Refining Circular Economy Practices Through Cooperation Between the Developer and the Contractor: Case Study

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Abstract

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With circular economy becoming globally ascendant, actors in all industries are compelled to assess and develop their practices towards sustainability. The purpose of this thesis is to examine the relationship between the commissioner's contractors and circular economy. The objective was to observe the factors preventing possible development or implementation of circular economy practices.

The literature in this research presents the reader with common terminology and practices of circular economy as well as specificities of circular economy in the construction sector. The literature is used to introduce the reader to the lifecycle of construction through the view of circular economy. In the third theoretical section, environmental certifications for construction were studied, and the significance of circular economy in the certification's assessment criteria is presented.

The subject was examined through conducting thematic interviews with contractors. Thereafter, the data was analyzed with grounded theory. Two hypotheses were drawn regarding the core issues preventing circular economy from taking place. The insights gained from the interviews were divided into two categories: workable and informational insights. The workable insights were further explored in a workshop hosted for the commissioner's employees. The findings were visualized with a process blueprint as well an informational insight table.

The main factors presented in the findings outline the lack of demand and set measurement methods, as well as the circular operating models on average being more resource intensive. To offset the asymmetry, the commissioner could determine set indicators for the valuation of circular economy, including testing budgets for innovation as well as developing working models in which the contractor is included from an earlier stage.

Keywords: Circular economy, green transition, ecological construction, environmental certification

Contents

1 Introduction

The climate crisis and environmental decline have become a pressing matter in both media and politics. The annual world waste production reaching 2.01 tons, and each decade surpassing its predecessor in temperature rise further validate the concerns (World Bank, no date; International Panel on Climate Change 2021, 3). Global actions have begun to prevent further decline of the environment.

To address the climate crisis through economics, the European Commission released its first circular economy action plan in 2015. The program consisted of established actions for each phase of a products lifecycle to maximize its use. It amended legislative rulings for waste management and waste material use (European Commission no date, a). In 2020 the new Circular Economy Action Plan (CEAP) was published consisting of a coherent plan of action intending to make sustainable products, services, and business models the new standard in Europe and eventually globally (European Commission 2020, chap. 1).

In Finland the resolution on promoting circular economy by the Ministry of the Environment (2021a, 2) presents a goal in which circular economy is the standard economic principle, and carbon neutrality has been reached by the year 2035. The goals set by the authorities have created pressure and highlighted several fields' roles and insufficiencies in sustainability.

The research conducted in this thesis aims to examine the implementation of circular economy practices in construction through a case study commissioned by SATO Oyj. The purpose of the research is to provide knowledge for the commissioner about the current state of circular economy employed by its contractors. Indeed, the research aims to provide insights into and derive solutions and plausible development proposals for the insufficiencies noted. The subject matter is examined through two angles, the contractors' perceptions, and the views of the commissioner's employees. As the outcome of the research the commissioner will receive both concrete development proposals as well as insights into the core issues preventing the realization of circular economy in their business functions. The results can be utilized for implementation of and ideation on further development regarding the commissioner's circular economy practices.

2 Case company

The research was commissioned by the construction company SATO Oyj. The company's business model resolves around buying, building, and maintaining ownership of apartments.

(SATO 2017,1) SATO's area of function is centered around Finland's metropolitan area and the working areas around the main railways. Outside of the metropolitan area the company intends to remain active in Tampere and Turku. (SATO 2022a, 5)

In the company responsibility program of 2023-2026, SATO (no date) states that it strives to become the leader in responsible rental housing. The goal consists of developing sustainable practices from carbon neutrality and circular economy to the tenant's wellbeing and transparency in business functions. In addition, the company has made an intention to explore available environmental certifications for construction (SATO 2022c).

Throughout SATO's history, external contractors have been employed to manage the construction process. The developer (SATO) acts as a client, ordering the construction work from external contractors. In the collaboration process examined in this thesis, SATO's role is the developer or the commissioner of the work. In the cooperation the contractors collaborate as independent actors to construct SATO's housing solutions. The research is specifically delimited at examining the construction processes in SATO's business.

An overview of the industry through circular economy

The built environment is a globally significant contributor to emissions and resource expenditure. According to The International Energy Agency (2020, 159) the building sector directly and indirectly consumed approximately 30% of energy used in the world in 2019. Although the laws and regulations are shifting to allow for more recycling and circular practices to be implemented, the large-scale realization of circular economy has yet to reach its peak in the construction industry.

In Finland, the construction sector plays a crucial role in expenditure and output of the country. Based on the official financial accounting published by Official Statistics Finland (2019) in 2017, construction sector amounted a total of 35 billion euros, which equals to 17,2% value added to Finland's gross domestic product (The Finnish Government 2020, 16). Of the production in 2022, SATO finished construction on 243 houses had 24 999 SATOhomes in possession (SATO 2022b, 12). The Finnish construction sectors transition into green economy is advocated by the European Union's directive on energy efficiency as well as Finland's renovation roadmap. Both parties intend for the sector to develop to a more sustainable nature through renovations for more to more energy efficient and carbon neutral housing (Rakennusteollisuus 2022, 2).

3 Circular economy

According to the European Investment Bank (2020, 1), the current prevailing economic model, linear economy, emerged in the second industrial revolution. After World War II, the world experienced a rise in wealth, leading to increased resource use and consumption. The United Nations (no date, a) states that the volatility of consumption and production is at the core of climate change, biodiversity loss and pollution crises. In neoclassical economics, which was prevalent throughout the last two centuries, nature is seen as a resource and a place to discard waste, resulting in a linear economic model (Brandão Lazarevic & Finnveden 2022; Gilpin R. & Gilpin J. 2001, 46). The process that linear economy employs begins with deriving materials from nature. After which the materials are processed and formed into a product. The product is distributed to the end-user and disposed of at the end of its life. (Acaroglu, no date a) Reducing consumption is only a short-term solution, as significant amounts of materials and energy are needed to upkeep the linear economic model. Therefore, reconstruction of the companies' operating models is needed (Webster 2017, 47).

The term circular economy made its first academic appearance in Pearce and Turner's seminar work Economics of Natural Resources and the Environment in 1990 (Brandão et al. 2022, 9). Since then, many definitions and interpretations of the concept have been drawn. Bourguignon (2016, 9), in the European Parliaments briefing of the new circular economy package, circular economy is defined as an economic model in which materials, components and products are recycled, reused, and shared between different stages of their lifecycle. Ellen McArthur Foundation's (2013, 26) definition of circular economy entails considering the emissions, material flows, labour and information consumption sustainably. In this research, the term circular economy is delimited to include precisely the functions related to environmental impact.

3.1 The lifecycle of a product

Lifecycles, in the context of consumer goods, refer to the processes and stages a product occupies from its ideation to its disposal. Employing circular business models can reduce the environmental strain of a product by modifying its material flows in each stage of the lifecycle, from extraction to the disposal of the resources and material (OECD 2018, 4).

The butterfly diagram by Ellen Mc Arthur foundation (2009) presents two types of circular economy processes: a technical cycle, referring to the lifecycle of non-biodegradable products, and the biological lifecycle, showcasing the lifecycle of a biodegradable product. The lifecycle of a non-recyclable product can be optimized by allowing for maintenance through repair, reuse, or redistribution of the material. At the end of its lifecycle, there must be an opportunity to recycle the materials for use elsewhere. A renewable material in a circular model is used optimally by passing it or its byproducts into other uses several times through its natural lifecycle. (See Figure 1)

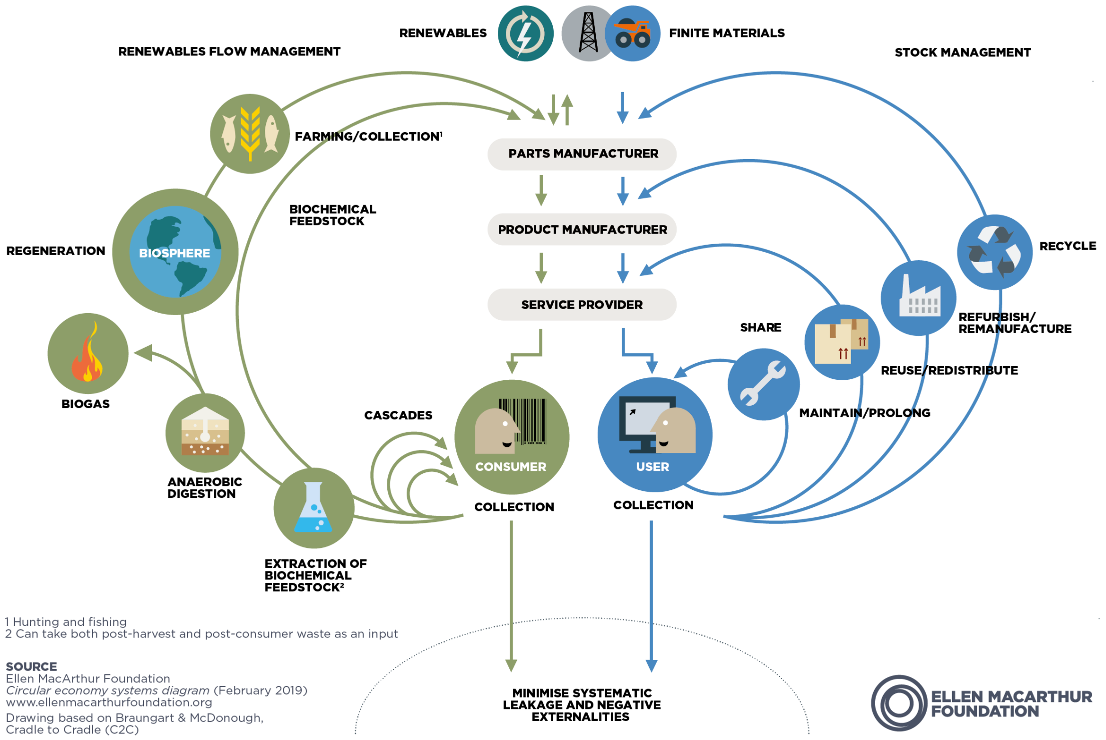


Figure 1: Circular Economy Systems Diagram (Ellen MacArthur Foundation 2009)

Lifecycle assessment

Lifecycle assessment is a methodology in which the inflows and outflows and the impact a product places on the environment are assessed (ISO 1997). A lifecycle assessment consists of two parts, analyzing the life cycle inventory analysis, which is then assessed with a life cycle impact assessment (Baccini & Brunner 2012, chap. 2). The lifecycle inventory analysis comprises the inputs and outputs in a quantifiable manner, whilst the lifecycle impact assessment analyses them from the perspective of potential environmental impact (ISO no date).

In the ISO14044:2006 a lifecycle assessment method proceeds in four steps:

1. Defining the goals and scope	2. Analyzing the inventory	3. Assessing the impact	4. Interpretation of the results

Supply chain management

Each product consists of raw materials that constitute to a global supply chain. The supply chain has several environmental impacts in its different phases. As the supply chain is examined and its effects are defined, sustainability can be attained through design (Acaroglu no date b, 12). Sustainable supply chain management is used to create longstanding business practices that provide social and economic value for the stakeholders (United Nations Global Compact Office & BSR 2015, 7). Green supply chains intend to reduce waste and environmental strain while maintaining or improving profitability and consumer satisfaction (Emmett & Sood 2010, chap. 1.2).

Supply chain mapping refers to the process in which the entirety of a product's supply chain is identified, and an illustration of it is formed. The supply chain map consists of all the resources that it takes to produce a functional product. The formation of a supply chain map presents an opportunity to distinguish the definite and potential risks of a product (UN Global Compact Office and BSR 2015, 32).

3.2 Sustainable development

In addition to establishing resource efficiency, companies must create new business models founded upon circular economy models, such as sharing resources, creating durable products, and aiding the reuse and recycling of their products (European Investment Bank 2020, 4). Furthermore, companies can contribute by designing products that are more suitable for circular economy. In the design and development phase of a product's life, approximately 80% of the environmental impacts can be determined. Companies can apply a proper planning process to establish products more coherent with circular economy practices. In a generic checklist for eco-design, the material sourcing, manufacturing, distribution, use and end-of-life are all considered (Charter 2019). The designing methods, also known as sustainable design strategies, can be implemented to revise faults in the supply chain practices for a more environmentally conscious process (Acaroglu no date b, 24).

Green transition

Green transition refers to the transition of companies into economic models which help sustain the environment, in contrast to depleting it. Making the green transition may include practices such as investments in environmental development, developing carbon neutrality roadmaps or providing new operating models suitable for circular economy (Ministry of the environment no date a). Lacy, Long and Spindler (2020 chap. 2) present five business models for circular economy. These services can present completely new independent business models or aid other businesses in establishing more circular functions. (See Figure 2 below.)

1. Circular inputs: Utilizing renewable energy and bio-based or raw materials in production.

2. Sharing platforms: Allowing users to retain from product ownership, by in turn facilitating a product with shared use.
3. Product as a service: both removing and preventing waste materials from accumulating through usage extension by distributing a product as a service. Thereby the company benefits when a product's lifecycle being extended.
4. Product use extension: Designing repairable, reusable, and upgradeable products, which extend the lifecycle.
5. Resource recovery: To emit the product from waste to a new resource for other products, completing the loop.

