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Towards a Dutch Sustainable Built Environment- An Analysis of Sustainability Policies from a Network Governance Perspective

Name: Luciano Lopez Santesteban

Supervisor: Jaap Rozema

Specialisation: Urban Environment, Sustainability and Climate Change

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Summary

This research studies the effect of Network Governance on the Integration of Circularity and Energy Efficiency in the Built Environment. On one hand, it explores how the Dutch Policies for Circularity integrate with the ones for Energy Efficiency to foster the transition towards a sustainable built environment. On the other hand, it studies how the existing networks, using different Network Management Strategies, contribute to that integration. Since the literature on Transition to Sustainability proposes Network Governance as the Government Approach that fits best the management of transitions, this paper intends to deepen into this understanding by looking at the specific case of transitions in the Built Environment. It analyses the specific case of the Netherlands, in which sustainability in this supply chain is affected by both the policies for Circularity and Energy Efficiency, and searches for answers regarding how these two integrate both in the practice and at the policy level.

The methodology comprises a mixed-methods approach supported by a survey, interviews and a document analysis for data collection. In the case of qualitative information, it is analyzed using a coding scheme around the variables Network Management Strategies and the Integration of Circularity and Energy Efficiency. The codes are lately assigned scores based on recurrence to produce a quantitative output. The findings are illustrated with their quantitative representation and using inverviewees' inputs to provide qualitative insights. The quantitative observations are also analyzed through multiple regression to test causality between variables.

The findings suggest that, indeed, the integration of circularity and energy efficiency can be promoted through the use of network management strategies, in this case finding relevant the ones of arranging and exploring content. In addition, they signal the risk of having multiple networks working on the same topic at the same time, which could lead to competence among them and spare the efforts towards the transition, and the need to create channels of communication and information flow for these networks to benefit and be complementary to each other. The finds also point at the used of biobased materials as the strategy with the most consensus around its potential to contribute to this integration. These materials, when designed in systems that can be mounted and dismounted for reuse, making use of passive design strategies, and incorporating concepts of circularity in the use of water, have the potential to integrate Circularity and Energy Efficiency and significantly reduce the GHG emissions of this industry, across the full life cycle of a building, meaning construction, usage and demolition.

This thesis wants to make a contribution to both, the research on transition governance, and the one about sustainability in the built environment, in times in which these topics become more urgent.

Keywords

Sustainability – Built Environment – Transition Governance – Transition Management – Climate Mitigation – Biobased materials – Circular Economy – Energy Efficiency

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Abbreviations

BE	Built Environment
CE	Circular economy
CEBE	Circular economy in the Built Environment
EEC	Energy Efficiency and Circularity
EED	Energy Efficiency Directive
EEPB	Energy Efficiency Policy for Buildings
EPBD	Energy Performance of Buildings Directive
EPI	Environmental Policy Integration
GHG	Greenhouse Gas Emissions
ICEE	Integration of Circularity and Energy Efficiency
IHS	Institute for Housing and Urban Development Studies
LCA	Life Cycle Analysis
NM	Network Management
NMS	Network Management Strategies
TACCE	Transition Agenda for a Circular Construction Economy

1. Introduction

1.1. Background information and problem statement

The term Climate Change refers to changes in the patterns of the world climate system motivated by an increase in the the greenhouse effect. The greenhouse effect is the natural result of different Greenhouse Gases (GHG), like CO_2, CH_4, O_3 and NO_x in the atmosphere, that help in retainin sun's radiation to keep the Earth warmer by about 33°C and make it inhabitable (Working Group 1- Intergovernmental Panel for Climate Change, 1990). However, as human society industrialized with the discovery of fossil fuels, its population grew, and agriculture developed, the concentration of GHG in the atmosphere also increased, due to the liberation of large amounts of CO2 resulting from the combustion of coal, gas, and, more recently, crude oil and its derivatives, together with deforestation and land-use changes. CO_2 concentrations grew from (Working Group 1- Intergovernmental Panel for Climate Change, 1990)280 ppm (parts per million) in pre-industrial levels (Working Group 1- Intergovernmental Panel for Climate Change, 1990), to 410 ppm in 2020. Increase also took place for other GHGs like nitrous oxide and methane (Intergovernmental Panel on Climate Change, 2023). The consequences of these increasing levels include more frequent and sever extreme weather events such as droughts, floods and heatwaves, the rise of sea level that puts coastal cities in danger, and risks to food security and health. Last reports of the IPCC state the need for urgent action in terms of climate change mitigation (Working Group II to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change, 2022), which includes both actions to drastically reduce greenhouse gas emissions, and to recapture them and store them in carbon sinks. Regarding the previous, the emissions from energy use in buildings represent 17.5% of the total globally, which together with the emissions from the cement industry (3%) and the production of iron and steel (7,2%) (Ritchie, Roser, & Rosado, 2020), and considering their phases of construction and usage, make buildings one of the main drivers of climate change, and therefore, a good opportunity for mitigation through the use of sutainable building practices.

Sustainable building practices consist of different techniques that aim to reduce the environmental footprint of buildings during their construction and usage phases (Nguyen & Gray, 2016; Zwickel et al., 2014). In practice, this translates into the selection of low-carbon or carbon-storing materials, a design that optimizes energy efficiency, and the optimization of the water use and treatment of wastewater, among others. In the Netherlands, efforts have already been made in improving the buildings' energy efficiency through the National Energy Efficiency Action Plan (Government of the Kingdom of the Netherlands, 2017) and the Energy Agreement (Sociaal-Economische Raad, 2013). However, as this policy motivated the increase of insulating materials in buildings, it also enlarged the environmental effects related to adding more materials into construction. In consequence, more recently the policy focus changed from energy efficiency to materials, with the signature of the Raw Materials Agreement in 2016 (Prinssen & Lieffering, 2020). This agreement, signed by 421 different stakeholders in 2020, from which approximately 180 are related to the construction sector (Circulaire Economie), set the foundations to broaden the perspective of sustainable building in this country. In 2018, after the signing of the agreement, the National Government set transition agendas to make the Dutch economy completely circular by 2050 (Transitieam Advies Circulaire Economie, 2022; Transitieteam Circulaire Bouweconomie, 2021). These transition agendas were organized around 5 topics, one of them being construction, and set implementation programs for the period 2019-2023(Government of the Netherlands, N/A). Considering that the concept of Circular Economy is a broad one that refers to designing systems to keep products, components and materials at their highest utility and value at all times (Schut, Crielaard, & Mesman, 2015), (2017)it is also possible to understand Energy as a resource that can be assessed through the lens of circularity (Winans et al., 2017). In this regard, it is notable that not only the transition agendas for circularity in the Netherlands remain focused solely on materials, but also that the policies that aim to reduce carbon emissions through energy efficiency disregard the carbon footprint of materials consumption. In both cases, these policies -at least partially- aim at reducing buildings' GHG emissions(Prinssen & Lieffering, 2020). The remaining challenge is to put both together improving energy performance while reducing the environmental impact of materials (Prinssen & Lieffering, 2020). This challenge could potentially be overcome if both policies are integrated in a way that these aspects are considered altogether. In the words of Persson (2004), Environmental Policy Integration poses a chance for environmental positive consequences to be improved, by bringing together a larger amount of actors who increase the pool of knowledge, looking for win-win situations and having better probabilities to avoid policy contradictions.

Another difference between these two policies is their model. While the policies for energy efficiency have a mandatory character over the forces of the market, those for circularity structured upon voluntary agreements suggest a Network Governance approach (NGA), one in which public policy and governance are supported by networks consisting of different stakeholders that rely on each other's resources and cooperate to arrive at outcomes that are on their common interests (Klijn, Erik-Hans, 2007). The NGA is instrumentalized using Network Management Strategies (NMS), being the most frequent Process Agreement, Exploring Content, Arranging and connecting. Process agreement refers to the way in which functioning rules are agreed upon among the members of the network; Exploring Content is about looking for goal congruency, by collecting information and researching innovative solutions to fit different actors' interests; Arranging refers specifically to organizational arrangements and Connecting to the process of bringing key stakeholders together. However, it is still debated whether coercive regulation is more effective in achieving environmental outcomes than voluntary agreements. While a traditional approach would identify public pressure as the main mechanism for improving companies' environmental performance, Camisón suggests that voluntary agreements are better at fostering environmental innovation and adaptation (2010). Nonetheless, the same author reports that in his case study, the diffusion of environmentally respectful practices continues to be low. The question remains, whether coercive practices are better at improving environmental outcomes than voluntary agreements.

The words of Klijn and Persson appear to have similarities: they both claim that by putting together different stakeholders around the same goal, outcomes can be improved. Persson understands that through policy integration different actors come together to produce policy outcomes, and Klijn that when stakeholders participate in a network using different network management strategies, there is a higher chance of achieving positives results. In our case study, the Dutch policies for circularity and energy efficiency are not integrated at a policy level, but still stakeholders come together in Networks to contribute to policy outcomes. What still needs to be understood is if Persson's idea could also work in the opposite direction. This means, if the stakeholders that participate in these networks can influence the integration from the bottom-up, from the ground to the policy level. Considering the voluntary character of participation in networks for circularity, it can be assumed that participants have a genuine drive to improve the built environment's environmental footprint and, consequently, are also aware and concerned about the impacts of energy consumption during buildings' usage phase. It is also assumed that given the lack of integration between circularity and energy efficiency at a policy level, building practitioners will develop their own solutions and strategies to do it during the stages of design and construction. Nonetheless, it remains unknown how this integration happens in practice, and if indeed there is a higher GHG reduction when Circularity and Energy Efficiency are approached in a holistic fashion. Moreover, despite the literature on network governance suggesting positive environmental outcomes in well-functioning networks, there is no specific evidence to support the claim that networks are equally effective to address different environmental challenges. How suitable can networks be towards the particular goal of mitigating climate change from the built environment? Also, can they play a role in integrating circularity and energy efficiency from the bottom up? All these different questions are yet to be answered to fill in the existing gap in the literature and contribute to a robust knowledge framework upon which society can build strategies that make the Built Environment's supply chain an active contributor in the fight against climate change.

This research will build upon the existing literature to study how Network Governance affects the Integration of Policies for Circularity and Energy Efficiency in the Netherlands using a mixed methods approach. On one hand, it will explore how different stakeholders are exposed to different Network Governance Strategies, and retrieve their perceptions regarding the integration of circularity and energy efficiency through a survey strategy. On the other hand, it will further delve into stakeholders' perceptions using a set of semi-structured interviews to better understand what enablers, barriers, challenges and opportunities they have found along the way. These findings will ulteriorly be analysed against policy documents to triangulate and validate the results.

1.2. Relevance of the research topic

In the previous section it was explained how the accumulative concentration of GHGs in the atmosphere influences global warming to drive climate change, and how this threatens humans' assets and lives. Scientists warn that if this crisis is not addressed rapidly, the global system will go over different tipping points, triggering feedback loops that will worsen the effects and from which will be impossible to return. This explains the urgency in designing efficient policies that can address multiple sources of emission at the same time. In the case of the built environment, it is imperious to develop effective and replicable policy experiences that drastically reduce this industry's GHG emissions. The Netherlands has proven to be a frontrunner even among EU countries, which are under the same umbrella of the EU- Green Deal that is pushing for some of the most progressive climate policies in the world. By studying and systematizing the knowledge that is being created in this country both through policymaking and practice, it could be possible to transfer the successful results of these experiences more effectively to other countries, allowing for a wider and faster diffusion of sustainable building practices.

1.3. Research Objectives

Considering the research gap identified in section 1.1 and the relevance in section 1.2. Relevance of the research topic, this research wants to enrich the existing knowledge to understand both the effectiveness of Network Governance in driving the transition to a sustainable built environment, and the different ways in which sustainable buildings can be conceived, aiming at providing a comprehensive picture with the different innovations being developed and discussed by the building community.

More specifically, this research's objective is to understand how NMS influence the integration of circularity and energy efficiency in the built environment from a stakeholders' perspective. On one hand, it intends to identify the different NMS that are being used by the Dutch networks for circularity. On the other hand, it will analyse in which ways circularity and energy efficiency are put together when building, to discuss if a higher exposure to NMS has a positive effect on the integration of the two.

1.4. Main research question and research sub-questions

The research objective mentioned before is summarized in the main research question (RQ)

- To what extent do network governance strategies influence the stakeholders' perceived outcomes in integrating Circularity and Energy Efficiency policies?

The RQ is further broken down into four different subquestions that will help better understand the Dependent and Independent variable, setting the foundation for the following sections.

- What are the Network Governance Strategies being used in the implementation of transition agendas for circularity in the built environment?
- To what extent do the voluntary Raw Materials Agreement foster the integration of circularity with the pre-existing policy for energy efficiency in the built environment from the perspective of stakeholders?
- What are the challenges and opportunities that stakeholders identify in the integration of these two policies?
- To what extent can GHG reduction performance of the built environment be improved through combining energy efficiency and circularity goals?

2. Literature review and hypotheses

2.1 State of the art of the theories/concepts of the study

2.1.1. Network Governance

The possibility for climate change to be mitigated will depend on its process of governance. In other words, it will depend on how the societal process is influenced in a directed way (Klijn, Erik-Hans, 2007) However, there are different models or schools that theorize about how these societal processes should be affected. Klijn (2007) identifies three main models, namely, the Rational Choice model, the Multi-Actor / Governance as Market model, and the Network model. The first one is characterized by a technocratic governance in which the Government in the Central Actor, assuming that policymaking can rely exclusively in scientific analysis to implement technical and programmable policies. Shortcomings of this approach include that the limited capacity of a single actor can hardly have access to all the availability of data to make well-informed decisions. These policies can be rejected by the implementation sectors, leading to failure. On the opposite hand, the Governance as Market model emphasizes the capacity of societal actors to self-regulate themselves. This model assumes that independent actors make their own decisions in a marketplace. It claims that through the exchange of resources people succeed in achieving their outcomes and that too much regulation interferes in this decision-making process (Klijn, Erik-Hans, 2007). As an alternative to that dichotomy, the Network Model aims at integrating elements of the two. It does not intend to reduce government action as much as possible, but it does not aim at a strong all-powerful government either. Instead, it understands that the Government is one more actor in a Network in which multiple actors develop their strategies. This model is based on the idea that these different actors have interests in common and complementary resources, and work towards their goals through an iterative process of exchange of problems and ideas and negotiations, which makes it suitable to address wicked problems like climate change, due to the multiplicity of diverging interests that are involved in the search for solutions, and the complex character of it. (Klijn, Erik-Hans, Edelenbos, & Steijn, 2010). From a Multi-Level Perspective, it is also proposed that this type of governance could be suitable to drive the transitional processes necessary to achieve new sustainable socio technical regimes (Frantzeskaki, Loorbach, & Meadowcroft, 2012). In our case-study, this would mean the transition from a socio-technical regime for the built environment that contributes heavily to GHG emissions, to one that is a mitigating force regarding climate change. The following paragraphs will explain what a network governance process is and describe its main characteristics.

A governance network is a relatively stable form of social interaction of specific stakeholders around a certain topic affected by public policy due to a dependency relation among them. Different actors understand that they have either similar or different opinions regarding a specific topic, but complementary resources to approach them. In other words, they see the benefits of cooperating with each other as opposed to working individually. Despite it is true that these interactions can lead to conflict, it is also true that they can facilitate the distribution of cost and benefits of the solutions. To identify a Governance Network, there are three factors that should be considered. These are: the presence of many actors and frequent interactions, the stability of those interaction over a 10 years time, and the complex nature of the issues at play (Klijn, Erik-Hans, Steijn, & Edelenbos, 2010). The deliberate intent to govern this interactive process is called Network Management (NM). To perform NM requires sound knowledge of the nature of the network, including its participants, the relations among them, and their dynamics. Based on this information, a network manager will be able to make decisions regarding different possible strategies (Klijn, Erik-Hans & Koppenjan, 2016). The four main Network Management Strategies identified are (Klijn, Erik-Hans et al., 2010):

- Connecting: Refers to the process of selecting actors to join the network, deactivate the ones that are not contributing to the progress, and encourage interactions. This strategy can be measured through the items below
  - There is enough time dedicated to communicating among parties.
  - Different parties are consulted and considered by Network Managers.
  - Network Managers consider the specific characteristics of stakeholders' relationships and its development processes.
  - Network Managers work to get opposite interests together.
- Arranging: Refers to the creation of organizational arrangements including
  - Involving the relevant public groups.
  - Involving the relevant private groups.
  - Involving the key stakeholders from the civil organizations.
  - Developing new connections in every new phase of the project.
- Exploring content: For parties with diverging interests to find opportunities together, exploring content is required. This strategy consists of contrasting different opinions and points of view and develop creative solutions that, ideally, manage to integrate everyone's points of view. This strategy can also help in finding common goals, influencing each other's perceptions, and fostering creative competition. Actions within this strategy comprise
  - Ensuring that all different opinions are visible and considered in the decision-making process.
  - Giving enough attention to exchange of perceptions.
  - Establishing initial common points and information needs.
  - There is significant attention to potential new parties when they can bring new ideas and solutions.
- Process agreement: Entails the setting of rules for interaction, conflict resolution, entry and exit of the network, information management and decision-making processes. In detail, this means
  - Explicit rules about the organizational form of collaboration.
  - There is special attention to rules for managing conflict.
  - There are rules regarding deviating from the main plan, when this is proven convenient.
  - There are rules for parties to withdraw when their interests are at risks.

