaper to promote the arrangement. Schools were contacted directly. An arrangement on social media was created and shared through LinkedIn, Facebook and Instagram.

Outcome and values: The arrangements resulted in inputs from citizen on how the new part of the city can look. The value of this is not only a contribution to what citizens wanted to be prioritized for the city development, but also a signal of citizen involvement.

Competence forum

The construction sector is a key stakeholder in a sustainable and circular construction of the new airport and city. The relevant actors in the construction sector include contractors, building entrepreneurs, demolishing companies, consulting companies, technology companies, retailers, waste companies and more, consisting of a high number of small to large actors with varying ambitions within circularity and sustainability.

Process: To get in closer contact to the sector, understand the current status and identify relevant actors, Bodø municipality initiated a forum for all involved actors in the construction of the new airport, called Kompetanseforum (Competence forum). Many of the relevant actors were identified to be hard to get to join long seminars and activities outside their main working field, and it was decided to keep the forum as concrete and relevant as possible and to keep them to less than half a day. The scope of the forum was decided to be sustainable city development, and thereby larger than only circular construction, to be able to fit the needs of more actors.

The forum was to be tested for one year, during 2022, before evaluating if it should be kept alive. A budget of approximately 15 000 EUR was dedicated by Bodø municipality to arrange a series of events, involve the right participants, and invite the most relevant competence in research and development within the field in Norway to share their knowledge.

Four events were conducted during 2022, with the topics: Overall environmental goals of the new city and new airport; zero emission construction and city development; building material reuse; and energy efficiency. Each event consists of presentations about the topics relevance for Bodø, presentations from some of the foremost

researchers on the field and a workshop/discussion of how the sector can work in the field in Bodø new city and new airport.

Prior to the events communication with the sector was important to concretize the topics to be interesting. As complete as possible lists of companies and people that should be interested in the topics were created, and much work was made to reach out to the participants by email or phone to invite and discuss. Participation forms were sent to the list before the event. A week before the event the participant lists were evaluated and the relevant participants that were not registered were contacted and reminded. Spending time on invitations and discussions prior to the event has proven to be a key to a successful event.

The **material reuse event** was arranged as a continuation of a seminar about circular construction in Bodø. The competence forum was arranged as the last part of the day, inviting representatives from establishing systems for reuse mapping, evaluating reuse potential for segments of building materials, experience from material marketplace from a different city and from reuse in large building projects. The last part of the event was set up as a workshop. The overall goal of the event was to get an overview of the current state of mind of the sector, to identify current initiatives and to get the discussion started in the sector.

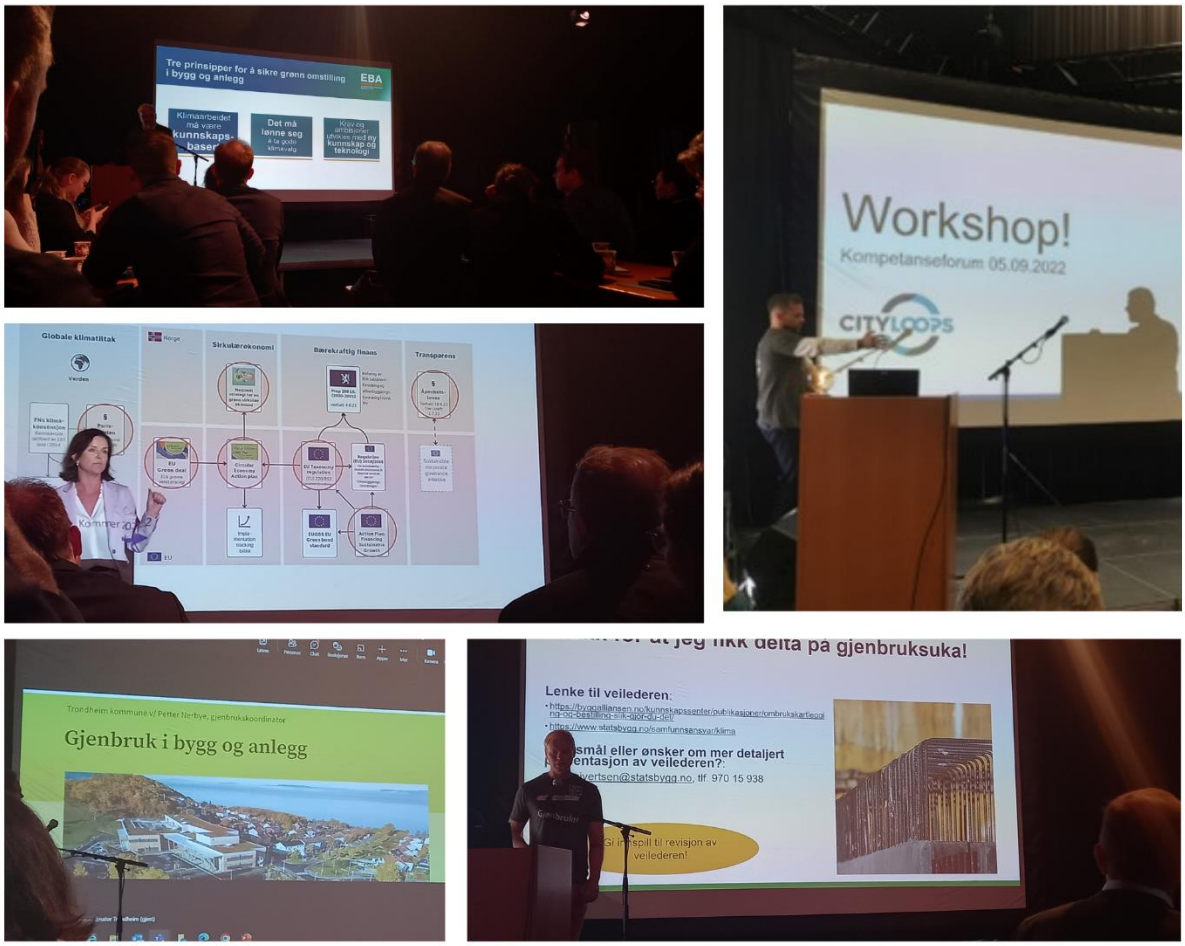


Figure 28. Images from different participants during the competence forum.

Collaboration: A team consisting of representatives from different departments in the municipality, including the New Airport New City Teams

Participant engagement: CityLoops Stakeholder analysis used as a contribution for selecting special invitation to actors in the relevant sector.

Outcome and values: Input from stakeholder with possession of relevant competence on how a market for reuse can be established.

Procurement workshops

Internal and external stakeholders, public and private, have provided the project with inputs that have been important in the preparation of a green and circular procurement policy in the municipality.

Process: an invitation to relevant stakeholders was sent to initiate the discussion about how procurement could be used as a tool to stimulate the acquisition of products and services considering to a higher extent aspects related to sustainable development and circularity.

Figure 29. The second procurement workshop. New procurement strategy is evaluated.

Collaboration: Departments from the municipality, including the building & property dept., technical dept., New Airport-team, and procurement dept. participated.

Participant engagement: CityLoops Stakeholder analysis used as a contribution for selecting special invitation to actors in the relevant sector.

Outcome and values: Inputs and comments on new procurement strategy from experts and stakeholders.

Internal network Bodø municipality

Internal logistics and not well-established communication paths within the municipality, this is identified as an important barrier to increase circularity in the municipalities own building projects.

Process: Understanding how the internal processes and how they relate, as well as trying to increase the degree of communication within and with other departments was a big part of this action.

Collaboration: The work with road and infrastructure constructions and building constructions is divided in two separate departments. To ensure robust integration of sustainability development work, formal internal networks with regular meetings have been established.

Participant engagement: The networks are focused on circularity, climate gas reduction and sustainability, and include representatives from planning, implementation, procurement, and development departments.

Outcome and values:The network with road and infrastructure has been a successful way to understand different perspectives and integrate sustainability in projects and municipal strategies, but it is a job that needs continuous development and strong communication.

New City Festival

Survey conducted by Bodø municipality and CityLoops where the goal was to identify how Bodø's inhabitants wanted to new part of the city to look and function. Results were interpreted, visualised using the 3D tool, and presented at the New City Festival in 2020.

Figure 30 Visualisation of architect's made concept using digital twin, extract from local newspaper. Translation: Look at the pictures – this is what the people want. Source: local newspaper

Process: Create an online survey and distribute it to all citizens of Bodø using digital support, as well as interpreting the results with a 3D visualization tool.

Collaboration: Communication department and New City Team

Participant engagement: Social media and newspapers.

Outcome and values: Inputs and comments on how citizens want the city to be developed. This data was modelled for the 3D Tool.

North Norwegian Europe Days in Bodø

Created awareness of the importance to be ready for innovation for the green transition as part of a series of conferences in Norway that involved citizens, private sector, academia, and public sector employees. In the panel called:

How can northern Norway realize its potential in Europe's green transition through public-private cooperation?

There were a set of discussions about generating value for society and its implications, how to do public and private cooperation happens in practice, innovation as an engine for the green transition, and it was emphasised a call for action from everyone who participated.

Figure 31. Participation in the Northern Norwegian European days conference

For more information you can find the program here:

https://www.northnorway.org/europadager-2022/bodo-programbeskrivelse/

Tekna conference

Tekna is a Norwegian organization for members who have a master's degree in technology, science, or natural sciences. They have about 100,000 members work every day to solve society's challenges through innovation and new technology. According to their website, Tekna is the largest master's association in Norway, and the largest association of academics.

CityLoops participated in the conference with the name:

Technology, sustainability, and innovation in Bodø municipality

It was presented at the centre for sustainable development in Bodø, called Kraft., the set of presentations were related to why it is important for the city to reach the goals, how we can use technology to reach the SDG, how the CityLoops project can help to reach those objectives. A demonstration of how the digital Twin works and what it can be used for, the successful case for Emission-free construction site, urban development projects, the material flow analysis in Bodø, and how to use technology for urban farming supported by entrepreneurial actions.

Figure 32. Collage from the presentations held at the Tekna conference.

For more information you can find the Tekna program here:

https://www.tekna.no/kursarkiv/44000/teknologi-barekraft-og-innovasjon-i-kommuner-i-bodo-kommune-44791/

Minecraft challenge

The city's younger generation were challenged to create their new city concept in Minecraft, taking into account the municipality's priorities regarding circularity and other environmental factors like emission free construction zones. The results were presented, and an award was given to the best solution. The best solutions are presented to politicians and decision makers in Bodø municipality.

Figure 33. The terminal building, built in Minecraft.

Process: Use expertise to create a model of the new city area and the terminal building

Collaboration: Technical dept. and communications dept..

Participant engagement: Social media and newspapers.

Outcome and values: Inputs and comments on how citizens want the city to be developed. Citizen involvement.

Academic collaborations

Nord University, Norway

CityLoops has formulated a set of municipal problems and challenged university MSc-students to come up with solutions to this. Some of the problems stated:

Case 1

You are asked to give an advice to project manager of city of Bodø that is planning to build a huge, new public building. Their ambition is that this building shall be made solely of reused materials (you can consider e.g. construction and demolition waste project (CDWP), namely Bodø, New City – New Airport project). Please discuss and

analyze how this can be done, and identify opportunities and barriers in operationalizing such ambitions?

Keywords: reuse, materials, SWOT, public procurement, circular economy principles

Case 2

The city of Bodø needs an overview over where potentially reusable resources that are located in the city. With the ambition of being more circular city, Bodø aims to utilize technology (ICT) to larger extent. Please discuss and analyze how technology, like visualization/digital twin can be used to get insights on the location and amounts of a city's resources that can be reused?

Keywords: digital twin, sustainable technology, data, visualization. circular economy principles.

Case 3

The city administration wants to develop part of the city with zero CO2 emissions and plan that it will be an energy saving area. Describe and analyze how the excess of energy as a part of circular economy can be transferred to other consumers in this area (e.g. companies, organizations, individuals) and in what ways this excessive energy can be re-used.

Keywords: zero CO2 emissions, excess of energy, cycle of energy flows, circular economy principles.

Case 4

The city administration wants to be more circular. The city does however lack of knowledge on how exactly circular the city is. Please discuss and analyze how would you perform a scan of Bodø to identify its degree of circularity?

Keywords: circularity scan, city metabolism, circularity degree.

Case 5

The city of Bodø is planning to improve its practice of circular public procurement, by defining new environmental criteria in its tenders. Please discuss and analyze how would you do this? Which criteria would you include and how would you communicate such city's demands to suppliers?

Keywords: circular public procurement, award criteria, market involvement.

Case 6

The city of Bodø is about to carry out several huge construction projects the coming next years. The city has set its ambitions high with regards to sustainable and circular use of materials in these projects. The city wants to involve stakeholders (private persons and businesses) in these processes to get access to competence, but also to act in line with the city's citizen involvement policies. Please come with suggestions on methods the city can use to involve stakeholders in city development processes.

Keywords: citizen involvement, stakeholders, circularity, co-development.

Case 7

During next years, excess materials with no specific purpose (from construction projects in Bodø city) are expected to be made available. This can be e.g. concrete elements, woodwork, rock, furniture, glass, etc. The city of Bodø wants to evaluate whether these second hand materials can be used for art and decoration in different spaces in the city. Please come with suggestions on how materials can be reused for the purpose of art. Be creative and make your own assumptions on available materials.

Keywords: reuse, upcycling, art, excess materials.

Case 8

The city of Bodø is the new owner of a huge area in the city after a military airport is relocated. On that site, there lies about 4000 concrete slabs with the dimensions of 2x2 meters. Please advise the military and the city of Bodø on how these concrete slabs might be reused.

Keywords: circular economy implementation, concrete, slabs, reuse, upcycling, architecture.

Case 9

Demand and accessibility of reused materials often happen at different times. Describe a system and how it can be set up to overcome the barrier of time differences of supply and demand. Use the construction sector and reuse in the planned new city district in Bodø (Hernes) as a case.

Keywords: circular economy cooperation, circular system development, construction sector.

Case 10

Describe and visualize the flow of materials and economy of one of the important sectors in Bodø (e.g. construction sector, fisheries, aquaculture, waste sector etc.) Analyze the flows and suggest measures on how it can become more circular. The system boundaries can be decided on

The students have by two occasions presented their suggested solutions to the municipality, where several departments have been present.

Figure 34. Student presentations for circular economy development in the city after their own analysis and reports with cases from CityLoops.

Disemination

Invitations to collaborate and disseminate information from different forums and for diverse target audience are crucial to continue generating awareness at all fronts. And it has been welcomed, initiated, and stimulated, all the opportunities that we find to help others and share our experiences matter and have been very much valued throughout the length of this project.