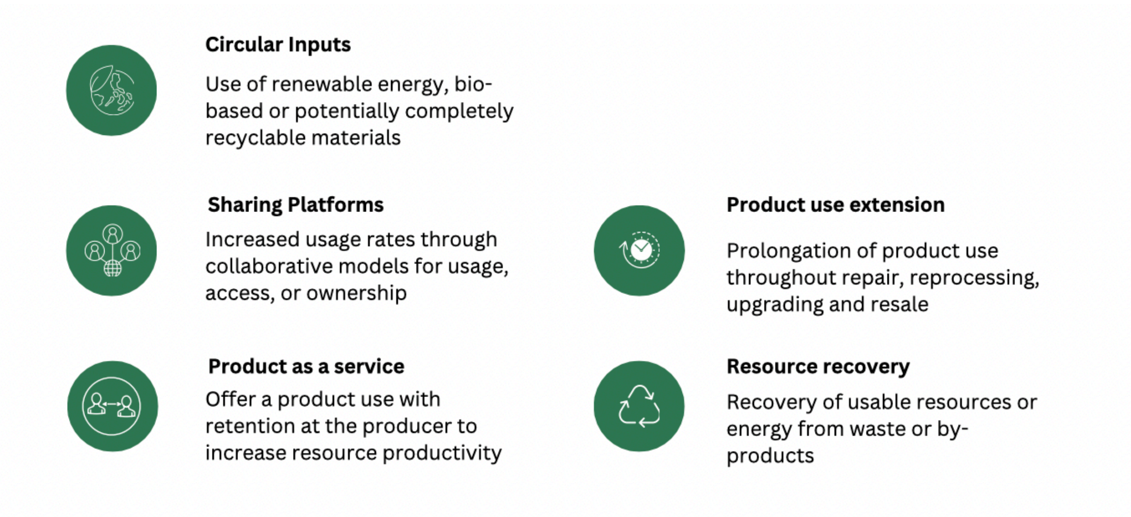


Figure 2: Five business models for circular economy (Lacy et al. 2020 chap. 2)

3.3 Renewable energy and carbon neutrality

In all business practices, the production of goods and the use of energy is bound to cause emissions (Kolstad 2011, 5-11). The use of fossil fuels is based on burning coal, oil, or gas, which consequentially releases greenhouse gases to the environment. When in turn utilizing renewable energy sources the emissions are reduced (United Nations no date, b). To further minimize the environmental strain caused by production, companies can participate in offsetting their emissions. Voluntary carbon offsetting refers to a practice in which a company, consumer or a public body can negate its carbon emissions by fulfilling reductions or removal of emissions elsewhere (The Ministry of Environment no date b). Although carbon offsetting has a positive impact on the environment, the practice fails to remove the occurring greenhouse gases. When considering carbon offsetting, it should be seen as an option for when all other steps have been taken to reach carbon emission reduction (Doerr 2021, 143-144).

Carbon neutrality is a claim a company can make when their product or service has reached an equilibrium on the carbon emissions caused and offsetting. When claiming carbon neutrality, a company must calculate the emissions caused and subtract the compensations from it, leading to the calculation summing up to zero (Ministry of Environment 2021b, 15). Achieving carbon neutrality requires a company to design its processes to cut surplus emissions, optimize energy efficiency and the supply chain, as well as record the emissions leftover and enact offsetting them (Doerr 2021, 152).

4 Circular Economy in Construction

The current concept of ecological construction emerged in the early 2000s. Later, practices derived from the circular economy model became relevant to construction, with practices such as prolonging a product's life and reusing heat and energy waste being implemented to attain a more environmentally conscious build (Huttunen 2021, 32).

According to the Finnish Government (2021, 66), circular economy in the construction sector reaches further than recycling: processes such as shared use, adequate renovation, and upkeep, and utilizing waste energy can be considered circular economy practices. The use can be extended by renovations and efficient upkeep, and the used goods can return to the cycle by re-distribution and reproduction. This is presented in Figure 3 below.

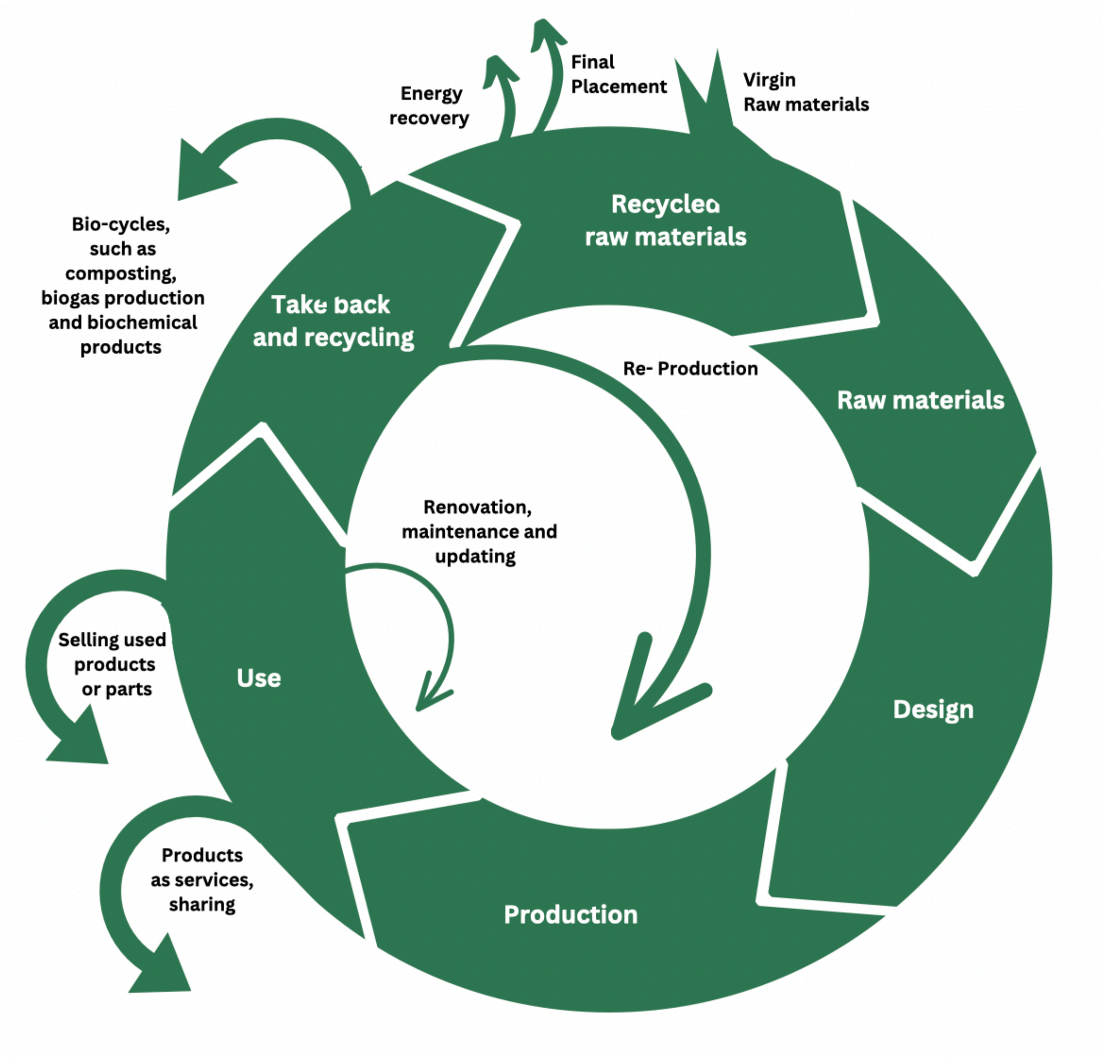


Figure 3: The circular economy is much more than recycling (The Finnish Government 2021)

The intelligent design of energy and material flows can be implemented to apply circular economy models into the built environment. To attain a resource and energy efficient build, the lifecycle of the construction is to be considered holistically (Tähtinen 2018). The physics of the building, as well as the materials, must be adaptive to changing demands and the longevity of the building's life. In addition to intelligent design, the longest lifecycles can be attained by performing adequate maintenance and upkeep (Rakennusteollisuus RT ry no date, 7).

Construction process

According to Häkkinen, Kuittinen and Suomela (2020, 147), in most cases, the construction planning and implementation proceeds according to the following steps: conducting a needs assessment, making a project plan, a proposal plan, a general plan, and an implementation plan followed by construction and lastly a warranty period for the consumer. In the different stages of the lifecycle, the responsibility of maintaining ecological awareness may be shifted from one actor to another. Huttunen (2021, 94) visualizes the handover of the environmental responsibility over a construction by using a table chart. Each step, from the design to demolition, has several actors included in the decision-making of the construction's circular design. See the revised and translated chart of Huttunen below.

Phases of a lifecycle	Design	Construction	Maintenance	Demolition
The deciders in each construction stage	Owner/contractor, designers, constructors	Owner/contractor, constructors, designers	Owner, administrative manager, property manager, repair and maintenance, facility management and tenants	Owner/contractor, demolition constructor, designers

Häkkinen et al. (2020, 19) divide the construction's lifecycle into three phases: product phase, usage phase and the end of the lifecycle. Expanding on the product phase, the excretion of raw materials, production, construction, and transportation are all included. In the usage phase, the building has a constant input of resources such as water and energy; in addition, maintenance may occur. At the end of the lifecycle of a building, the construction faces demolition, which includes processing the waste through sorting, transport, and reuse. (See figure below)

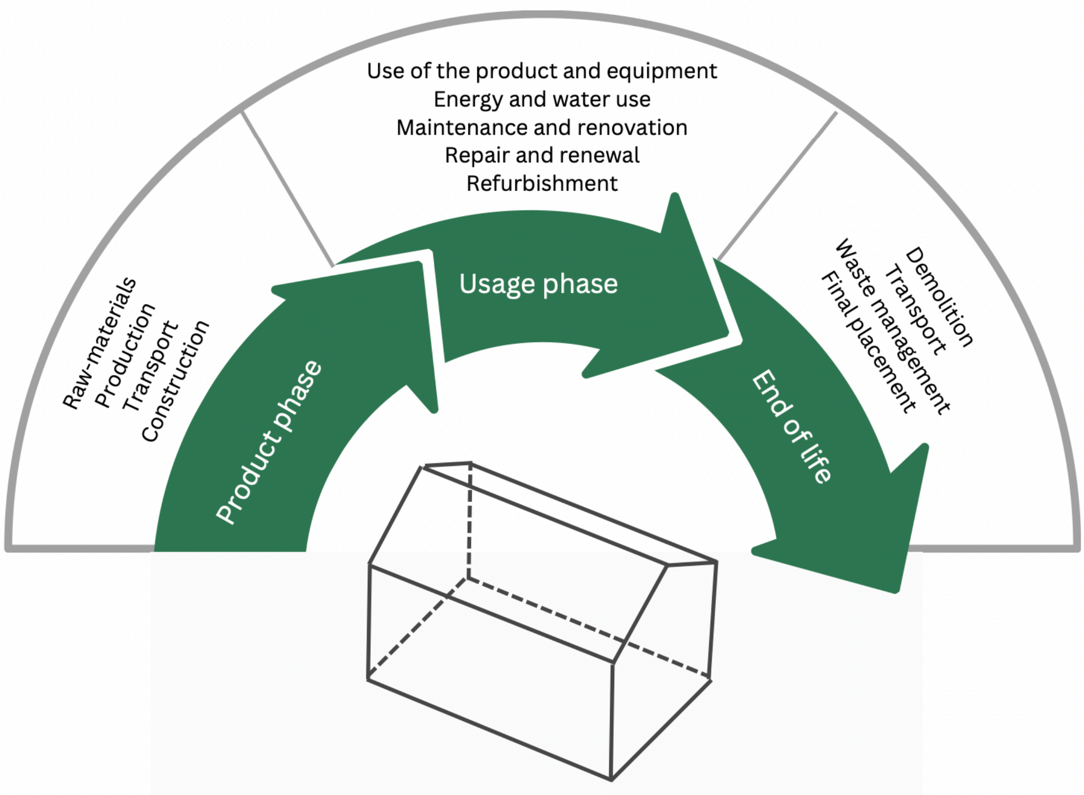


Figure 4: The phases of a construction's lifecycle (Häkkinen et al. 2020, 19)

The carbon footprint of a construction

The carbon footprint of a construction can be divided into two categories; embodied carbon, which accumulates from several phases in the construction process and operational carbon, which amounts through the building's usage. Each step in the lifecycle of a construction that includes materials can release carbon emissions. Therefore, the acquisition and processing of raw materials, transportation, maintenance, and disposal of materials contribute to the construction's carbon footprint (Marriage 2022). However, according to Bionova Oy (2017, 11) most of the carbon footprint of a construction accumulates in its use rather than the construction process. Operational carbon accumulates from decades of a building's usage phase through tenants' energy use, maintenance, and repair processes. Therefore, the energy efficiency of the construction site only amounts to a minute proportion of a building's carbon emissions (Ministry of the Environment 2021d, 25).

Green Deal: Emission free construction site

A Green Deal is a binding contract that can be formed between the Finnish government and actors in business in either the public or private sectors. The agreement binds the parties involved into the execution of mutually agreed environmentally and societally significant actions (Ministry of the Environment no date c).

In 2020 a green deal was signed between the Ministry of the Environment, Senate properties, Helsinki Region Environmental Services (HSY) and the cities of Helsinki, Espoo, Vantaa, and Turku (Muona, Valovirta, Markkanen & Heino 2021). The green deal bound the participants to progress towards reaching emission-free construction sites by 2030 (KEINO no date). The goal is to be reached by the implementation of three main actions: tracking and reporting the emissions of the construction sites, recording the equipment, and acquiring new fossil-free equipment (KEINO 2021). To participate in the green deal, the contractors must provide a listing of the equipment that showcases that the equipment used at the construction site suits the green deal standards. Separate standards have been composed for maintenance projects, new buildings, infrastructure construction and pavement procurement. Each criterion sets out the specific mandates for each machinery that must be reached; with certain exceptions, most of the equipment used must comply with either STAGE IV or EURO VI classifications (KEINO 2022).

4.1 Circular practices in the construction and design phase

Design plays a crucial role in product ecology. According to the Finnish Government (2021, 93), the design of a product can determine up to 80% of a product's environmental impact. Specifically in construction, the building's convertibility, as well as its ability to be refurbished or demolished, are determined in its design phase (Finnish Government 2022, 22). Essentially, in the design phase, all decisions, from material sourcing to the utilization of wastewater and heat, are made. Efficient lifecycle design entails the assessment of the different phases of a construction's lifecycle.

As presented in the chart below, Green Building Council Finland (2013,14) illustrates the importance of the most significant aspects measured by carbon footprint. The most crucial decisions are made in the design phase with the convertibility, intended lifecycle and material choices being made. Therefore, the construction site's responsibility is less significant.

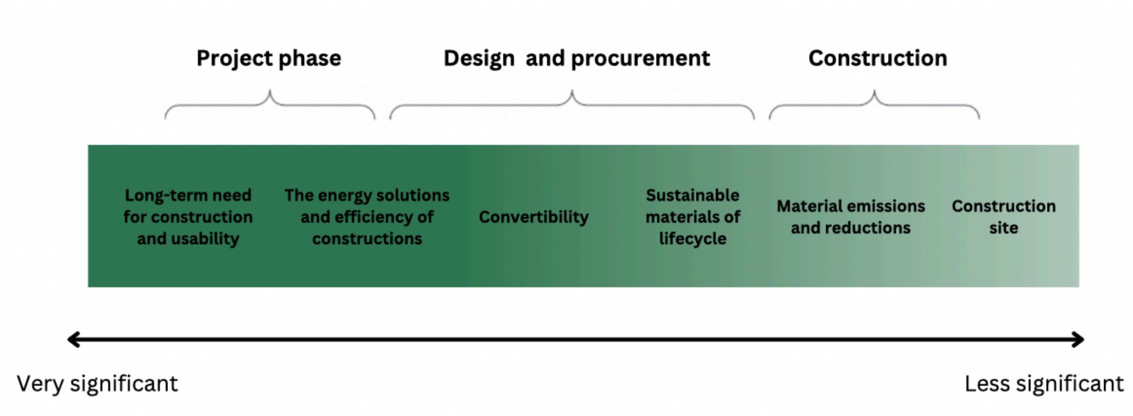


Figure 5: The most significant phases of an apartment buildings lifecycle measured by carbon emissions (Green Building Council 2015)

According to UN Climate Technology Centre & Network (no date) a design process in which the lifecycle is considered can reached by using one or more approaches presented below:

1. Interdisciplinary and interactive approach, in which several fields collaborate to bring their innovations and perspectives to the design process.