2.1.2. Mitigating Climate Change from the Built Environment

2.1.2.1. Energy Efficiency Policies for the Built Environment

Different policies have already been implemented in countries across the world to reduce energy consumption in buildings. In China, the first efforts started in the year 1986 with the Code of Thermal Design for Residential Buildings. Later, extra policies included the Energy Conservation Design Code for Heating Residential Buildings (1986), a design code for heating, ventilation and air conditioning (1987), an upgraded code of thermal design in residential buildings (1993), and energy conservation design standard for the building envelope and air conditioning in tourist hotels (1993), and upgrades for energy conservation standards in new residential buildings in 1995 and 2001 (Yao, Li, & Steemers, 2005). Clarke et. Al. (2008) discuss the role of policymaking into improving the energy efficiency of buildings in the UK. These authors affirm that the main driver behind enhancing energy efficiency in the built environment is legislation and enforcement. Nonetheless, they also recognize that "[…] *a step-change in performance will require the integration of new technologies in both energy supply and demand* […]" (Clarke et al., 2008, p. 4607). Some of the technologies referred include:

- The use of smart façades: Consisting of advanced glazing that provides high insulation while allows solar daylight capture or exclusion depending on needs.
- Solar energy collection/conversion: Achieved using passive features such as mass walls, glazed atria, and solar ventilation and the use of devices like solar thermal collectors and photovoltaic components.
- Heat pumps: Aimed at improving water heating energy efficiency, heat pumps have the potential of saving 50% of energy consumption compared to electrical resistance heaters (Willem, Lin, & Lekov, 2017).
- Design tools: The use of modelling tools for building's energy performance could allow designers to anticipate a building's consumption using different strategies for energy efficiency. These models can provide assistance both for new buildings and retrofitting existing ones.
- Smart meters: Giving consumers updated information of their consumption is proven to be effective in reducing domestic energy use.

In the European Union, The EU energy efficiency policy for buildings (EEPB), which began in the early 1990s, is structured around two main directives: the Energy Performance of Buildings Directive (EPBD) and the Energy Efficiency Directive (EED). In addition to them, the EU produced the 2000 and 2006 Energy Efficiency Action Plans, that contributed to setting the strategic vision. The technological improvements of this policy aimed at enhancing thermal insulation and efficient glazing, eliminating thermal bridges and leaks, installing efficient heating/cooling generation and distribution systems, optimizing building orientation, incorporating the effective use of thermal mass and passive solar systems for heating and cooling, and promoting on-site energy generation with solar photovoltaic. To achieve its goals, the EEPB's instruments have consisted of modifying building codes, setting efficiency requirements for energy-consuming equipment, a directive for the removal of barriers to invest in energy efficiency, and the provision of financial support for renovations or retrofits. (Economidou et al., 2020)

In summary, the experiences to develop policies for energy efficiency in the built environment have developed for decades. In practical terms, they mostly aim at reducing energy consumption related to temperature comfort, but in a smaller degree also consider the one related to domestic appliances. For temperature comfort they encourage the use of different types of passive strategies including insulation, orientation, thermal mass, natural ventilation and passive heating and cooling, solar heaters, etc. Additionally, they also stablish mechanisms for periodic maintenance of heating and cooling devices to improve performance. Another element considered in this regard is the use of energy-generating devices in buildings, such as solar photovoltaic, to cover part of the demand. In other words, strategies aim at reducing the energy deficit of buildings through minimizing its consumption and improving its generation. To materialize these strategies, policies count on two main elements. For new buildings, the modification of building codes establishing minimum energy efficiency standards. For existing buildings, the Certification of Energy Efficiency that helps to create market incentives, and the provision of financial support, are the main mechanisms through which the policies studied expect to reduce energy consumption and its consequent carbon emissions.

2.1.2.2. Circular Economy and the Built Environment

Circular economy (CE) is a concept that refers to conserving all the available resources within a cycle in it for as long as possible, as opposed to the concept of linear economies that operate in a extract-consume-dispose fashion. Circular systems aim at the removal of pollution, enlarging the life cycle of products and materials, and regenerating natural ecosystems (Çimen, 2021). CE is influenced by the bio-mimicry school and intends to design for the emulation of natural systems in which nutrients are recycled in an eternal loop and waste does not exist (Bockholt, Kristensen, Wæhrens, & Evans, 2019). (Kozlovsky, 1968)

When applying Circular economy in the Built Environment (CEBE), these ideas translate into a new way of design that considers the three stages of the life cycle of buildings construction, usage and demolition (Çimen, 2021). A first principle of CEBE is the **adaptive reuse of existing buildings**, which preserves the embedded energy and materials utilized in the construction of it. However, when reuse of an existing building is not an option, CEBE intends for the **reuse and recycling of materials**. This could happen in different ways: Materials obtained during demolition can be reused/recycled on-site in the new building, or they can be moved into a different construction site where they are useful (Osobajo, Oke, Omotayo, & Obi, 2022)The way in which CEBE is applied varies depending on their different scales: (2021)the micro level, comprising components of a building; the meso level, encompassing whole building units; and the macro level, covering cities and regions (Mhatre, Gedam, Unnikrishnan, & Verma, 2021). The strategies "End of life management", "circular building materials" and "Material stocks" together seek to ensure the reuse of materials after demolition, minimizing the waste sent to landfills through their reuse as materials for new constructions. These strategies rely on mapping and documenting all material stocks available within the built environment, to allow its future reuse in Urban Mining. To translate these ideas into clear indicators of circularity in the built environment, the following CE strategies are identified (Rahla, Mateus, & Bragança, 2021):

- Recycled/recovered content: Refers to the use of materials from demolition, in order to reduce the input of virgin ones.
- Recyclability: Consists of the intrinsic property of a material to be recycled after demolition.
- Reusability: Is the capability of materials to be given a second-life after demolition.
- Ease of deconstruction: Requires that selected materials are easily disassembled during demolition, causing no to little damage for them to be suitable for reuse.
- Maintainability: States that materials' lifetime should be able to be extended through proper maintenance.
- Durability: Resistance to deterioration over the years.
- Energy recoverability: Refers to the possibility of a material to be used for energy extraction purposes through incineration.
- Upcycling potential: Is the potential to add value to the materials obtained in the demolition phase.
- Biodegradability: Denotes material's capacity to decompose into basic elements minimizing its environmental impact.

The use of mixed Circular Strategies focused on materials, like the ones described in this section can reduce GHG from 5% to 99% in functional units (Gallego-Schmid, Chen, Sharmina, & Mendoza, 2020).

When it comes to promoting transitions to CEBE through policymaking, the European Union and China have the world most developed policies in this regard (Munaro, Tavares, & Bragança, 2020). Based on the analysis of 318 academic articles published worldwide, Munaro et. Al identify as the focuses of these policies the Circular Cities initiatives, Circular Business models and the promotion of Adaptive Reuse of Buildings. Nonetheless, the authors identify a research gap in the terms of understanding the role and participation of different key stakeholders (Namely Academy, Industries and Governments) in CE in the Built Environment, the definition of stakeholders' responsibilities in shaping material flows to circularity, the identification of infrastructure requirements to Circular Cities, the definition of a regulatory framework, the support of organizations that are implementing circular actions, the formulation of policies that promote the maintenance of materials, systems and products, and the possibilities of different industries to reuse materials at the end of their use life.

In conclusion, while in the academic literature there is substantive development of the different concepts and ideas about CEBE, the knowledge about how those concepts and ideas are brought to life through policymaking still seems to be at an early stage.

2.1.2.3. Integrating Energy Efficiency and Circularity in the Built Environment

Environmental Policy Integration

This research wants to understand the effect of network governance in the integration of circularity and energy efficiency. According to Persson (2004, p. 1), Environmental Policy Integration (EPI) "[…] *refers to the integration of environmental policy aspects and policy objectives into sector policies* […]". EPI facilitates rational policymaking, helping to identify and prevent the negative environmental consequences of sector policies and maximize the positive ones (Persson, 2004). Persson builds upon the pre-existing literature to develop a typology of criteria to assess EPI based on the Policy Process (Procedural criteria) and Policy Output (Substantive criteria). In this classification, the substantive criteria includes the environmental effects that the integrated policies aim at achieving together. In other words, substantive criteria aims at assessing EPI from the perspective of the compound outcomes of the different policies under study.

When it comes to integrating Energy Efficiency and Circularity (EEC) in the Built Environment, on the procedural side we will look at how these two policies integrate the actors, time, space, issues, goals and mechanisms for EEC to amalgamate within buildings. On the substantive side, we want to understand and measure what are the environmental effects that both policies will achieve together. As this section studied the Integration from the perspective of policymaking, the following section will dive into the technical aspects of that integration, looking for concrete examples that illustrate how EEC integrate in the built environment and what are the environmental effects that they can achieve together.

Energy Efficiency and Circularity in the Built Environment

Sections 2.1.2.1 and 2.1.2.2 explained the main concepts and strategies supporting the implementation of Energy Efficiency and Circularity in the Built Environment separately. It was shown that while for the previous there is extensive academic knowledge and policymaking experience, the latter remains a younger field in which policymaking still needs to be developed. This section attempts to provide an overview of how they could integrate in practice. The question is double. First, how can the insulation materials required for improved energy efficiency be more circular? And later, how can circularity broaden its scope from just the circularity of construction materials, to also the circularity of energy and water, considering the water-energy nexus?

While the addition of insulating materials for energy efficiency purposes can reduce its carbon footprint regarding energy consumption, it adds to the footprint of a building when considering the embodied GHG emissions that the newly added insulation poses. Depending on the environmental impact of the materials, their period to reach carbon neutrality can take from less than one up to ten heating seasons (Kunič, 2017). In addition to that, some of the mainstream insulation materials like polystyrene, polyurethane and polyethylene are derived from petrochemicals and pose toxicological risks (Abu-Jdayil, Mourad, Hittini, Hassan, & Hameedi, 2019). To transition to a circular economy, new materials with lower negative impacts (or even positive ones) that can be easily reused and recycled need to be considered. Wiprächtiger et. al. (2020) explore this concept proving that through increased recycling and use of biogenic materials the contribution of insulation materials to climate change and their toxicity can be reduced. These materials include flax, hemp, jute, and kenaf, which are already being used as insulating materials in the automotive industry (Barth & Carus, 2015). Natural fibres have a net carbon emission of 0.5/0.7 ton $CO_{2\text{-eq}}$ per ton (from cultivation to factory exit gate) compared to the 1.7/2.2 ton $CO_{2\text{-eq}}$ per ton of glass fibre. The replacement with bio-based/natural insulation could lead to a reduction of two thirds from their mineral counterparts.

Another example of a thermically-efficient material that is suitable for a CEBE is hempcrete. Hempcrete is an innovative carbon-sink material made of limestone and hemp with good thermal and hygrometric properties (Arrigoni et al., 2017). During its growing phase, hemp plants absorb carbon dioxide through photosynthesis and contribute to soil phytoremediation while requiring low pesticides and fungicides inputs (Barth & Carus, 2015). As a result, hemp captures between 1.39 (Barth & Carus, 2015) and 1.84 (Arrigoni et al., 2017) Kg CO_2 per Kg of fibre (2022). In addition to the hemp, the binder limestone also captures CO_2 in the process through which the calcium hydroxide ($Ca(OH)_2$) present in it reacts with the CO_2 in the air to form calcium carbonate ($CaCO_3$). (Arrigoni et al., 2017)At the end of life of a building, hempcrete blocks are suitable to be reused after demolition or recycled into soil amendments for agriculture (Lecompte, Levasseur, & Maxime, 2017). (Barth & Carus, 2015)(Wu, Trejo, Chen, & Li, 2021)

In addition to the above, Gooroochurn (2022) proposes a concept of Circular Homes that integrates the energy-water-material nexus. Gooroochurn identifies carbon emissions as pollutants resulting from the built environment and suggests that the use of Passive Design strategies can aid in designing CO_2 out of the cycle, in line with CE principles. The Passive Design principle includes elements such as thermal insulation and thermal mass, glazing and windows' size, the shape of the building, shading devices and buildings' orientation. (Omrany & Marsono, 2016). During the competition Solar Decathlon Europe buildings were required to rely only on their passive strategies. In this period, 10 out of 13 houses managed to keep interior temperatures in a range between 21°C and 26°C, with outdoor temperatures ranging from 10°C to 20°C (Rodriguez-Ubinas et al., 2014). By analysing this it is possible to say that Passive Design strategies also contribute to another principle of CE "To keep resources within the cycle for as long as possible" as the use of thermal storage keeps thermal energy within the buildings for longer periods. (Calatan, Hegyi, Dico, & Mircea, 2017)

In line with Gooroochurn, Sala Benites et. al. (2021) propose that circular practices evolve to a regenerative circularity approach that integrates nature-based solutions to address human wellbeing and achieve biodiversity benefits, generating *bioconnections*. An example of this is the use of microalgae reactors to simultaneously capture CO_2 in the biomass of the algae, while generating energy. These reactors help to purify wastewater extracting its nutrients and produce biomass that can be used afterwards as a biofuel, fertiliser, animal feed, or to generate biogas for an extra energy generation, illustrating how an innovative approach can integrate water and energy. Additionally, the use of biobased materials like bamboo and timber can serve for carbon storage purposes. If this is addressed correctly through long-term management involving modularity, durability, flexibility and reversibility, this model could help achieve circularity in the construction industry. Sala Benites also points at the use of a circular urban approach to water incorporating green infrastructure like wetlands, to reduce surface runoff, improve retention and infiltration, and filter pollution. Water in cities is normally used in a linear way: It is extracted, treated for consumption, distributed, consumed, polluted, treated with different levels of success, and finally discharged (Pearlmutter et al., 2021). This cycle can be closed the adoption of rainwater harvest and the reuse of greywater recycling it in Vertical Green Systems (VGS). VGS not only help to recycle and give greywater a second use, but they also contribute to improving buildings' energy efficiency through the envelope as an element of Passive Design that can provide shading and insulation. Since energy costs can represent up to 80% of the cost of water supply (Pearlmutter et al., 2021) a circular approach to water is needed to tackle the built environment greenhouse gas emissions in a wide and comprehensive understanding that also includes the circularity of energy and materials.

Summarizing, despite most of the literature about circular economy being focused solely on materials, it is possible to see that some authors broaden the scope to energy and water and propose strategies to increase the circularity of insulating materials like reusing and recycling, enhancing the use of renewable sources, and phasing out of toxic materials. It also becomes clear that broadening the scope of circularity from materials to energy and water can create positive connections among them and harness opportunities to further decrease the Built Environment environmental footprint.

2.1.3. Integration Circularity and Energy Efficiency in the built environment through Network Governance

The previous sections have addressed the different aspects of study of this thesis. On one hand, it described the main characteristics of network governance and the different strategies through which this approach is applied. On the other hand, it delved into the literature for Energy Efficiency and Circularity in the Built Environment, looking for connections between the two and illustrating different opportunities for their integration. As a last step, this section will attempt at exploring how Network Governance Strategies can influence the integration of Energy Efficiency and Circularity policies in the Built Environment, based on the existing literature.

The impact of Network Governance Strategies on stakeholders' perceived outcomes has already been proved by Klijn et.al. (2010), who claim that the previous have a strong influence on the latter. In their article "*The impact of Network Management on Outcomes in Governance Networks*" the authors conduct a survey with 337 respondents involved in different environmental projects. They claim that this type of projects are "[…] *extremely suitable for testing assumptions about the relationship between network management strategies and outcomes, because they are good examples of decision-making process in governance networks* […]" (Klijn, Erik-Hans et al., 2010, p. 1064) To assess the influence of one variable over another, the authors recognize that it is very difficult to measure the "Objective" outcomes of the project and, instead, use the indicator "Perceived outcomes" as a proxy to measure the outcomes of governance networks. They further classify perceived outcomes into Process and Content outcomes, the latter being more relevant for this thesis as it intends to measure the integration between Energy Efficiency and Circularity in terms of results. To characterize Content Outcomes, the article refers to the following aspects:

- The innovative character of the outcome.
- The integrative aspect of the solution.
- The impact of the involvement of the stakeholders in the decision-making process.
- The extent to which the solutions really address the problem.
- The cost-benefit relation of the results.

By applying those aspects to the topic of this research, it could be expected that a statistically significant relationship is found between the number of NGS used and the Integration of Circularity and Energy Efficiency (ICEE), measured through the following indicators:

- The innovative character of the solutions proposed to integrate Circularity and Energy Efficiency. Meaning, based on section 2.1.2.3, one or more of the following:
  - Use of passive design strategies.
  - Use of natural/ bio-based materials for energy efficiency (Which also serve as a carbon sink)
  - The design for reusability
  - Recycle/reuse of water through green vertical systems.
- The extent to which solutions really contribute to that integration.
- The cost-benefit relation to integrate Circularity and Energy Efficiency in the Built Environment.

By looking at these indicators it is possible to see connections with the concepts of Policy Integration proposed by Persson (2004) about measuring "substantive criteria" as an indicator for Policy Integration, and more specifically, measuring the environmental outcomes achieved by two policies together. The indicators proposed by Klijn et.al. in relation to perceived content outcomes described above and adapted to the integration of Energy Efficiency and Circularity in the Built Environment can work as a proxy to measure the substantive criteria proposed by Persson. Finally, as Klijn et.al. state that Network Management Strategies indeed have a strong effect on Content Outcomes but more specifically Exploring Content and Connecting are the ones with a higher influence, It could be hypothesized then that a higher number of Exploring Content and Connecting Strategies in our case study will lead to a higher ICEE.