One example can be the collaboration where the Project leader of CityLoops Bodø, was invited to participate in a podcast from the Nordland County to reflect on environmental solutions in a podcast called:

Can we reuse ourselves from municipal collapse? Thinking about recycling doesn't have to be expensive. (Translated from Norwegian)

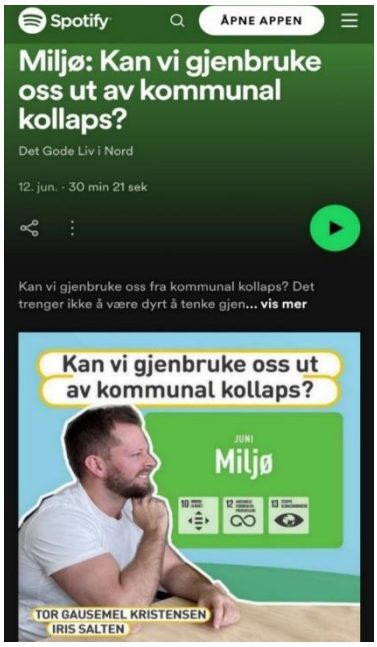


Figure 32 Environmental Podcast providing circular summer tips for Nordland.

Where he gave some circular summer tips from the perspective as head of development and sustainability at Iris Salten the local waste management company. This is particularly important because Bodø is one city with about 52,000 citizens but the Nordland county is a bigger regional instance that governs and impulses regional development in a vast number of cities in Norway included in its competence, and of about 240,000 inhabitants. Local actions have a bigger positive impact for regional development.

Podcast available in the link below:

https://open.spotify.com/episode/6U0ix9s2cgsA9yOfwSkh1S?si=30badf27ed3f4ea3&nd=1

Saxion University; Netherlands.

A collaboration with Saxion university was encouraged by the CityLoops team to receive students for one week, they were staying at Nord University with their professor, During their visit, different activities were arranged, lectures with students from Nord University, a visit to the Municipality, a visit to the Airport which was in fact one of the priorities ad they came to evaluate possibilities to reuse materials from the old terminal and provide suggestions for the outcome when the old terminal became a part of the new city district in Bodø.

The students were in Bodø for a week, and they were provided with information about the city and the terminal building such as the architectural drawings and maps for their further development.

After they left, they worked for about two weeks in their proposals that were then presented to the municipality's colleagues of the CityLoops project, as well as their professor.

Figure 35. Screenshots from the video made as part of the student visit by Bodø Municipality's communication department.

The presentations were recorded, and they as well as their suggestions are to be sent to other municipal authorities and employees to evaluate their potential and provide more ideas for city planning from different perspectives.

You can find the video in the link below:

https://fb.watch/lb1NnwnuY3/

the reports from the groups of Saxion university were divided into four.

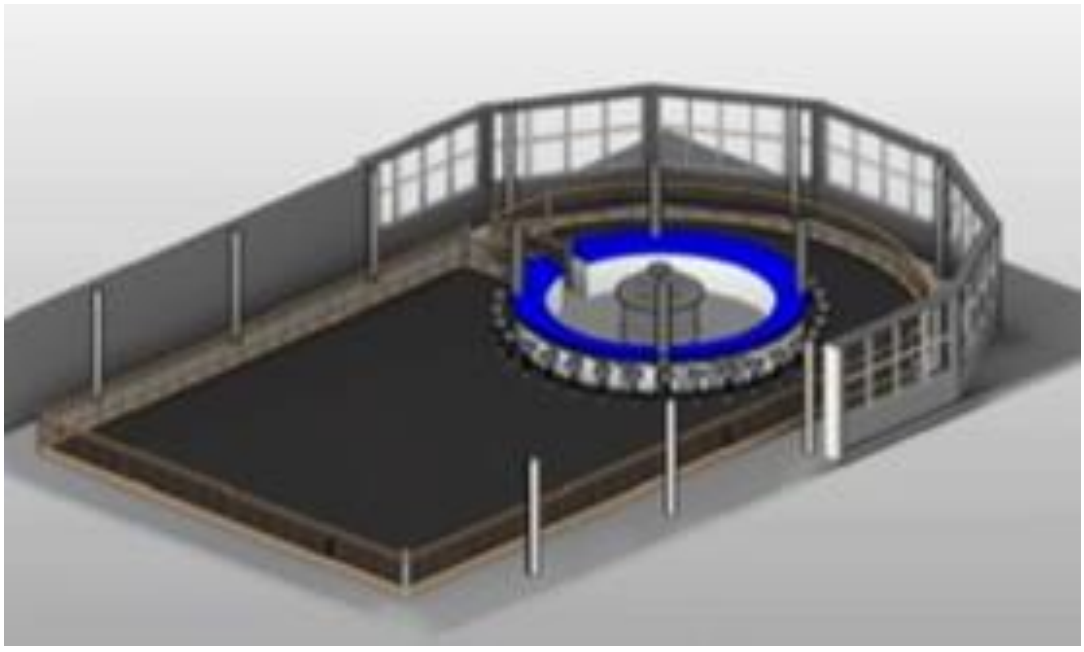
The first group focused on repurposing the building for the young population of Bodø's city, among their ideas, the development of a sky club, a nightclub, an arcade, and a snack bar similar to a kebab shop was suggested, as they think that it is important to have a place for young population if the goal of the city is to attract young people to stay and settle down here.

Figure 36. Screenshot from the first presentation of students from Saxion University to Bodø Municipality

The second group emphasized the need to focusing on the building's functionalities while including climate and environmentally friendly suggestions, they wanted to keep the structural parts of the building, as well as the exterior but to do minor adaptation changes in non-structural parts of the building, as well as repurposing structures, such as the communications and vigilance tower to be transformed into a climbing tower.

Figure 37. Screenshot from the second presentation of students from Saxion University to Bodø Municipality. And the proposed climbing area for the airport's vigilance tower

They had some interesting proposals to reuse different areas of the building while focusing on universal design for people with reduced mobility., as well as the design of a roller skate track.



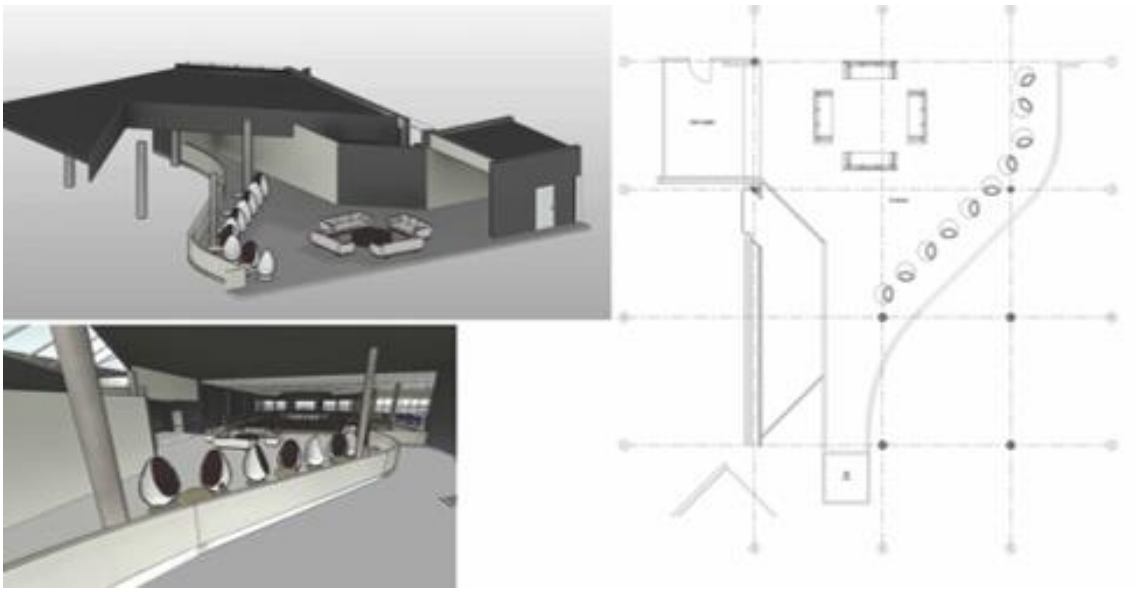


Figure 38. Screenshots from the second presentation of students from Saxion University to Bodø Municipality. And the proposed design of the roller skate track and the mock design of an entrance for people with reduced mobility

The third group, they conducted a small-scale survey at Nord University and CityNord (the local mall) where the results showed that the main focus should be on children, therefore their suggestions were linked to a playground with Butterflies and nature, a kart-track, and a climbing wall using the ground land first level of the airport.

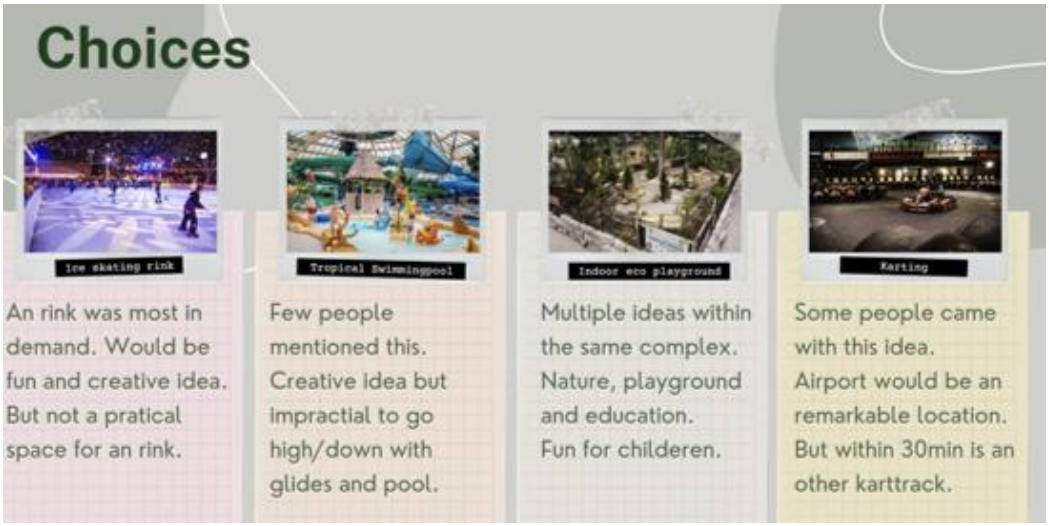


Figure 39. Screenshot from the third presentation of students from Saxion University to Bodø Municipality. Showing the results that they obtained from the survey to local population.

Figure 40. Screenshot from the third presentation of students from Saxion University to Bodø Municipality. Showing the sketch designs of the butterfly garden and the climbing wall

They did an analysis of circularity for different materials of the airport based on the R-ladder of circularity.

The fourth group had a wider focus on different ages of population from Bodø distributed in different sections of the airport, and the design of for example a theatre re-purposing the structures around the airport, as well as the airport's current chairs. A restaurant with live cooking concept for guests, to reuse baggage carrousels as wall covering, to reuse the boarding gates as entrances for the restaurant experience, among others.

Figure 41. Screenshot from the fourth presentation of students from Saxion University to Bodø Municipality. Showing the sketch designs of the restaurant concept.

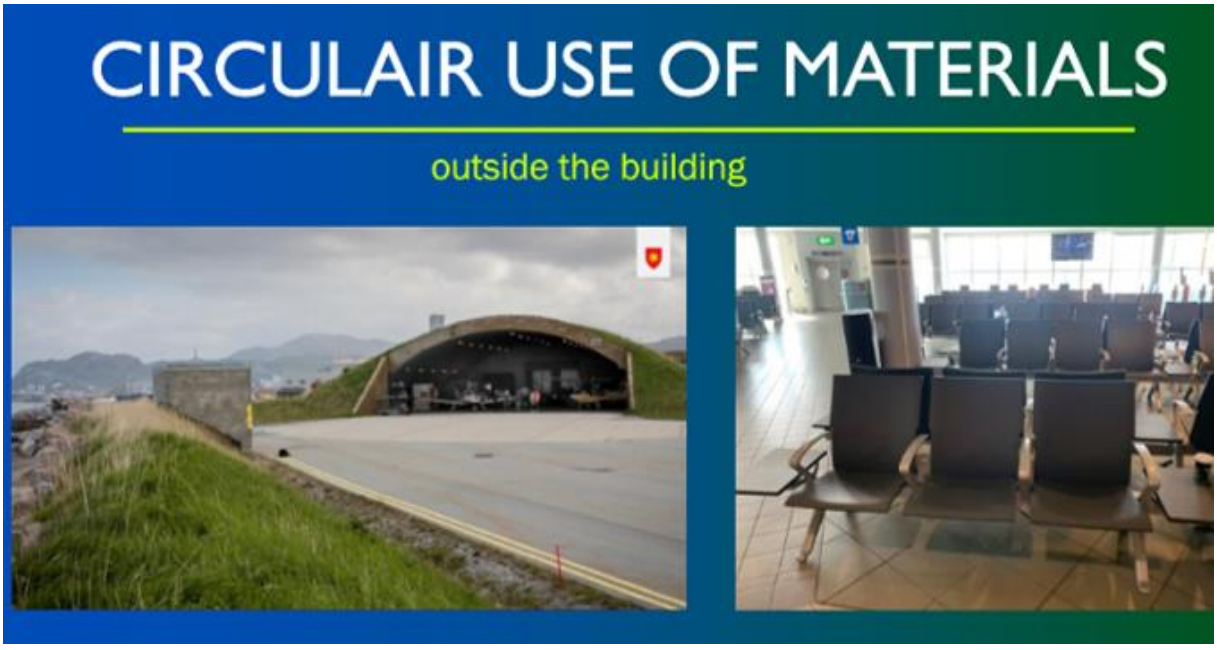


Figure 42. Screenshot from the fourth presentation of students from Saxion University to Bodø Municipality. Showing the potential repurpose of a structure as a theatre with reused chairs

Figure 43. Screenshot from the fourth presentation of students from Saxion University to Bodø Municipality. Showing the potential repurpose of structures inside the airport for the restaurant concept.

3.2.2 Instruments and tools

Visualization for communication purposes

One of the biggest strengths of using a digital twin is for communication purposes. The system can visualize complex data that typically are placed in excel or even PDF documents. By making this data easier to comprehend and accessible, decision makers and city planners will be able to make data-driven decisions with less time and mental strain. Efficient use of data visualization may help to support arguments for diverse purposes, rendering it very useful for communication.

Digital twin- access

Access to digital twin technology is not a procurement in the true sense of the term, as the access is through a research and development project with a software company that delivers 3D visualization solutions to offshore companies. Bodø participation in this R&D-project is to explore how such technology can be used for monitoring and planning for sustainable city planning. This is done in the CityLoops projects, and findings, lessons learned, usage potential are subject for replication.

3.2.3 Lessons learned.

Increasing competence and knowledge development.