2. Lifecycle based decision making, referring to the consideration of the full lifecycle in all the design choices made. This entails considering the materials used, the embodied use of energy, and the needed renovations and lastly demolition.

3. Computer assisted design tools. In design, technology can be used to provide estimates of the performance of a construction, whether it is in its carbon emissions or embodied energy, the calculations can often be made assisted by technology.

The logistics of a construction site

To attain ecological logistics, the deliveries of goods should be timely, and the area and product quality should be managed effectively (Emmett & Sood 2010). As demonstrated in the chart below, Lavikka, Peltokorpi & Tetik (2019) present four solutions for the logistical issues within a construction site. The solutions include: just-in-time deliveries of goods; kitting, forming kits of all the materials needed for a particular step of the construction that are then to be delivered precisely at the stage that they are needed; vendor-managed inventories, that refer to stores within construction sites that entail the products the site may need, that can be purchased when the need occurs and lastly utilizing consolidation centres for storing materials that are to be used later.

Just-in-time deliveries	Kitting	Vendor managed inventories	Consolidation centers
Optimizing the delivery of goods to produce minimal storing at the construction site	Delivering goods in kits consisting of the specific materials and equipment needed to complete a certain step of the construction	Stores within construction sites that entail the products the site may need. The products can then be purchased when the need occurs	Storing materials that are to be used later in consolidation centers

The use of virgin construction materials can contribute to environmental strain by using depletable resources and by causing emissions to either the atmosphere or waters (The Ministry of the Environment 2021c, 11). In addition, according to Eurostat (2020), 11,8% of Finland’s economic and household waste in 2020 was produced in the construction and demolition process. To utilize recycled materials in construction, they must be tested case to case to ensure that the quality and safety requirements set by authorities are met. Compared to new materials, this additional step results in increased expenses (Nordic Innovation 2021). The Circl house by ABN AMRO utilized several flows of recycled materials. In the project, old window frames were used for walls, the insulation of the ceiling consisted of old jeans, and many other innovative recycled materials were used (Achterberg, Brekelmans, Buijs, De Wit Petran van Heel, Fischer, Kubbinga, Ramkumar & Van Amerongen 2017, 9).

In addition to the use of recycled materials, bio-based technology has been studied in several materials in the field of construction. A bio-based material is one which comprises mainly of living matter, also known as biomass (Curran 2010). Referring to the Nova Institute (2017), The European Commission (2017a) states that by using a biobased substance in the production process of the main ingredients of industrial paints, the emissions may be reduced by 50%. In addition, the European Commission (2017b) refers to Bailey and Zoorob (2012) by stating that asphalt that has biobased additives has been shown to be more resilient, which could lead to a prolonged lifecycle. Other benefits include a positive impact on the application, binding, and the mixing temperature (European Commission 2017b; Delfosse et al. 2012). Other uses of biobased materials are bio-based paints and coatings for embellishment and as a protective coating (European Commission 2017c). In addition, bioplastics can be used in infrastructure construction by choosing traffic signs and benches from biobased materials, such as ones derived from grass and wood waste (European Commission 2017d).

On the construction site, the key contributor to circular economy is the quality of the construction. If built attentively, the construction can fulfil its intended lifecycle. (Green Building Council Finland 2013) In addition to the quality of the construction, the equipment used, as well as the practices of the construction, can affect the environmental strain (Kestävien hankintojen green deal-sopimus no date). The most significant amounts of emissions are commonly released through heating the building, drying concrete, and transporting goods to and away from construction sites (Kestävien hankintojen green deal-sopimus no date, 2).

4.2 Circular practices in the usage phase

In the usage phase, the responsibility for acting in accordance with circular economy is mainly delegated to the occupants and condominium of the housing solution. According to Achterberg et al. (2017), practices such as sharing platforms as well as lifecycle extension can be used to make a building more adapted to circular economy. However, the responsibility for maintenance renovations and solutions falls into the hands of the owner and constructors. According to The Ministry of the Environment (2016), the examinations of building's conditions should be conducted systematically. A building condition assessment plan should be established within the first ten years of a building's life to determine the upcoming renovations. Thereafter, the condominium must ensure that the renovations are conducted according to the realized condition of the house.

4.3 Circular practices at the end of life

When a building reaches the end of its life as is, the option that the owner of the building faces is whether to extend the lifecycle of the construction further or to demolish it. To gain the most value from a building, its lifecycle should be prolonged for as long as beneficial. In 2020, the sum expended on repair construction in Finland amounted to a total of 7,7 billion euros (Official Statistics of Finland 2021).

Demolition and waste management

The Finnish State of Councils Act of Waste (978/2021) declares that it is intended for 70% of the waste produced in construction or demolition to be recycled in other uses than energy. This claim excludes the use of hazardous waste and earth and stone materials derived from rock and soil.

In all demolition or refurbishment projects, an audit is to be conducted for the materials removed from the construction. A pre-demolition audit designates the recyclable waste that may be utilized elsewhere, as well as designating the hazardous waste that requires excretion (European Commission 2016, 8). If a material contains hazardous elements, it is not to be reused in any other project (Finland's Environmental Administration no date). Conducting a waste audit ahead of demolition ensures that the masses of material derived from it are handled appropriately. In a waste audit, the amounts of waste and their placement or recycling are recognized (European Commission 2018, 5). As the buildings being demolished have most likely been constructed decades ago, there may be a lack of adequate knowledge on how to recover and dissemble the construction as intended in its design phase. Additional difficulty may occur from repurposing the recovered materials (Nordic Innovation 2021).

In Finland, pre-demolition audits are required throughout the whole country. However, the specificities are determined by municipalities based on the materials disposed (Hradil, Wahlström & Rudenhausen 2018,16). In demolitions, waste management is controlled by different actors in different stages of the process. European Commission (2018, 14) presents a chart dividing the general responsibility allocation within the demolition recycling process. First, the owner of the waste establishes the elements and materials of the demolitions, allowing for the auditor to specify each product's opportunity for recycling. Lastly, the waste manager handles the use of recyclables and non-recyclables. See the figure below.

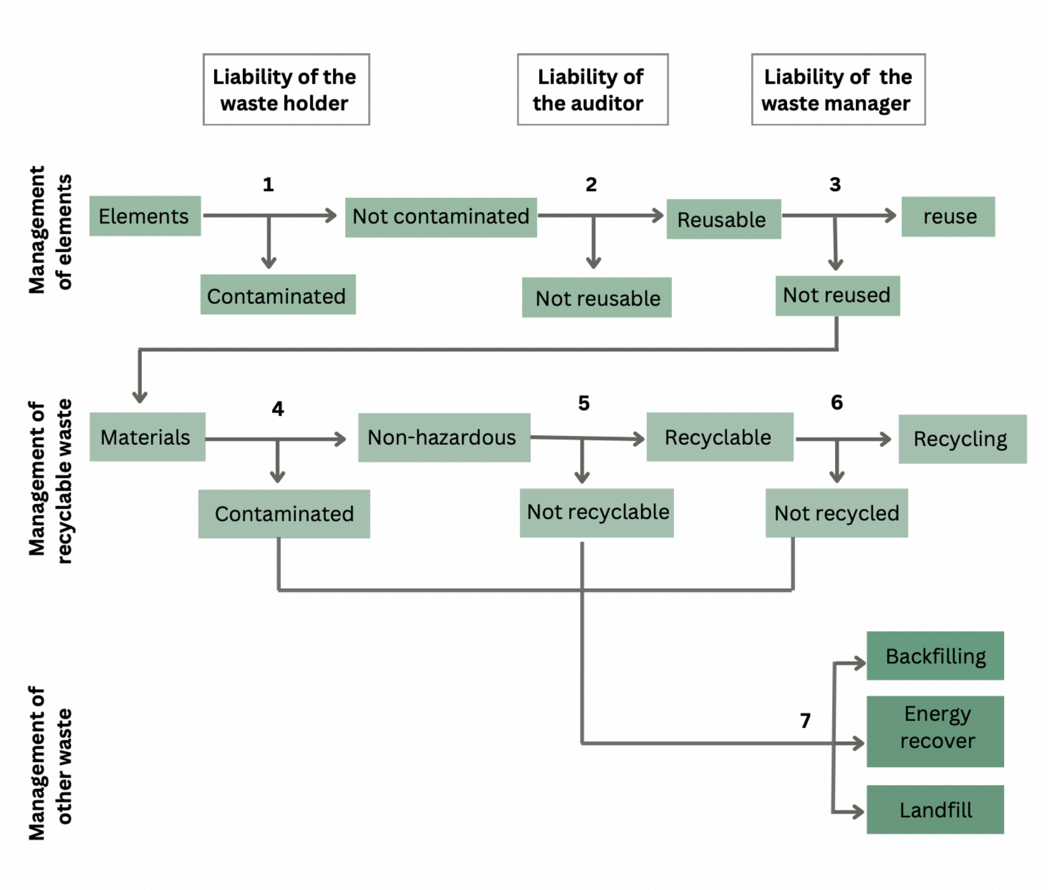


Figure 6: Roles and responsibilities of actors in a waste audit (European Commission 2018)

Lifecycle extension: The convertibility of an old building

According to Nordic Innovation (2021), buildings are often demolished prematurely. Premature demolition is often due to the buildings' inability to transform with the user needs throughout its lifecycle. Häkkinen and Tarpio (2021, 12) explain the adaptability and flexibility of buildings as means to expand the construction's lifecycle. Adaptability refers to the construction's ability to endure renovations throughout its lifecycle to expand or change its use. Flexibility is defined as the construction's malleability to adhere to its tenants' changing life situations.

Flexible design techniques can be utilized to ensure the adaptability or resource-efficient disassembly of a construction. Including flexible design solutions in the plan of the construction can ensure that alterations can be made in accordance with its end user's needs (CIRCUIT no date a). In Vantaa, the flexibility of construction was explored by designing a flexible school solution in the Circuit project. The intent was to create a solution in which a school is adaptable to the changing number of students, meaning that its capacity can be either increased or decreased with minimal renovation (CIRCUIT no date b). The two illustrations of the school prototype from the Circuit program are presented below. Although the project is still in its prototyping phase, the construction is intended to be enacted between 2026 to 2027 (Koivisto 2021).

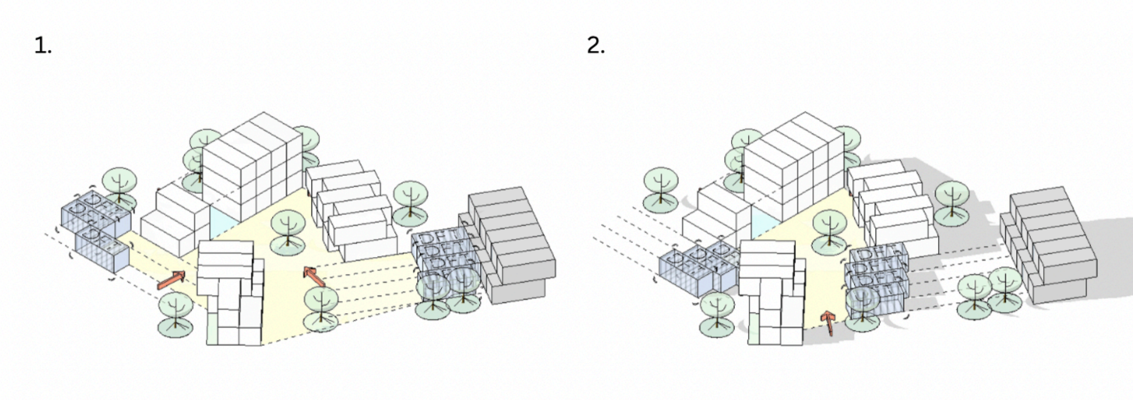


Figure 7 Vantaa Hybrid School (CIRCUIT no date)

When considering conversion on a building, not only are the economic factors to be considered, but the details of the structures, such as condition, required renovations, location, and age, are to be noted (Collins & Pinfold 1984, 33). Through conversions, an old out-of-use construction can gain a new life. In Slovakia, an old mill was transformed into a residential building. The design provided new value by allowing over ten homes to be located within an out-of-use structure (Burák, Doroudiani, Moňoková, Sedláková, Tomková & Vilčeková 2020).

5 Environmental certification for construction

Increasing performance requires strategic planning of goals and performance indicators, benchmarks against one's equals and analysis of past occurrences for development (OECD no date). Performance indicators are commonly used across fields to measure and track the performance of procedures. The use of performance indicators allows for practices to be benchmarked for internal development as well as external reporting. Green Building certifications function comparatively to a checklist by which the construction companies can assess their processes compared to pre-set criteria. Completing the assessment commonly provides a score that thereby represents their performance by points referring them to a pledge or a category (Piccardo, Alam, & Hughes 2021,132).

According to Kubba (2012 chap. 2), the first environmental certification system was the Building Research Establishment Environmental Assessment Method (BREEAM), introduced in 1990 in the United Kingdom. Eight years later, the United States Green Building Council established LEED, an evaluation system notably based on BREEAM. Thereafter, many alterations and versions have emerged throughout different regions and subcategories. The reporting systems range from measuring specific process phases to providing in-depth analysis for location-specific needs. Such tools include consideration of the climate and working environment in a specific region or country.

Below is an exploration of the most prevalent environmental certifications in construction. The research presents a summary of the current state of evaluation at the time of the thesis writing process. The reader must note that the environmental certification exploration intends to provide an overview of the assessment methods available, thereby outlining the main factors affecting the valuation of an environmentally friendly construction.