Regarding the potential of these different actions in lowering the Built Environment's GHG emissions, Huang et. al. (2022) calculate the potential reduction in CO2 emissions using a Life Cycle Analysis methodology that covers the different stages: Production of materials, Construction, Usage and End-of-Life (Demolition). These authors quote pre-existing literature to propose that embodied carbon emissions can be reduced up to 30% by using less and lower carbon-embodied materials. In their own case-study, the same authors evaluate different scenarios to conclude that carbon neutrality can be achieved by using a mix of Energy Efficiency, Renewable Energy (Through photovoltaic technology), eco-friendly occupants, and the use of low carbon mobility. In this case, the authors consider users' practices and transport, which fall out of the main interest of this research and disregard the use of low-carbon materials within the analysis, although they admit that materials' embodied carbon can represent up to 50% of a building total life cycle emissions and suggest "building with less" as a suitable strategy. In a different paper overseeing 77 LCAs from different buildings, it was found that most studies focus solely on the manufacturing stages dismissing usage and end-of-life phases (Pomponi & Moncaster, 2016). In conclusion, while we understand the large contribution of the built environment, to climate change, the available data to understand the true potential of an integral understanding of the built environment that considers the energy-water-materials nexus is limited. The available studies tend to focus either on the reduction of emissions from a materials perspective, or from an energy one. Water management practices and embodied emissions of water have not been found in those studies, either.

2.2 Conceptual framework

The conceptual framework summarizes the main variables and its indicators. In line with what was explained in section 2.1.1, Network Governance -or Management- Strategies are the result of the use of Connecting, Arranging, Exploring Content and Connecting. The integration of Circularity and Energy Efficiency is the result of Substantive Outcomes, measured trough the proxy "Perceived outcomes", which in turn will be later studied through other indicators (See operationalization table). In this case, Substantive Outcomes will represent how stakeholders perceive that the integration of circularity and energy efficiency is happening in practice. "Consistency among policy objectives" however, aims at understanding how Circularity and Energy Efficiency integrate at a policy level. The overall conception of ICEE includes both the way stakeholders integrate in practice, and the way this integration happens through policymaking.

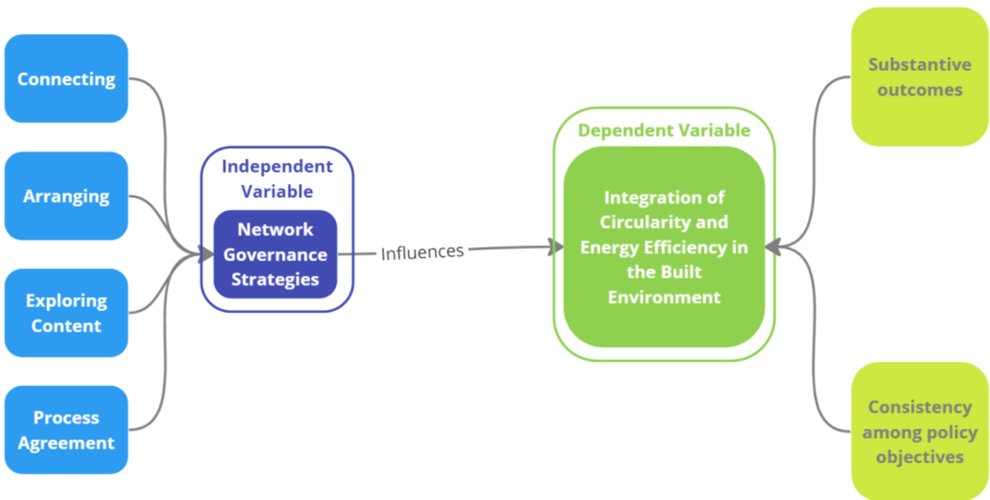

Figure 1: Conceptual Framework

3. Research design, methodology

The role of the previous chapter is that of providing theoretical background upon which the rest of the research will be built. Following with the literature reviewed and the conceptual framework provided, Chapter 3 develops the research strategy with which the different RQ will be answered. Section 3.1 describes the sample population, and the methods used to collect and analyze the data. Section 3.2. explains in detail how the variables will be measured for Operationalization purposes. Section 3.3 concludes mentioning possible challenges and limitations.

3.1 Description of the research design and methods

This research studies the Integration of Energy Efficiency and Circularity in the Dutch Built Environment (Dependent Variable) as an effect of the Network Management Strategies utilized since the signature of the Raw Materials Agreement (Independent variable). The data collection and analysis comprise a mixed methods approach. A mixed methods approach can be implemented in different ways, using different rationales. In this research, those rationales are Triangulation and Completeness. The need for Triangulation is for the data to be mutually corroborated, increasing the validity of the results (Bryman, 2012). In addition, the Completeness rationale is that of providing qualitative insights to the quantitative findings. While the quantitative analyses aids in defining a statistically significant relationships between variables, the qualitative one provides depth and greater meaning to previous. Not only aiding in determining causality between the variables, but also in providing answers regarding in which ways that causality happens, what are the underlying mechanisms behind it, as well as the challenges and opportunities found on the way. In this way, the qualitative data helps in making the quantitative data more robust. The chosen case study for this research is the Netherlands. This choice is justified in this country being one of the forerunners in the global circular economy (Circle Economy, 2020). By studying and systematizing the information of one of the most advanced countries in the matter, this research intends to make its progress available to other nations, contributing to the process of knowledge diffusion and to develop faster solutions to face the urgent climate-related challenges.

3.1.1. Sample Population

The population sample comprehends the stakeholders that signed the Raw Materials Agreement plus relevant experts that participate in Transition Networks for a Circular Built Environment. For these interviews and surveys, a stratified random sample is taken, with the objective of ensuring that different groups of stakeholders are represented, namely, government organizations at local, provincial and national scale; private businesses and NGOs.

Survey sample

In order to study the effect of Network Governance on the Integration of Circularity and Energy Efficiency in the Built Environment, the survey focuses on the signatories of the Raw Materials Agreement that are relevant to the construction industry -Estimated around 180-. The survey was sent to the 180 organizations involved, aiming at the people in these organizations whose roles relate to Circular Economy and/or Sustainability. The total number of respondents is 47, divided in the following groups: 15 respondents completed 100% of the survey, 1 completed 72%, 2 completed 19%, 14 completed 17%, 15 respondents did not fill any answer to questions. From the first two groups, which are used later for analysis, the characteristics of the respondents are as per the tables below:

Managerial Position	
Yes	12
No	4

Type of organization	
Local Civil Servants-Including Counties and Waterboards-	2
Provincial Civil Servants	1
National Civil Servants	0
Private Sector	8
Non for Profit/ Non-Governmental Organizations	3
Others	2

Phase of the project	
Initial Ideas	2
Planning/Development phase	6
Implementation phase	5
Post implementation phase (Monitoring, Evaluating, Maintenance)	1
No project derived from the Agendas for Circularity	2

Interviews sample

Given the initial difficulty in finding respondents for the survey, the sample for the interview is diversified to a larger audience comprising participants of the different Networks for Circularity in the Built Environment. The sample of interviewees (15) is in turn composed by members of the National Transition Team (6)- More information about the Transition Team in the following section-, organizations that signed the Raw Materials Agreement (11), and other organizations (4) that did not sign the Raw Materials Agreement but participate in Networks for Circularity in the Built Environment. 10 out of 15 hold managerial positions in their organizations. More detailed information about the respondents is described below. These here characteristics Managerial Position, Signatories of the Raw Materials Agreement and being or not part of the National Transition Team, combine differently in each respondent, contributing to the diversity of the sample group. A more detailed description of these combination is available in the table below.

	Parent organization	**Managerial position**	**Linked to the Raw Materials Agreement**	**Part of the National Transition Team**
Interviewee 1	National Government	Yes	Yes	Yes
Interviewee 2	Construction Company	Yes	Yes	Yes
Interviewee 3	Manufacturer of biobased products for construction	Yes	Yes	No
Interviewee 4	Architectural Studio	Yes	No	Yes
Interviewee 5	Municipality	No	Yes	No
Interviewee 6	Real Estate company	Yes	No	No
Interviewee 7	Sustainable Building Consultancy	Yes	Yes	No
Interviewee 8	Non for-Profit organization for Research and Consultancy in Sustainable Built Environment	No	Yes	No
Interviewee 9	Private company specialized in Water Solutions (Circular Use of Water)	No	No	No
Interviewee 10	Knowledge institution	Yes	Yes	Yes
Interviewee 11	Private Bank	No	Yes	Yes
Interviewee 12	Knowledge Institution/ Knowledge Network	Yes	No	No
Interviewee 13	Provincial Government	No	Yes	No
Interviewee 14	Recycling Network	Yes	Yes	Yes
Interviewee 15	Cooperative with strong focus con CE	Yes	Yes	No

3.1.2. Data Collection

The main data collection methods for this research are Surveys, for the quantitative information, and Semi-Structured Interviews, for qualitative. Extra qualitative information is obtained from Policy Documents by performing a Document Analysis. The documents consulted are:

- Raw Materials Agreement, Ministry of Water and Infrastructure, Government of the Netherlands.
- Purchasing with the Environmental Performance of Buildings MPG, Nationale Milieu Database, 2020.

- Transition Agenda Circular Economy 2018 Ministry of Water and Infrastructure, Government of the Netherlands.
- National Program Circular Economy 2021-2023.
- Advisory Route to a Circular Economy for Construction, 2022.
- Final goal 2050 Circular Construction Economy Transition Agenda for a Circular Construction Economy, vision from the Transition Team Circular Construction Economy, 2021.
- Calculation method for determining the environmental performance of structures during their entire lifespan, based on EN 15804, Nationale Milieu Database, Version 1.1. 2022.
- Homes with heat pumps harmful to the environment, LPB Sight 2023.
- Draft proposal for a law containing rules on energy markets and energy systems (Energy law), 2021.
- Law implementing EU Acts on Energy Efficiency.
- Websites of Networks identified (Cited in the presentation of results).

3.1.3. Data Analysis

Analysis of Survey Data

The data collected in surveys is used to analyse if there is a statistically significant relationship between the IV and DV using a multiple regression model. This model allows to test a Dependent Variable against different Independent ones. It is called a "model" because it intends to reunite the different independent variables that affect the Dependent one, to identify the different factors that cause the dependent variable to vary. Independent variables here are also called "explanatory" variables because they help to explain the nature of the change in the DV. Multiple regressions work through performing hypotheses tests. The null hypothesis in a regression analysis test expects that there is no statistically significant relationship between an explanatory/independent variable and the dependent one. The analysis aims at rejecting the null hypothesis either with 10%, 5% or 1% confidence level, to prove causality. In the outputs of the analysis, is evident by looking at the P-value. P-values below 0.1 are statistically significant at 10%, while below 0.05 are significant at 5% and below 0.01 at 1%, holding other factors constant. As different explanatory variables obtain different p-values and different coefficients, looking at the output of a multiple regression analysis allows the researcher to understand which values have indeed an effect on the DV and in which degree. The analysis also looks at the R^2 (R squared) and root-MSE. These two values help to understand to what extent the IV's included in the model help to explain the variation in the DV. R^2 yields values between 0 and 1, in which 0 represents a model that does not explain the change in the DV, and 1 is a model that explains 100% the change in the DV. A mix of a R^2 close to 1 and a low root-MSE suggest reliable results to explain the topic under study, and vice versa.

Analysis of Interview Data

The results of the semi-structured interviews are analysed by counting the occurrence with which each code appears. The codes are representations of the sub-indicators that help to measure the frecuency of each indicator. As a result, codes that have higher occurrence, provide the indicators they belong to with higher values. For example: If one interviewee claims to participate in three different networks that involve private parties, the indicator "Involvement of relevant private groups" for that respondent yields a value of 3, generating a ratio type of data. The different codes that aid in measuring the IV and DV are detailed in
Table 1: Coding Scheme. The sum of the different values of each code belonging to the same variable, yields the final value of that variable for a specific respondent. In the end, each respondent has a value for the DV, a value for the IV and values for the different control variables. Simultaneously, the sum of the values for a single indicator considering all respondents, yields a value with the occurrence of that indicator and allows to compare its frequency with other indicators. For example, the sum of all values for Connecting can be compared with the sum of all values for Arranging to analyse which of the two NMS is used the most. Moreover, the quantitative values obtained from the coding analysis are also analysed through regression analysis in the same way that the results of surveys. It is important to note that in the Coding Scheme, there are codes considered to gain depth on stakeholder's perceptions regarding integrating circularity and energy efficiency. These codes are "Position towards the integration", which aims at retrieving respondents' opinions on whether Circularity and Energy Efficiency should be put together or not, and "Challenges and Opportunities". The results of the later are analysed inductively, also through a scoring system based on frequency of each challenge and opportunity quoted, to ultimately highlight what are the ones that there is more consensus around. An additional analysis performed over the qualitative data is a co-occurrence analysis. This analysis helps to find potential relationships between codes. In this research, different networks are inductively identified during

respondents' interviews, and different NMS are also associated to each of them. The co-ocurrence analysis helps to better understand what and with which frequency different networks use different NMS, as well as which networks have the higher values of NMS and have, therefore, a higher importance in the circular building landscape of the case study.

Table 1: Coding Scheme

Variable	Indicator	Code names
Network Management Strategies	Arranging	Involvement of Educational/ Research Institutions
		Involvement of Governmental Organizations/ Public Groups
		Involvement of Private Companies
		Involvement of Relevant Civil Groups
		Development of New Connections
		Others Arranging
	Connecting	Collective Character of Decision Making
		Communication between different parties
		Consideration of Relationships
		Integration of Opposite Interests
		Others connecting
	Exploring Content	Attention to Differences
		Diversity in Opinions
		Establishment of Common Points
		Openess to New Parties and Ideas
		Others Exploring Content
	Process Agreement	Agreements Made
		Agreements on Withdrawal
		Conflict Management
		Flexibility to Change
		Others Process Agreement
Integration of Circularity and Energy Efficiency	Position towards the integration	In favour of ICEE
		Not in favour of ICEE
	Innovative character of the solution	Bio-based materials for Energy Efficiency
		Circular Use of Water
		Recycled/ recyclable material for energy efficiency
		Reused/reusable Materials for Energy Efficiency
		Use of Passive Design
		Others Integration of Circularity and Energy Efficiency

	Positive about Network Outcomes	
	Cost- Benefit Relation	
	Effectiveness in the future	
	Challenges and opportunities	Challenges to Integrate Circularity and Energy Efficiency
		Opportunities to Integrate Circularity and Energy Efficiency
Characteristics of the Respondent	Parent Organization	Educational/Research Institution
		Local civil servant
		National Civil Servant
		NGO/ Civil Society
		Private Company
		Province Civil Servant
		Others
	Managerial/ non Managerial Position	Managerial Position
		Non-managerial Position

Document Analysis

Documents are analysed using a Content Analysis approach. Using this approach, the codes “References to Circularity” are applied in all cases in which Policy Documents for Energy Efficiency connect their strategies with Circularity of Materials. The code “References to Energy Efficiency’ is applied in all cases in which the Policy Documents for Circular Construction Economy make links with energy consumption. The final occurrence of each code provides an idea of how much each policy references or coordinate actions to the other, helping to understand the integration at the policy level.

3.2 Operationalization: variables, indicators.

The Independent variable (IV), Network Management Strategies, is measured through 4 indicators representing different NMS, each of them consisting of 4 different items, as presented in the operationalization table and following the method of Klijn et. Al. (2010). 16 different items are considered, each of them measuring a different strategy. In the case of surveys, each indicator is measured through likert scales ranging from 1-disagree to 5-agree. In the case of interviews each indicator receives the value of its occurrence. Once data collection is finished each group of 4 items within each indicator will be averaged to measure the indicator performance. this can yield a value for each indicator between 1 and 5, and give the variable an equal final range, as well. For interviews, the value is infinite, going as high as codes are assigned during the coding process, the value of each item is summed up to the value of the indicator, which in turn sums up to yield a value to the variable.

The Dependent Variable (DV) reflects the integration of Circularity and Energy Efficiency from the perspective of involved stakeholders. This is measured as a proxy of “ Substantive Outcomes” following the definition of Persson explained in the Literature Review. For this, 5 indicators are considered, being: Innovative character of the Solution, Involvement of Actors (Recognizable contribution), Effectiveness of the Solutions, Effectiveness in the future and Cost Benefit Relation. ICEE will be measured using an ordinal score for four of the five criteria mentioned ranking from 1-5, as in the methodology cited. In this score 1 is Disagree, 2 Slightly disagree, 3 Neutral, 4 Slightly Agree, and 5 Agree. The exception to this system is the indicator “Innovative character of the solution”. To make this indicator case-specific, it will be measured by creating a value composed by all the different possible innovations that could integrate Energy Efficiency and Circularity found in the literature. Using a list with 7 innovative solutions, respondents are provided with the same scales than the items before, which are averaged to produce a final value between 1 and 5 to measure “Innovative character of the solution”. Finally, the values resulting from the 5 indicators are also averaged, yielding values between 1 and 5 for the variable “Integration of Circularity and Energy Efficiency in the Built Environment” (ICEE) measured through stakeholders’ perceptions. The dependent variable is additionally studied through Document Analysis, looking for references to circularity in Energy Efficiency documents and vice-versa. The results of the content analysis help to provide qualitative depth to the findings, but it is not included in the final measurement of the DV.