One of the barriers that can hinder organizations to embrace innovative solutions such as the use of a digital twin software are the dilemmas or incognita on how to use it. Resources both economic aspects and capable human capital capable of using and manipulating the interface. Good project management and prioritization abilities are important aspects that should not be overseen. Therefore, here in the Bodø we:

- Engage participants in different activities to show that it is possible to have a better data visualization.
- Encourage colleagues and other stakeholders to reach us for support.

- Have used the digital twin in different projects or for decision making process.
- Have built scenarios that help others understand the potential of using such a tool.
- Have organized training for different employees, to assure that knowledge is shared and used in different departments.
- We are working to raise awareness among different employees and departments about this existent solution that we have at our disposal.

The digital twin of the city has proven to be a useful tool for urban planners, policymakers, and researchers alike. It allows them to gain a comprehensive understanding of the city's functioning, including its infrastructure, traffic patterns, and energy consumption, among others. This information can help identify areas of improvement, optimize resource utilization, and design interventions that lead to better outcomes for citizens. There is however still some potential for improvement in the digital twin's functionality, with the shortcomings on making data calculation in the program itself.

Theses' recommendations

One master thesis explored how and if Bodø Municipality has been practicing circular procurement. Data gathering was conducted, and a representative selection of tenders in different categories were compared to best practice examples from the EU. A set of recommendations were made based on this analysis. One of the recommendations was to increase the practice of early market involvement in procurement tenders.

Another student was challenged to analyze whether this is practiced in Bodø municipality. A set of recommendations to increase the degree of early market involvement was prepared.

A recent, master thesis, analyzed whether CityLoops initiatives have resulted in improved circularity in procurement competition announcements, as well as market

dialogue with information from the years 2019 to 2022, the results show that there have been improvements in circular criteria, as well as the level of specialization in the developing of the tender basis; that market dialogue is crucial for the good result of a tender; and that it appears to be easier for procurers in Bodø to set circular criteria to products than to services. The last thesis recommended to develop a routine to have readily, available and up to date data from procurement by using tools for visualization, for example the digital twin to support decision making processes.

3.3 Demonstration action 3: 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.

3.3.1 Activities

Overall environmental program: Soil management in the city

An Overall environmental Program was created and manifested for the new city district development policies for the four categories: nature conservation, mass handling, circular treatment of materials, and energy efficiency. CityLoops has been a driver to

prepare the mass handling-category and a substantial contributor in the circular treatment of materials-category.

The overall environmental program is a part of the overarching framework for the development of the new city district and gives the framework for climate and environmental goals in the development. It can be seen as a manifested mass treatment policy for Bodø's development of the new city district.

Objectives for soil management in the new city district:

- It is an overarching goal for the urban development area that all masses are to be reused.
- When supplying new masses, these must, as far as possible, be non-virgin.
- Transport of masses must be reduced to a minimum by means of local intermediate storage and reuse.

Objectives for circular material use in the new city district:

- All of the new city district is to be developed after circular economy principles, including residential areas, industries and offices, infrastructure, outside areas and other city functions.
- Reuse materials and masses in constructions
- Design for disassembly
- Use products and materials with long lifespan.
- Use products and materials suitable for reuse and recycling.
- Use products and materials made from sustainable sources and production processes or made from waste or bio-products.
- Implement circular business models, such as sharing, reuse, reparation, etc.

Tendering and procurement - incl new buildings/ Procurement Handbook

- Involvement in implementing circularity in demolition tender of a school.

Soil and mass management

Soil strategy

Soil and mass management is an important topic in Bodø, with low availability and long transport distances of quality masses and large amounts of traffic and direct CO2 emissions from mass handling in projects. Little is reused today due to the 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 a 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 discuss to test 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.

Sjøgata road renovation project

- Sjøgata is one of the main streets going through Bodø city center.
- It was decided to be a pilot road project for low emission and circularity as a pilot for work with the new airport.
- Close cooperation between the technical road management department, procurement department and development department to decide level of ambitions and prepare the public procurement.
- Discussed solutions for cleaning contaminated soil with local actors. The local landfill management company offered to make necessary investments for cleaning contaminated soil with per ton prices for cleaning.
- The procurement received public funding from national authorities (Klimasats) to support additional costs with sustainability measures. Total additional funding of 9,5 mill NOK (approx. 950 000 EUR) was added to the procurement for these measures.
    - Zero emission construction machines were an important part of this budget.
    - Material reuse was another important criterion.
- The total price from the winner was approximately 90 mill NOK (~9 mill EUR).
- Criteria: all masses that can be reused internally in the project are to be reused (or recycled). This may involve sorting, cleaning of slightly contaminated soil and reuse of slightly contaminated masses where they were removed.
- Intermediate storage could be used for sorting, cleaning, and storage.

3.3.2 Instruments and tools

Use of visual tools and social values

In the demonstration project, 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 in to 176 neighbourhoods 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 is dust, noise, emission, safety, traffic.

Tools used for visualisation: Power BI, digital twin.

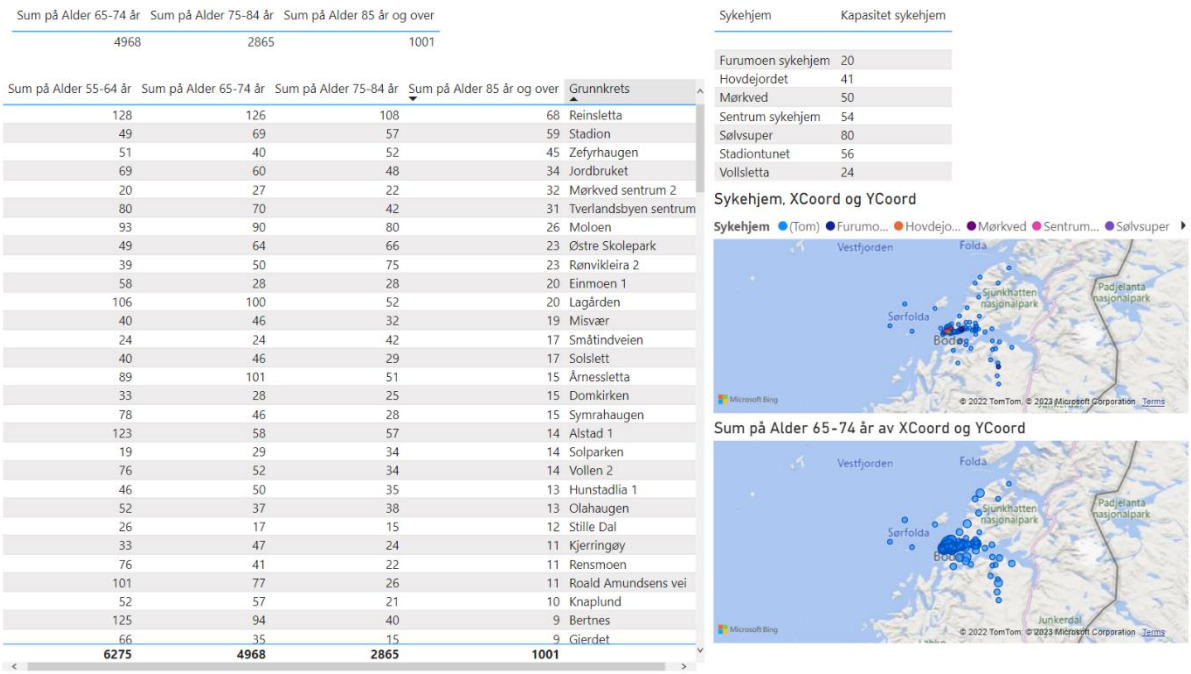
Usage: Tool is used to map sociodemographic values in the city. This information is then used to plan how the city can be developed in terms of e.g., nursing homes, kindergartens, facilities for refugees, youth facilities. Sociodemographic information gives insight about the city's status, but this can also be used to estimate future values.

For example, if we know how many people from 64-85 that lives in the different neighbourhoods in the city, we can estimate how many people over 85 years old that lives 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 identity correlations between increased practise 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 is counted how many people from 65 to 84 year lives in Bodø in the city's 176 neighbourhoods. It is also counted how many over 85 that lives in the city. Findings: it will likely be more people over 85 years 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	Gierdet
6275	**4968**	**2865**	**1001**	

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

Figure 44. Information for potential use to provide services for elderly inhabitants in Bodø.

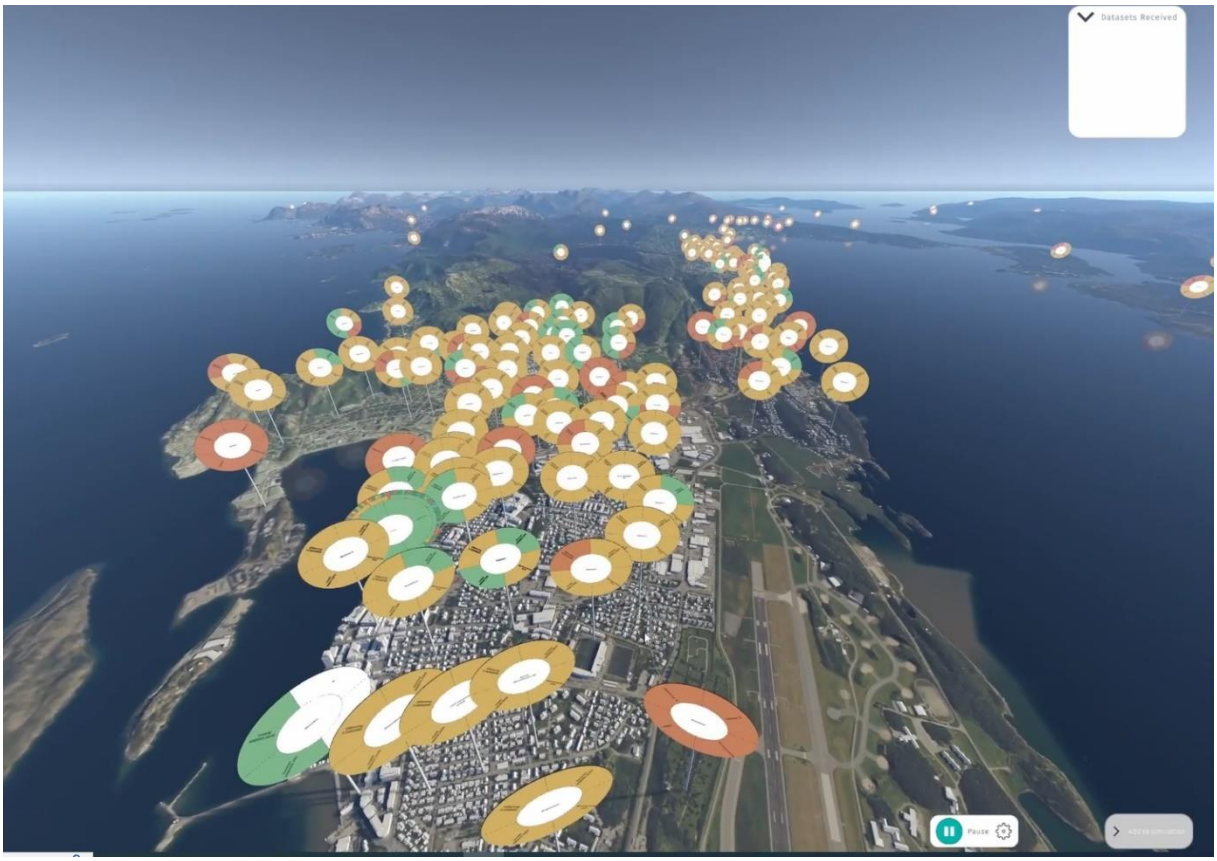


Figure 45. Visual representation of how different neighbourhood's average income, net worth, level of education and age are placed in comparison to a city average.

3.3.3 Lessons learned

Municipal mindset commitment and awareness

The CityLoops project has been an active stimulator of organizational change, it has created awareness of how circularity is linked to several aspects of the everyday city operations.

There has been a closer collaboration of departments to involve them in co-creation. As an organization, there has been a continuous development now for example in the procurement department there is one specific employee working solely with development of different aspects related to improving efficiency, implementing best practices and achieve innovative solutions, as well as the strategy towards more inclusion of circularity and sustainability aspects. Although it must be said that it is not

a result of one single department, joint organizational efforts and awareness have made possible the development of different solutions like this one.

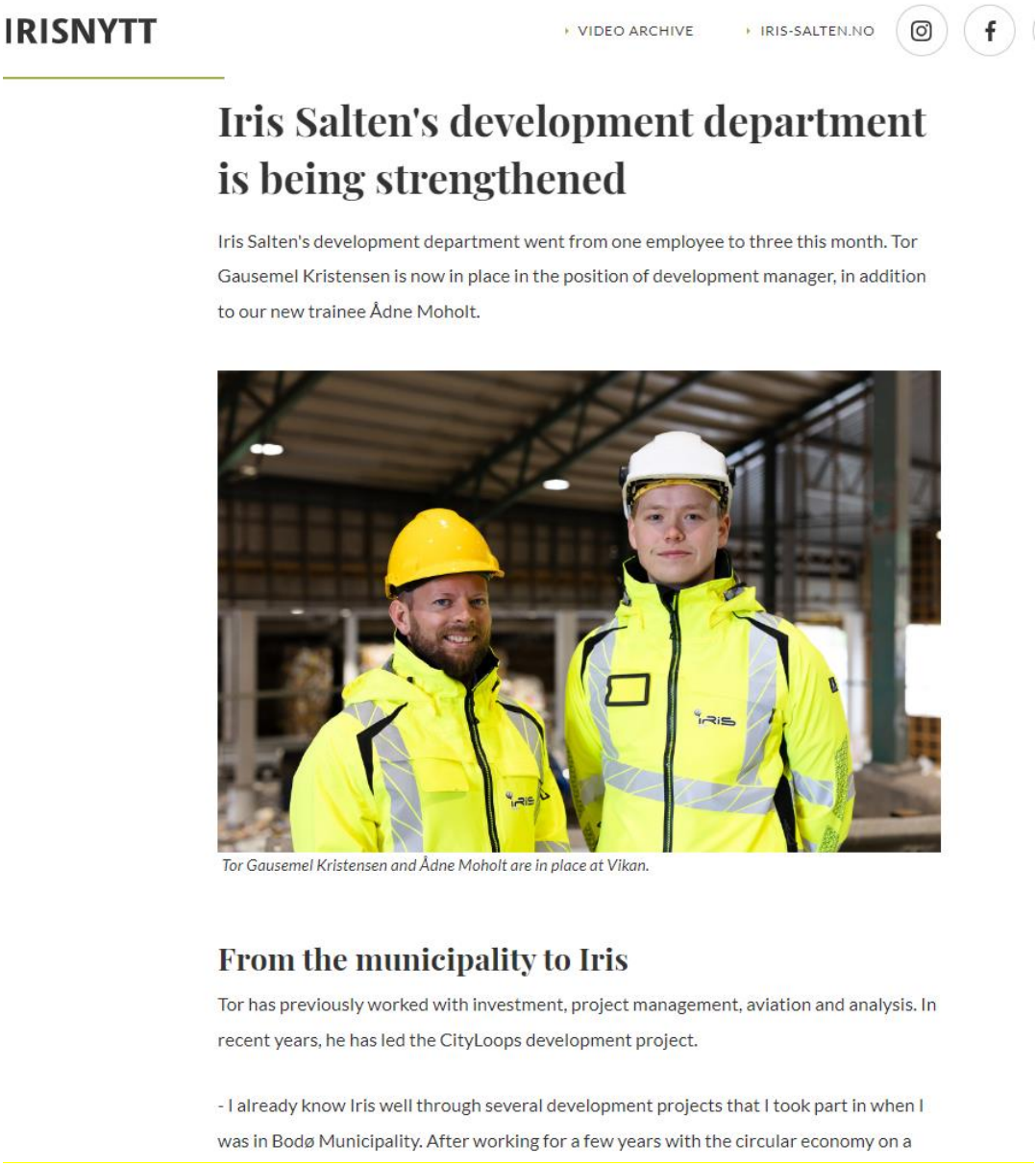
Recently, two positions, a legal adviser and a procurement adviser have been posted and inside the job publication it was mentioned the importance for these new employees to collaborate in tasks that help pursuing the organizational goals and use tools to strategically collaborate in the reduction of CO2 emissions.