BREEAM

As mentioned above, Building Research Establishment's Environmental Assessment Method, also known as BREEAM, is a sustainability framework introduced by BRE Group ltd in 1990 (Kubba 2012, 12). In 2021, the certification was used in the evaluation of over 590 000 buildings in over 85 countries (BRE Global Ltd 2021). The BREEAM standard has been modified to create several national standards and six standards for different building types. The international assessment standards are available for new construction, refurbishment and fit-out, in-use buildings, communities, infrastructure, and home quality (Bre Global Ltd no date). Each assessment examines a particular type of construction in different phases of its lifecycle.

New construction and refurbishment and fit out

The standard for new construction is applicable for the assessment of a new building in its design or construction phase. In the scheme's technical manual, new construction is defined as a construction that results in a new detached structure or a new extension to an existing structure (BRE Global Ltd 2021). In contrast, the refurbishment and fit-out scheme entails the standards for assessing the construction projects for improvements of function, performance, or condition of an existing building, as well as the several kinds of fit-out works (BRE Group 2015, 13).

Assessment and scoring

BREEAM assesses and rates a building's sustainability using a balanced scorecard method (BRE Global Ltd 2021, 30). Each project is assessed independently to include the suitable scheme parts and appropriate scoring and weighing of sectors. Therefore, a pre-set weighing and point system is not in place. An official BREEAM Assessor examines each project to declare the credits for each of the nine assessment sections. The credits are calculated with the section weights to provide the overall BREEAM score (BRE Global Ltd 2015, 27). Although the credit weighing differs, the core categories assessed mostly remain the same. In the refurbishment and fit-out scheme, the assessment evaluates management, health and wellbeing, hazards, energy, transport, water, materials, waste, land use and ecology, pollution, and innovation. In the New Construction assessment scheme, hazards are not included in the grading (see chart below). A project must receive a score above 85% for an excellent rating. The minimum passable score is 30% (BRE Global Ltd 2021). On the BREEAM new construction and refurbishment and fit-out schemes, seven criteria assess directly or indirectly circular economy. (See chart below) The points assessed will differ in each project however, it is worth noting that most criteria assessed are circular economy or ecology related. The criteria between the two differ from each other by the BREEAM refurbishment and fit-out scheme, including hazards in the assessment (BRE Global Ltd 2021, 17-18; BRE Global Ltd 2015, 27).

BREEAM New Construction	**BREEAM Refurbishment and fit out**
Management	Management
Health and wellbeing	Health and wellbeing
Energy	Energy
Transport	Transport
Water	Water
Materials	Materials

Waste	Waste
Land use and ecology	Land use and ecology
Pollution	Pollution
Innovation	Innovation
	Hazards

Level(s)

Level(s) is a reporting and assessment framework designed by the European Commission for the built environment. The framework intends to create a standardized language for evaluating specific buildings in accordance with the targets set by European policies (European Commission no date b). By design, Level(s) assesses a minimal number of indicators, with the intent of establishing a system that can be used as a prelusive basis for assessment across Europe (European Commission no date b, 9).

The tool consists of three assessment levels: simplified measuring, benchmarking, and detail-oriented optimization. Having multiple assessment levels allows the use of the method for different actors in several stages of a construction's lifecycle (The Ministry of the Environment no date d). Level 1 consists of the qualitative assessment of the design choices of a construction. The intent is to review whether each indicator is addressed in the planning of the construction. Level 2 includes the design process, as well as the construction. The design in Level 2 must be more systematic by including calculations and reporting of the results. Level 3 assesses the built and in-use building at the use stage of its lifecycle. The purpose of Level 3 is to establish an understanding of the actualized processes as well as the climate impacts (Dodd, Donatello & Cordella 2020, 15). Level(s) uses a Calculation Assessment Tool (CAT) to produce calculations assessing the environmental impact of the construction. CAT allows the user to pilot different versions of the construction to differentiate the environmental impacts of the design choices (European Commission Directorate-General for Environment 2022).

Assessment and scoring

The Level(s) assessment criteria is based on six macro-objectives set by the European Commission. The macro-objectives act as guidance for the eight indicators used to assess the performance of a construction (European Commission no date b, 5). The six macro-objectives are "Greenhouse gas emissions along a building's lifecycle, resource efficient and circular material life cycles, efficient use of water resources, healthy and comfortable spaces, adaptation and resilience to climate change and optimized life cycle cost and value.” (European Commission no date b, 6).

In total, in the Level(s) assessment tool, eight out of 15 micro-objectives address circular economy. In the chart, assessments from 1.1 to 3.1 and 5.3. are metrics measuring the environmental impact of a construction through its lifecycle (European Commission no date b, 6). See chart below.

1.1 Use stage energy performance
1.2 Lifecycle Global Warming potential (CO2 eq./m2/yr)
2.1 Bill of quantities, materials, and lifespan
2.2 Construction & Demolition waste (CDW) and materials
2.3 Design for adaptability and renovation
2.4 Design for deconstruction, reuse and recycling
3.1 Use stage water consumption
4.1 Indoor air quality
4.2 Time outside of thermal comfort range
4.3 Lighting and visual comfort
4.4 Acoustics and protection against noise
5.1 Protection of occupier health and thermal comfort
5.2 Increased risk of extreme weather
5.3 Sustainable draineage
6.1 Lifecycle costs (€/m3/yr)
6.2 Value creation risk factors

LEED

The Leadership in Energy and Environment Design rating system (LEED) is a certification system developed by the United States Green Building Council (USGBC), a non-profit organization that advances the sustainability of the construction sector. The LEED rating system consists of five assessment categories, each of which provides a score. The total score fits into one of four categories: Certified, Silver, Gold, or Platinum (Meisel 2010, 9).

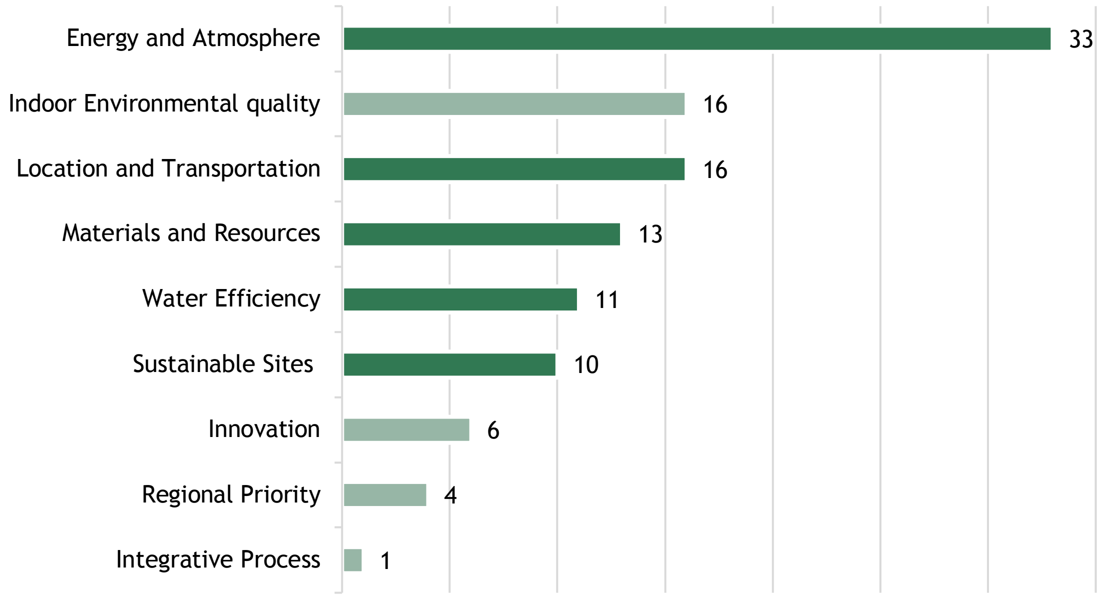
LEED offers solutions for different kinds of built environment or construction projects. The chart below presents all the currently available LEED certifications. The Building Design and Construction (BD+C) is intended for the assessment of several housing solutions for new construction or significant renovation projects. The Interior Design and Construction (ID+C) is intended for complete interior fit-out construction. The Building Operations and Maintenance (O+M) assesses existing buildings with minor renovations. The Neighborhood Development (ND) assessment covers the development of existing neighbourhoods. The Homes certification is for low-rise residential buildings. The LEED cities assesses the performance of existing cities (U.S. Green Building council no date b).

Building Design and Construction (BD+C)	Building Operations and Maintenance (O+M)	Neighborhood Development (ND)
Interior Design and Construction (ID+C)	Homes	Cities

Assessment and scoring

In the assessment for Building Design and Construction (BD+C), the system awards points by fulfilling criteria in location and transportation, sustainable sites, water efficiency, energy efficiency, energy and atmosphere, indoor environmental quality, integrative process, innovation, and regional priority (U.S. Green Building Council no date a). GBCI reviews the project and the grading. In the assessment, approximately 35% of the score consists of credits addressing climate change, 20% are related to health, 10% environmental economy, 5% community and 5% the impact on earth’s resources (U.S. Green Building council no date b). From the LEED assessment categories, a total of four address circular economy: Energy and Atmosphere, Location and Transportation, Water Efficiency, Materials and Resources, and Sustainable sites. In total, the scoring rewards 83 points from these categories. (See Table below.)

Table 1: LEED Building Design and Construction point structure (U.S. Green Building council no date b)



RTS-environmental classification

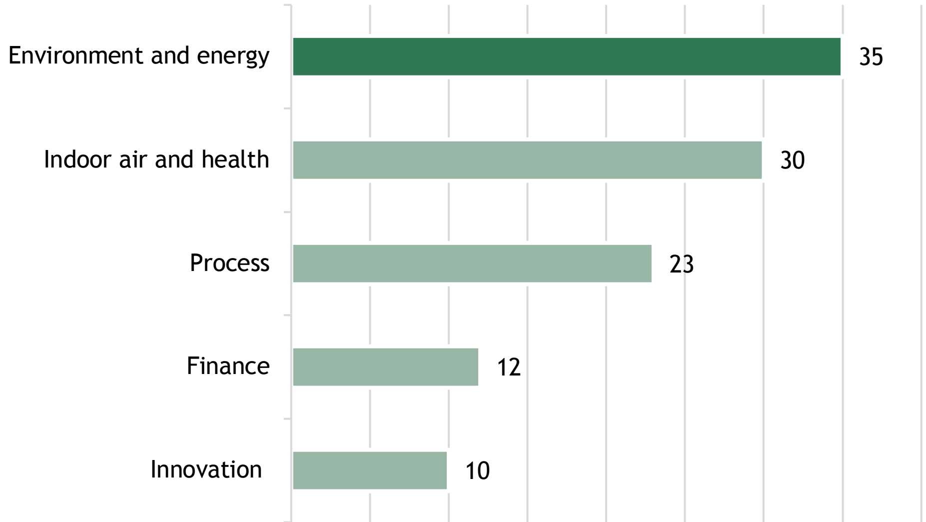
The Building Information Foundation (RTS) has developed an environmental certificate specifically designed to regard the Finnish working environment, including the environment and legislation. The standard utilizes both European standards and Finnish methods in several phases of the assessment. The RTS standard is applicable for both new construction and renovation projects (The Building Information Foundation RTS no date a).

In addition, RTS offers a separate standard for evaluating buildings that are in use. The assessment provides criteria for both the property management and the tenant. The responsibilities of each party are assessed separately, with each category specifying criteria for both (The Building Information Foundation RTS no date, b). To attain the certificate, a candidate must register as a user and enlist a project onto the web-based tool. The certification includes a charge, which is met when a new project is registered on the tool (The Building Information Foundation RTS no date c).

Assessment method and scoring

The RTS standard assesses construction projects based on a scoring system. The total number of points available sums up to 100 points, with an additional ten points available for innovation. The RTS standard consists of four core assessment categories as well as an additional category assessing innovation. The primary categories assessed are process, economy, environment and energy and lastly, indoor air quality and health. The rating is represented with a star system in which one star indicates the minimum acceptable score, and five stars signify an above 85% score of the total points available (Sariola 2020, 5). The environment and energy categories in the RTS assessment can provide the assessed with 35 out of 100 points, excluding the ten innovation points. (See chart below)

Table 2: RTS certification point breakdown (Laura Sariola 2020, 4)



The Nordic Swan Ecolabel

The Nordic Swan Ecolabel is a label used in the Nordics that signifies a product's ecological responsibility to the consumers. The label was developed by the Nordic Council of Ministers and published in 1989 (Nordic Ecolabelling no date a). The label is applicable for several services and products, and therefore each category has a document outlining its specific criteria (Nordic Ecolabelling 2016a, 4). In addition to the criteria, the categories all employ individual costs for the attainment of the label (Ympäristömerkintä Suomi Oy no date).

Nordic Ecolabelling has applied the Nordic Swan Ecolabel to the built environment in the form of two separate criteria: the criterion for housing and the criterion for renovation. The criterion for housing provides an evaluation for buildings intended for residential purposes, schools, small houses and the temporary buildings accompanying them. (Nordic Ecolabelling 2016b, 4) The criterion for renovation applies to the renovation of residential buildings and schools, kindergarten buildings or office buildings.

Criteria for housing

The Nordic Swan Ecolabel for housing signifies to the stakeholders that the lifecycle of the building has been considered to have met the Nordic Ecolabelling standards. The categories assessed are energy, waste, indoor environment, chemical products, construction products goods and materials, and quality management of the construction process (Nordic Ecolabelling 2016b).

The attainment of the label is based on a point system in which a minimum score must be reached. The different housing solutions have different grading scales; therefore, apartment buildings, small houses and pre-schools and school buildings are assessed with different points. Overall, to achieve the minimum accepted score, one must attain approximately 40% of the points available (Nordic Ecolabelling 2016b, 9).