For the regression model, additional control variables are added when analysing the results of both survey and interviews. These are:

- Managerial/ Non-managerial position of the respondent
- Parent Organization
- Stage of the Project
- Duration of the interview (Just for regressions based on the scores obtained from interviews): Since longer interviews have higher chances of recurrence for the different items that measure the DV, this variable intends to control that higher values for the DV are not the result of longer interviews

The semi-structured interviews adapt the methodology described above, using the same indicators and sub-indicators described for the survey but measured through the process of coding and analysing their recurrence to assign scores and values. For the IV, the interviews aim at deepening stakeholder's perceptions about how the different NGS have been used and how the process of working in a Network unfolded. The DV is studied in the same interviews also following the indicators defined for the survey, to understand what innovations have taken place, the perceptions regarding the integration of circularity and energy efficiency, and identify challenges and opportunities. Both the IV and the DV are assigned values for each respondent based on the recurrence of the codes.

Table 2: Operationalization

Variable	Indicator	Indicator definition	Item	Method of research/ data collection	Quantitative/ Qualitative
Network Management Strategies	Process Agreement (Klijn, Erik-Hans et al., 2010)	Refers to the rules for the network to work as such. It can include rules to enter and exit the network, decision-making processes, and rules to solve conflicts, among others.	Agreements Made	Survey and Interviews	Quantitative (Ordinal scores, each item measured with Likert Scales from 1-5, averaged afterwards to yield values between 1 and 5 for each Indicator.) Qualitative (Building Ratio scores based on the frecuency of appearance of different Items)
			Conflict Management		
			Flexibility to Change		
			Agreements on Withdrawal		
	Exploring content (Klijn, Erik-Hans et al., 2010)	Is the process through which stakeholders' clarify their goals and perceptions, and look for innovative solutions to overcome common issues and create new opportunities.	Diversity in opinions		
			Attention to Differences		
			Establishment of common points		
			Openness to new parties and ideas		
	Arranging (Klijn, Erik-Hans et al., 2010)	Arranging refers to setting temporary organizational structures for the completion of the Network's goals. E.g: An organization for a specific project.	Involvement of relevant public groups		
			Involvement of relevant private groups		
			Involvement of relevant civil action		
			Development of new connections		
	Connecting (Klijn, Erik-Hans et al., 2010)	Is the strategy through which multiple stakeholders are activated to work together, fostering interest to invest resources in the interaction through the Network.	Consultation for decision making		
			Consideration of relationships		
			Integration of opposing interests		
			Agreements on the form of cooperation		

Variable	Indicator	Indicator definition	Item	Method of research/ data collection	Quantitative/ Qualitative
Integration of Circularity and Energy Efficiency in the Built Environment (Adapted from Klijn and Edelenbos (2010)) (Persson, 2004)	Substantive Outcomes (Klijn, Erik-Hans et al., 2010) or Environmental effects to be achieved together (Persson, 2004)	Substantive criteria is an indicator oriented towards measuring a Project Output or result. In this research this indicator is used as a proxy of "Environmental Effects to be Achieved together", an indicator of Environmental Policy Integration. This indicator will be measured adapting the items proposed by Klijn et. al. and mixing them with Innovative solutions found in the literature that can help integrate Circularity and Energy Efficiency in the Built Environment.	Innovative Character of the Solution Subitems: 1) Use of Passive Design, 2) Use of Natural/ Biobased Materials, 3) Incorporation of reused materials for Energy Efficiency, 4) Incorporation of materials for energy efficiency that can be reused after demolition, 5) Carbon-Negative or Carbon-Sink Materials (Sequester more than emit), 6) Upcycled/ Upcyclable materials for Energy Efficiency, 7) Recycle/reuse of water through green systems (Green walls, artificial wetlands, etc.) , 8) Others	Survey and Interviews	Quantitative- (Likert Scales 1-5 for each subitem, averaged to yield a score for the indicator also between 1 and 5) Qualitative (Ratio scores based on the frecuency of appearance of different Items and subitems)
			Involvement of Actors (Recognizable contribution)	Survey	Quantitative (Ordinal scores from 1-5 according to categories Disagree, Slightly Disagree, Neutral, Slightly Agree, Agree.) Qualitative (Ratio scores based on the frecuency of appearance of different Items and subitems)
			Effectiveness of the Solutions		
			Effectiveness in the future		
			Cost Benefit Relation		

Variable	Indicator	Indicator definition	Item	Method of research/ data collection	Quantitative/ Qualitative
	Consistency among policy objectives (Persson, 2004)	Consistency will study the connections between circularity and energy efficiency in the Built Environment based on the published documents for both policies.	Links from one policy to another in policy documents	Document Analysis	Qualitative
Characteristics of the respondent	Managerial / Non-managerial position		N/A	Survey and Interviews	Qualitative to Quantitative (Nominal value Yes-No transformed into 1-0)
	Parent organization	Refers to the type of organization the respondent work for	N/A		Qualitative to Quantitative (Nominal value ranging from 1 to 6 where 1) Local Civil Servants, 2) Provincial Civil Servants, 3) National Civil Servants, 4) Private Sector, 5) Non for Profit/ Non-Governmental Organizations 6) Others
	Stage of the Project	Ranges from planning to monitoring, including intermediate stages for	N/A		Qualitative to Quantitative (Nominal value ranging from 1 to 4 where 1) Initial Ideas, 2) Planning/ Development phase, 3) Implementation phase 4)Post implementation phase (Monitoring, Evaluating, Maintenance) 5) No

Variable	Indicator	Indicator definition	Item	Method of research/ data collection	Quantitative/ Qualitative
					project derived from the Agendas for Circularity

3.3 Challenges and limitations

The collection of the data is conditioned by two factors. The first one being the Language Barrier in cases in which respondents do not speak English. The second one is respondent's willingness and time availability to participate in the research. To overcome the previous one, the survey is offered both in English and Dutch with the aid of translation software. However, this is not possible in the case of interviews, which are limited to an English-speaking population.

4. Results, analysis and discussion

Chapter 4 presents the findings of the data collected for the research. Section 4.1 gives background information about the effects directly linked to the Raw Materials Agreement, providing background for the presentation of results linked to the IV and DV afterwards. Section 4.2. describes the way in which different networks use different NMS, and explains what NMS are used the most based on recurrence scores. Section 4.3. describes the findings around how Circularity and Energy Efficiency integrate in practice and at the document level. Section 4.4. put together the previous two sections to analyse the causality between the IV and the DV. Section 4.5. inductively organizes the information around challenges and opportunities to highlight the ones around which there is higher consensus: these inputs contribute in understanding what mechanisms are preventing Energy Efficiency and Circularity from being more integrated and identify opportunities, to nurture further recommendations. Finally, Section 4.6. wraps up the chapter discussing the findings and the limitations of the analysis.

4.1. The Raw Material Agreement and the Transition Agenda for a Circular Construction Economy

The Raw Materials Agreement was signed in 2017 under the initiative of the National Government. After its creation some of its signatories worked together to design Transition Agendas around the topics of Construction, Biomass and Food, Plastics, Manufacturing Industry and Consumer Goods (Government of the Netherlands, N/D). Therefore, at beginning of this research it was assumed that all the relevant signatories to construction would be involved in this Transition Agenda and the questions were structured around understanding the Network Governance Strategies used to implement it. The direct effects of this agreement on the circular construction economy can be seen in two different ways. **On one hand**, it is observed that no networks were created directly after the Raw Materials Agreement with its signatories, nor this agreement necessarily triggered a process of collaboration among them. This was noticed in the first place when asking its signatories to fill in the survey and receiving multiple responses indicating that the questions did not apply to their situation because they have not participated since then, or they do not know who signed it in the company, and therefore they could not fill in the information requested. The respondents' claims are consistent with the low degree of participation in the survey: 16 responses out of 180 contacts, with another 31 who entered the survey but decided not to complete it after reading the introduction, and the first 3 questions. The in-depth interviews helped to shed a light on this. Interviewees explained that no direct actions or effects took place after the Raw Materials Agreement (I3, I10, I11), arguing that some of the signatories did not know what they were signing (I1) or that they signed it because they were mainly interested in gaining publicity (I2, I7). In other cases, interviewees who are part of organizations that signed the Agreement are not aware of its relevance for their current operations (I8, I13, I15). **On the other hand**, interviewees also express that the Raw Materials Agreement was the start of the Circular Economy, and that it kickstarted a lot of new policies and projects (I1, I8). A specific direct effect linked to this agreement is the creation of the National Transition Team (TT) for a Circular Construction Economy (I1, I2, I10, I14). The TT is a multidisciplinary group formed by professionals in the different elements of the supply chain who are, in turn, connected to different networks for Circularity in the Built Environment. These different elements include NGOs, knowledge institutions, Architects, Recycling, Construction, Government, Banking and Housing. The members of the TT do not participate necessarily on behalf of the company they work for, but they do it mainly on their own individual names. Through participation in different networks and the use of different Network Governance Strategies, the TT serves as a facilitator between the Government and the broader ecosystem of organizations working on this topic, retrieving information from different networks to provide inputs for policymaking (I1, I2, I) and working as a network itself. Since its creation, the TT has worked on creating the conditions to speed up the transition and has identified different aspects that need to be addressed for the transition to happen (I10). Some of them being Market Development (Stimulating supply and demand), Policy and Regulation, and the need for Developing Indicators to measure success. The transition team uses the different NMS in the following way: It applies the strategies of arranging and connecting through organizing four working groups with representation from the supply chain different sectors. In this working groups, it uses the strategies of exploring content and process agreement to discuss the necessary innovations that need to take place in the transitions, share experiences and agree on recommendations for policy making. The Transition Team is currently working on a "base camp", a summary of all the necessary elements for this socio-technical regime to stabilize before it can disrupt the markets: Regulations, standardized practices and measuring systems, indicators, etc. The analogy of the base camp is that of being well prepared and setting a basement from where to escalate towards the summit.

4.2. Networking for Circularity in the Built Environment

4.2.1 Interviews and documents' findings

This research identified different networks either completely dedicated to Circularity in the Built Environment in the Netherlands or related to the construction/sustainability sector in other ways and still with some relevance in circularity. This section describes those networks as well as the different NMS used in each of them, to describe the findings regarding the DV. It complements interviewees' explanations regarding networks with the information provided by these networks themselves through their websites and documents.

The most quoted network was the transition team itself (57 quotes), followed by Cirkelstad (17 quotes), Lenteakkord 2.0 (13 quotes), Circulair Bouw 23 (10 quotes), Toekomst Bestendig Bowen (9 quotes), The Green Village (8 quotes), City Deal Circular and Conceptual Buildings (4 quotes), Building Balance (4 quotes), Metropolitan Region of Amsterdam (4 quotes), the Council of Architects (3 quotes), CIRCOLLAB (3 quotes), Water Alliance (3 quotes), Praktijk- & Innovatiecentrum Circulaire Economie -PRICE- (3 quotes), Samen Klimaat Bestendig (2 quotes), and Building Academy Amsterdam , Biobased Building Zuid Holland, Circular Sprong, and We Grow (1 quote each). The higher relevance of the transition team in the quotes is at least partially explained by a higher participation of interviewees who are part of it in the sample. The different character of some of these networks and the presentation of findings regarding how these different networks apply NMS is provided below[1]:

- Cirkelstad: Under the formal figure of a Cooperative, Cirkelstad acts as a Network Manager putting together public and private partners who develop solutions for the Circular Built Environment. This network utilizes the strategies of Connecting and Exploring Content to put multiple stakeholders together, organizing 4 meetings a year to share perspectives, inspire each other, develop new solutions and arrive at common understandings of what Circularity in the Built Environment means in practice (I2, I5, I7, I10). It further spread this knowledge through its annual reports emitted since 2018 and the Cirkelstad Academy. Moreover, it puts in practice de strategy of Arranging through the creatin of working groups organized per city all across the Netherlands, giving the network national presence (Cirkelstad, N/D) One of Cirkelstad's most remarkable achievement is the creation of Het Nieuwe Normaal, a set of guidelines to standardize and measure circular construction practices (Het Nieuwe Normaal, N/D).
- Circulair Bouw 23: This network also aims at connecting the different partners of the construction sector that have circular ambitions, with the aim of drawing sector wide agreements, which links with the strategies Connecting and Process Agreement. To achieve this, it is organized (CB '23, N/D) in working groups (Arranging) that build and share the knowledge (Exploring content) upon which the agreements are drafted. The current working groups are Future Reuse, Circular Design and Passports for Construction. This network works actively in building consensus within the market (I2, I7). As a result, the working group circular designed has emitted guidelines for measuring circularity, and material passports and reusability. The guidelines for material passports intend to help materials to be comparable and interchangeable for future reuse (CB'23, 2022).
- Lenteakkord 2.0: Is a network organized by the trade associations NEPROM, Aedes, Bouwend Nederland, IVBN and WoningbouwersNL and their members, in cooperation with the Ministry of Interior and Kingdom Relations with the goal of increasing the feasibility and scalability of circular housing (Lente-Akkoord-2.0, N/D). A requirement to get into this network, is to be a frontrunner in the Circular Construction Economy (I7) and be part of the trade associations that initiated it (I10 + Network's own website). This network's got the ambition to realize an entirely circular housing project by 2024.
- City Deal Circular and Conceptual Buildings: Led by the Ministry of Interior and Kingdom Relations (I10), this network is more informal than the previous, but contributes to Exploring Content through sharing examples to inspire construction stakeholders (I5). This network is organized around the themes Biobased Building, Industrialized Conceptual Building and Valuation and Financing Models. This network has link with others like Cirkelstad and De Bouwcampus.
- Building Balance (BB) and WeGrow: BB is a network in the intersection between builders and farmers. It works towards fostering the use of biobased materials in construction, while helping farmers transition into business models that are compatible with the climate targets of the country (I3, I7, I11), and to address both the housing crisis and the tension with farmers and the country's climate ambitions. By developing this model, this network's participants intend to provide the construction sector with a material that stores carbon, is available locally, and makes a positive contribution in the transition to a sustainable agriculture too. BB is organized in

[1] The transition team is not described in this list due to being explained in the previous section.

"Chain Projects" each of which has its own dynamics and methods (Arranging). These chains are organized geographically, having a national and different regional one (BuildingBalance, N/D). We Grow shares BB's ambitions and focuses on the strategies of connecting and exploring content.

- Biobased building Zuid Holland: Managed by the homonym provincial government (I3), this network has set its own Transition Agenda and its working on the knowledge areas Energy, Materials, Agricultural and Value transitions.
- CIRCOLLAB: Is a knowledge network initiated by the Amsterdam University of Applied Sciences (Coordinator), Windesheim University of Applied Sciences and Amsterdam University of Arts, together with 32 partners. It is organized around the themes Circular Thinking and Doing, Circular Entrepreneurship, Circular Human Capital, Circular Collaboration (I12).
- Toekomst Bestendig Bowen: Network organized around the signing of a covenant(I5), a voluntary, non-legally binding agreement (Process agreement) between public and private parties (Connecting) through which participants subscribe agreements in the fields of energy, circularity, climate adaptation, nature-inclusive building, sustainable mobility and health, advocating for a future-proof building.
- Samen Klimaatbestendig/ The Green Village: These networks main interests' is to develop solutions related to climate adaptation. They, among other things, explore innovative solutions to make a circular use of water for adaptation purposes (I9).
- Water Alliance(WA): The WA is a partnership of public and private companies, government departments, and knowledge institutions related to the circular use of water and water technologies (WaterAlliance, N/D). One of these network goals is to address changes in the legislation that contribute to a more circular use of water (I9).

The final scores per respondent for the IV and its indicators are as per the table below.

Table 3: Scores for the qualitative indicators and final values for the variable

	Arranging	Connecting	Exploring Content	Process Agreement	NMS
1) Interviewee 1	7	1	3	5	16
2) Interviewee 2	3	1	5	2	11
3) Interviewee 3	0	1	2	0	3
4) Interviewee 4	4	0	2	0	6
5) Interviewee 5	3	2	4	1	10
6) Interviewee 6	2	0	1	1	4
7) Interviewee 7	2	3	2	6	13
8) Interviewee 8	3	1	2	1	7
10) Interviewee 10	8	0	5	3	16
11) Interviewee 11	4	0	2	2	8
13) Interviewee 13	7	1	2	1	11
14) Interviewee 14	4	1	1	3	9
15) Interviewee 15	3	0	1	0	4
Totals	50	11	32	25	118

However, NMS were not found evenly in all networks. While the co-ocurrence analysis shows that the strategies of Arranging and Exploring Content are the ones used the most by the different networks, it also shows that CB23, Cirkelstad, the Green Vilage, Toekomst Bestendig Bowen and the Transition Team are the ones using a mix of the different four. When looking at the use of NMS from networks, the strategy of arranging is used in 12 different networks, while connecting is in 6, exploring content in 13, and Process Agreement in 8. This means that while in the recurrence score per NMS arranging leads the top with 50 and a distance of 18 points from exploring content, the count of strategies per amount of networks that use them shows that arranging and exploring content are used at a similar rate, or have the same relative importance among the other NMS.