Source: https://karrierestart.no/ledig-stilling/2317665

Direction/Legacy.

When collaborators switch job positions or join different departments or companies, they keep the competence and knowledge with them, bringing it to other horizons and it helps though a direct and indirect method to continue working with a development mindset and entrepreneurial focus to solve challenges with a circular economy approach.

Changes are necessary and having a progressive way of working, and collaboration has the overreaching potential to support goals and achieve them from different fronts.



IRISNYTT

VIDEO ARCHIVE IRIS-SALTEN.NO

Iris Salten's development department is being strengthened

Iris Salten's development department went from one employee to three this month. Tor Gausemel Kristensen is now in place in the position of development manager, in addition to our new trainee Ådne Moholt.

Tor Gausemel Kristensen and Ådne Moholt are in place at Vikan.

From the municipality to Iris

Tor has previously worked with investment, project management, aviation and analysis. In recent years, he has led the CityLoops development project.

- I already know Iris well through several development projects that I took part in when I was in Bodø Municipality. After working for a few years with the circular economy on a

Figure 46. Communication post from Iris Salten, the local waste management company in Bodø and the Salten region of Norway.

Source: https://irisnytt.iris-salten.no/artikler/utviklingsavdelingen-til-iris-salten-styrkes

These positive outcomes:

- Have been collaborative processes involving distinct areas of the municipality.
- Are processes that take time to be implemented.
- Need an open dialogue.

- Need intensive use of resources and active involvement of different stakeholders.
- Are needed to reach organizational objectives.
- Have proven to be beneficial.
- Have promoted direct and indirect actions with dissemination and strong communication.
- Need good communication and dissemination channels to spread the word.

Decisions regarding material management.

Material handling goals and actions have been stimulated by the project CityLoops, for example, with the development of the new city district after the future relocation of the airport, new ambitions have gained importance.

Objectives for circular material use in the new city district:

- All of the new city district is to be developed after circular economy principles, including residential areas, industries and offices, infrastructure, outside areas and other city functions.
- Reuse and recycled materials and masses in constructions
- Design for disassembly
- Use products and materials with long lifespan.
- Use products and materials suitable for reuse and recycling.
- Use products and materials made from sustainable sources and production processes or made from waste or bio-products.
- Implement circular business models, such as sharing, reuse, reparation, etc.

4 Findings and lessons learned.

4.1 Overall environmental program

Organizational changes, planning and decision-making process.

- An Overall environmental Program was created and manifested for the new city district development policies for the four categories: nature conservation, mass handling, circular treatment of materials, and energy efficiency. CityLoops has been a driver to prepare the mass handling-category and a substantial contributor in the circular treatment of materials-category.
- CityLoops Decision making tool for circular construction projects was used in the planning of a demolition- and construction of a school project.

Recommended measures for soil management:

- Plans for soil handling in the projects must be based on circular economy and environmentally friendly handling (the waste pyramid should be indicative)
- All available knowledge and digital tools must contribute to decisions in the planning of mass handling.
- Established guidelines and best practice for handling clean and contaminated masses must be used as reference when mass handling strategies are laid.
- Facilities/reception equipment must be established for intermediate storage of masses that can be used in future or ongoing projects in the same or nearby area.
- Mass accounting/databank and a digital marketplace for released masses should be prepared.

Municipal soil strategy

Through project work in municipal soil management group, it was decided to create a suggestion for a strategy for soil management in Bodø municipality. The strategy work was started by CityLoops but will not be finished by the end of the project. The strategy will be short and directly connected to the different roles involved in soil management, with an objective for improved cross-sectorial collaboration.

The group has suggested the following strategic goals for the municipality:

- Efficient **resource utilization** (less extraction and less landfilling)
- **Minimal emissions** from soil management
- **Minimal costs** from soil management
- Bodø municipality shall have a **good overview** of **where the soil ends up** and **what it is used for.**
- It shall be easy and efficient to **monitor/follow up** that soil management is done after the plan and in a good way, and deviations shall be **followed up and sanctioned.**
- Bodø municipality shall be **experts on optimal utilization** of the soil typically found in Bodø. Optimal utilization follows the waste hierarchy (reduce, reuse at site, high quality reuse in other project or agriculture, low quality reuse in other projects, backfilling, landfilling).

4.2 Tendering and procurement - incl new buildings/ Procurement Handbook

4.2.1 Procurement strategy

Revolutionized procurement strategy

Through workshops, data gathering and awareness communication, CityLoops has in Bodø Municipality been an initiator and contributor to the preparation of a new more circular procurement strategy (Procurement strategy annex). Qualitative and quantitative data is gathered from accountancy, workshops, interviews, three master theses, and tender assessment. The findings from these have enabled the municipality to identify potential and challenges. Which have been taken into consideration for the new procurement strategy. The new procurement strategy is politically manifested and unlike the earlier practice, when no such strategy existed, now, it shall ensure that circularity is required with the providers of products and services to a greater extent and where most feasible to assure the greatest effect. A selection of tenders was analysed at the beginning of the project, and it was compared- to a selection of tenders at the end of the project. The results from this comparison suggest that the initiatives from CityLoops have had a significant positive effect (see figure 44).

Qualitative and quantitative data on procurement processes are gathered. A representative selection of tenders was evaluated. This data is combined with qualitative data from a workshop facilitated by RWS in 2020. And a second workshop in 2021 with diverse stakeholders.

The evaluation of the tenders in 2019, before the start of CityLoops resulted in baseline values that is measured at the end of the projects.

Furthermore, Bodø's spend data, through public accountancy is evaluated, giving the municipality a chance to identify which cost categories have the greatest potential for improvement.

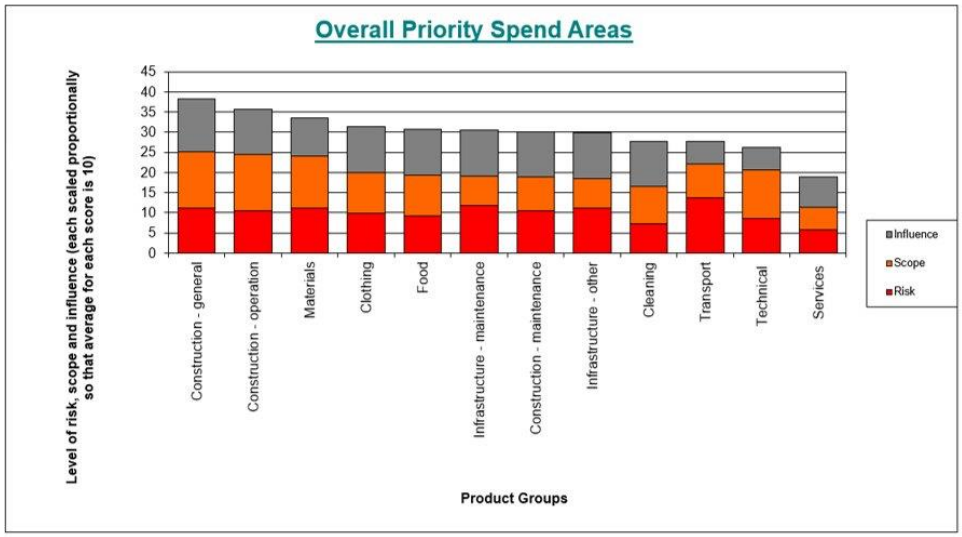


Figure 47. Suggested categories to be prioritized in procurement improvement processes from the RWS workshop.

The procurement strategy of Bodø Municipality was formally accepted by the city council in October 2022, and it is showcased in the image below:

Figure 48. The house of public procurement strategy found as case PS 157/22 presented to the City Council in October 2022

This new strategy, on its implementation process now encompasses aspects called pillars related to sustainability, differentiating the three types of it, and considering the

quality of services as a fourth pillar. It analyses how the organization and governance inside the municipality contributes to innovation, as well as recognizes that cooperation together with digitalization and system support are essential aspects that contribute to fulfil the needs and requirements presented to the procurement department, furthermore it encompasses the need to analyse whether or not a product or service can be provided with the existing internal assets or competence stimulating the avoidance of acquiring new products and services, as the best procurement practice is the one that reduces the need to procure.

Source for the Procurement strategy: https://bodo.kommunetv.no/archive/194

4.2.2 Master theses

Academic work and data analyses have enriched the collaborative work, in this case with the findings and recommendations from three master theses (enclosed)

- **How good is Bodø municipality on green and circular procurement compared to an EU best practice?**

- **How can Bodø municipality implement methods to practise early market involvement?**

A set of recommendations based on data was prepared and has contributed to implementation in the procurement department's daily operations and in the overall strategy. This has resulted in the engagement of a specific employee in the procurement department which is solely working to improving tenders and procurement processes.

A third master thesis evaluated whether tenders have improved regarding criteria part of the tender basis with circularity requirements:

- **How can circularity indicators in public procurement lead to smarter, more informed decisions? The case of Bodø Municipality**

The findings in this thesis provide an important contribution to the indicators for the evaluation in Task 6.3 measuring CityLoops' effect on procurement practice in Bodø municipality thought out a selected timeframe, as well as the importance of goals, strategy, and market dialogue to develop the tender basis of tenders, analysing information by years and categories of products and services.

Findings from the evolution of the tender basis from the year 2019 to 2022		
Award criteria	In 2019 **3** competition announcements with obligatory declaration included explicitly requirements related to circularity in 3 categories.	In 2022 **15** competition announcements with obligatory declaration included explicitly requirements related to circularity in 6 categories.
Qualification criteria	From 2019 to 2022 there has been a stable circular criteria requirement related to CO2 emission reduction and Environmental management systems, also considering the International Labour Organization regulations but there was a case where circularity was remarkably considered in 2021 in an ICT competition announcement.	
Specification criteria	In 2019 **7** competition announcements from 3 different categories required ambitious circular related criteria from three categories.	In 2022 **19** competition announcements from six different categories required ambitious circular related criteria.

Figure 49. Table that represents some of the results from the analysis of the tender basis from competition announcements from a four years' time frame evolution as part of the third thesis

Examples of conducted actions based on recommendations from procurement data gathering:

Early market involvement

The third master thesis conducted research about the market dialogue which the municipality initiated, and findings from that research suggest that:

In 2020

- **The Smart Architecture**. was focusing on using the internet of things to enhance better planning, data sharing, collection, and training to create knowledge for architecture projects.
- **Craftsman and painting services.** aimed to get feedback and suggestions to avoid and prevent asking exclusionary criteria in tenders to increase best practices.

In 2021

- **The climate and environmental requirements for zero emission construction sites.** Focused on co-creation, looking for solutions to highly intensive CO2 emission municipal projects such as the future construction projects of roads, relocation of the airport, and other plans and construction projects looking for new technologies and better requirements in procurement.
- **The acquisition of electric vehicles**. Focused on increasing knowledge and competence of previously unexplored areas related to environmentally friendly vehicles and their implications for the local conditions and performance.

Examples of conducted actions based on recommendations from procurement data gathering:

- Early market involvement
- Take into account the entire value chain, including transport, packaging, surface treatment.
- Improve assignment and eligibility requirements.
- Categorical requirements
- Own employee to follow up procurements.
- Framework agreements
- Proof from supplier s
- Focus on longevity; include service agreements in tenders.
    - Using the criteria wizard in the tenders

- Procurement sheet
    - When a substantial procurement is to be initiated information about the procurement needs to be registered in a sheet that will be evaluated by the procurement dept., including the employee that works with optimizing green procurement practiced.

These activities have resulted in an important contribution to the procurement department's new strategy.

Tender for parallel mission

A tender was created where architect and city planning companies were challenged to create concepts for the new airport, taking into account the municipality's environmental priorities. CityLoops were responsible for preparing the requirements regarding circularity for the tender basis.

Three companies were chosen to work 3 months with their concepts.

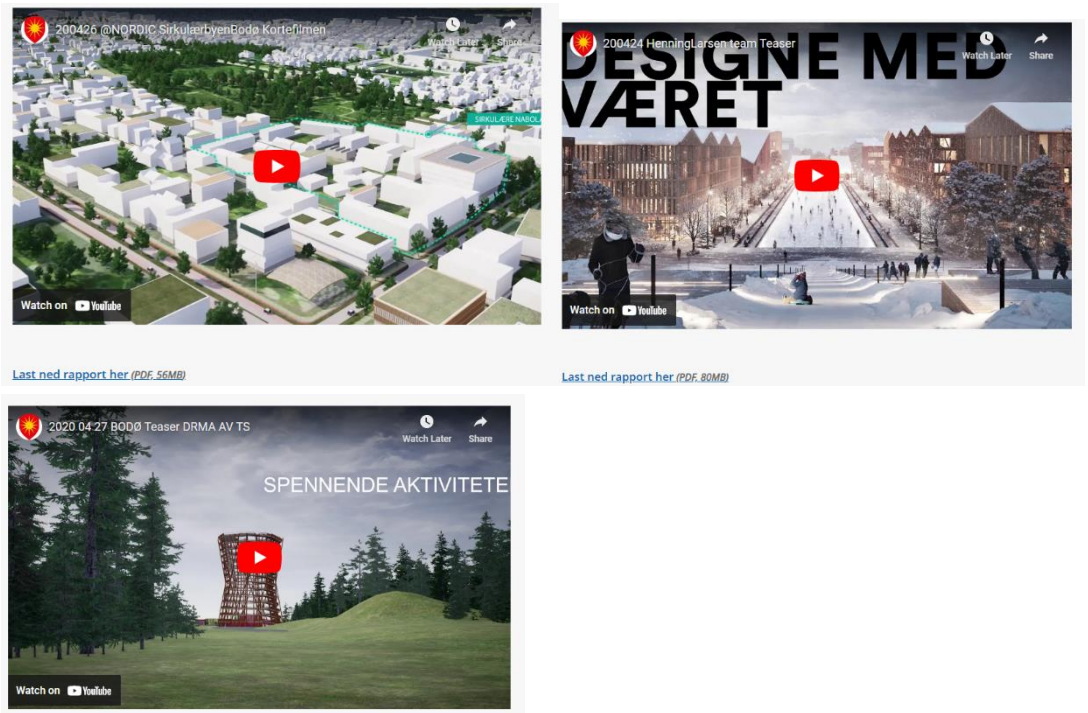


Figure 50. Concepts developed for the parallel mission.