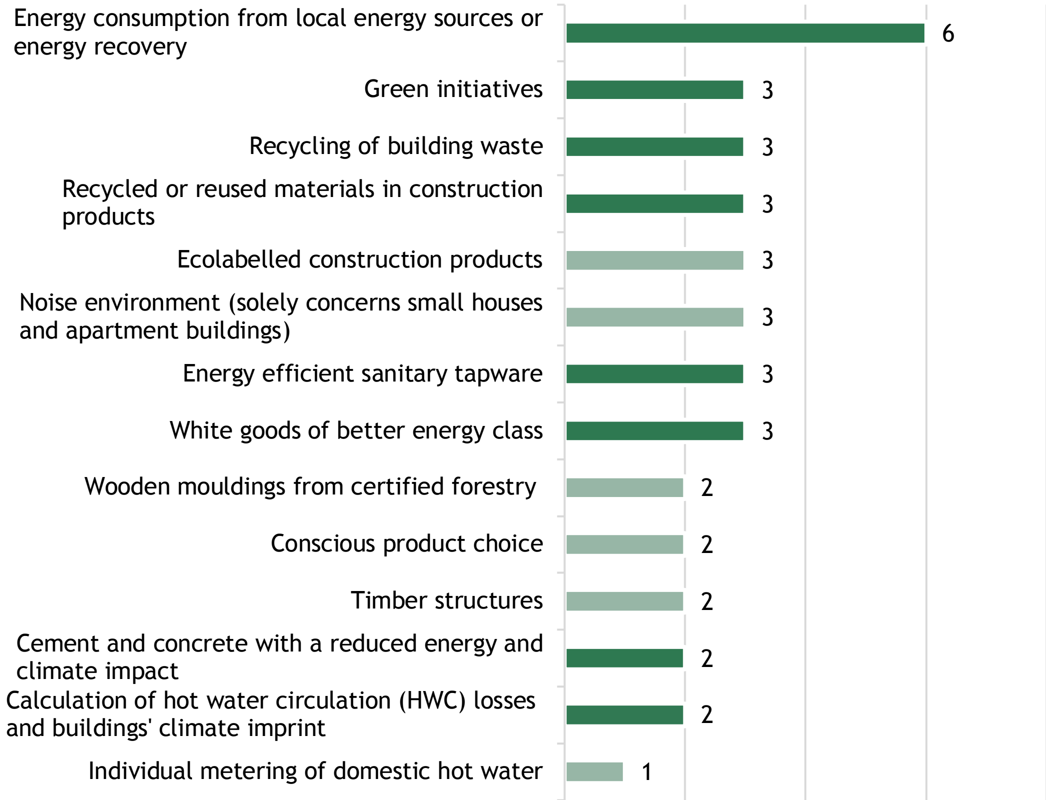
Criteria for renovation

The Nordic ecolabelling criteria for renovation ensures that a renovated building has reached the set criteria of the Nordic Swan Ecolabel. For a renovated construction to meet the Nordic Swan Ecolabel criterion, it must be energy efficient, the material choices must comply with circular economy, and the handling of the hazardous waste must have been appropriate throughout construction (Nordic Ecolabelling 2020, 4).

Assessment and scoring

The process of attaining the label consists of filling the application document with evidence that the criteria have been met. Thereafter, the Nordic Ecolabelling organization assesses it and may require further information or seek third-party validation in the form of laboratory samples or control visits. As presented in the table below, a total of fifteen points are credited for supporting circular economy function in the construction (Nordic Ecolabelling 2016).

Table 3: (Nordic Ecolabelling 2016)Nordic Swan Ecolabel point breakdown



GRESB Real Estate Assessment

The GRESB Real Estate Assessment is an ESG benchmark and reporting standard intended for actors in the real-estate field, including real-estate companies, private property funds, real-estate investors and developers. The standard can be used to analyze the performance of portfolios including standing investments and development projects. The purpose of the standard is to provide the investors with a standardized metric to assess the Environmental, Social and Governance (ESG) position of their investments. The tool provides a score of the total ESG performance of a company and an assessment of the overall performance (GRESB 2022a).

Assessment and scoring

The GRESB assesses the companies by using a scoring system. The system consists of several indicators, which are broken down into questions. The answers to the questions are evidence based, which means that the document requires submissions of evidence. The evidence is thereby assessed as either accepted, partially accepted, or not accepted. The level of acceptance is used as a multiplier to the points. Inefficient evidence can thereby lower the scoring or completely negate it (GRESB Real Estate 2022b). The assessment is divided into three components: Development, Performance, and Management. The Management components assesses the company's strategic management the Performance category is designed to convey the performance of the subject's asset portfolio, and the Development section assesses the subject's ability to act in accordance with ESG-policies throughout the construction.

The scoring of the Real Estate Benchmark consists of combining the Performance and Management sections, whereas the Development Benchmark assesses the Management and Development categories. (See figure below) However, an actor can fill out all assessment forms to attain both reports (GRESB 2022a).

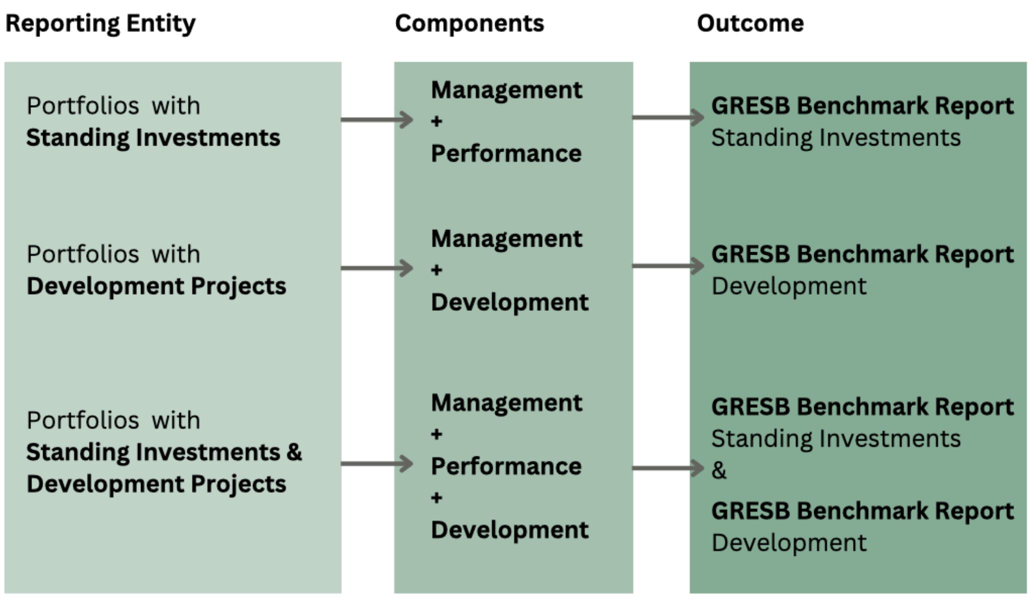
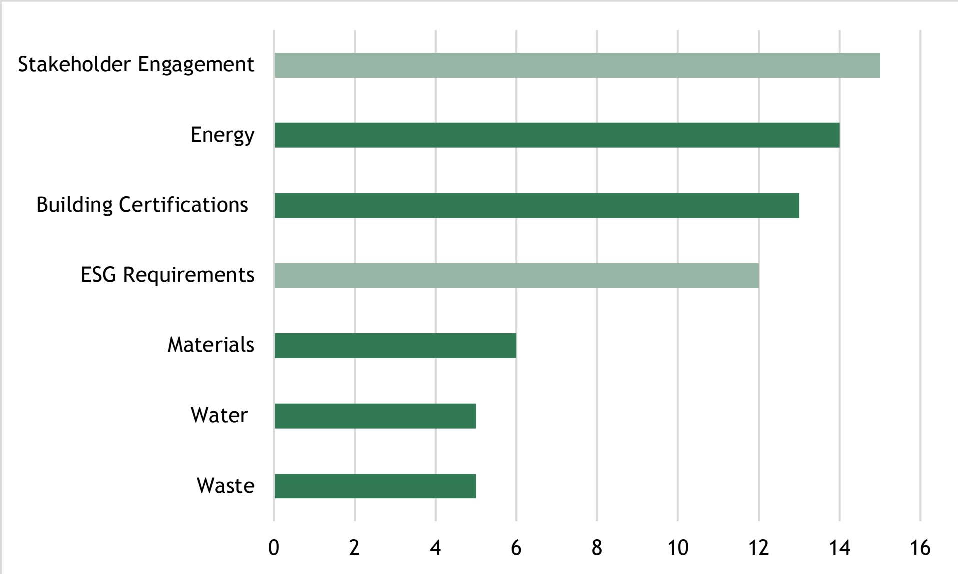


Figure 8: GRESB portfolios to reports (GRESB 2022a)

Development

The development section sums up to a total of 70 points. Of these points the sections energy, building certifications, materials, water, and waste imply the portfolios performance in circular economy. (See chart below) Each resource indicator, water, energy, and materials asses the responsible consumption as well as the proportion of recycling (GRESB 2022b). Therefore a total of 43 points assess ecology.

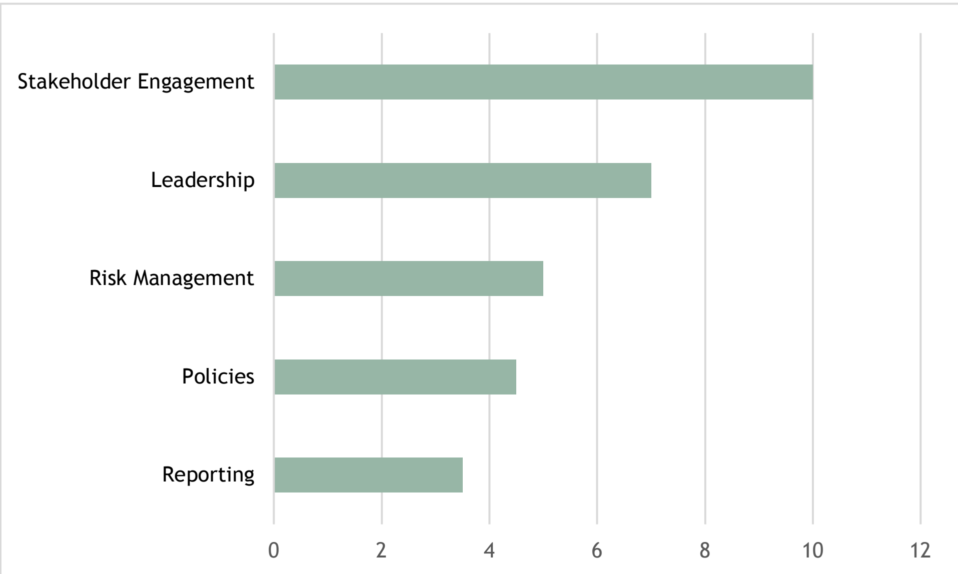
Table 4: GRESB Development category point breakdown (GRESB 2022b)



Management

The management section consists of 30 points total (Gresb 2022a). The section focuses on assessing the policies and efforts of the management to control the environmental performance. Therefore, the category does not have a direct impact on circular economy, however, may evoke an impact on the long term.

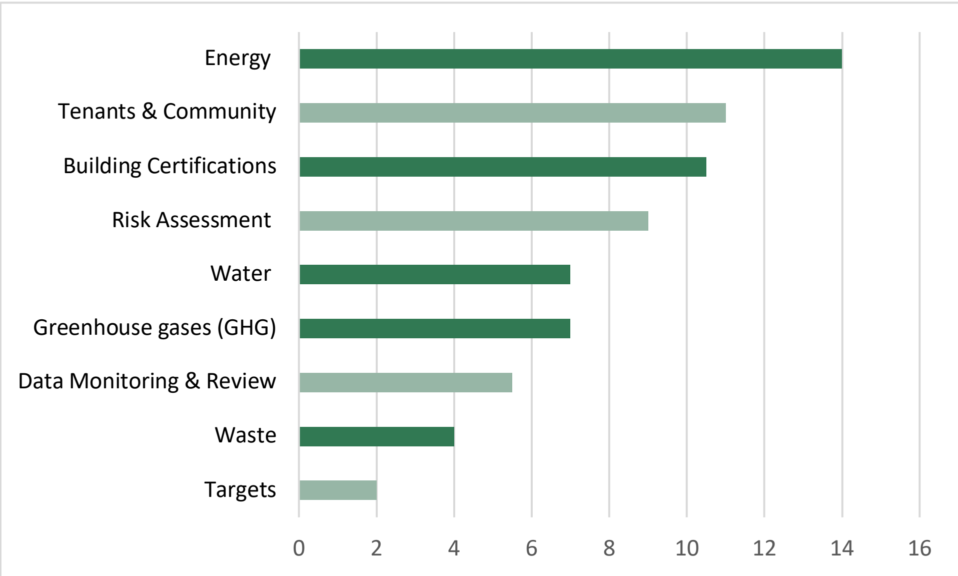
Table 5: GRESB Management category point breakdown (GRESB 2022a)



Performance

The performance sector produces a detailed review of the realized impacts of the portfolios functions. The performance section can produce a total of 70 points of which 42,5 address circular economy (GRESB 2022a).

Table 6: GRESB Performance category point breakdown (GRESB 2022a)



Each category totals to 100% in a maximum score which is thereafter, weighted using the E, S and G marks. The E-mark refers to the practices and their efficiency for producing a portfolio with minimal environmental impact. The social impacts and the relations with the stakeholders are assessed in the S-mark. G-mark explores the entity's ability to govern its ESG-policies. As presented below, in the different subsections each marks provides a different weighting to the calculation (GRESB 2022a).

	E	S	G
Management	0%	35%	65%
Performance	89%	11%	0%
Development	73%	21%	6%

Figure 9: E-S-G weightings (Gresb 2022a)

Others

Green Globes is a Canadian assessment tool for green building. The system functions on an online platform which intends to make the assessment simpler and more cost efficient (Kubba 2012, chap. 1). Energy and Environmental Canada (EDC) introduced the Green Globes assessment system in 2000. The certification was initially designed for Canada, but now assessment is available also in the United States of America (Green Building Initiative, Inc. no date).

The German adaptation to environmental certifications for construction is DGNB. The DGNB differentiates itself from the other assessment tools by considering the projects full lifecycle in each step of the evaluation. The assessment consists of three main sustainability standards; ecology, economy, and sociocultural issues, all of which hold the same weight in the assessment (DGNB GmbH no date).

HQE is a standard originates from France, the assessment highlights the integrity of a constructions environmental and energy, performance as well as its ability to support health and comfort. In contrast to other assessment methods, HQE allows for objectives of the project to be determined by the owner, allowing flexibility when making design decisions (HQE no date).

Miljöbyggnad is a Swedish environmental certificate for buildings, that provides proof that a building has been constructed with a third-party assessment of its environmental performance. The assessment includes the inspection of energy, indoor environment, and materials (Sweden Green Building Council no date).

Commonalities and externalities

Many different programs and their grading were assessed within the report, and therefore similarities and patterns were found between the systems. Below is an exploration of the different assessment categories and their reoccurrence between the different programs.

Energy performance

All seven main environmental certifications had a criterion for the assessment of energy performance. The assessment of energy often included the energy used in the site and planning the energy used throughout the construction’s lifecycle. Preference was shown for in the Nordic Swan Ecolabel for consumption of local energy sources as well as considering energy efficiency in the sanitary tapware. Choosing energy efficient tapware can reduce water and energy consumption and therefore reduce the emissions caused by the energy use (Joint Research Centre no date). Furthermore, Energy was the most highly valuated score in the LEED (BD+C), RTS, Nordic Swan Ecolabel, and in the GRESB assessment before the weightings in the performance category and in second place in the development category. Therefore, it can be concluded, that the energy decisions, whether it is in construction or in use, is a crucial for environmentally conscious construction.