		Arranging 56	Connecting 11	Exploring C... 37	Process_Agr... 28
Networks Identified: Building Academy Amsterdam	1			1	
Networks Identified: CB23	10	1	4	5	3
Networks Identified: CIRCOLLAB	3	4		1	
Networks Identified: Circular Sprong	1			1	
Networks Identified: Cirkelstad	17	11	3	3	9
Networks Identified: City deal	4	2		1	
Networks Identified: Council of Architects	3			1	
Networks Identified: Lenteakkord 2.0.	13	2		4	6
Networks Identified: Metropolitan Region of Amsterdam (MRA)	4	2		1	
Networks Identified: Platform Circular Flevoland	2	2	1		
Networks Identified: Praktijk- & Innovatiecentrum Circulaire Ec...	3	2			
Networks Identified: Samen Klimaat Bestendig	2				1
Networks Identified: The Green Village	8	2	1	3	1
Networks Identified: Toekomst Bestendig Bowen	9	3	1	3	2
Networks Identified: Water Alliance	3				2
Process_Agreement	28	1		2	
Transition Team	57	30	2	17	9

Figure 2: Co-occurrence analysis of Networks Identified and Network Governance Strategies

4.2.2. Survey's Findings

Table 4 and Table 5 illustrate the results of the survey. The median for Process Agreement, Exploring Content, Arranging and Connecting are 3.13, 3.7, 2.96, and 3.21 respectively. All values sit between 3 = neutral and 4= slightly agree. To begin with, this means in general respondents no not agree on having participated actively in any NMS. The strategy of exploring content's value of 3.7 has the closest value to "slightly agree", suggesting that to some extent stakeholders' develop solutions or exchange ideas under the Transition Agenda for a Circular Construction Economy.

Table 4: Scores and values for NMS indicators and variable

	Total Process Agreement	Total Exploring Content	Connecting	Arranging	Total NMS
Respondent 1	3	3	3.5	2.5	3
Respondent 2	3	4	2.75	3.5	3.3125
Respondent 3	3	3.5	3.5	2	3
Respondent 4	3.25	4.5	3.75	3.25	3.6875
Respondent 5	3.5	4.25	4	3.25	3.75
Respondent 6	3.25	5	4	4.5	4.1875
Respondent 7	3.5	4	2.75	2.75	3.25
Respondent 8	4	4.75	4.5	4	4.3125

Respondent 9	2.5	3	3	2.5	2.75
Respondent 10	1.5	2.5	2.5	2	2.125
Respondent 11	1	1	1	1	1
Respondent 12	4.75	4.75	4.75	4	4.5625
Respondent 13	3.5	4.25	2.25	2.75	3.1875
Respondent 14	4.25	4	3	3.5	3.6875
Respondent 15	3	3	3	3	3
Total	3.133333	3.7	3.216666667	2.966667	3.254167

Table 5: Summary of results per indicator and final value

Variable	Obs	Mean	Std. dev.	Min	Max
Total_Expl~t	15	3.7	1.057288	1	5
TotalConne~g	15	3.216667	.948997	1	4.75
Total_Arra~g	15	2.966667	.90567	1	4.5
Total_Proc~t	15	3.133333	.9536896	1	4.75
TotalNMS	15	3.254167	.8918864	1	4.5625

4.3. Integrating Circularity and Energy Efficiency

4.3.1. Interviews and documents' findings

When asked about whether Circularity and Energy Efficiency should be approach separately or together, most interviewees (I1, I2, I5, I6, I7, I8, I10, I11, I13, I14, I15) agree that these two dimensions cannot be separated and need to be considered as part of a whole, although one interviewee explicitly challenges this vision claiming that despite being connected they remain separate things (I4). Some interviewees take this integration further by proposing different aspects of a holistic vision for the built environment that considers nature-inclusivity/biodiversity, nitrogen pollution, phasing out of toxic materials, climate adaptation, health and water (I7, I10, I13). In relation to how to measure the integration of circularity and energy efficiency, some interviewees suggest that the adoption of CO2eq reduction can be used as an indicator for it (I1, I5, I7, I8, I10, I13, I14, I15). However, the methods to calculate the environmental impact of both Energy Consumption and Materials still remain disconnected. As Interviewee 5 says: *"I really believe that's the next step in this system because we have the method of calculating the energy efficiency of a building. We also have a method of calculating the environmental footprint of the materials within a building. And I really believe you should put those two together to create a CO2 footprint per square meter per year, for example, of a building. And the' architects or designers and advisors can design their buildings towards the lowest CO2 footprint".* The main and official methodologies the interviewee is referring to are:

- **MPG**, stands for Millieu Prestatie Gebouw, or Environmental Performance of Buildings: It uses a Life Cycle Methodology to calculate the environmental impact of buildings' materials. This methodology recognizes that the Operational Energy Consumption and Water Use of a Building (Referred to with the codes B6 and B7) are part of an overall sustainability assessment of the whole life cycle, but deliberately excludes them for this calculation (NMD, 2022).
- **BENG** stands for Bijna Energieneutrale Gebouwen and translates as Almost Energy Neutral Building. This indicator's requirements emerge from the European Energy Performance of Buildings Directive and is compulsory in the Netherlands since January 2021. In the European Directive this indicator is called NZEB, standing for Nearly Zero Energy Buildings (RVO, 2023).

While these official indicators measure circularity of materials and energy efficiency separately, a private initiative developed the **MEPG**, an integral measure that aims at putting these two areas in a single analysis. The company that developed this measure, LBP Sights, presents it in a case study in which it compares the environmental impact of a heat pump compared to that of a gas boiler (Jeanette Levels-Vermeer & Jourdain Martens, 2023). In this case study, it assesses the overall impact of a heat pump compared to that of a Central Boiler System. In the first case, the Heat Pump has an initial higher impact due to the larger number of materials but reduces its impact in the operational phase given its energy efficiency. In the case of the boilers, they need to be complemented with solar panels to reach the requirements for energy efficiency. This increases the initial impact of materials of the second option. When comparing options 1 and 2 considering both the impact of materials and the energy consumption during the usage phase, researchers conclude that the overall impact of the Heat Pump is smaller than the Central Boiler and Solar Panels option.

When discussing the Innovations to integrate Circularity and Energy Efficiency in practice, the use of bio-based materials for energy efficiency gets the highest score with 14 quotes after coding the interviews, followed by 7 for Reused/reusable materials for Energy Efficiency, 5 for Passive Design Strategies, 2 for Circular Use of Water and 1 for Recycled/Recyclable materials for Energy Efficiency and Circular use of Water. The use of bio-based materials is one of the topics with higher potential to integrate Circularity and Energy Efficiency: They are available locally, they provide a substitute market for farmers who are affected by national climate goals, they store carbon, and they are non-toxic, biodegradable, and renewable. The bio-based topic has even networks of its own, like the Biobased Building Zuid Holland. But biobased was not the only discussed strategy for the integrations. Another feature that would help integrate circularity and energy efficiency, is the design of insulating structures for demounting, allowing them to be dismantled at the end-of-life of the building, and transported to a new location where they would be reused. These two principles can also be mixed when designing insulating panels for modularity and demounting, which are in turn made from biobased materials. Nonetheless, the concept of building in a demountable/reusable way can also be of use when using non-biobased materials. This option normally carries a higher environmental impact due to the synthetic nature and toxicity of traditional insulating materials, but there is room for this impact to be reduced if these materials are designed to be reused at the end of a building's life cycle. These structures combined with the use of passive design and strategies for the circular use of water, would summarize the different views about how to integrate circularity and energy efficiency towards an integral understanding of a sustainable built environment. Interviewee 2 comments based on their own designs and life cycle assessments that the combined use of these strategies can lead to a reduction of up to 70% in emissions, but there is still a 30% that cannot be addressed through design and needs to be offset to produce carbon-neutral buildings. Interviewee 7 proposes a more comprehensive view that includes building nature-inclusive, promoting biodiversity. Interviewee 13 builds upon this understanding, and complements it by advocating for an even more integral perspective of the built environment that also considers health, mobility and climate adaptation, to aim at a "future proof built environment", as stated in the Covenant Toekomst Bestendig Bowen.

However, the circular use of water, which consists in a series of strategies ranging from capturing rainwater to recycling and reusing water within a building to reduce consumption, remains absent in the mainstream conversations about circularity. This topic, instead, has gained attention in the Networks around Climate Adaptation, like Samen Kilmaatbestendig, which also has a dedicated work group for biodiversity (I9), and VP Delta (The Green Village) which explores solutions to retain water in buildings under the agenda to reduce heat stress, to produce a cool-down effect due to evaporation. These strategies have also the potential to contribute to energy efficiency, as they reduce the need for air conditioning during heat stress periods. Other solutions for a circular use of water include the upfall showers, a system that is claimed to reduce shower water consumption to 1.2/1.5Litres per minute through a process of continuous filtering, purification and reuse, and the use that encompasses all these different aspects of sustainability, comprising materials, energy and water use, and potentially impacts on biodiversity is still yet to come, which represents a barrier for these strategies to be developed further. The final scores per respondent for the DV and its indicators are as per the table below.

Table 6: Scores and value for ICEEBE and its indicators

	Cost-Benefit Relation	Doubtful about Network Outcomes	Effectiveness in the future	Innovative Character of the Solution (ICS)	ICS: Biobased Material	ICS: Circular Use of Water	ICS: Recycled/ recyclable materials EE	ICS: Reused / reusable materials EE	ICS: Use of Passive Design Strategies	Total ICEEBE
1) Interviewee 1	1	0	1	3	2	0	0	0	0	9
2) Interviewee 2	0	1	1	1	1	0	0	0	1	5
3) Interviewee 3	0	0	0	2	1	0	1	1	0	5
4) Interviewee 4	0	0	0	0	0	0	0	0	0	0
5) Interviewee 5	1	1	1	2	1	0	0	0	0	6
6) Interviewee 6	0	0	1	1	0	0	0	0	1	3
7) Interviewee 7	1	0	0	4	2	0	0	0	0	8
8) Interviewee 8	0	0	0	4	1	0	0	1	0	6
10) Interviewee 10	1	0	0	6	1	0	0	2	1	11
11) Interviewee 11	1	0	0	3	1	0	0	0	1	7
13) Interviewee 13	1	0	1	6	2	2	0	1	1	15
14) Interviewee 14	0	0	0	2	1	0	0	1	0	5
15) Interviewee 15	0	0	0	2	1	0	0	1	0	4
Totals	6	2	5	36	14	2	1	7	5	84

4.3.2. Survey's Findings

When it comes to innovations for the ICEE, the strategy of using reusable components for energy efficiency appears this time as the most relevant one, keeping a high score consistent with the findings of the interviews, in which it is the second most relevant one. Biobased materials, contrary to the highest score presented in interviews, here comes after upcycled and Upcyclable materials, and the use of Passive Design, sharing the 4th place with Circular Use of Water. Although it is also true that 10 out of 15 respondents have values between 4 and 5 for biobased, meaning that they slightly or totally agree with having included it in their projects. When looking at the total ICEE value, 7 out of 15 respondents have values between 4 and 5, suggesting that 46% of the sample is somehow making progress in integrating these two dimensions.

	ICS: Use of Passive Design Strategies	ICS: Biobased Material	ICS: Reused/ reusable materials EE	ICS: Upcycled/ Upcyclable materials for Energy Efficiency	ICS: Circular Use of Water	ICS: Others	Innovative Character of the Solution	Effectiveness of the Solutions	Effectiveness in the Future	Cost-Benefit Relation	Total ICEE
Respondent 1	2	1	2	4	4	3	2.6	4	5	5	4.166667
Respondent 2	4	4	4	4	4		4	4	4	3	3.75
Respondent 3	1	1	2	3	5	5	2.8333	4	4	3	3.458333
Respondent 4	5	1	5	5	4	5	4.166667	5	5	3	4.291667
Respondent 5	4	4	4	3	1	4	3.333333	4	5	5	4.333333
Respondent 6	3	5	5	3	5	3	4	1	3	3	2.75
Respondent 7	3	2	4	5	2	5	3.5	2	3	2	2.625
Respondent 8	5	5	5	5	5		5	5	4	4	4.5
Respondent 9	5	5	5	5	5		5	3	3	3	3.5
Respondent 10	3	3	5	4	1	1	2.833333	5	5	5	4.458333
Respondent 11	5	5	5	5	5	5	5	4	5	1	3.75
Respondent 12	5	5	5	5	5	5	5	5	5	4	4.75
Respondent 13	4	4	3	4	2	3	3.333333	2	2	4	2.833333
Respondent 14	3	5	4	2	2		3.2	4	4		3.733333
Respondent 15	5	5	5	5	5	5	5	4	4	4	4.25
Totals	3.8	3.6	4.2	4.1	3.6	4	3.924444	3.733333	4.066667	3.5	3.81

4.4. Analysing the effect of Network Governance on the Integration of Circularity and Energy Efficiency through Multiple Regression

While the sections above help to provide background and better describe the findings related to each variable, this sections' goal is to test causality through regression analysis.

4.4.1. Analysis of Survey Results

Table 7 summarizes survey's results putting together the indicators that are analysed through regression. It presents the scores for the DV, the IV and its main subitems, and the control variables.

Table 7: Summary of IV, DV and Control Varibles from Survey results, analyzed through regression

	Managerial_Position	Type_of_organization	Phase of_theProject	Total Process Agreement	Total Exploring Content	Connecting	Arranging	Total NMS	Total ICEE
Respondent 1	1	6	2	3.0	3.0	3.5	2.5	3.0	4.2
Respondent 2	1	1	1	3.0	4.0	2.8	3.5	3.3	3.8
Respondent 3	2	4	4	3.0	3.5	3.5	2.0	3.0	3.5
Respondent 4	1	6	2	3.3	4.5	3.8	3.3	3.7	4.3
Respondent 5	1	5	3	3.5	4.3	4.0	3.3	3.8	4.3
Respondent 6	2	4	3	3.3	5.0	4.0	4.5	4.2	2.8
Respondent 7	1	4	1	3.5	4.0	2.8	2.8	3.3	2.6
Respondent 8	2	2	2	4.0	4.8	4.5	4.0	4.3	4.5
Respondent 9	1	4	5	2.5	3.0	3.0	2.5	2.8	3.5
Respondent 10	2	1	2	1.5	2.5	2.5	2.0	2.1	4.5
Respondent 11	1	4	5	1.0	1.0	1.0	1.0	1.0	3.8
Respondent 12	1	4	3	4.8	4.8	4.8	4.0	4.6	4.8
Respondent 13	1	4	2	3.5	4.3	2.3	2.8	3.2	2.8
Respondent 14	1	5	3	4.3	4.0	3.0	3.5	3.7	3.7
Respondent 15	1	4	3	3.0	3.0	3.0	3.0	3.0	4.3

The output of the multiple regression ran upon the results of the survey and shown in Figure 3 has an adjusted R-squared of 0.3, indicating that the model explains 30% of the variation in the Integration of Circularity and Energy Efficiency. This means the data collected during the survey is not enough for strong conclusions regarding how different NMS affect the ICEE in the Built Environment. A low value for the Root-MSE at 0.57 is also an indicator of a low dispersion of the observations. The P value of 0.029 for Connecting shows that there is a statistically significant relationship between this Strategy and the Integration of Circularity and Energy Efficiency, holding other factors constant, at 5% and 10% significance levels. For the other strategies and the variables of Managerial Position, Parent Organization and Phase of the Project, no statistically significant relationships were found at 1%, 5% or 10%

significance levels. The graph below shows the distribution of the observations for the values of Connecting (Axis X) and the Integration of Circularity and Energy Efficiency (Axis Y) in a scatterplot, and the fitted line for the model.

```
. reg Total_ICEE Managerial_Position Type_of_organization Phase_of_the_Project Total_Process_Agreement Total_Exploring_Content Total_Arr
> anging TotalConnecting

      Source |       SS           df       MS      Number of obs   =        15
-------------+----------------------------------   F(7, 7)         =      1.88
       Model |  4.33190608         7  .618843726   Prob > F        =    0.2114
    Residual |  2.30066535         7  .328666478   R-squared       =    0.6531
-------------+----------------------------------   Adj R-squared   =    0.3063
       Total |  6.63257143        14  .473755102   Root MSE        =    .57329

------------------------------------------------------------------------------------
          Total_ICEE | Coefficient  Std. err.      t    P>|t|     [95% conf. interval]
---------------------+--------------------------------------------------------------
 Managerial_Position |  -.5163617   .5122227    -1.01   0.347    -1.727576    .6948525
Type_of_organization |  -.2015266   .1427566    -1.41   0.201    -.5390923    .1360391
Phase_of_the_Project |  -.0856106   .1637548    -0.52   0.617    -.4728292     .301608
Total_Process_Agreement | .1065108  .3865571     0.28   0.791    -.8075514    1.020573
Total_Exploring_Content | -.7757178 .4585084    -1.69   0.135    -1.859918    .3084822
      Total_Arranging |   .2038033   .4231697     0.48   0.645     -.796834    1.204441
      TotalConnecting |   .8895518   .3251175     2.74   0.029     .1207711    1.658333
               _cons |   4.432711   1.065348     4.16   0.004     1.913563    6.951858
------------------------------------------------------------------------------------
```