The mission resulted in three concepts, including reports of 150-200 pages consisting of technical information and models on how the city would function.

For information about the concepts:

https://nybybodo.no/ny-by-ny-flyplass/ny-bydel/hvordan-vil-du-at-den-nye-bydelen-skal-bli-1

One example is the company Nordic Archtects concept called Circular Bodø. This concept was modeled in the 3D Visualization tool to evaluate its hypothetical effect on the city.

In the concept, there was a strong focus on for example:

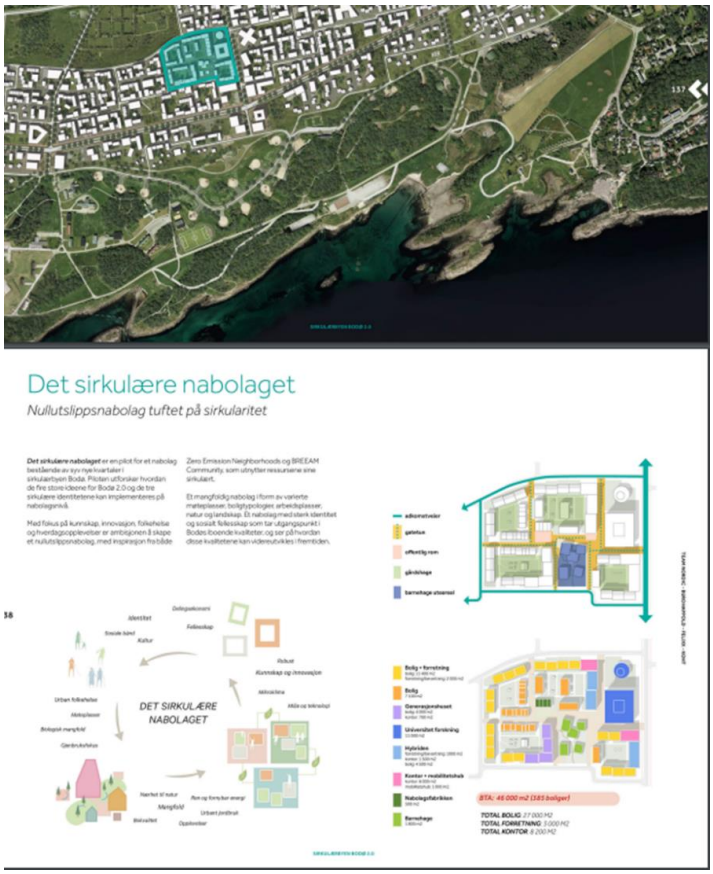
- The Strategic construction enabling deconstruction rather than demolishing in the future.
- The fact that the most sustainable buildings are already built.
- 

Figure 51. translated: The circular neighbourhoods, zero emission design.

Figure 52. Architecture and materials with potential reuse from roofs, façade, ground levels, etc.

4.2.3 Soil management and climate/environment in infrastructure tenders

CityLoops have actively been working together with the construction department to include climate reduction measures and soil reuse in construction tenders. The following describes the learning points and results from the process.

In the pilot road construction project Sjøgata in Bodø city centre which at the same time has been the first road construction project in Bodø with high focus on climate, circularity has been a strong focus. Its importance relies on the fact that it has not only generated experience with this type of tender process, but also showed that it is possible to reach ambitious goals through collaboration and market dialogue, because the market dialogues from 2020 and 2021 have contributed to achieve a successful planning process and tendering one.

It was decided to make a quite open tender where the construction sector would qualitatively compete on solutions.

With a tight budget for new constructions the potentially added cost has been an important barrier for the initiation of more climate friendly constructions. To overcome the barrier Bodø municipality applied for national funding for added costs. This was combined with funding from another budget than the initial construction project, amounting to 9 million NOK (850 000 EUR). The contractors were challenged to describe how they would spend this designated climate budget. Total budget for the project was estimated to be around 90 million NOK.

Two factors were especially important in the tender: electrical excavators and soil management. For soil management it was a criterion that the contractor should reuse all soil from the project that was suitable for reuse. Suggestions for access to intermediate storage were given in the tender, for the contractor to decide on the best solution. to a municipally owned intermediate storage (intermediate storage options

described under 4.3.3 Intermediate storage for soil and in the CityLoops Bodø business model).

Four offers were received for the job competition. There were large spans in the prices offered, but the price did not seem tightly corelated with measures for climate and circularity. The winning offer had the second largest price, and their climate measures tipped them to the winning position.

During the first part of the contract the soil management was followed up closely to ensure reuse of the surplus masses, and the CityLoops business model has been used to find the most suitable options. Because of the need for improvements of the municipal intermediate storage, they have decided to use the intermediate storage at IRIS for the first part of the project. Before the construction project IRIS did not offer intermediate storage, and the contract is a good example of how it has influenced the market in Bodø.

The electrical machinery was another important measure in the offer, and the excavation is solely done with use of two electrical excavators, furthermore, the company is waiting for two electrical dump trucks for soil management. This is also quite new and innovative in Bodø and has gotten significant national attention.

The experience from the Sjøgata tender has led to willingness to include electrical machines and soil reuse in more tenders. Bodø is now working to create a calculator for quantitative evaluation of offers for contracts, where the contractors input documented emission factors for materials to be used, distances for soil management and use of fuel. Reused soil is given a climate footprint of zero (excluding transport) to incentivize soil reuse. Virgin soil must have documented climate emissions connected to the production.

The model is under development together with external partners, and it is called the RDP-model.

4.2.4 Circular principles in demolition procurement

Because of delays in the airport demolition, CityLoops Bodø has not been able to take part in the tender for the demolition the airport structures. Instead CityLoops is involved in the tendering process of the school at Løding in Bodø.

To demolish the school and construct the new kindergarten in its place it is desirable to save as much of the materials as possible for use in the new construction (first priority) or make them available for other projects. The process is still ongoing and is yet to be finalized.

As of now the plan for reaching the goal is to make a tender for the demolition and construction in one tender. This will ease the job to save the materials for future reuse. This is a new practice for Bodø municipality that has not been tested before, but it is considered a substantially better way to enable reuse.

In this case a collaboration with the local waste management company has as well been a crucial part, as the collection of second-hand inventory has been done by Iris Salten and then, donated to Kirkens Bymisjon, a local charity organization which is making sure to create value from those materials and ensure that the benefits reach people who need it.

4.3 Instrument for circular soil handling – incl CO2 calculation

Improved circular soil management is an important part of the CityLoops objective in Bodø Municipality. The relevant goals are to establish systems for improved soil management, mapping, and planning of masses at the airport and establishment of databank and intermediate storage for soil.

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

Background

Bodø is a coastal city with close distance to mountainous areas. most of the city is in the lowlands, and the most common soil in groundworks can be characterized by marine sediments, dense clay, sand, and some rock materials. Large parts of the city burned during the war, and many areas have light to high contamination. The map below shows mapped areas of soil contamination in Bodø. It is however more areas with contamination, and further soil analysis is often required before reuse can be done.

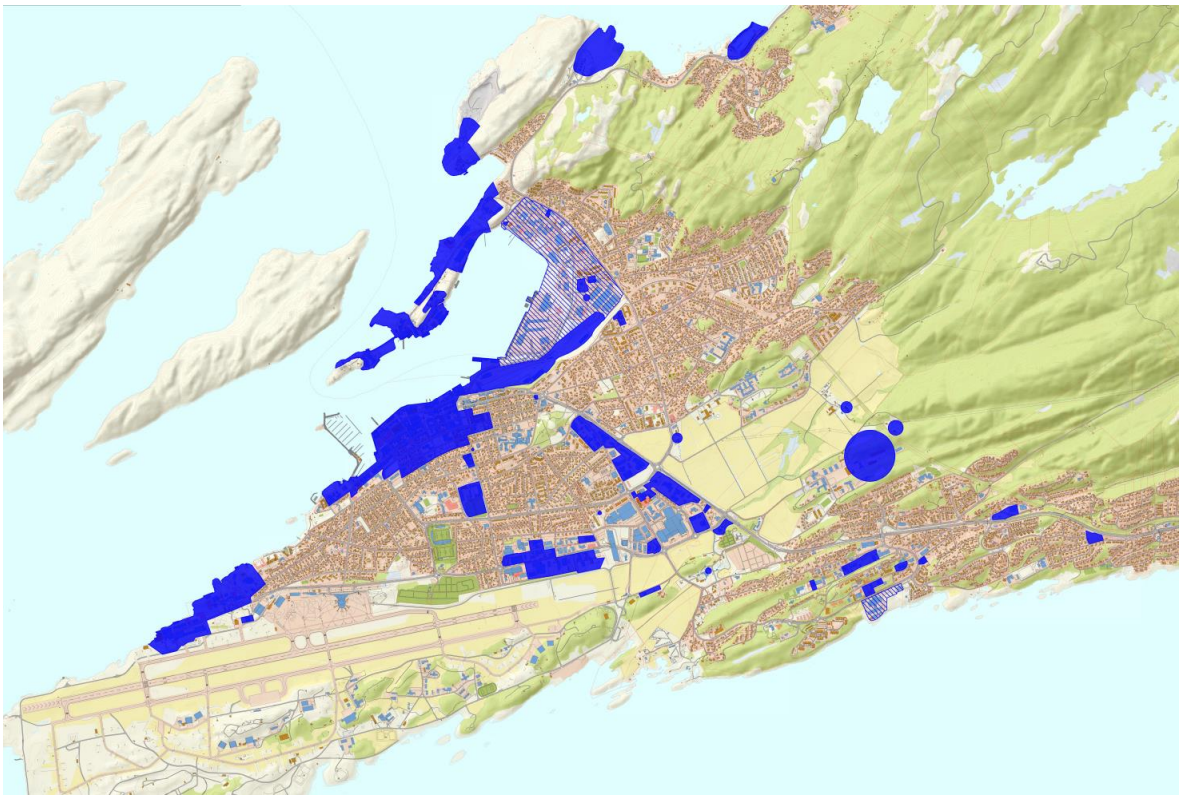


Figure 53. Map of contaminated soil in Bodø

The local rock materials are rock types with low strength and are not suitable for purposes with higher quality criteria. Close to all quality and infill materials does therefore come from the island Tomma, which is located around 130 km from Bodø. The masses are transported by boat to Bodø. The distance makes a significant impact on the masses used in construction projects in Bodø.

The clay and sedimentary soil in the lowlands have low potential as quality construction materials. It does, however, have a much higher potential for recycling and reuse than current practice. This requires good planning, efficient logistics systems, matchmaking systems for the available soil to find the soil needs (marketplace), as well as good tools to evaluate the potential use for the masses of varying quality. CityLoops has been a considerable facilitator to improve the soil management in Bodø, described further in this chapter.

Planning for soil reuse and soil prediction tool

One of the tools Bodø would learn from in the project was the CityLoops Soil Prediction Tool. The prediction tool gives an estimate of the soil volumes to be freed in the coming years, based on municipal city plans. This can be used to plan for soil transfer between projects. The tool is created by the consultancy company NIRAS and is openly available online.

A meeting was held between NIRAS and city planners in Bodø to evaluate if it would be possible to use the method in Bodø. It was considered possible. The city plans, however, have high uncertainty in terms of timeline and are changing frequently. Soil predictions were therefore considered to have high uncertainty in a longer term than a few years. The varying soil quality and contamination of Bodø were not considered in the tool, increasing the uncertainty further. A prediction was considered valuable for improved soil planning, but with high uncertainty.

Through a market analysis to look for alternative soil prediction tools, a young software company called Material Mapper was found. They automatically collect data from municipal city planning and a national construction mapping company to map close to all coming construction projects in the coming years and estimate the soil volumes from each project. The software provides location, timeline, contact information and estimated soil volumes for each project in a map or report layout. The software can automatically give updated soil predictions for the city for a chosen time period and a chosen area. In addition the software have functionality for soil exchange between projects (further described under section 4.3.1 Soil databank/marketplace) and useful functionality for estimating waste and material use from construction projects, digitalization of reuse mappings and a useful overview of all coming city projects in a more visual way than the city planners are currently using, further described under 0 Digital marketplace and construction material tool.

The soil predictions from Material Mapper are considered to still lack information about quality and contamination, and still have high uncertainty, but the uncertainty was considered to be lower than the alternatives because of the dynamic and automated

updates and possibility to narrow the location and time. It uses a general estimator for soil volumes and types created for the specific types of constructions, based on type of construction, size, basement area and location. The estimates are not exact or reliable but provide a useful overview of where surplus soil can be expected. Below are screenshots of how the tool shows future projects and some of the information that can be found for each project.