Water use

Six of the seven total environmental certifications presented assessed the use of water. The water use often addressed the plans for avoiding the loss of water or utilizing leftover water streams. In addition, the water heating throughout the lifecycle was often considered. Water use did not commonly hold the majority of the points receivable, however, its prevalence in many assessments confirms that it is to be considered carefully in design.

Pollution or greenhouse gases

Out of the seven certifications, five had a category for pollution or greenhouse gases. In the LEED BD+C criteria, atmosphere was assessed in a shared category with energy. In addition, the Nordic Swan Ecolabel addressed the pollution through energy efficiency and choosing green energy.

Notable mentions

In four out of seven certifications Materials, Waste and Innovation held an assessment criterion. The materials included material decisions within the constructions design. The waste category addressed both the management and production of construction waste. The innovation category was often used as additional points to incentivize the applicants to include innovations into their construction process.

6 Research

The research is conducted in the form of an explorative Case study, in which an understanding of a phenomenon is formed through observations, leading to the development of hypotheses or development proposals (Hirsijärvi, Rejes & Sajavaara 2012, 138). The specific intent of the research is to observe the operating models of SATO’s contractors and the development opportunities which arise from their knowledge and ideas. In qualitative data analysis process, the objective is to form a holistic perception of the matter, from which reliable conclusions can be derived (Puusa, Juuti, & Aaltio 2020 chap. 9).

The commissioner, SATO has made efforts to develop its business model to become more suitable for circular economy. The company has enacted on several pilot projects which address the issues of the implementation of circular economy. Although initiatives taken towards a more sustainable business model, the large-scale implementation of circular economy practices has not taken place yet.

6.1 Progression of the research

The research process can roughly be divided into three stages: The interview process, workshop, and process mapping. Each step consists of smaller steps taken to ensure detailed execution.

As can be seen in the figure above, the themed interviews consisted of first developing the themes for the interviews. The themes were derived from a document provided by the commissioner in the initial stages of the thesis process to outline the subject matter. For the researcher, this document acted as the outline for the specific matters the commissioner wished to gain insight upon through the research. The document consisted of several questions to which the commissioner wished to gain insight on. The questions were categorized to form the four themes of the interviews.

After choosing the themes, a pilot interview was conducted with a voluntary participant to practice the thematic interview process. The official interviews were conducted, and the data was studied by using grounded theory as the intent was to develop theories founded upon the issues that prevent circular economy from actualizing.

The coded data was thereafter formed into a set of insights: developmental and informational in nature. The developmental insights were to be used in the workshop to assess the feasibility of the finding’s implementation. The workshop required gathering the insights and formulating a suitable method for the workshop. To establish a suitable method for the workshop, a pilot was conducted with a voluntary participant. After choosing the method, and conducting the workshop, the findings were gathered to a chart outlining the most feasible development opportunities.

The final stage of the research consisted of creating a tangible visual, which would highlight the core areas that could be developed to be more inclusive of circular economy. For this phase a process map, or a blueprint was used. The process map combined relevant literature as well as input from the workshop attendees to form firstly the initial process map, presenting the commissioner's current process. Thereafter the developmental proposals were inserted into the illustration to portray plausible working models for the future.

6.2 Themed interviews

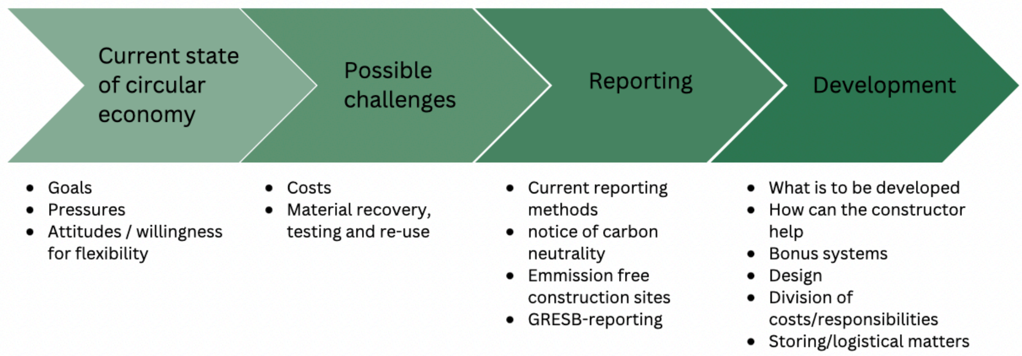
The chosen data collection method was themed interviews. A themed interview entails guiding a detailed conversation based on themes that have been selected prior to the interview. This interview style allows for branching into further subjects that arise during the interview (Kananen 2015, 143). The use of themed interviews was based on two factors: the researcher's limitations of prior knowledge of the subject matter and the need for qualitative detailed data to gain an in-depth understanding of the matter.

Due to the interviewees being experts in different aspects of construction, some specializing in planning, some on new construction and some fit out, it was crucial for the interview style to be adaptable to attain the most out of each of expert's knowledge. If a pre-selected consistent array of questions were to be used in the research, not only the information but also the answers may have remained surface level, failing to provide a detailed view of a complex matter. In total, five people with expertise in different aspects of construction were interviewed.

Field of interviewee	Number of interviewees
New construction	3
Refurbishment	1
Construction planning	1

Use of the method in the research

Interviews of the contractors were based on four themes; the current state of circular economy in construction, the possible challenges that arise from circular economy, reporting environmental factors and development opportunities. (See themes below).



Word Cloud

To supplement the insights, the data was visualized by forming a word cloud. A word cloud is a cluster of words that presents the frequency of words occurring in qualitative data through magnifying or darkening the most frequently used words of phrases (Martin & Hanington 2012, 207). When presenting the findings from the interviews, the intent was to provide the reader with the most accurate description of the interviewees concerns and opinions regarding circular economy. The word cloud acts as an indication of the most prevalent matters on the interviewee's minds regarding the implementation of circular economy in construction.

In the making of the word cloud the interviewer's speech and questions as well as all parties' vocal disfluencies were removed from the transcript, thereby leaving a raw set of qualitative data. Thereafter the data was uploaded to a word cloud software. The word cloud presents each word magnified by each repetition within the transcriptions. Therefore, the smaller words are matters only repeated occasionally, whereas the larger words present matters with several occurrences throughout the interviews. The most pressing matters reoccurring within the interviews were materials, costs, recycling, design, goals, temporary storage and demand. (See figure below)

Figure 10: Word Cloud from reoccurring words from the themed interviews

Materials

The word repeated the most throughput the interviews was materials. The context in which materials were discussed included the decision of using recycled materials, testing materials for recycling and lastly logistical matters such as the storage of the recycled materials.

Costs

Costs arose as the following matter from the interviews. As an overview of the interviews, circular economy solutions were often perceived as more expensive in comparison to their linear counterparts.

Design

The decision process was highlighted in the interviews in regards to the materials and lifecycle thinking in the design stage. Unless circular economy is addressed in the design of a construction, its implementation becomes increasingly challenging in later stages.

The data analysis process

The analysis process of the qualitative data derived from the interviews was based on grounded theory. According to Corbin and Stauss (2012) Grounded Theory is a methodology first introduced by Glaser and Strauss (1967) that entails building theories derived from data. To relate this term to the context of the research conducted in this thesis, the research intended to build hypotheses of the precise complications preventing circular economy from prevailing through the contractor's perceptions. Therefore, the outcome of the qualitative data analysis was to form theories presenting the issues as well as plausible solutions. The method was used to create a new theory specifically designed to provide the commissioners with insight on their current processes and the limitations within them.

The grounded theory by Corbin & Strauss (2012) was modified to suit the research and it consisted of the following steps:

1. Building research questions, in this case themes
   As mentioned above, the themes resolved around matters that the commissioner had determined as areas of interest for the research. The final themes included the current state of circular economy, possible challenges, reporting and development.

2. Transcription
   The transcription was roughly completed by the software on Teams, in which the interviews were conducted. The researcher then went on to listen to the recordings again to correct any inaccuracies within the transcription.

3. Open coding
   Open coding refers to the practice of labelling excerpts of the raw data by their qualities. In this research approximately 20 codes describing the concepts were formed in the open coding stage.

4. Axial coding
   The axial coding consists of referring the codes to each other and thereby forming more in-depth codes to represent a larger set of insights in a more concise and accurate matter. The number of codes was thereby reduced to eight main codes representing the concepts.

5. Comparative analysis
   In the comparative analysis the excerpts were compared between each other, allowing for a deeper definition of the codes. Thereby the saturation was explored, and the main concepts were noted.

6. Building theoretical models
   As a final stage in grounded theory, the researcher derives theories to portray the data.

Theories

The main findings of the data analysis were in the form of understanding the reoccurrences and main issues. Thereby two main hypotheses were formed to explain the matters preventing circular economy from actualizing for the commissioner:

1. The developer controls the demand, thereby possessing an opportunity to impact the decisions on including circular economy.

2. Currently, solutions supporting circular economy are often more resource heavy, and thereby unattainable with the current process.

Informational and workable insights

As the intent of the research was to provide insight as well as developmental proposals, the insights gained were further explored by grouping and visualization. The saturation of the statements was assessed, and similar statements were formatted into one. Thereafter, the data consisted of statements that could be divided into two categories: informational insights and developmental insights.

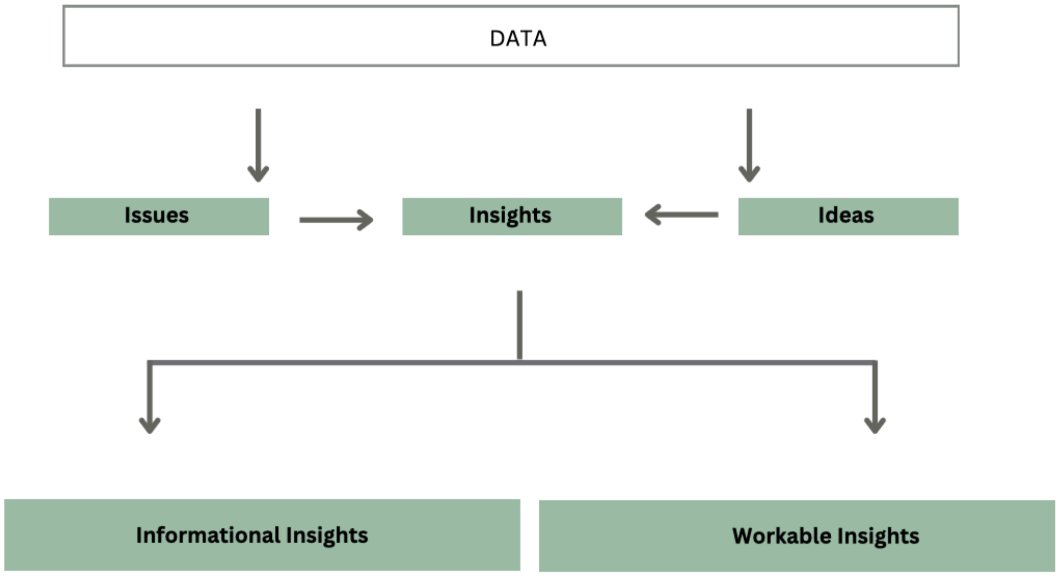


Figure 11: Forming the informational and workable insights

Results

The derived insights were compiled into a chart. By nature, some insights were more informational details about the nature of the field and its issues, whereas other matters were concrete and development towards solving them relied in the hands of the commissioner.

Thereby a chart was devised to portray the insights divided into two categories: informational insights, and workable insights. To view the Informational and workable insights chart, see Appendix 1. The intent behind the informational and workable insights was to present both, the contractors’ perceptions as well as possible solutions to the matters presented.

Below is a summary of the findings of the research. To maintain transparency and provide the reader with an accurate representation of the interviewee’s views, some excerpts from the interviews are included within the findings.

Theme 1: Current state of circular economy

This theme intended to explore the industry norms, best practices and subject matters that are creating conversation currently around the subject. The coding which addressed this theme was legislation, industry, and current actions.

Legislation

Within the interviews, multiple interviewees raised conversation upon the significance of recent legislation settling in. The intent of the legislation is to provide an easier way for the construction site to attain material approvals for recycled materials. The interviewees raised concern about the ease of the attainment of clearance for the materials in practice. As the legislation has not yet fully settled in, there was concern regarding this matter. This may cause uncertainty for planning of use of recycled materials.

The current state of the industry

Within the industry, overall development towards circular economy is in progress, however all five interviewees recognized that the built environment is still in its initial stages regarding circular economy. An aspect that raised questions within the interviews was the customer’s perceptions of circular housing solutions. The customers valuation for circular solutions should exceed linear one’s to justify the plausible surplus costs and steps for attaining a circular build.

> *” Of course, when using old materials, it can be used to create added value through its history or story, however, if the customer and other stakeholders do not see the value in that, it may not be as justifiable.”*

Within the construction of business premises, circular economy is more prevalent, with environmental certifications being used in most business premise construction projects. In contrast, in residential construction, environmental certifications and the demand for circular housing seems to be the minority.

> *” In the construction of business premises, the use of point systems or sustainability marks is almost the majority, and in the consumer sector it is the clear minority.”*

Current actions

All five of the interviewees stated, that their company has made or participated in projects or goals advancing the development of circular economy. Development is commonly undergone in the form of forming roadmaps to reach carbon neutrality, piloting innovations, developing ESG-policies, and making regulations on the desired recycling rates or energy use on the construction sites.

An interviewee’s statement regarding a recent project that intended to create a holistically circular housing solution:

> *“In our plan we included many things related to circular economy, there were shared cars and bikes, and the ownership of items was to be reduced […] When creating circular housing solutions, we think about the entirety of the matter.”*

Pressures

When assessing the pressure to attain more circular practices, the interviewees stated that the pressures can come internally from the company’s leadership, or externally through environmental legislation, taxonomy, funding, consumer, and developers demands. The opinions were mixed, where some felt more significant pressures, whereas others stated that there may be some minute pressures, but nothing too significant. The examples of pressures used were public environmental claims by the client (developer) or the direct demands of the developer.

Theme 2: Possible challenges

The exploration of possible challenges emerged within the interviews in several stages. Conversation was had about challenges in different stages of the construction process. As stated above, the word cloud acts as a representation of the subject matters that arose most during the interviews. Most of the reoccurring topics throughout the interviews revolved around the current challenges.