Figure 3: Output of the Regression Analysis of Survey Results, separated per NMS

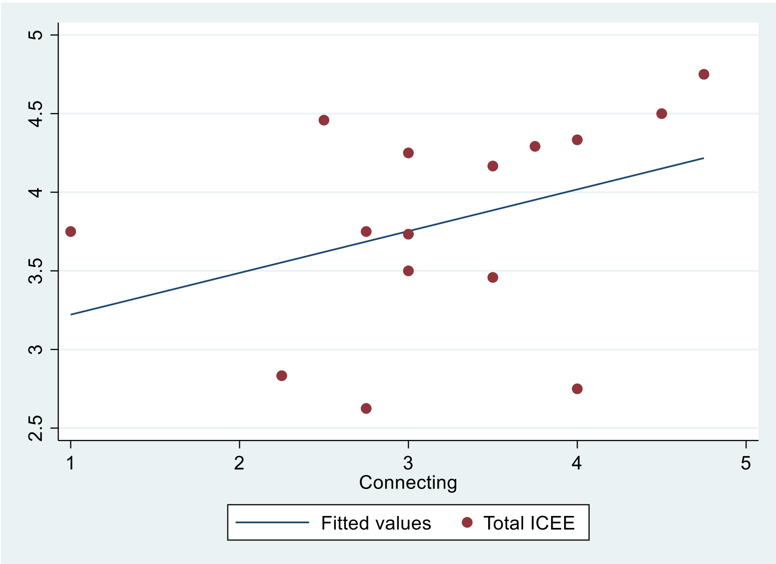

Figure 4: Representation of respondents' values for Connecting and ICEE in a scatterplot

When analysing the effect of the four NMS together on ICEE, no statistically significant relationship between the two was found at 1%, 5% or 10% significance levels.

```
. reg Total_ICEE Managerial_Position Type_of_organization Phase_of_the_Project TotalNMS

      Source |       SS           df       MS      Number of obs   =        15
-------------+----------------------------------   F(4, 10)        =      0.52
       Model |  1.14177755         4  .285444389   Prob > F        =    0.7235
    Residual |  5.49079387        10  .549079387   R-squared       =    0.1721
-------------+----------------------------------   Adj R-squared   =   -0.1590
       Total |  6.63257143        14  .473755102   Root MSE        =      .741

--------------------------------------------------------------------------------------
          Total_ICEE | Coefficient  Std. err.      t    P>|t|     [95% conf. interval]
---------------------+----------------------------------------------------------------
 Managerial_Position |  -.2753185   .5142761    -0.54   0.604    -1.421197      .87056
Type_of_organization |  -.1659229   .1656793    -1.00   0.340    -.5350795    .2032337
Phase_of_the_Project |   .0967332   .1924917     0.50   0.626    -.3321649    .5256313
            TotalNMS |   .3311643   .2594311     1.28   0.231    -.2468842    .9092129
               _cons |   3.343237    1.25907     2.66   0.024     .5378548     6.14862
--------------------------------------------------------------------------------------
```

Figure 5: Output of the Regression Analysis of Survey Results, with a single value for NMS

4.4.2. Analysis of Interviews

During the process of coding, each interview was assigned a value for Connecting, Exploring Content, Arranging or Process agreement, based on the different networks that Interviewees participate in, and the use of the different Network Governance Strategies in each of them. Additionally, each interviewee was assigned a score for the Integration of Circularity and Energy Efficiency (ICEE), based on the innovations they are working on, the effectiveness in the future and the cost benefit relation of participating in a network. The results are available in

Table 8: Summary of IV, DV and Control Variables from Interviews' coding, analysed through regression

	Duration of Interview	Managerial Position	Parent Organization	Arranging	Connecting	Exploring Content	Process Agreement	NMS	ICEE
1) Interviewee 1	52	1	3	7	1	3	5	16	5
2) Interviewee 2	54	1	4	3	1	5	2	11	3
3) Interviewee 3	45	1	4	0	1	2	0	3	2
4) Interviewee 4	37	1	4	4	0	2	0	6	0
5) Interviewee 5	42	0	1	3	2	4	1	10	5
6) Interviewee 6	51	1	4	2	0	1	1	4	4
7) Interviewee 7	52	1	4	2	3	2	6	13	6
8) Interviewee 8	42	0	5	3	1	2	1	7	4
10) Interviewee 10	55	1	6	8	0	5	3	16	7
11) Interviewee 11	53	0	4	4	0	2	2	8	5
13) Interviewee 13	48	0	2	7	1	2	1	11	9
14) Interviewee 14	46	1	4	4	1	1	3	9	3
15) Interviewee 15	23	1	5	3	0	1	0	4	2

By looking at the total values for Network Management Strategies and for the Integration of Circularity and Energy Efficiency in each respondent, it is possible to see that the higher values of the previous correspond to higher values of the latter too. A representation in a scatterplot (Figure 6) with a fitted line makes this relationship clearer:

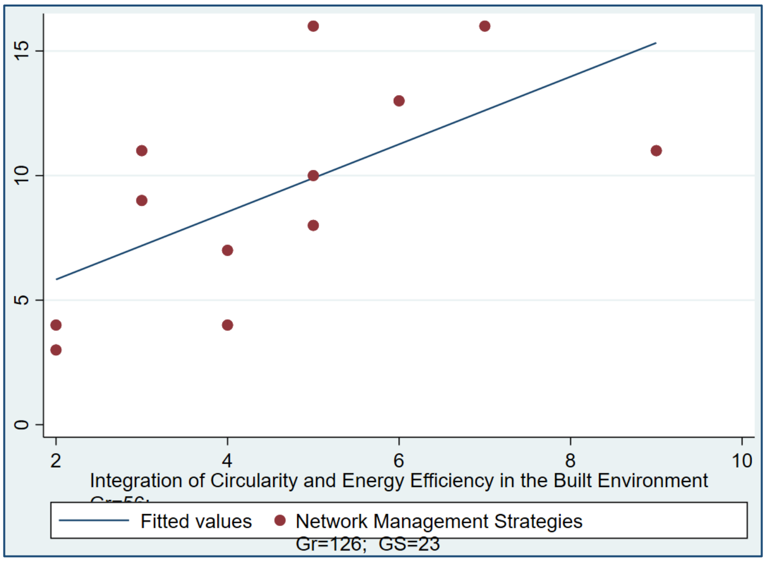

Figure 6: Representation of respondents' values for the IV and DV in a scatterplot

The quantitative output of interviews' analysis was tested through a multiple regression analysis (Figure 7), to obtain an adjusted R-squared value of 0.5, indicating that the model explains 50% of the variation in the ICEE. When looking at the p-values of the different NMS, none of them present statistically significant scores apart from Arranging with 0.06 being significant at 10% holding other factors constant. When this analysis is performed again, summing up all the 4 NMS into a single value, the results indicate that there is a statistically significant relationship for NMS, holding other factors constant, at 10% significance level (Figure 8), with this variable also holding a positive coefficient of 0.26. The positive coefficient helps to predict that a higher number of NMS will have a positive effect on the integration of circularity and energy efficiency. The control variables Duration of Interview, Managerial Position and Parent Organization have not presented statistically significant values in any of the two analyses.

. reg ICEE DurationofInterview Managerial_Position Parent_Organization Arranging Connecting Exploring_Content Process_Agreement

Source	SS	df	MS			
				Number of obs	=	12
				F(7, 4)	=	2.59
Model	38.4429828	7	5.49185468	Prob > F	=	0.1872
Residual	8.4736839	4	2.11842097	R-squared	=	0.8194
				Adj R-squared	=	0.5033
Total	46.9166667	11	4.26515152	Root MSE	=	1.4555

ICEE	Coefficient	Std. err.	t	P>|t|	[95% conf.	interval]
DurationofInterview	.1199587	.0750709	1.60	0.185	-.0884715	.328389
Managerial_Position	-.7333192	1.228479	-0.60	0.583	-4.144123	2.677484
Parent_Organization	.2462121	.473654	0.52	0.631	-1.068862	1.561286
Arranging	.8646647	.3318487	2.61	0.060	-.056695	1.786024
Connecting	1.639567	1.075956	1.52	0.202	-1.347767	4.626901
Exploring_Content	-.4400051	.4068397	-1.08	0.340	-1.569573	.689563
Process_Agreement	-.5592347	.5658988	-0.99	0.379	-2.130422	1.011952
_cons	-4.052065	4.661802	-0.87	0.434	-16.9953	8.891172

Figure 7: Output of the Regression Analysis of Coding Scores, with separate analysis for different NMS

. reg ICEE DurationofInterview Managerial_Position Parent_Organization NMS

Source	SS	df	MS			
Model	29.6034188	4	7.40085471	Number of obs	=	12
Residual	17.3132478	7	2.47332112	F(4, 7)	=	2.99
				Prob > F	=	0.0979
				R-squared	=	0.6310
				Adj R-squared	=	0.4201
Total	46.9166667	11	4.26515152	Root MSE	=	1.5727

ICEE	Coefficient	Std. err.	t	P>|t|	[95% conf.	interval]
DurationofInterview	.0388094	.065342	0.59	0.571	-.1157	.1933187
Managerial_Position	-1.878808	1.092301	-1.72	0.129	-4.461691	.7040743
Parent_Organization	-.0346518	.4034133	-0.09	0.934	-.9885728	.9192692
NMS	.2666272	.1313194	2.03	0.082	-.0438939	.5771483
_cons	1.659377	2.989954	0.55	0.596	-5.410741	8.729495

Figure 8: Output of the Regression Analysis of Coding Scores, with a single value for NMS

4.5. Challenges and Opportunities for the Transition to a Sustainable Built Environment

The observations for challenges and opportunities have been analysed inductively to find patterns in what different respondents manifested as such. The sections below present the findings of those analysis.

4.5.1. Challenges

The different challenges manifested by interviewees and their scores are summarized in the list below.

- Mindset and Practices Changes (9 quotes): With the highest score of quotations, this category refers mainly to the changes that need to happen in techniques, procedures, and routines in the construction industry, more specifically around the stages of design and demolition (I1, I2, I4, I5, I8, I11). A Circular Construction Economy requires a careful process of demolition that safeguards the original value of buildings' components for future reuse. Interviewee 5 explains some of the reasons behind this challenge "*The construction sector is very, extremely efficient in a linear process. So, you have a contractor, an architect, a builder, the one that uses the building basically, and then you demolish it and you get rid of the debris or recycle it. So, that's a very linear process that's very efficient. But to make it more circular, you have to create a different kind of process. And that requires different kinds of business models, different kinds of collaborations between stakeholders.*". This is also consistent with the testimony of Interviewee 8 when describing a previous project that intended to use materials from the circular economy but found limited availability of them in the market. To address this barrier changes are necessary at the design level, designing for demountability (I4, I8), and at the level of demolition practices (I1, I4). In the words of Interviewee 4 *"That's something that is possible, but it's not the culture in the building industry*".
- Challenges to Measure Success (8 quotes): In line with the findings reported in section 4.3., the lack of a single measurement methodology and indicator that combines both Circularity and Energy Efficiency (Among other environmental aspects) poses a barrier in the transition. While some interviewees agree that CO_{2eq} could be an indicator of success (I1, I5, I7), this still poses some issues. For example, the incorporation of biobased materials could be measured as "biogenic stored carbon" serving as an offset for the other emissions. However, Interviewee 1 explains the counterarguments in this way: "*There is always discussion about if you use biobased materials, they say CO2 is kept inside the material. But the critics, the critics say, well, after you use it, it will be burned or rotten and then the CO2 comes out again. But these are particularly critics who have a lobby and big company behind them.*" Extra challenges on this topic refer to the lack of accurate information in the methodologies to reflect the real environmental benefit of the solutions: calculation tools give concrete the best values, without reflecting the benefits of biobased materials correctly (I2).
- Financial Implications (7 quotes): To begin with, building sustainable was reported to be more expensive (I2, I5). Additionally, in the current context of inflation, the price of construction materials is rising, which drives companies into cutting off costs in sustainability (I2). In the cases of buildings that have not been designed for demountability, recovering their materials af the end-of-life requires more work, increasing costs too.

Interviewee 6 adds to this discussion by explaining the difficulties in accessing traditional funding for façade -as-a-service. Traditional morgages are granted with a guarantee based on the value of the property. When the owner of the façade is not the same owner than the one of the land (and the rest of the building), it becomes impossible to access those loans, difficulting its funding. Interviewees highlight the need of having successful business cases to prove the financial feasibility of circular models and further diffuse these practices in the market (I2, I5, I6).

- Regulations (4 quotes): When commenting on the difficulty in access to funding for façade -as-a-service solutions, the financial aspects are tied to the legal ones. According to Interviewee 6, the current legislation does not consider situations in which a façade can have a different owner than the land owner, which increases the financial risk aspects described in the previous section. In addition, façades that are removed from a building and need to be repaired before reuse can only do it in the Netherlands since they are typified as "waste", eliminating the possibility of transporting it to countries with lower processing costs. These repairing stages also seem to be critical to address, as another regulatory barrier identified is the need for construction materials to comply with quality standards (I8), which impedes recovered materials from being reused. Last but not least, there is a demand from the market for more strict regulations on circularity, accompanied by enough time to adapt to stricter standards (I10). Interviewee 10 explains there is a paradox in this regard, as the government still lacks evidence of successful business cases that prove the feasibility of stricter standards to impose them on the broader market.
- Lack of demand (3 quotes): While the supply side is preparing for the transition, the demand still needs to be encouraged. Interviewees manifested issues in finding clients for biobased products (I3), lack of consistent and trustworthy demands for circular projects (I6), and a customers' requirement for quality buildings before any circular considerations (I8).
- Competition with other policies (3 quotes): As was previously explained Circularity and Energy Efficiency are measured through different indicators and subject to different policies' goals, the same happens with the funding they have allocated: most of the governmental financial inputs and attention are focused on the Energy Transition, while circularity is receiving less attention (I1, I11).

4.5.2. Opportunities

As some of the challenges presented before can also be understood as opportunities, this section will describe why and how they can be used as enablers for the transition. In addition, it will describe extra opportunities that were not yet covered.

- Integration of measurements' indicators, methodologies, and practices: It has already been described how Circularity and Energy Efficiency are formulated separately at a policy level and consequently measured in different ways too. It has also been described how this generates competition between the two, with more funding and attention currently being given to Energy Efficiency. However, a comprehensive approach that considers both together could potentially allow for those available fundings to make a higher impact. If a comprehensive methodology is adopted to look at Circularity and Energy Efficiency from the holistic perspective of the Sustainable Built Environment, there is a possibility of creating a positive feedback loop within the two that allows for a better use of existing resources. In this way, available funding for energy efficiency could help in designing for circularity, and funding for circularity can also support the energy transition. There is general consensus that CO_{2eq} can be an indicator for this integration (I1, I2, I3, I5, I7, I8, I10). Metabolic, one of the leading organizations in Circularity, also supports the idea for the integration, and agree with the interviewees who said that the use of biobased materials could bridge the two, by providing insulation materials that work as carbon sinks. In their report for Biobased materials Metabolic explains that 470.000 houses in Amsterdam need to be insulated to facilitate the transition to sustainable energy. When comparing the carbon footprint of traditional insulation materials (Rock wool) with biobased, the latter poses a reduction in 2 billion tons CO2 compared to the previous (Metabolic, N/Da).
- Farmers' crisis and biobased materials: In a different topic related to the Netherlands' transition to sustainability, agriculture has become a challenge in reducing GHG emissions, with farmers' protests extending nation-wide to reject the caps in the number of livestock they could hold and organizing their own political movements to fight back climate policies. This represents a window of opportunity for biobased materials, as being able to produce them from local sources would allow to reduce CO2 emissions (I3, I7, I11), while providing farmers with an alternative income stream. The networks We Grow and Building Balance are already

working on this topic. Considering that farmers are receiving government funds to support them in this transition, there is also an opportunity for these funds to power the biobased economy.

- Designing low tech: Interviewee 10 quotes a study by metabolic to explain that a high-tech energy transition would require large quantities of raw materials that the Netherlands simply does not have the means to obtain. Indeed, the study claims that a climate-neutral scenario for the Netherlands that relies on wind and solar farms as the main strategy, would require 1.800 million tons of Iron, which is equivalent to the amount of that metal produced worldwide in 2020. Within the solutions proposed by the same document, number 1 "Rethink" is consistent with the idea of building low-tech. This principle aims at reducing energy consumption by redesigning the system to reduce raw materials demand (Metabolic, N/Db). The use of passive design strategies combined with biobased materials fits perfectly well under this understanding, as it drives down energy consumption through design, using renewable materials. The establishment of a working group (Arranging) in Lenteakkord 2.0. to discuss this topic also shows the consensus around the idea and constitutes a valuable example of how Network Management Strategies are contributing to the integration of Circularity and Energy Efficiency (Lente-akoord-2.0, 2023)
- Business opportunities: As the policies keep pushing for a complete circular economy and the necessary techniques and regulations are being developed by different sectors, it is expected that the Circular Construction Industry disrupts the market in the years to come. Companies that are prepared for this would be able to harness the advantage and position themselves in the future economy (I5).
- Workforce: While the market is still slow in adapting and developing circular solutions, the educational sector is leading the way, having circularity and sustainability integrated into their curriculums. Therefore, the new generation of professionals will be better aware and prepared to collaborate on this transition (I5).
- Policy support: Not only the Transition Agendas for Circularity are fostering the transition to a circular built environment, but also the recent recognition of Construction as one of the Topsectoren will help in this regard by providing the sector with an additional stream of income for innovation (I10). Topsectoren are the different sectors recognized by the national government as strategic for innovation and development.