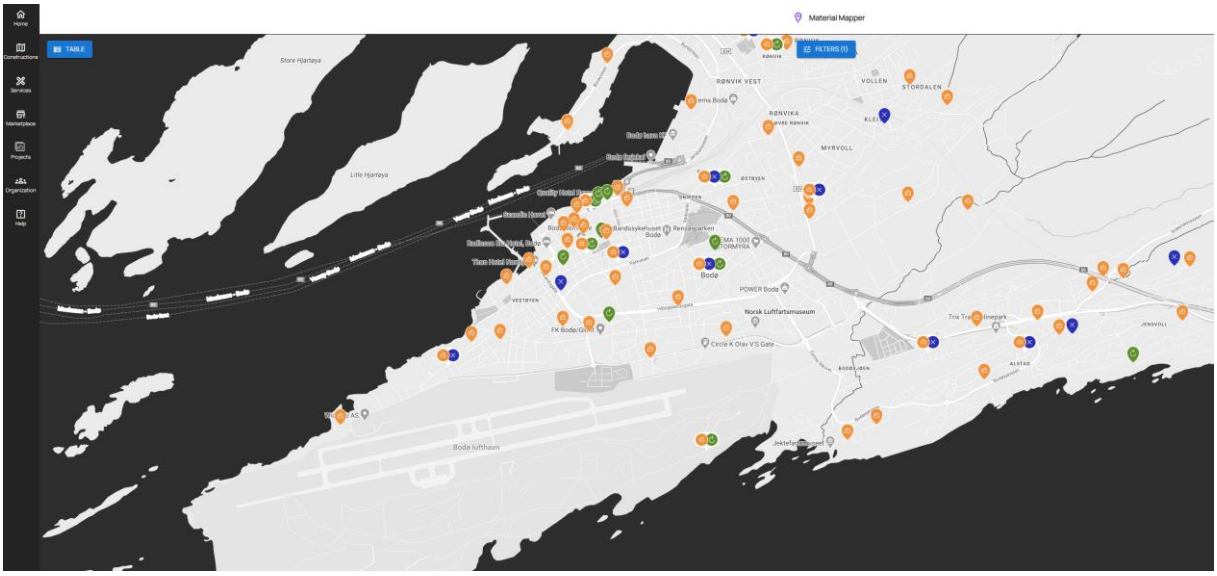


Figure 54. Material Mapper map view of upcoming construction, rehabilitation, and demolition projects

Material Mapper also provides a Soil Prediction report, which can be found in the annex. The report gives an overview of upcoming projects and their estimated timeline and soil volumes, with highlight of some projects of special interest. It also provides information about the need for infill materials in some projects. In addition, it has a calculator/estimation of costs and socioeconomical costs for soil management, with the possibility to test scenarios for reuse cases. The calculator has been shared with Bodø municipality for feedback and further development.

Below is a screenshot of the socioeconomic analysis. It needs further development, but it gives an impression of the potential use. The table is translated from Norwegian by Google translate.

	Soil	Clay	
Number of m3	50 000,00	50 000,00	
Number of tonnes	90 000,00	60 000,00	
Pollution degree			
Clay / Soil			
69% pure	62 100,00	41 400,00	
20% slightly contaminated	18 000,00	12 000,00	
11% heavily polluted	9 900,00	6 600,00	
Land case			
Base case	**Soil**	**Clay**	**Sum**
Distance to landfill	514 800,00	343 200,00	858 000,00
Transport cost	7 464 600,00	4 976 400,00	12 441 000,00
Fee	6 949 800,00	4 633 200,00	11 583 000,00
SUM	**14 929 200,00**	**9 952 800,00**	**24 882 000,00**
	Base case	**Reuse scenario**	**Potential Savings**
Distance landfill (km)	**14,00**	14,00	
Round trip (km)	28,00	28,00	
Number of trips	2 812,50	515,63	2 296,88
Total number (km)	78 750,00	14 437,50	64 312,50
Transport cost			
Cost for tonnage	4 290 000,00	471 900,00	3 818 100,00
Number of hours driven	1 312,50	240,63	1 071,88
Average speed	60,00	60,00	
Cost total km	563 062,50	103 228,13	459 834,38
Cost of hours driven	938 437,50	172 046,88	766 390,63
Total transport	**5 791 500,00**	**747 175,00**	5 044 325,00
prerequisites Environment			
CO2 emissions full car	38 705,63	7 096,03	31 609,59
CO2 per km empty car kg	25 554,38	4 684,97	20 869,41
CO2 Avg	32 130,00	5 890,50	26 239,50
Total CO2 emissions	**64 260,00**	**11 781,00**	52 479,00
Particles full car (kg)	4,13	0,76	3,38
Particles empty car (kg)	2,73	0,50	2,23
Particles Avg	3,43	0,63	2,80
Total Particles	**6,86**	**1,26**	5,60
Socioeconomic value of external costs (NOK/km)			
Transport economic unit prices	554 400,00	101 640,00	452 760,00
Air pollution	100 800,00	18 480,00	82 320,00
Climate change	6 300,00	1 155,00	5 145,00
Noise	17 325,00	3 176,25	14 148,75
Accident	218 137,50	39 991,88	178 145,63
Congestion	76 387,50	14 004,38	62 383,13
Infrastructure	134 662,50	24 688,13	109 974,38
Sum	**1 108 012,50**	**203 135,63**	904 876,88

Figure 55. Material Mapper Socioeconomic analysis of soil management in Bodø for the registered upcoming projects

Kirkeveien 39, 8076 Bodø, Norway

Bodo Municipality

New construction

Block/apartment/terraced house 4700 m^2

Etablering av boliger og dagligvarebutikk i Bodø. 100 boliger samt dagligvarebutikk på rundt 900m2 i første etasje. Størrelse tomt 3,6 dekar

STATUS

Venter på byggesøknad

MODEL START	END DATE
30.8.2023	10.10.2024

APPLICANT	PROMOTER	CASE WORKER
n/a	T.Kolstad Eiendom AS Daniel Thomassen daniel.thomassen@tkeiendom.no	n/a

Building Phases - CO_2 Emissions from construction period (kg CO_2-eq.)

please keep in mind this is estimated data

Building part / Phase	A1-A3 kg CO_2-eq	A4 Transport kg CO_2-eq
Structural systems	294,000	41,900
Exterior walls	267,500	267,500
Interior walls	375,500	59,150
Covers	486,500	83,000
Outer roof	175,500	26,100
Stairs and balconies	51,500	5,750
Total	1,650,500	481,400

Estimated Masses

please keep in mind this is estimated data

Type	Amount (tn)
Soil	10,546,800
Clay	1,128,000

Figure 56. Some of the information given about each construction project in Material Mapper. Under the Estimated Masses heading the calculated amount of clay and soil from the project. The division into soil and clay is subject to be improved. At this point the numbers still have a high uncertainty level

Mapping soil pollution and quality

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

Dashboard with soil information

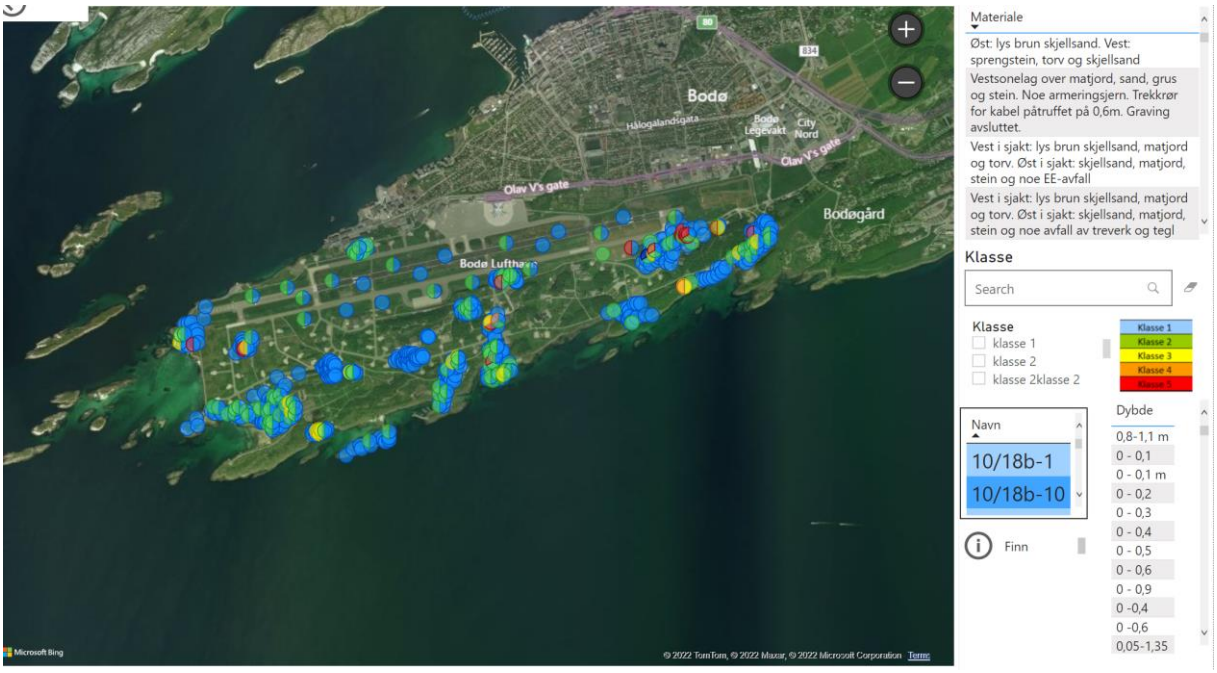
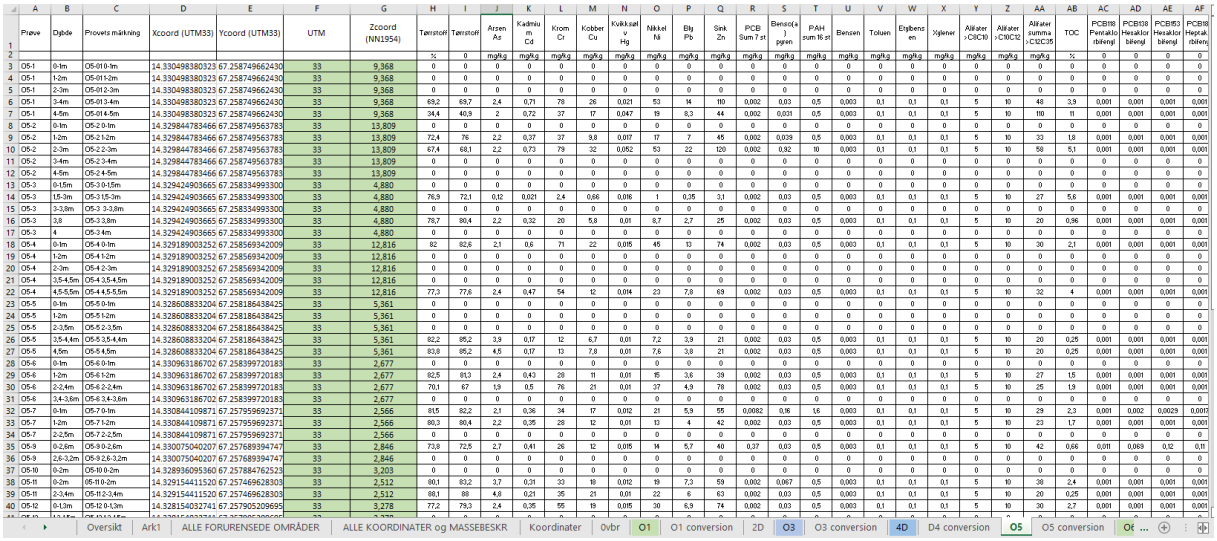


Figure 57. Excerpt from Power BI Dashboard showing levels of contaminated soil in different zones in Bodø.

Functions:

- Qualitative description of soil masses
- Classification of degree of pollution
- Depth information
- Link to detailed information about technical qualities (ex: figure 59)



	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 >C12C35	TOC	PCB118 Pentaklorbifenyl	PCB138 Heksaklorbifenyl	PCB153 Heksaklorbifenyl	PCB180 Heptaklorbifenyl
1																															
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	%	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
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
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
6	O5-1	3-4m	O5-01 3-4m	14.330498380323	67.258749662430	33	9,368	68,2	68,7	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	0,92	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	0,68	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	8,7	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	3,4-3,6m	O5-6 3,4-3,6m	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
32	O5-7	0-1m	O5-7 0-1m	14.330844109871	67.257959692371	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	67.257959692371	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	67.257959692371	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
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	0,27	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
37	O5-10	0-2m	O5-10 0-2m	14.328936095360	67.257884762523	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
38	O5-11	0-2m	O5-11 0-2m	14.329154411520	67.257469628303	33	2,512	80,1	80,2	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	67.257905209655	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 | O6 ...

Figure 58. Data source from excel for the visualization in Power BI.

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.

4.3.1 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 59. Description of Bærum Ressursbank marketplace criteria. More information at Bærum Ressursbank webpage.

For information visit the website here: https://www.baerum.kommune.no/politikk-og-samfunn/samfunnsutvikling/om-barum-ressursbank/

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 0 Digital marketplace and construction material tool.

4.3.2 Soil roadmap and municipal soil management group

The municipality is involved in soil management through different departments and processes, and with quite different focus areas for the soil management. This makes soil management in the municipality a complicated topic that is challenging to get a good overview of. The CityLoops Soil Roadmap is a tool to describe the different municipal roles involved in soil management in an understandable way.

To make a precise and useful roadmap, and to gather the relevant departments to improve the soil management practice, a project group was selected to get the overview of current practice and discuss the way forward. To keep the project focused it was decided to involve all involved roles in the municipal soil management, but to limit the participation to one representative for each “role”. In Bodø this amounted to 13 participants.

It was also decided to limit the project period to two and a half intense months with clear goals and significant involvement by all the participants. Five project meetings were planned, where the project leader should ensure clear agendas and milestone results during the project periods. The project was planned and lead by CityLoops Bodø representative.

To make the results of the group as useful as possible, the result should not primarily be a larger report or plan, which would be land-filled in the cloud together with lots of other plans that are never again to be read. During the first meeting it was decided that the results of the group should be:

- A list of actions required to improve the current practice. Each action should in sufficient detail describe what, why, how, who and when.
- Plan for an updated soil management plan for Bodø municipality (disposition)
- An overview of the relevant roles, responsibilities, processes, and regulations in the municipality, presented through a soil roadmap and a flow diagram.

The soil management can be divided in the categories:

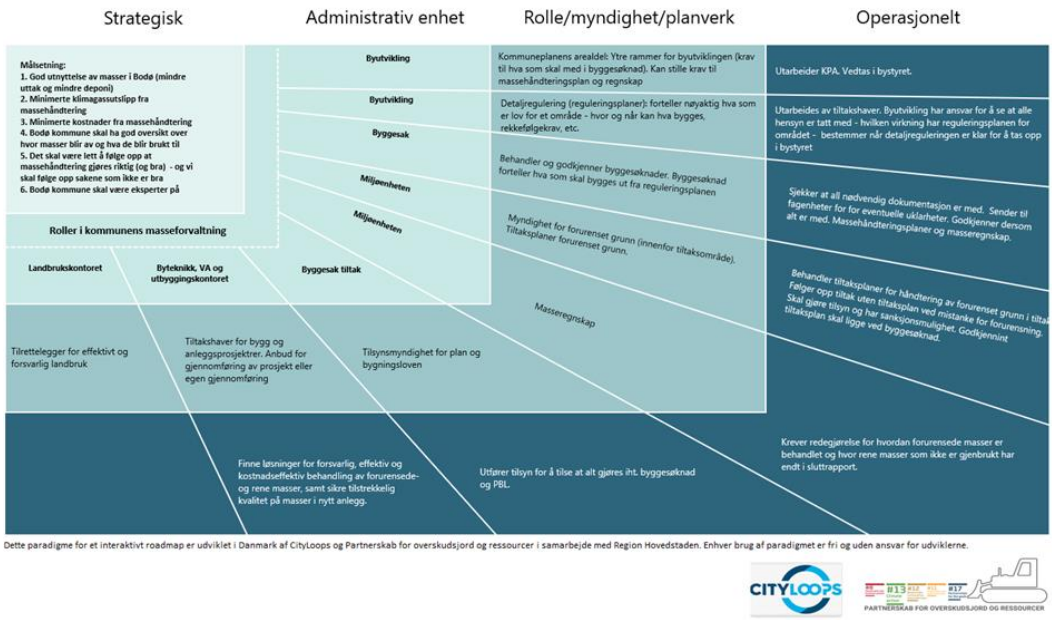


Figure 60. CityLoops Tool 3 Interactive soil roadmap developed in Denmark.