Costs

The cost structure of including or practicing circular economy functions was discussed in each interview. The overview is that generally, the construction tender often prefers options that are lower in costs and lower in the construction's duration. Thereby, including circular options in the construction proposal becomes ineffective for the contractors.

> *" …if the customer does not value anything but the price, it would not be beneficial for us to price ourselves out of the competition. If circular economy provides a monetary benefit, then implementing it is easier, however as soon as it increases the price […or] requires further examinations or permits, the workload grows, and which course is an extra expense that we cannot then offer"*

> *" … it must be understood what we are doing here. If a client starts a project, it starts by an Excel calculation that shows that this project is profitable. The profitability is impacted by the duration of the construction. If we start including as an example, new low carbon concrete, that prolongates the construction process, it will then reduce the profitability."*

Knowledge

Within construction sites, circular solutions are included at different rates. Thereby there is not much knowledge of which materials are most suitable for reuse and which may be the easiest to remove as whole pieces.

> *" A challenge that I hear from the construction sites is the common understanding of the terms. If we are talking about having to recycle 70% of the waste as material, what does it mean in reality? Everyone must have a common understanding of the terms before we can make big advancements in the matter"*

> *"Professional advisory must be used to recognize which materials should be tested for re-use. Imagine if a cement element was transported around to a testing facility, then another construction site to be used. That would not be ecological whatsoever."*

Preliminary storage and material placement

Including material recycling in the construction plan requires for additional logistical efforts in deciding when or where to store the reusable materials. Sometimes, the storing can be placed within the construction site, however in smaller plots of land the storage may become difficult. Thereby some recyclables require temporary storage and therefore additional planning. In addition to storing the materials, finding a placement for the recyclable materials may be a tedious process.

> *"The field has this disposal culture […] We must understand that the process in circular economy is much more demanding. One architect said it well that to reuse materials you must be very tenacious to find a place of reuse."*

Theme 3: Reporting

The reporting theme included both, conversation regarding internal and external reporting as well as conversation regarding environmental certification. In addition, which performance indicators of circular economy were followed and reported was discussed.

Current reporting

The different companies have different practices regarding the analysis and reporting of material flows on the construction sites. Some sites have more digitalized solutions provided by the demolition or waste management companies, whereas others still recorded on more traditional methods, such as Excel. In addition, some sites use the European Waste Catalog (EWC) codes, whereas others do not. Therefore, in some cases the actors must translate materials to the codes afterwards which causes manual labor.

> *"…We collect some of the data to an Excel, which I think causes unnecessary manual labor, that people fill an Excel file and we read it using an AI. It even causes errors."*

> *"Here's an example form the beginning of this year […] This has to do with the EWC-codes, not everyone uses them, and some use different codes for the same material. We must translate the materials to the correct [codes] and then see which codes can be calculated for our recycling rate and which belong to the contractors or some other third party."*

Missed streams of recycling

When reporting the recycled materials, different actors own the material and hold responsibility for its recycling. In some cases, this causes so-called "missed streams of recycling", meaning that some recycling numbers are not indicated in the contractor's reporting.

"The actors that come to the construction sites and collect the leftover materials to re-sell them specifically as materials are currently going above this equation. They are not seen in any of [our] recycling numbers"

"Our waste maintenance is handled by [company X], but demolitions and some particular constructions, for example pile driving which produces either heavy cement or steel. The waste will go as an off stream for someone, from where it came from or to some other contractor who will then recycle them. We should then all be able to count these materials to our recycling rates."

Measuring circular economy

As previously stated, circular economy is still finding its footing within the construction sector. Therefore, the measurement of its indicators is not equal between different actors. The companies presented different measures that were collected internally, most included at least the recycling rate.

"…There's much to learn and understand and one of the big challenges is that when we begin to measure, what exactly should be measured and how can it be measured…"

Theme 4: Development

The most developmental opportunities were perceived in controlling the demand and establishing concrete practices for the consideration of circular economy. The interviewees stated that the demand for circular economy is often not visible in the construction tender. In addition, many statements regarding the development needed within the industry were made.

Developer's role

The developer is responsible of controlling the demand as they are the client of the contractors. In addition, the developer can impact the design decisions and material choices of the construction. The choices can be used to impact the actions in the construction site as well as the buildings long-term performance and recyclability.

"The client can practically impact what kinds of surface materials are used and what kinds of solutions are implemented, more specifically their transformability. When the end user's life situations change can the walls be moved or are the in-house materials durable, so they do not have to be

replaced immediately. Do the materials please the masses that they are not changed as soon as the house is taken into use?"

Development within the industry

Through the interviewee's perception, the current economic model in construction is still closely related to the linear economic model. There are external factors such as laws and regulations shifting the industry slowly. In addition, for the development of the field, innovations need to be tested and progressed expediently.

"I recognize that many actors must progress in this matter… It may be the taxonomy that guides the financing to become green in a way that you cannot produce projects that are harmful for the environment and the earth."

6.3 Workshop

The observations were further explored with the intention of creating tangible solutions. The development issues were derived from the data of the interviews. The issues found were thereafter be examined by hosting a workshop. In service design, workshops are used to produce solutions to often a pre-set problem with creative activities. Workshops are effective at collecting insights and later on support on the developed matters from the participants (Marting & Hanington 2012, 61-62). The intention of the workshop was to create conversation around the matters that arose through the interviews. The workshop was held for representatives of the commissioner.

The chosen practice for this workshop was insight sorting. In insight sorting, the insights are derived from data and formed into so-called insight statements, thereafter the statements are clustered into segments by the members of the workshop (Kumar & LaConte 2012, 140). In this research, the data analysis and formation of insight statements was carried out prior to the workshop to save time of the participants. The categories were determined prior to the workshop; however, the premise was to assess the developmental opportunities through the lens of the probability of solving them. The tangible outcome of the workshop was a matrix presenting the issues, development proposals and a ranking of the feasibility of each solution.

Results

As stated above, the intent was to gather the insights into a matrix that presents the participants views upon the statements. Each statement is grouped into one of five categories by the participants: Already applied, Plausible in the near future (0-5yr), Plausible in far future (5yr. <) Needs additional work and Not applicable. Each attendant's categorization is presented as a tick in the categories slot (1/4). Each row presents the total number of persons grouping the statement into each category. Some votes were in between and shall therefore be either summed up with other halfway votes or presented as ½ /4. See Appendix 1.

Assessment and discussion about the insights

Within the conversation, the incentives for each prompt came up. The commissioner needs to be able to justify the practices that are taken into place. Thereby, the inclusion of circular economy currently is often seen as an act of good will. During the workshop the attendees expressed the same concerns as the contractors for increased costs. Many prompts were also seen as things that other stakeholders should take responsibility for. According to some of the attendees, the field is developing to allow for more circular solutions, however, the government holds the most potential for influencing the field through enforcing regulations and taxonomy.

Figure 13 presents the most favored development solutions from the workshop. In total 10 development proposals were sorted and six of the most favorable one's received at least two persons stating that the solution could be feasible in the near future. (See figure below)

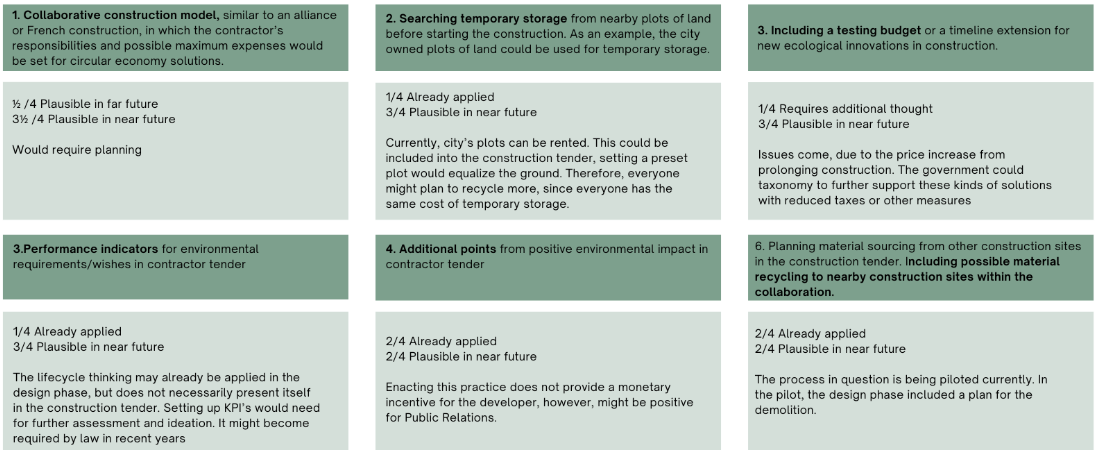


Figure 12: Most plausible development proposals

Below are presented the six most suitable development solutions for the commissioner:

1. Collaborative construction model, resembling an alliance or French construction, in which the contractor's responsibilities and possible maximum expenses would be set for circular economy solutions

   3 ½ out of 4 categorized the insight into plausible in near future ½ of four said Plausible in Far future.

2. Searching temporary storage before starting the construction from nearby plots of land. As an example, the city owned plots of land could be used for temporary storage.

   One out of four states that it is already applied, 3 out of 4 thought that it is plausible in the near future. Currently, city’s plots can be rented. This could be included into the construction tender, setting a preset plot would equalize the ground. Therefore, everyone might plan to recycle more, since everyone has the same cost of temporary storage.

3. Including a testing budget or a timeline extension for new ecological innovations in construction

   3/4 stated that it is Plausible in near future, 1/4 stated that it may requires additional work. Issues come due to the price increase from prolonging construction. The government could support these kinds of solutions.

4. Performance indicators for environmental requirements/wishes in construction tender

   3/4 participants voted for plausible in near future and one vote was set for already applied. The lifecycle thinking may already be applied in the design phase, but it does not necessarily present itself in the construction tender. Setting up performance indicators would need for further assessment and ideation. It might become required by law in recent years.

5. Additional points from positive environmental impact in contractor tender

   2/4 voted for Already Applied and 2/4 in Plausible in near future. Providing additional points in the construction tender does not provide a monetary incentive for the developer, however, might be positive for public relations.

6. Planning the material sourcing from other construction sites in the construction tender. Within the collaboration possible material recycling could be included to nearby construction sites.

   2/4 voted already applied and 2/4 voted for plausible in the near future. This is being piloted currently, in the design phase the demolition was already planned.

6.4 Process analysis, blueprinting

As an analysis and visualization tool, the research utilized a process map. Process mapping is a development method that entails crafting a diagram in which a process is presented. By using a table as visualization, one can pinpoint inefficiencies and develop improvement ideas to the process (Cogner 2011, 37). When utilizing a process blueprint in a development project, the effect of each step and each actor can be defined precisely (Ojasalo, Moilanen, Ritalahti 2009, 158).

How it will be used in this research

A base for the process map was formed based on theory as well as discussion from the workshop. The process map presents the current collaboration process between contractors and the developer. Thereafter, the possible new solutions and steps will be included into the process map. The solutions present the steps that could be added into the current process to establish a more collaborative operating model. The blueprint presents a rough draft of what the current process looks like.

Result

The construction tender is the first step in which the contractor and developer start their collaboration. Prior to this stage, the developer is responsible for the design and planning process with the architects. Within the construction, the developer's role is minimized and in the warranty period and usage phase, the developer's opportunity to impact the refurbishment decisions becomes close to null. (See process blueprint below)

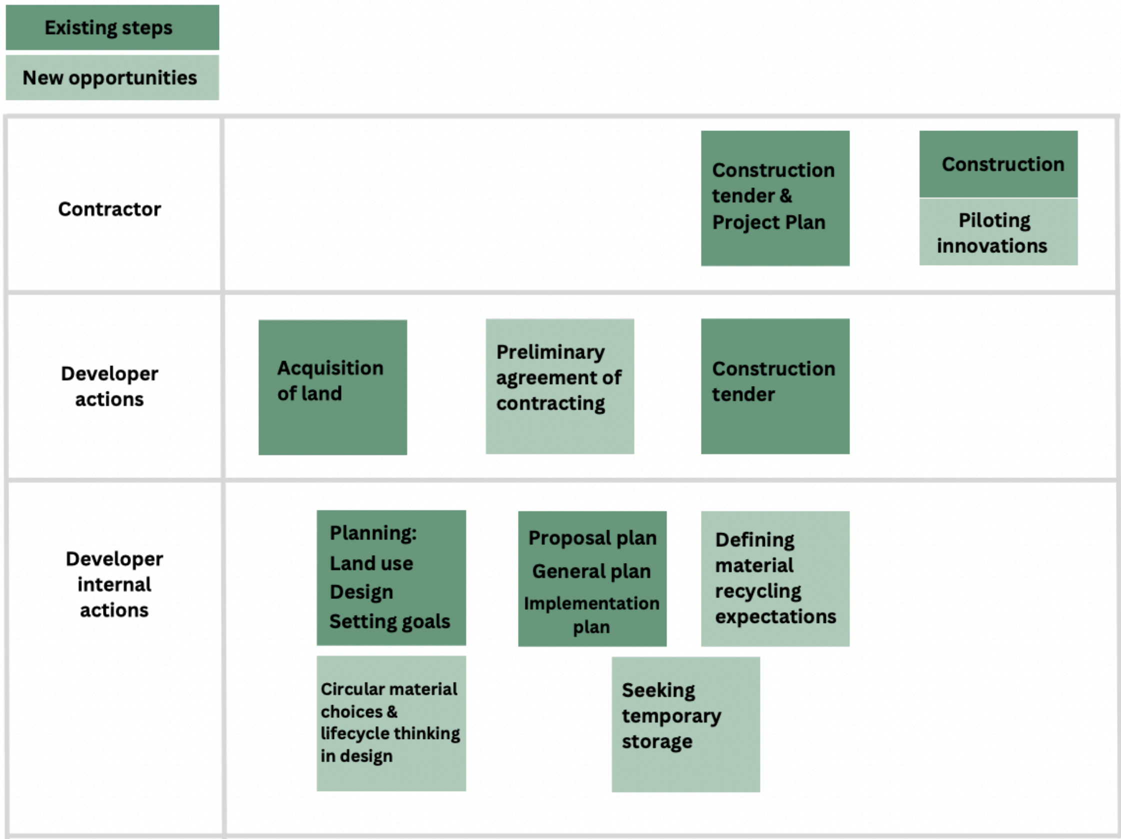


Figure 13: Process blueprint

Improvement

Within the initial ideation of the workshop the possibility of including the contractor in the design phase arose. By increasing the touchpoints that the contractors have with the project, their ability to provide feedback and more concrete details of their practices immerses. Within the construction tender the opportunity to set clear goals for environmental standards became a plausible option. Seeking preliminary storage for materials could be undertaken within the main planning for the plot. The final development opportunity is within the construction in which circular economy options or innovations could be piloted.