4.6. Discussion

This research has studied the effect of Network Governance in the Integration of Circularity and Energy Efficiency based on the Dutch case-study. The findings show that there are 19 different networks that approach this topic in different ways using all types of different Network Management Strategies. The comparison of quantitative analyses between survey and interviews' results presents contradiction between the outcomes of the regression for NMS and ICEE. While the regression performed over the survey results does not show a statistically significant relationship between the two, the one performed over interviews' values does show a statistically significant relation between NMS and ICEE. Additionally, when looking at the four NMS separately, the analysis performed over the survey results found a statistically significant relation for Connecting strategies over ICEE with a positive coefficient, while the analysis over interviews did not find that strategy significant, but it did it with Arranging. The diverging results between Survey and Interview outputs can be explained in this way: At the beginning of this research, it was expected to find a Network created around the Raw Materials Agreement and the subsequent transition agendas for circularity. Therefore, survey's questions were tailored to understand participants' experience in this expected network. The results of the analysis showed that this was not the case and that, despite the Raw Materials Agreement indirectly influenced the creation of all these different networks, it did not trigger the creation of a network by itself. This is consistent with respondent's reactions via email explaining they were not involved in networks related to the Raw Materials Agreement and can explain why the data obtained through surveys does not match the findings of the interviews. However, the interviews served better to understand what network each respondent's organization participate in, and what NMS are being used in those networks, to later retrieve respondent's perceptions on the Integration of Circularity and Energy Efficiency. While the output of the regression analysis performed over interviews' results show a positive coefficient for NMS when analysing all NMS together, the analysis performed treating the different NMS separately presents a higher adjusted r-square, indicating a better representation of the model. In other words, while the use of different NMS altogether is showing a contribution to integrate Circularity and Energy Efficiency, the specific use of Arranging strategies, which in this case specifically means the participation of actors that represent different components of the supply chain (Private, public, education, etc.) seems to have a higher importance in relation to other strategies. The qualitative findings of the interviews explain this better: Through the process of connecting a diverse array of stakeholders, creating spaces for them to discuss and develop new methods and ideas, creating ad-hoc working groups for specific sub-topics and putting in place mechanisms for decision-making, multiple solutions are being developed, that will likely contribute to the integration of circularity and energy efficiency in the future. This is pictured by Interviewee 5: "*There's one party, for example, that guides the process or that is being paid to make sure there are meetings and reports and stuff like that. They do the research, but they are paid by, say, 20 parties or so. So, each party individually does not have to pay a lot of money, but collectively, that does allow a large budget to be realized. That does accelerate the transition towards more circular buildings.*" In that quote, Interviewee 5 is explaining how the role of a network manager using the strategies of connecting and arranging to create meetings, where ideas are discussed to be later shared with other stakeholders in reports (exploring content), is contributing to the outcomes of the transition.

A remaining question is whether having so many different and independent networks make a positive contribution or if it scatters the interactions and makes it more difficult for the ideas to spread. Some interviewees identify positive aspects of this, arguing that diversity, spontaneity, and a certain degree of informality allows stakeholders to have different options and join the networks that they feel more related too (I11, I12). However, communication issues between people who participate in different networks were also noticed (I11), as well as the difficulties related to choose which networks to participate and not to participate given the time-investment needed for each of them (I13). Therefore, it safe to say that the way in which networks work nowadays has positive aspects, but that the diversity and multiplicity difficult a clear flow of information among them and forces participants to choose which ones to take part in, leaving others aside and scattering the interactions. While the deductive part of this research tested the previous literature in Network Management and Outcomes, the inductive findings of it extracted from the analisis of challenges and opportunities suggest, among other things, that a high number of networks and NMS around the same topic can generate miscommunication and competition, delaying or complicating the achievement of outcomes. If the current literature has proven that Network Governance leads to positive outcomes, there is the need for extra research around how different networks coordinate efforts with each other in transitions to sustainability, to improve resource-efficiency and achieve greater outcomes.

5. Conclusions

This research has studied the effect of Network Governance on the integration of Circularity and Energy Efficiency in the Netherlands by a mixed methods comprising surveys, interviews, quantitative and qualitative analysis. To conclude, this section will retrieve the original research questions, together with the literature review, and attempt to provide answers for them.

5.1. Subquestion 1: What are the Network Governance Strategies being used in the implementation of transition agendas for circularity in the built environment?

As explained in section 4.3., 12 different networks were found in the Netherlands, that collaborate in different ways to implement the transition agendas for circularity in the Built Environment. The four NMS have been identified in these networks, with prevalence of Arranging and Connecting. Klijn et. al (2010) suggest that the previous has a higher effect on Process Outcomes, while Connecting does it on Content Outcomes. In this case, the strategy of connecting presented a higher relevance in survey results, while arranging did it for interviews' results. During data collection it was found that the strategies for arranging and exploring content where the ones utilized the most among different networks.

5.2. Subquestion 2: To what extent do the voluntary Raw Materials Agreement foster the integration of circularity with the pre-existing policy for energy efficiency in the built environment from the perspective of stakeholders?

Interviewees agreed that the Raw Materials Agreement by itself did not directly foster a process of networking and cooperation but recognize that it indirectly set the foundations for other processes to occur, like the creation of a Transition Team and Transition Agenda for a Circular Construction Economy. This transition agenda does not have yet elements that connect it with Energy Efficiency, and these two policies remain mostly disconnected, having different implementation and funding strategies, and indicators of success. Nonetheless, it is also true that most members of the transition team are aware of this and agree on the fact that the underlying goal that connects the two is the reduction in CO_{2eq} emissions. Additionally, the process of innovation favoured by the existence of these policies and networks is contributing to the development of solutions that could help integrate these two dimensions, like the use of biobased materials for insulation, or the design for disassembly and reuse of façades that have insulation properties. Elements for the integration of circularity and energy efficiency were not found at a policy level, but are appearing within the innovation niche, and could be further strengthened through policymaking once there are successful cases of success that prove their feasibility.

5.3. Subquestion 3: What are the challenges and opportunities that stakeholders identify in the integration of these two policies?

The challenges and opportunities to address this transition have largely been covered in section 4.6. Summarizing, stakeholders agree that Mindset and Practice Changes represent one of the biggest barriers, together with the challenges to measure success, financial implications, regulations, and lack of demand. On the other hand, the integration of Energy Efficiency and Circularity at both the policy and the practice level can pose a great opportunity to create synergies between the two, allowing for a better use of the funds allocated to these currently separated policies. The integration of these two strategies through biobased materials and low-tech design (Including passive design and demountability), can also be leveraged by linking with the farmers who need to transition to sustainability and find replacements for the highly emitters dairy and meat, also benefiting from the governmental resources available to support them. The development of an integrated indicator that encompasses the overall carbon footprint of the built environment and reflects the real benefits of these practices with accurate data, holds the potential to show the capacity of this supply chain to mitigate climate change and become a reliable tool for companies and governments that want to reduce their GHG emissions.

5.4. Subquestion 4: To what extent can GHG reduction performance of the built environment be improved through combining energy efficiency and circularity goals?

Given that most policies and studies still consider energy efficiency and circularity separately, there is not enough information found to answer this question completely. In the literature review, it was observed that both materials and energy consumption during usage represent together the largest share of GHG emissions of the built environment, although the exact percentages vary. It became clear that the impact of materials can be addressed through designing for reuse and incorporating carbon-sink materials like the biobased ones. It is also evident that energy consumption can be reduced through a mix of passive design (Insulation strategies are within this category too) and the on-site generation of energy through solar photovoltaic panels, solar water heaters and heat pumps. The last solutions, however, require a large number of raw materials for those devices to be produced, and are consequently less suited to the Circular Economy, but could be complementarily to low tech measures like passive design. Theoretically, integrating circularity and energy efficiency would help to put together the two mains' stages of the life cycle of buildings, namely, Construction and Usage, driving down most of buildings' emissions. One interviewee commented that models that use a mix of these solutions have shown a reduction of up to 70% in GHG after calculation using life cycle analysis methodologies.

5.5. RQ: To what extent do network governance strategies influence the stakeholders' perceived outcomes in integrating Circularity and Energy Efficiency policies?

In conclusion, there is evidence to support that the existence of networks, when they use different Network Management Strategies, make a positive contribution in how stakeholders perceive the integration of Energy Efficiency and Circularity, collaborating in the transition to a sustainable built environment. These strategies help different members of the supply chain to discuss issues, explore solutions, debate conflict of interest and agree on recommendations for policy-making, facilitating the transition. Interviewees who are the most exposed to these strategies tend to be more familiar with the most innovative ways to integrate circularity and energy efficiency, such as:

- The use of locally available biobased materials that fix carbon and reduce transportation emissions.
- The implementation of low-tech cooling heating passive design in buildings to reduce the need of extra raw materials associated with a high-tech energy transition.
- The development of demountable structures to build, serving as floors, walls, and roofs, well suited for energy efficiency, that could be dismantled and reused at the end-of-life.
- The incorporation of circular water management practices that aim at capturing rainwater, recycling greywater, harnessing the potential of wastewater for energy generation.

Those solutions are not exclusive, but complementary to a larger array of measures that aim at a future-proof built environment that also provides habitat for biodiversity, a healthy inner environment and is adapted to the climate challenges to come. No projects were found in the data collection that suggest that these measures are already being fully implemented. Instead, it seems that most of these ideas are still in early stages of planning and pilot experimentation.

This research studied the effect of Network Governance on the Integration of Circularity and Energy Efficiency in the Built Environment. It built upon the existing knowledge on how Network Governance can be a driver in Transitions to Sustainability, to theorize an integrative conception of the Sustainable Built Environment. By studying the case of the Netherlands, it looked at the innovative contribution of the Networks for a Circular Built Environment, and highlighted the risk of fragmentation between circularity, energy efficiency and water management, and the need for an integral, comprehensive understanding of the Sustainable Built Environment from a policy perspective to foster its role as a driver of success in the race to stopping climate change, and regenerate Earth's natural systems. While the literature review described a requirement of 10 years of existence for networks to be considered as such, this case-study also showed that networks can emerge and act as such as soon as their members decide to work together, adapting the existing knowledge available on Network Governance to delve into the specific transition in the Supply Chain of the Built Environment, and contribute to the larger discussion about climate change mitigation. Additionally, while the literature reviewed indicated a relation between different NMS and Network Outcomes, in this case study it was noted that while a high number of networks with different strategies over a same topic can facilitate participation, it can difficult the integration of different stakeholders' visions, causing competition between networks and fragmentation in discussions.

5.6. Recommendations

5.6.1. Recommendations for research

Further studies could help in better understand the role of the networks identified on this paper in the Transition to Sustainability, diving into the inter-network relations and the benefits/disadvantages of multiple networks working on the same topic simultaneously and looking for optimal models of collaboration to drive change. while the existing literature measures the effect of single networks in achieving sustainable outcomes, there is a need for research that studies the interaction of multiple networks working simultaneously around the same topic when driving transitions to sustainability in a way in which multiple projects and agendas are also pursued simultaneously. This research could help in optimizing mechanisms for knowledge sharing and collective decision-making among networks. Moreover, the survey strategy could be adapted and repeated with/through the multiple networks found in this study, in order to get larger samples that enhance the validity of the results.

Additional research could also deepen into the debate of an ideal conception of Sustainable Built Environment, and strategies to enhance its role as a carbon-capturing supply chain that plays a role in nature regeneration. The use of integrated methodologies to measure the overall environmental impact of the built environment should also be further explored to understand the true potential in addressing the water-energy-materials nexus. Once a tool is available to measure the environmental impact of the built environment in a holistic way, the solutions identified in this study could be analysed through a comprehensive approach to understand better their real contribution and identify which strategies have the best relation investment/outcomes.

5.6.2. Recommendations for policy-making

Following with the need of extra research to understand interactions between networks, public policies could start by actively looking for mechanisms that enhance knowledge sharing and put together different networks vision of the sustainable built environment into a single one.

There is also an opportunity in improving the resource-efficiency in governments' contribution to sustainability if policy formulation considers a comprehensive understanding in the Transition in the Built Environment and Agriculture. By looking at the agricultural sector as a potential carbon sequestrator that supplies carbon-storing materials to the industry of sustainable building, and considering this industry as one that looks at all its different aspects in a holistic way, it could be possible to produce synergic effects that potentiate benefits on the different elements of the equation. To advance on this way, some barriers that needs to be addressed related to mindset and practices changes, the need for an integral measure of success, the financial implications of implementing more sustainable strategies, changes in the regulations, and policies to increase demand. Addressing all those elements in a systemic way would help the transition move from a stabilization stage towards the disruption one, helping to scale up a positive impact on the natural systems.

Bibliography

References

Abu-Jdayil, B., Mourad, A., Hittini, W., Hassan, M., & Hameedi, S. (2019). Traditional, state-of-the-art and renewable thermal building insulation materials: An overview. *Construction and Building Materials, 214*, 709-735.

Arrigoni, A., Pelosato, R., Melià, P., Ruggieri, G., Sabbadini, S., & Dotelli, G. (2017). Life cycle assessment of natural building materials: The role of carbonation, mixture components and transport in the environmental impacts of hempcrete blocks. *Journal of Cleaner Production, 149*, 1051-1061.

Barth, M., & Carus, M. (2015). Carbon footprint and sustainability of different natural fibres for biocomposites and insulation material. *Hürth: Nova-Institute.Available Online at: Http://Eiha.Org/Media/2017/01/15-04-Carbon-Footprint-of-Natural-Fibres-Nova1.Pdf (Accessed Sept 5, 2017),*

Benites, H. S., & Osmond, P. (2021). Bioconnections as enablers of regenerative circularity for the built environment. *Urban Planning, 6*(4), 25-39.

Bockholt, M. T., Kristensen, J. H., Wæhrens, B. V., & Evans, S. (2019). Learning from the nature: Enabling the transition towards circular economy through biomimicry. Paper presented at the *2019 IEEE International Conference on Industrial Engineering and Engineering Management (IEEM),* 870-875.

Bryman, A. (2012). *Social research methods* (Fourth edition ed.) Oxford University Press.

BuildingBalance. (N/D). Bouwmaterialen van eigen bodem. Retrieved from https://buildingbalance.eu/

Camisón, C. (2010). Effects of coercive regulation versus voluntary and cooperative auto-regulation on environmental adaptation and performance: Empirical evidence in spain. *European Management Journal, 28*(5), 346-361. doi:10.1016/j.emj.2010.03.001

CB '23. (N/D). Action teams. Retrieved from https://platformcb23.nl/actieteams

CB’23. (2022). *Guide to passports for the construction sector, parts 1 + 2, working agreements and substantiation for passports in a circular construction sector* Retrieved from https://platformcb23.nl/images/downloads/2022/Guide-to-Passports-for-the-Construction-Sector_3.pdf

Çimen, Ö. (2021). Construction and built environment in circular economy: A comprehensive literature review. *Journal of Cleaner Production, 305*, 127180.

Circle Economy. (2020). *Circularity gap report* Circle Economy. doi:https://circulareconomy.europa.eu/platform/en/knowledge/circularity-gap-report-netherlands

Circulaire Economie.*Grondstoffenakkoord: Intentieovereenkomst om te komen tot transitieagenda’s voor de circulaire economie*

Cirkelstad. (N/D). Over ons. Retrieved from https://www.cirkelstad.nl/over-ons-2/

Clarke, J. A., Johnstone, C. M., Kelly, N. J., Strachan, P. A., & Tuohy, P. (2008). The role of built environment energy efficiency in a sustainable UK energy economy. *Energy Policy, 36*(12), 4605-4609.

Economidou, M., Todeschi, V., Bertoldi, P., D'Agostino, D., Zangheri, P., & Castellazzi, L. (2020). Review of 50 years of EU energy efficiency policies for buildings. *Energy and Buildings, 225*, 110322.

Frantzeskaki, N., Loorbach, D., & Meadowcroft, J. (2012). Governing societal transitions to sustainability. *International Journal of Sustainable Development, 15*(1-2), 19-36. doi:10.1504/IJSD.2012.044032

Gallego-Schmid, A., Chen, H., Sharmina, M., & Mendoza, J. M. F. (2020). Links between circular economy and climate change mitigation in the built environment. *Journal of Cleaner Production, 260*, 121115.

Gooroochurn, M. (2022). Circular homes–An energy-water-materials nexus for community climate engagement and action at grassroots level in the built environment. *Results in Engineering, 15*, 100548.

Government of the Kingdom of the Netherlands. (2017). *The fourth national energy efficiency action plan for the netherlands*. Netherlands:

Government of the Netherlands. (N/A). Circular dutch economy by 2050.