4.3.3 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 settle 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.

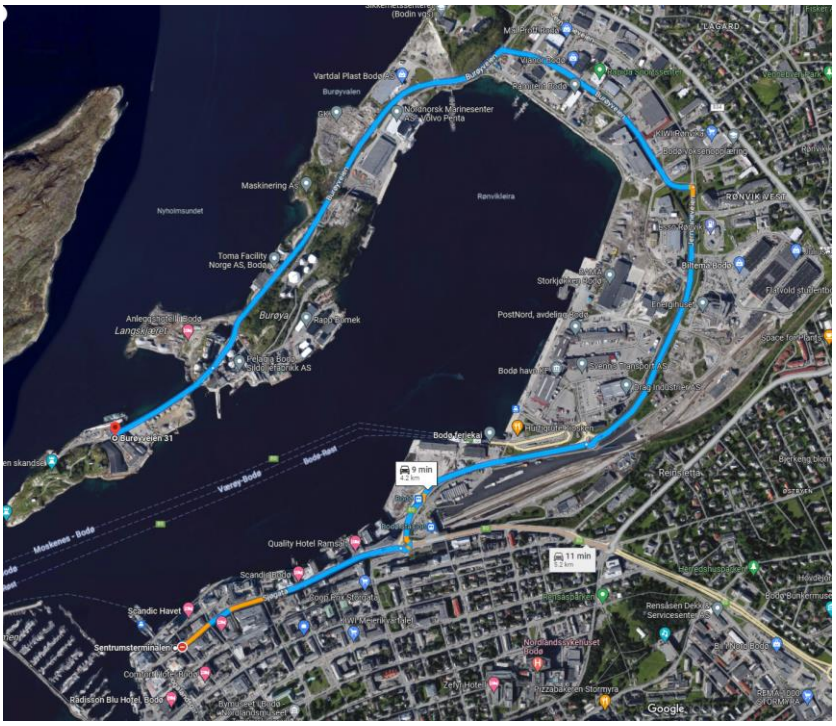


Figure 61. Map showing the location of Burøya intermediate storage. The storage is 3-4 km by road, or less than a kilometer by boat from the road construction project in Sjøgata in Bodø city center.

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 centre 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.

4.3.4 Soil management in construction tenders

Sjøgata road renovation project

- Sjøgata is one of the main streets going through Bodø city center.
- It was decided to be a pilot road project for low emission and circularity as a pilot for work with the new airport.
- Close cooperation between the technical road management department, procurement department and development department to decide level of ambitions and prepare the public procurement.
- Discussed solutions for cleaning contaminated soil with local actors. The local landfill management company offered to make necessary investments for cleaning contaminated soil with per ton prices for cleaning.
- The procurement received public funding from national authorities (Klimasats) to support additional costs with sustainability measures. Total additional funding of 9,5 mill NOK (approx. 950 000 EUR) was added to the procurement for these measures.
    - Zero emission construction machines were an important part of this budget.
    - Material reuse was another important criterion.
- The total price from the winner was approximately 90 mill NOK (~9 mill EUR).
- Criteria: all masses that can be reused internally in the project are to be reused. This may involve sorting, cleaning of slightly contaminated soil and reuse of slightly contaminated masses where they were removed.
- Intermediate storage could be used for sorting, cleaning, and storage.

4.4 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.

4.4.1 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.

4.4.2 Phases for processes

In the process of developing physical material banks and digital marketplaces, there are a number of steps that must be taken in order to design a successful outcome; these steps can be adapted to various local circumstances.

Spot the problem. For the creation of physical material banks and digital marketplaces, a thorough understanding of the requirements is essential. While physical space is required for the storage of physical material banks, the issue with digital marketplaces may lie in their scope, dissemination, and the need for someone to keep it up to date. However, for both physical material banks and digital marketplaces, resources (technical, physical, economic, human, etc.) for running their operations and assure continuity is a shared common challenge.

Find a group of collaborators. People can contribute expertise, knowledge, and perspectives to the creation of physical material banks and digital marketplaces; therefore, a combination of broad knowledge, experience, experts, and inter-disciplinary teams is of great value during this phase.

Establishment of commitments and objectives. Once a team has been formed, it is necessary to determine everyone's commitments and objectives, as well as the project's ambitions and ambition levels.

Negotiation and ideation. Sharing responsibilities and duties, as well as discussing the benefits for each stakeholder, will ensure the stakeholders' prior commitments. In this phase, it is essential for the group to engage in a variety of creative and innovative discussions and to be open to suggestions that may or may not have been tested previously.

Planning. Once there is an idea and responsibilities and benefits have been established planning takes place. Management of time, dates, data and resources can shape the way forward to develop those physical material banks and digital markets. Communication is critical, establishing a channel of communication and sticking to the plan must be a priority. However, some unanticipated problems may arise along the way, and the group should ideally be open to modifying and enhancing expectations and procedures; if possible, it is prudent to allocate additional time for deviations.

Implementation. This is the hands on the job part, actions following plans and creative problem solving developed in previous phases will help to apply the knowledge for the development of markets both digital and physical, As stated previously, some deviations may occur, but a strong and resourceful group of collaborators can find solutions. It is important to build resilience and to dare to test, this practical part might entail some failures, learning from failures is good and provides us with important knowledge we would not have gotten otherwise.

Evaluation. Either after having finished the project or as a continuous step involved in several phases, evaluating milestones, and comparing it with expectations can provide us with a picture of what went better than expected and where we need to improve. This plays an important role for continuous improvement and serves as a guiding tool for future replications as well.

Figure 62. Physical material banks and digital market phases general phases.

4.5 Stakeholder / Citizen involvement

Facilitated by CityLoops partner Nordland Research Institute, a stakeholder analysis (Stakeholder Analysis.pdf) is made. This has been to a huge extent been used to arrange stakeholder and citizen involvement actitvites described in detail in an enclosed appendix (Sakeholder Engagement in CDW in Bodø, Norway. Extract of the demonstration report.)

- The Reuse Lab – Citizen's involvement
- Competence forum
- Procurement Workshops
- Internal network Bodø municipality
- New City Festival
- Minecraft challenge

- Parallell architect missions
- Student engagements
    a. Nord University (Bodø)
    b. Saxion University (Apeldoorn)

Scalability

The methods on stakeholder involvement are described in the stakeholder Engagement in CDW in Bodø, Norway. Extract of the demonstration report made available for replicators. Stakeholder involvement activities are very replicable, and manhours are often the biggest resource needed to execute them.

5 Business cases & risk handling

Business cases – Sjøgata, Bodø

Mass treatment and transport at a road development project

Figure 63. Mass treatment and transport at a road development project (Photo: Bodø Municipality)

The business case in a brief

This business case will explore different alternatives (scenarios and options) for mass treatment and -transport at a road development project in midtown Bodø. This is localized close to the CityLoops demonstration site (Bodø Airport) and will function as a pilot. This means that the lessons learned from this business case will be applied to mass treatment processes in the demonstration project.

Different options for mass treatment and transportation are assessed, and pros and cons of the alternatives are evaluated. Factors of significance are financial, environmental, and social impacts.

Lessons learned and conclusion.

From a monetary perspective, the business case analysis favours the solutions where reuse is practiced, either it is practiced at an intermediate storage facility or at the waste management facility. In the best-case scenario, reuse at the intermediate storage at Langskjæret is preferred, while in the worst-case scenario (with less reusable masses), reuse at Iris is preferred. Given the fact that IRIS is in possession of more competence and equipment to handle the masses, the business case analysis in general suggests Option 2 that entails reuse at Iris. In terms of social values, the solutions with the shorter distance and workplace generation are preferred. From an environmental perspective, Option 3 is preferred for the “best case”, while option 2 is preferred for the “worst case”.

The business case in details

To get an understanding of the price for disposing masses, data from IRIS (local waste management company) is gathered. This data show that in total, the sum of clean and polluted masses ending up in the landfill, amounts to 27 155 tonnes in 2022, allocated like this:

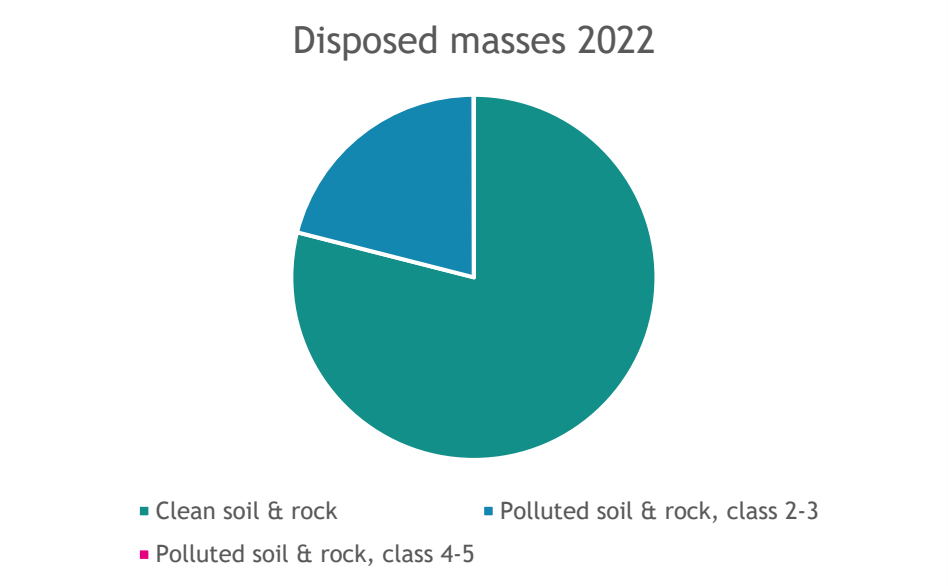


Figure 64. allocation of municipal disposed masses 2022

Clean soil & rock	21 445	Tonnes
Polluted soil & rock, class 2-3	5 705	Tonnes
Polluted soil & rock, class 4-5	5	Tonnes
Sum	**27 155**	Tonnes

With this pricing model pr ton

Clean soil & rock	NKR 87	€ 7,70
Polluted soil & rock, class 2-3	NKR 378	€ 33,35
Polluted soil & rock, class 4-5	NKR 594	€ 52,40

Meaning that the total cost for disposed masses in 2022 is:

Cost 2022		
Clean soil & rock	NKR 1 865 715	€ 164 647
Polluted soil & rock, class 2-3	NKR 2 156 490	€ 190 308
Polluted soil & rock, class 4-5	NKR 2 970	€ 262
Sum	**NKR 4 025 175**	**€ 355 217**

Based on this information, we see that even though the amount of (mainly lightly) polluted masses are significantly lower than clean masses, the price of treating them is higher:

Figure 65. Graph that shows the price level of treating masses of different contents

5.1 Alternative routes for mass transport

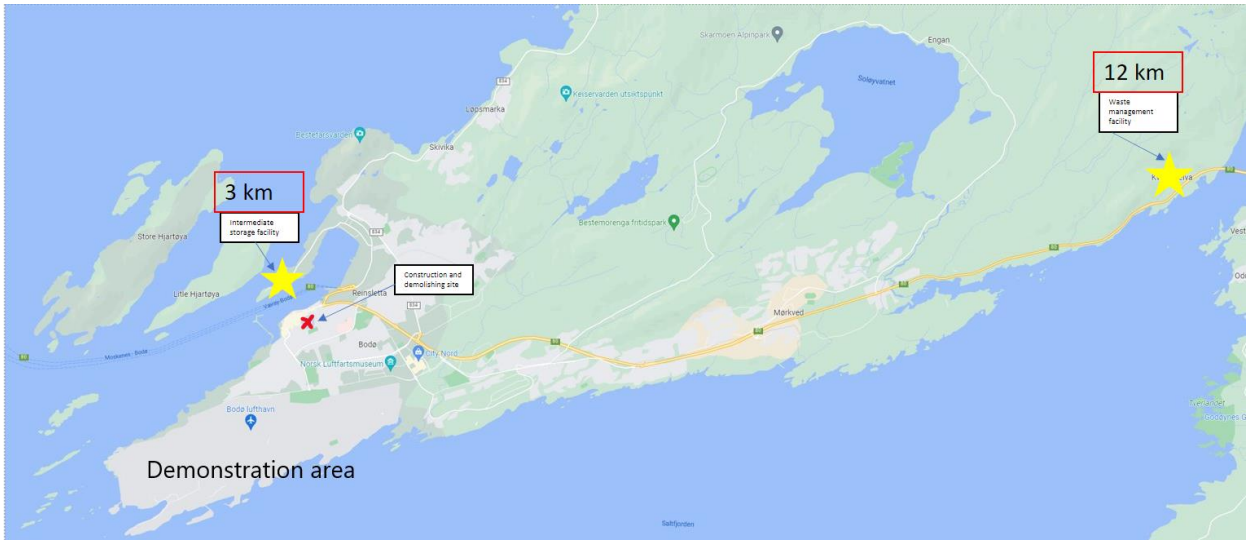


Figure 66. Map with construction site and current mass treatment sites

The star that is marked as 3 kms from the construction site (red X) is the location of the intermediate storage facility (Langskjæret). The star marked as 12 kms from the

construction site is the waste management facility. This business case evaluates where the different masses should be transported and how they should be treated.

In the business case, it is discussed whether the masses should be transported to the intermediate storage facility, or to the waste management facility. Or a combination. In discussing where masses should be transported, these are the most important advantages and disadvantages that have been described:

Waste management facility, advantages:

- Approved landfill
- Crew and equipment for e.g., waste sieving

Waste management facility, disadvantages:

- Longer transport distance than alternative
- Expensive waste treatment

Intermediate storage facility advantages:

- Shorter transport distance
- Free, and municipal ownership

Intermediate storage facility disadvantages:

- Not approved as landfill
- Investments of new equipment for sieving is necessary.