7 Reliability of the research

The knowledge gained from qualitative research is not intended for representation of mass experiences. The goal is to derive in-depth information regarding the complexities and structures of a very specific phenomenon or group being studied (Puusa, Juuti & Aaltio 2020 chap. 11). In this study, the intent was to gather very specific information about the commissioner's functions through the eyes of its contractors. Prior to the execution of the research an assessment of reliability was conducted.

By nature, qualitative data is more prone to being more varied, flexible, and multifaceted than quantitative data. Thereby, the analysis of qualitative data must be intricate and attentive to these traits to produce reliable findings (Research Methods for Business Students 2015, 568). The methods commonly used to justify the reliability of quantitative research such validity and reliability become improper when assessing qualitative research (Hirsjärvi & Hurme 2008, 189). The reliability of qualitative research can be presented to the reader through portraying a holistic and accurate representation of the research process and methodology (Syrjälä, Ahonen, Syrjäläinen & Saari 1994, 131). The reliability of qualitative research can be established through examination of the researchers' actions, the interviewees answers and how accurately they have been portrayed in the research (Hirsjärvi & Hurme 2008,189).

Confidentiality

To ensure that the participants of the study provided insights that are accurately representative of their true feelings, anonymity was established for the research. The study separated the interviewees from the workshop attendees, removing any conflicts of interest arising from the business relationship. All parties included had significant work experience in the sector and most had experienced work in different functions within the construction industry. In total nine professionals contributed to the research with their views experiences and perceptions.

Interpretation errors

In themed interviews the main concerns regarding the reliability were interpretation errors, leading questions, and reactivity. Confirmability was used to subset these issues during and after the interviews. During the interviews, the flexibility of a themed interview was utilized to implement confirmability. When a complex matter arose during an interview, the researcher was prepared for asking defining questions, such as "Can you define what you meant by referring to […] The term is unfamiliar to me." and "[…] did I understand this correctly?". The questions allowed for the interviewee to confirm or correct the researcher real-time throughout the interview. Both questions used above were quotations from the conducted interviews.

Another opportunity for interpretation errors occurs within the analysis phase of the themed interviews. When turning the qualitative materials into the workable insight statements, the risk for misquoting presents itself. At the end of each interview the researcher asked permission for confirming the findings from the interviewee. Therefore, there was an opportunity to confirm any unclear matters as well as reassess that the insight statements were accurately representative of the interviewee's perceptions. Due to the thematic analysis of the materials, the insight statements were structured to represent not necessarily the views of one subject, but a collection of views presented into one statement. Therefore, one statement often had multiple voices behind it, to support its validity. When categorizing excerpts and editing the statements from the interviews, there was a careful consideration of not removing nor adding substantial details of the statements being utilized. As qualitative research entails the researcher being heavily familiar with their data, when questions arose during the workshop about the meanings of the insight statements, the researcher was able to provide examples and further explain the statements being addressed.

Leading questions

Prior to the interviews the themed interview method was refined by conducting a pilot interview. In this interview the subject was specified with leading questions and asked to point them out for the researcher as they occur. This pilot interview provided an opportunity for the researcher to develop a notice for when the questions were going to become leading.

The definite control for leading questions was conducted within the data analysis stage. When transcribing the interviews, all leading questions were highlighted and the answers of them were examined for the impact of the leading. Thereafter the answers were either discredited or included, if the leading did not seem to have an impact on the answer.

8 Findings and development proposals

The intent of this research was to gain insight on the opportunities and threats to the implementation of circular economy practices that the contractors face in their processes. As the outcome of this research the commissioner was provided with both, insights about the industry and tangible solutions that can be further explored within the company.

Industry

Within the construction sector constant effort to develop circular economy are implemented by actors in the field and regulatory forces. Circular economy in construction is still finding its footing and efforts from all stakeholders are required. Therefore, each actor in the process needs be included into the conversation and further development is to be prioritized. Currently, it is commonly understood that circular economy solutions can be resource heavy in comparison to their linear counterparts. This inflates the issue of linear practices within the field. However, taxonomy and legislative rulings have an opportunity to nudge the actors into further development of the green transition. For an industry to transform, all stakeholders must understand the changes ahead and their necessity. Many potential business opportunities lie in the green transition of construction. Issues such as the lack of temporary storage options or material re-distribution may inspire new actors to join the industry to further develop it towards sustainability. In addition, the consumers must acknowledge that circular housing solutions may be the norm of the future. Therefore, the possible expectations of what a new house looks like, feels like, or consists of needs to be aligned with this reality.

Contractors and developers

Within the collaboration of the two actors many practices have become the norm that may no longer be suitable business models for circular economy. The main role that the developer plays in implementing circular economy is controlling the demand. The material choices, lifecycle design and choosing the contractor are all aspects that the developer can influence. Therefore, it is advised that the developer pays careful consideration to the design choices and demands on the contractors. For both parties piloting new innovations in ecological constructions is advised, whether is in large-scale testing or individual cases. Further development can be reached if processes are actively piloted and developed to include more concrete measures and innovative solutions.

As mentioned prior, SATO intends to become the industry leader in circular rental properties. To attain this goal, the company needs to find opportunities from the challenges found in this research. Below is presented a chart presenting the opportunities that the commissioner may explore to find further development for the matter.

Challenges to opportunities

Challenge	**Opportunity**
Including more innovative circular economy solutions with increased costs	Seeking public funding to support the costs
Pre-selecting indicators that would be demanded from the contractors within construction tender	Utilizing the knowledge from environmental certifications to include demands regarding Energy, water use, pollution, materials, waste, and innovation
Lack of knowledge about material recycling prospects in demolition	Conducting pilots for the demolition of different materials, using professional advisory for choosing which materials to re-use
Finding storage	Seeking storage before beginning construction

Offsetting costs by applying for public funding: The company may explore the Finnish public funding market to seek out financial support to cover the costs from piloting and including circular solutions within its projects. At the time of the research, Business Finland is distributing 500 million euros of Recovery and Resilience Funding (RRF) between 2021-2023 for projects that entail ecological advancement (Business Finland no date a). In addition, at the time of the research, Business Finland had an open application period for a funding round intended for establishing carbon neutrality in the built environment (Business Finland no date b). Similar funding opportunities can be sought out from municipalities, ELY-centers, and other actors in the public funding sector.

No regulated knowledge or demand for performance indicators: The company may utilize the information regarding environmental certifications to formulate its own set of performance indicators demanded from the contractors. This step may provide additional benefit, if the company chooses to apply for an environmental certification for the construction.

Lack of knowledge about material recycling: As stated by an interviewee, within all construction projects lies an opportunity for piloting circular solutions. Therefore, the company holds an opportunity to gain immense amounts of knowledge if piloting and research is prioritized. In the demolition phase, useful information regarding which materials are easy to remove as whole can be gained. This can be used to impact the material selection of the future.

Seeking temporary storage: The company can level the playing field for the contractors in the construction tender by including a pre-selected plot of land designated for storing the recyclable materials. Thereby the contractors are not disincentivized from recycling materials due to the additional cost of the storage plot.

Final summary of the research

As the final summary of the research, all feasible development opportunities were compiled into a three-tier chart of proposals. The chart presents the development opportunities in three categories: Minimal effort opportunities, Opportunities requiring time and thought, and Long-term opportunities. See figure below.

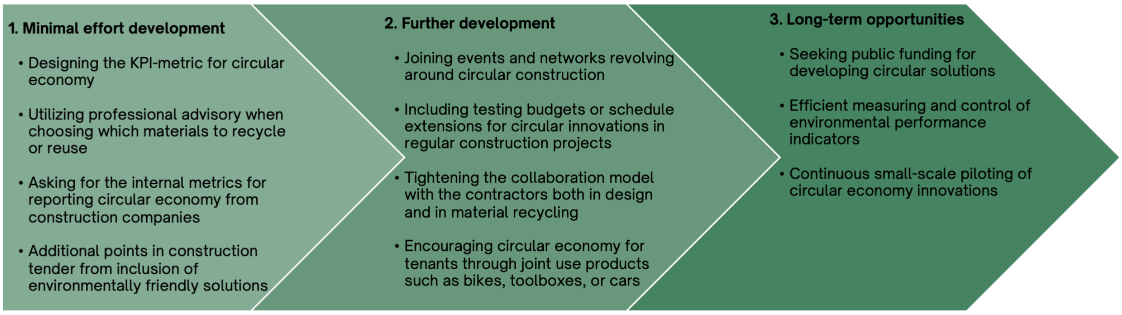


Figure 14: Step-by-step proposals of circular economy implementations

The Minimal effort opportunities

The minimal effort opportunities summarize the efforts that the company may start exploring or designing as soon as receiving the development proposals. Most solutions presented within this category are choices that may require internal approval or further planning and piloting. Overall, if considered in a timely manner, the proposals may be implemented shortly.

The environmental certifications presented in this research may be used in constructing the performance indicator (KPI) listing for circular economy. Additional points for environmental impact may be implemented into the construction tender to sway the demands for a more positive environmental impact. The design phase can address the durability and visual preferences of the consumers to lessen the amount of needed consumer renovations. When conducting new material recycling pilots, professional advisory may be utilized to choose the most suitable materials for recycling. The company may also open conversation with the contractors regarding their internal measurement of circular economy. the contractors existing internal reporting could be used to broaden SATOs knowledge of their constructions environmental impact.

Opportunities requiring further time and thought

The opportunities presented in the second tier of proposals include solutions that demand internal development as well as external collaboration. The implementation of the proposals within this category is dependent on planning and the success of the pilots.

The company may begin to implement itself in the conversation regarding environmentally sustainable construction by seeking groups and programs that drive the environmental development of the construction field. The implementation of the collaborative construction model would require participation from both the contractor and the developer. In addition, the practice should be piloted on a smaller scale to assess its advantages and disadvantages.

Finally, the inclusion of testing budgets and schedule extensions in construction for circular innovations would require approval from the deciders of SATO.

Long-term opportunities

The long-term opportunities include one’s which require further efforts and organization. The execution of the long-term proposals may require the implementation of the lower order proposals presented above. Therefore, this category is the furthest tier of proposals presented.

The company may begin to seek and apply for public funding solutions to support the costs caused by the development of circular economy. If the opportunities presented above are applied, the company may be equipped to produce continuous small-scale pilots of circular solutions. In addition, the company’s environmental performance can be efficiently controlled as productive measurements are in place.

Further research proposals

As costs were the prevailing theme throughout the research, further research on the monetary constraints of circular economy in construction could be explored. In addition, an audit of innovations could be conducted to provide the actors with an up-to-date presentation of possible products or practices to pilot.

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Figures

Tables

Appendices

Appendix 1: Informational and workable insights from the interviews

Industry insights	Workable insights
There are different kinds of processes in recycling. Certain materials are melted or molded to create a new material. It would be beneficial, if in some materials, like wood plates, this process could be completely avoided, and the material could be transferred to its next use as is.	Waste production could be reduced by designing with standardized materials. If less common materials are used, they may be produced less often, which leads to ordering excess to ensure that the material does not run out.
When using recycled solutions, is the expectation that it works as a new one would? We must change our quality expectations. When the end user takes a new product into use, can we really call it a product new, if it has been used for 30 and is now taken into new use.	Could the construction tender collaboration models be connected to demolition? As an example, construction tenders could be used to collaborate on material recycling from and to the contractors and developers construction sites.
There is no clear knowledge within the industry about the true costs of recycling.	Could the developer have a pre-set performance indicator list of the required environmental demands?
There are new business opportunities in the field regarding construction storage, as this is seen as a challenge.	Demanding a certain score on environmental certifications. If demanded, the contractor will plan the construction to form the desired score.
In the construction of office premises the use of environmental certifications is more prevalent than in the private consumer sector, therefore circular economy is also more thought out in the construction of office premises.	Could the final electricity connections be taken into use already in the beginning stages of the construction. Therefore, more ecological electricity could be used and the final electricity connection would be formed.
The recycling and reselling of unused leftover materials is not currently shown in the recycling numbers.	How are the budget or schedule extensions caused by environmental benefit noted?

It is tough to get numbers of the material inflows. In the material waste side automation has been more successful, although in some sites the waste flows are still tracked manually.	The measuring of circular economy should be done in a controlled manner, why do something that does not produce benefits? If circular economy was measured in a standardized way, its long-term development could be reported more accurately.
Usually, when any conditions assessment is made, the conclusion is that in 5-10 years the subject should be renewed, when it could possibly be hold up for another 50 years. There is a prevailing unacknowledged culture of excessive renewal.	When conducting a construction tender, could environmental solutions be prioritized with additional points?
A problematic waste on the construction sites is wood, when used as a mold.	When a construction requires a temporary storage for materials, there may be free plots owned by the municipalities which could be used. These opportunities could be sought out before the construction begins.
Some construction sites use EWC-codes, while others don't. If the codes are not used, the measurements need to be translated to the EWC codes later on.	Could testing budget for circular solutions be implemented?
The delegation of the recycling numbers causes some confusion in the construction. Some waste belongs to the contractors and some to other actors such as the waste management companies.	In demolitions is moving unused constructions elsewhere considered in place of demolition.
	Are durable and materials pleasing to the eyes of the masses prioritized? This could help reduce refurbishment done by the tenants.

Appendix 2: Insight assessment in workshop

Insight	Already applied	Plausible in near future (0-5yr)	Plausible in far future (5yr <)	Requires additional thought	Not applicable
Listing of most easily utilizable materials		4/4			
KPI indicators for environmental requirements/wishes in contractor tender	1/4	3/4			
Additional points from positive environmental impact in contractor tender	2/4	2/4			
Building electricity lines in the initial stages of a construction	4/4				
Planning the material sourcing from other construction sites in the construction tender. Within the collaboration possible material recycling could be included to nearby construction sites.	2/4	2/4			
Including a testing budget or a timeline extension for new ecological innovations in construction		3/4		1/4	
Demolition decisions should be examined, what is behind a demolition decision.		1/4		1/4	2/4
Collaborative construction model, similar to an alliance or French construction, in which the contractor's responsibilities and possible maximum expenses would be set for circular economy solutions.		3 ½ /4	½ /4		
Searching temporary storage before starting the construction from nearby plots of land. As an example the city owned plots of land could be used for temporary storage	1/4	3/4			

Choosing standard materials which please the eyes of masses.	1 ½ /4	2 ½ /4			