5.2 Scenarios

To build different scenarios, we must look at IRIS' price model. The fact that Bodø Municipality in order to treat masses in a circular way, has to buy back its own disposed masses to IRIS, has to be taken into consideration in the trade-off analysis. In the scenario building financial values will be of significance. However, a CityLoops-developed LCA-calculator will also be used to help us quantify CO2-emissions from the different alternatives that will also be of significance. Furthermore, reflections around social values on the different alternatives are made, making sure triple bottom line [Link] are taken into consideration.

Clean masses pr ton		
Disposal	NKR 87	€ 7,70
Treatment	NKR 60	€ 5,25
Polluted masses pr ton		
Disposal	NKR 78	€ 33,35
Treatment	NKR 78	€ 24,50
Procurement of cleaned masses (originally disposed) pr ton.	NKR 100	€ 8,80
Collection of stored massed pr ton	NKR 40	€ 3,50

Figure 67. price model for mass disposal IRIS Waste Management Facility

Two different scenarios are evaluated. One scenario described as a "best case" where the masses have a greater degree of reusability than the second scenario described as a "worst case". Based on information that already has been gathered about the masses, chances are that the quality of the masses is characterized somewhere in between the two scenarios. To these two scenarios, three different ways of treating the masses are evaluated.

The calculations that lay the foundation for the analyses are attached in an Excel-sheet.

Scenario 1 – "Best case"

- 1 year of digging
- 5,000 tonnes of soil/stone masses
- 40% contaminated.
  - 10% to landfill
  - 30% is cleaned and reused.
- 60% pure
  - 30% is sieved and reused.
  - 30% is reused without sifting.
- 20% disappears when sifting.

Mass treatment option 1

- Case 1
  - Everything is deposited.

Mass treatment option 2

- 90% is sent for reuse on IRIS.
  - 30 % polluted and reused.
  - 30 % clean, sieved and reused.
- 20 % disappears.
  - 30 % clean and directly reused.

Mass treatment option 3

- 30% is temporarily stored at Langskjæret.
- 60% treatment and reuse at IRIS.
- 10% to landfill.

The cost of these three options is visualized in this model:

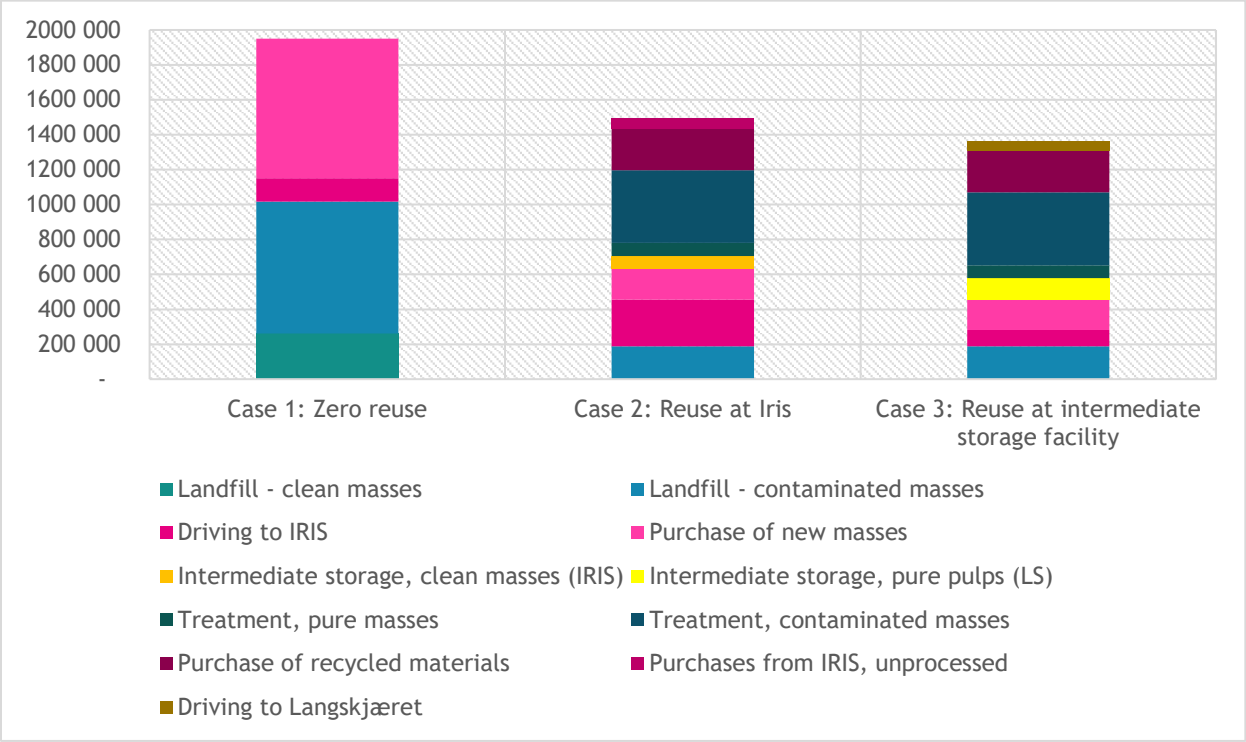


Figure 68. This model shows visualize the costs in the three options in Scenario 1

With this scenario, the analysis suggests that the most inexpensive way of treating the masses is at the intermediate storage facility but that that this might lead to more requirements to how masses are treated at site. The complexity of mass treatment should be considered at a cost/benefit analysis.

Scenario 2 – "Worst case"

- 1 year of digging
- 5,000 tonnes of soil/stone masses
- 40% contaminated.
  - 10% can be cleaned and reused.
  - 30% is deposited.
- 60% pure
  - 30% is deposited.
  - 20% can be reused after sieving.
  - 10% can be reused without sifting.
- 20% disappears when sifting.

Mass treatment option 1

- Everything is deposited.

Mass treatment option 2

- 60% is deposited at IRIS.
- 30% is processed and reused at IRIS.
- 10% is temporarily stored and reused at IRIS.

Mass treatment option 3

- 10% is temporarily stored at Langskjæret
- 30% treatment and reuse at IRIS
- 60% to landfill

The cost of these three options is visualized in this model - see next page:

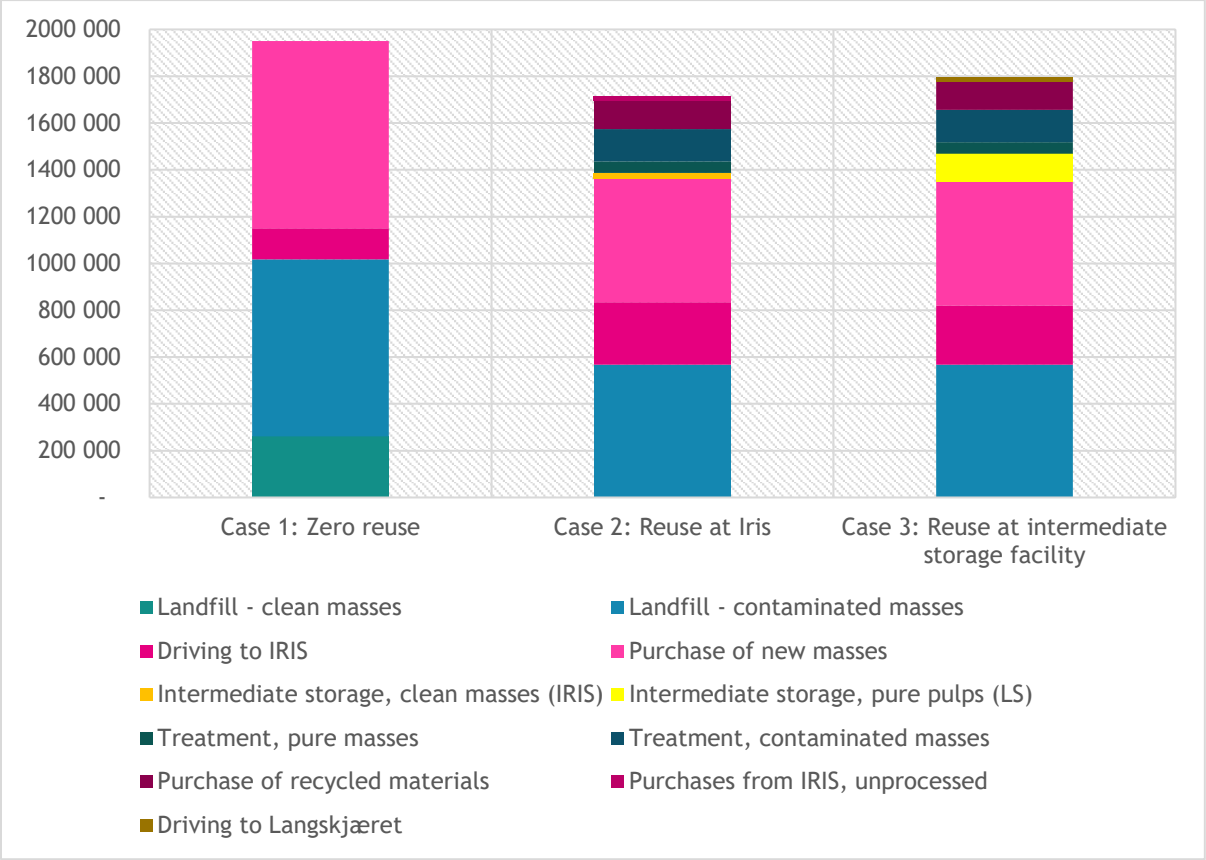


Figure 69. This model shows visualize the costs in the three options in Scenario 2

At a scenario where the reusability of the masses is lower than in the best-case scenario, the analysis suggests that sending the masses to the waste management facility in the most inexpensive way of doing it. This complexity of treating the masses will then accrue IRIS that has more competence in this than Bodø Municipality.

5.3 Environmental considerations

In this discussion, emission will from the different alternatives will be evaluated. To quantify the amount of CO2 the different alternatives will lead to, a CityLoops-developed LCA-tool is applied [Link].

The results of these analyses are summarized in this matrix:

Options	CO2 spend “best case”	CO2 spend “worst case”
Option 1	**4 878 tonnes**	**4 878 tonnes**
Option 2	**3 735 tonnes**	**4 327 tonnes**
Option 3	**3 678 tonnes**	**4 461 tonnes**

Figure 70. Matrix for result analyses

This suggests that Option 2 in both scenarios are the least CO2-emission intensive solutions to handle and transport the masses.

Find calculations behind the results in the matrix in Appendix 1.

5.4 Social values

Social values are something that should be taken into consideration in the business case. In this specific case it is believed that it would not benefit the inhabitants of Bodø if infrastructure is affected by heavy load of industrial transport. Particulate matter, traffic load, noise, wear on roads and safety are factors that are believed to influence the quality of life of Bodø’s inhabitants.

As a result of an informal workshop with employees at the Business & Society Department in Bodø Municipality, this matrix that that discusses social factors were made.

The result of this suggests that the most socially sustainable way of transporting masses in general, when the two alternatives are compared, is the shorter route on 3 km to Langskjæret. This is because it will be exposing a shorter road stretch to noise, pollution, wear, and tear and will pass a lower number of people.

Increasing the mass treatment activities at the intermediate storage facility will possibly lead to increased degree business activities and workplaces. From a social perspective this is probably considered as a beneficial effect.

Even though case 3 come out as the best option, the social impact of all the cases can be considered low, as the roads are built for heavy transport and go through areas with low population. The first section has a more significant impact, but because this is the same for all cases and hard to avoid, it is therefore not considered in detail.

Enclosed to this demonstration report lies an appendix (CityLoops Business Case.pdf) with a business case that explores different alternatives for mass treatment and -transport at a road development project in midtown Bodø. This is localised close to the CityLoops demonstration site (Bodø Airport) and will function as a pilot. This means that the lessons learned from this business case will be applied to mass treatment processes in the demonstration project.

Different options for mass treatment and transportation are assessed, and pros and cons of the alternatives are evaluated. Factors of significance are financial, environmental, and social impacts.

6 Assessment of replicability and recommendations.

The CityLoops project has facilitated collaboration among cities in their pursuit of transformative and innovative processes. In the specific context of adopting circular practices related CDW, it becomes apparent that such adoption necessitates a distinct utilization of resources.

Drawing insights from the experiences of others has proven to be a catalyst and a driving force behind participatory methodologies aimed at generating knowledge and facilitating the exchange of information.

The development of various tools, including the two tools:no.12 Stakeholder engagement developed by Bodø, tailored for specific activities is a crucial factor in enhancing the efficiency and effectiveness of processes. These advancements have resulted in the creation of multiple tools that aid decision makers in making well-informed decisions grounded in high-quality data. The utilization of digital twin technology has facilitated the creation of data visualizations, enabling the development of various scenarios. These data-driven scenarios serve to either validate or dismiss certain decisions.

The stakeholder engagement platform has strengthened the collaboration and mutual understanding of circular economic strategies of stakeholders in all processes in the value chain.

The implementation of a circular economy can contribute to the achievement of the climate and environmental objectives outlined in the city or municipal plans. This approach can effectively reduce emissions, facilitate targeted interventions in areas with the greatest environmental impact, and implement necessary corrective measures as required.

The cultivation of a transformative mindset, coupled with the continuous integration of technological advancements, new knowledge, and innovative practices, constitutes a significant aspect of it. Engaging in rigorous testing, diligent study, and meticulous replication of actions establishes a robust framework for learning from past errors and sustaining long-term solutions that effectively address the unique needs and circumstances of a given society.

The utilization of material stream analysis and material mapping has facilitated the identification of potential applications for secondary materials, taking into consideration their quality and the opportunities for upcycling, reuse, repurposing, or rethinking. This approach aims to prevent landfill disposal and mitigate environmental contamination and degradation.

Selective demolition and effective construction project planning, which can be facilitated by tools such as the Life Cycle Assessment, are commendable practices that enable organizations to quantify the cumulative benefits or cost savings associated with adopting a more environmentally friendly approach. The actions and studies conducted have clearly demonstrated the necessity for the establishment of intermediate storage facilities to facilitate the reuse of masses. Additionally, it has become apparent that distances and collaboration are crucial factors that significantly impact all stakeholders involved in this process.

The topic of procurement has garnered significant attention throughout the project, as it possesses considerable potential to influence the acquisition of products and services, particularly with regard to circular criteria or criteria that facilitate circularity practices.

To enhance the likelihood of favourable outcomes in planned projects and goals, it is crucial to thoroughly examine various materials, costs, scenarios, and comparable cases. Additionally, careful consideration of environmental, social, and economic factors is essential.

Simultaneously, it is imperative that goals are attainable, and that indicators for monitoring and evaluating specific actions are developed and regularly assessed. The successful implementation of circularity in decision making within a specific city necessitates the active involvement of dedicated and proactive leadership, decision makers, and engaged colleagues.

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.

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