Government of the Netherlands. (N/D). Accelerating the transition to a circular economy. Retrieved from https://www.government.nl/topics/circular-economy/accelerating-the-transition-to-a-circular-economy

Het Nieuwe Normaal. (N/D). Aan de slag. Retrieved from https://www.hetnieuwenormaal.nl/leidraden/aan-de-slag

Huang, B., Xing, K., Ness, D., Liao, L., Huang, K., Xie, P., & Huang, J. (2022). Rethinking carbon–neutral built environment: Urban dynamics and scenario analysis. *Energy and Buildings, 255*, 111672. doi:10.1016/j.enbuild.2021.111672

Intergovernmental Panel on Climate Change. (2023). AR6 synthesis report: Climate change 2023. *Ipcc sixth assessment report (ar6)* () Retrieved from https://report.ipcc.ch/ar6syr/pdf/IPCC_AR6_SYR_LongerReport.pdf

Jeanette Levels-Vermeer, & Jourdain Martens. (2023). *Woningen met warmtepomp schadelijk voor het milieu?* LBP Sight, Develop Inc. Retrieved from https://www.lbpsight.nl/wp-content/uploads/2023/05/Woningen-met-warmtepomp-schadelijk-voor-het-milieu.pdf

Klijn, E., Steijn, B., & Edelenbos, J. (2010). The impact of network management on outcomes in governance networks. *Public Administration, 88*(4), 1063-1082.

Klijn, E. (2007). Governing policy networks : A network perspective on decision making in network society. In G. Morcol (Ed.), *Handbook of decision making* (pp. 169-187). New York: CRC press.

Klijn, E., Edelenbos, J., & Steijn, B. (2010). Trust in governance networks: Its impacts on outcomes. *Administration & Society, 42*(2), 193-221.

Klijn, E., & Koppenjan, J. (2016). Analyzing governance networks. In E. Klijn, & J. Koppenjan (Eds.), *Governance networks in the public sector* (pp. 259-288). Abingdon: Routledge. Retrieved from https://www.taylorfrancis.com/books/9781315887098

Kunič, R. (2017). Carbon footprint of thermal insulation materials in building envelopes. *Energy Efficiency, 10*(6), 1511-1528.

Lecompte, T., Levasseur, A., & Maxime, D. (2017). Lime and hemp concrete LCA: A dynamic approach of GHG emissions and capture. *Academic Journal of Civil Engineering, 35*(2), 513-521.

Lente-Akkoord-2.0. (N/D). Over het lente-akkoord 2.0 circulair industrieel bouwen. Retrieved from https://www.lente-akkoord.nl/over

Lente-akoord-2.0. (2023). Minder installaties voor betere milieuprestatie gebouwen. Retrieved from https://www.lente-akkoord.nl/nieuws/minder-installaties-voor-betere-milieuprestatie-gebouwen

Metabolic. (N/Da). *Biobased renovation* Retrieved from https://www.metabolic.nl/publications/biobased-renovation/

Metabolic. (N/Db). *Towards A circular energy transition* Retrieved from https://www.metabolic.nl/publications/towards-a-circular-energy-transition/

Mhatre, P., Gedam, V., Unnikrishnan, S., & Verma, S. (2021). Circular economy in built environment–Literature review and theory development. *Journal of Building Engineering, 35*, 101995.

Munaro, M. R., Tavares, S. F., & Bragança, L. (2020). Towards circular and more sustainable buildings: A systematic literature review on the circular economy in the built environment. *Journal of Cleaner Production, 260*, 121134.

Nguyen, H., & Gray, M. (2016). *A review on green building in vietnam* doi:10.1016/j.proeng.2016.02.053

NMD. (2022). Bepalingsmethode. Retrieved from https://milieudatabase.nl/nl/milieuprestatie/bepalingsmethode/

Omrany, H., & Marsono, A. K. (2016). Optimization of building energy performance through passive design strategies. *British Journal of Applied Science & Technology, 13*(6), 1-16.

Pearlmutter, D., Pucher, B., Calheiros, C. S., Hoffmann, K. A., Aicher, A., Pinho, P., . . . Galvão, A. (2021). Closing water cycles in the built environment through nature-based solutions: The contribution of vertical greening systems and green roofs. *Water, 13*(16), 2165.

Persson, Å. (2004). Environmental policy integration: An introduction. *PINTS–Policy Integration for Sustainability Background Paper.Stockholm Environment Institute: Stockholm,*

Pomponi, F., & Moncaster, A. (2016). Embodied carbon mitigation and reduction in the built environment – what does the evidence say? *Journal of Environmental Management, 181*, 687-700. doi:10.1016/j.jenvman.2016.08.036

Prinssen, P., & Lieffering, P. (2020). *Inkopen met de milieuprestatie gebouwen (MPG)*. Rijswick, Netherlands: Stichting Nationale Milieudatabase. Retrieved from https://milieudatabase.nl/wp-content/uploads/2020/11/Publicatie_Inkopen_met_MPGdef.pdf

Rahla, K. M., Mateus, R., & Bragança, L. (2021). Selection criteria for building materials and components in line with the circular economy principles in the built environment—A review of current trends. *Infrastructures, 6*(4), 49.

Ritchie, H., Roser, M. & Rosado, P. (2020). CO2 and greenhouse gas emissions . Retrieved from https://ourworldindata.org/emissions-by-sector#citation

Rodriguez-Ubinas, E., Montero, C., Porteros, M., Vega, S., Navarro, I., Castillo-Cagigal, M., . . . Gutiérrez, A. (2014). Passive design strategies and performance of net energy plus houses. *Energy and Buildings, 83*, 10-22.

RVO. (2023). Energieprestatie indicatoren - BENG. Retrieved from https://www.rvo.nl/onderwerpen/wetten-en-regels-gebouwen/beng/indicatoren

Schut, E., Crielaard, M., & Mesman, M. (2015). *Circular economy in the dutch construction sector: A perspective for the market and government* Rijkswaterstaat, National Institute for Public Health and the Environment.

Retrieved from https://rivm.openrepository.com/bitstream/handle/10029/595297/2016-0024.pdf?sequence=3&isAllowed=y

Sociaal-Economische Raad. (2013). Gebouwde omgeving. Retrieved from https://www.ser.nl/nl/thema/energie-en-duurzaamheid/energieakkoord/domeinen/01

Transitieam Advies Circulaire Economie. (2022). *Adviesroute naar een circulaire econonomie voor de bouw.* (). Retrieved from https://open.overheid.nl/documenten/ronl-fbdabeac71fadc3ba4ee2fd69cf6cab53b3f8ce0/pdf

Transitieteam Circulaire Bouweconomie. (2021). *Einddoel 2050: Transitieagenda circulaire bouweconomie.* (). Retrieved from https://circulairebouweconomie.nl/wp-content/uploads/2021/12/Einddoel-2050-CBE-4.2.pdf

WaterAlliance. (N/D). About us. Retrieved from https://wateralliance.nl/en/about-us/

Willem, H., Lin, Y., & Lekov, A. (2017). Review of energy efficiency and system performance of residential heat pump water heaters. *Energy and Buildings, 143*, 191-201. doi:10.1016/j.enbuild.2017.02.023

Winans, K., Kendall, A., & Deng, H. (2017). The history and current applications of the circular economy concept. *Renewable and Sustainable Energy Reviews, 68*, 825-833.

Wiprächtiger, M., Haupt, M., Heeren, N., Waser, E., & Hellweg, S. (2020). A framework for sustainable and circular system design: Development and application on thermal insulation materials. *Resources, Conservation and Recycling, 154*, 104631. doi:10.1016/j.resconrec.2019.104631

Working Group 1- Intergovernmental Panel for Climate Change. (1990). In J.T. Houghton, Ephramus J. J. and Jenkins G. J. (Eds.), *Climate change: The IPCC scientific assessment* (2nd ed.). Cambridge: Cambridge University Press. Retrieved from https://www.ipcc.ch/report/ar1/wg1/

Working Group II to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change. (2022). *Climate change 2022: Impacts, adaptation, and vulnerability.* ().IPCC. Retrieved from https://www.ipcc.ch/report/sixth-assessment-report-working-group-ii/

Yao, R., Li, B., & Steemers, K. (2005). Energy policy and standard for built environment in china. *Renewable Energy, 30*(13), 1973-1988.

Zwickel, T., Edenhofer, O., Pichs-Madruga, R., Minx, J., Sokona, Y., Farahani, E., . . . Von Stechow, C. (2014). *Climate change 2014 mitigation of climate change. working group III contribution to the fifth assessment report of the intergovernmental panel on climate change*. Cambridge, UK and New York, USA: Cambridge University Press. Retrieved from https://www.ipcc.ch/site/assets/uploads/2018/02/ipcc_wg3_ar5_full.pdf

Appendix 1: Survey Structure

Variable	Indicator	Item		Survey questions	Answers
Characteristics of the Respondent	**Managerial / Non-managerial position**		Q1	Do you hold a managerial position in your organization, in relation to the implementation of the agendas for Circularity?	Yes/ no
	Parent organization		Q2	Which of these categories represents your organization better?	1) Local Civil Servants-Including Counties and Waterboards-, 2) Provincial Civil Servants, 3) National Civil Servants, 4) Private Sector, 5) Non for Profit/ Non-Governmental Organizations 6) Others
	Stage of the Project		Q3	If any projects arised from the Agendas for Circularity, in which phase of the project is your organization now?	1) Initial Ideas, 2) Planning/Development phase, 2) Implementation phase 3) Post implementation phase (Monitoring, Evaluating, Maintenance) 4) No project derived from the Agendas for Circularity
Network Management Strategies	**Process Agreement**	Agreements Made	Q4	Since your participation in the Agendas for Circularity, explicit agreements have been made about the organizational form of cooperation among different participants	1- Disagree 2- Slightly disagree 3- Neutral 4- Slightly agree 5- Agree
		Conflict Management	Q5	The agreements made include conflict-solving procedures	1- Disagree 2- Slightly disagree 3- Neutral 4- Slightly agree 5- Agree
		Flexibility to Change	Q6	Within the agreements made, there is room for deviating from the original plan, if this is of advantage	1- Disagree 2- Slightly disagree 3- Neutral 4- Slightly agree 5- Agree
		Agreements on Withdrawal	Q7	The agreements made allow parties to withdraw from the projects, if this is necessary to protect their interests	1- Disagree 2- Slightly disagree 3- Neutral 4- Slightly agree 5- Agree
	Exploring content	Diversity in opinions	Q8	Within the agendas for Circularity, it has been attempted as much as possible to make different opinions visible and included in Decision-Making	1- Disagree 2- Slightly disagree 3- Neutral 4- Slightly agree 5- Agree

		Attention to Differences	Q9	Within the agendas for Circularity, there has been satisfactory attention to the exchange between different viewpoints	1- Disagree 2- Slightly disagree 3- Neutral 4- Slightly agree 5- Agree
		Establishment of common points	Q10	In the collection of information, the emphasis of the Agendas of Circularity has been on the development and establishment of common points of departure and information needs	1- Disagree 2- Slightly disagree 3- Neutral 4- Slightly agree 5- Agree
		Openness to new parties and ideas	Q11	Within the agendas for circularity there has been satisfactory attention to involving external parties that can bring new ideas and solutions	1- Disagree 2- Slightly disagree 3- Neutral 4- Slightly agree 5- Agree
	Arranging	Involvement of relevant public groups	Q12	Within the agendas for circularity, the relevant public groups have been involved via the organized forms of negotiation and/or discussion platforms	1- Disagree 2- Slightly disagree 3- Neutral 4- Slightly agree 5- Agree
		Involvement of relevant private groups	Q13	Within the agendas for circularity, the relevant private groups have been involved via the organized forms of negotiation and/or discussion platforms	1- Disagree 2- Slightly disagree 3- Neutral 4- Slightly agree 5- Agree
		Involvement of relevant civil action	Q14	Within the agendas for circularity, the relevant civil action groups have been involved via the organized forms of negotiation and/or discussion platforms	1- Disagree 2- Slightly disagree 3- Neutral 4- Slightly agree 5- Agree
		Development of new connections	Q15	Since the signature of the Raw Materials Agreement, in every new phase of the Agendas for Circularity, new parties are sought out and new connections are developed	1- Disagree 2- Slightly disagree 3- Neutral 4- Slightly agree 5- Agree
	Connecting	Communication between different parties	Q16	Within the Agendas for Circularity, there has been satisfactory time devoted to the communication between the different parties	1- Disagree 2- Slightly disagree 3- Neutral 4- Slightly agree 5- Agree
		Consideration of relationships	Q17	The project leaders in the Agendas for Circularity consider the relationships between parties and persons, what they are based on, and how they have developed and are developing	1- Disagree 2- Slightly disagree 3- Neutral 4- Slightly agree 5- Agree
		Integration of opposing interests	Q18	The management seeks to bring the opposing interests closer together	1- Disagree 2- Slightly disagree 3- Neutral 4- Slightly agree 5- Agree
		Collective character of decision-making	Q19	The project leaders consult and include those implementing the project in their decisions. It can be said that decision-making occurs collectively	1- Disagree 2- Slightly disagree 3- Neutral 4- Slightly agree 5- Agree
ICEEBE	**Substantive Outcomes (Klijn, Erik-Hans et al., 2010) or**	The innovative character of the solutions proposed to integrate Circularity and Energy Efficiency		The following have been identified in the literature as innovative ideas that could help to integrate Energy Efficiency and Circularity in the Built Environment. Please indicate the ones that your organization has developed, implemented,	

	Environmental effects to be achieved together (Persson, 2004)			promoted or somehow involved in as a result of the Agendas for Circularity.	
			Q20	1) Use of Passive Design Strategies	1- Disagree 2- Slightly disagree 3- Neutral 4- Slightly agree 5- Agree
			Q21	2) Use of Natural/ Biobased Materials for insulation	1- Disagree 2- Slightly disagree 3- Neutral 4- Slightly agree 5- Agree
			Q22	3) Incorporation of reused materials for Energy Efficiency	1- Disagree 2- Slightly disagree 3- Neutral 4- Slightly agree 5- Agree
			Q23	4) Incorporation of materials for energy efficiency that can be reused after demolition	1- Disagree 2- Slightly disagree 3- Neutral 4- Slightly agree 5- Agree
			Q24	5) Carbon-Negative or Carbon-Sink Materials (Sequester more than emit)	1- Disagree 2- Slightly disagree 3- Neutral 4- Slightly agree 5- Agree
			Q25	6) Upcycled/ Upcyclable materials for Energy Efficiency	1- Disagree 2- Slightly disagree 3- Neutral 4- Slightly agree 5- Agree
			Q26	7) Others	1- Disagree 2- Slightly disagree 3- Neutral 4- Slightly agree 5- Agree
		Impact of stakeholders in decision-making to affect the integration of Circularity and Energy Efficiency	Q27	In general, do you think that the involved actors have delivered a recognizable contribution to the development of the results?	1- Disagree 2- Slightly disagree 3- Neutral 4- Slightly agree 5- Agree
		Effectiveness of the solutions to integrate circularity and energy efficiency	Q28	Do you think that the solutions that have been developed help to integrate Circularity and Energy Efficiency?	1- Disagree 2- Slightly disagree 3- Neutral 4- Slightly agree 5- Agree
		Effectiveness in the future	Q29	Do you think that the solutions developed to integrate Circularity and Energy Efficiency are durable solutions for the future?	1- Disagree 2- Slightly disagree 3- Neutral 4- Slightly agree 5- Agree
		Cost-benefit relation to integrate Circularity and Energy Efficiency in the Built Environment	Q30	Do you think that, in general, the benefits exceed the costs of the cooperation process?	1- Disagree 2- Slightly disagree 3- Neutral 4- Slightly agree 5- Agree

Appendix 2: Interview Guide

Introduction

1- Welcoming

Hello! Thank you for your time today. I am a student of the master's in Urban Management and Development, at Erasmus University of Rotterdam.

2-Purpose of the interview

The purpose of this interview is to understand the experience of different actors who participated in Transition Networks for Circularity in the Built Environment. It intends to explore how the more recent Circularity has integrated with pre-existing strategies for Energy Efficiency and how participating in a Network influences that integration.

3-Duration of the interview, types of questions.

This interview is intended to last for approximately 45' minutes. If you feel like stopping at any time, you can also let me know and we will stop. It will include open and closed questions that invite you to express your thoughts and feelings about Networking for a Circular Built Environment. Please note that there are no right or wrong answers here. The only person that knows how your experience on this was is you; therefore, we can say that you are the only expert on it. In that regard, I will be learning from you and your thoughts.

4- Privacy and ethics

The outcomes of this interview, and any other materials that you share with me-if you do- will be used for the purposes of the qualitative research course at the university only. You will not be referred to in any way that allows the reader to identify you. The outcome will be stored in the cloud environment and accessed only by me and my supervisor and thesis readers. If you want, before submitting my analysis I can share it with you for your ultimate approval.

5- Consent

Before proceeding I need your permission to record this interview. Because we want to keep it anonymous, I am not going to mention your name at any time during the recording to protect your confidentiality. Is this ok with you?

6-Informed consent

Now that you know the purpose of this interview and the confidentiality, do you still consent to take part in it?

Do you consent to use the outcomes of this interview for research and education?

Please note that if at any time you change your mind we can stop and I will erase the recording.

Opening

1- How long have you worked in this organization?
2- What is your position?

Characteristics of the respondent

3- What type of organization do you work at? (Government, private, education, etc)
4- Do you hold a managerial position in that organization?
5- Have you implemented projects related to circularity in the Built Environment already? If yes, in which phase are you? (Initial ideas, planning, implementing, monitoring).
6- How does your role refer to Circularity in the Built Environment?

Identifying the Network

7- The initial contact with your organization relates to it being mentioned within the Signatories of the Raw Materials Agreement. Are you familiar with this agreement? Have you participated at the time it was signed?
   a. Can you tell me more about what has happened since then?
   b. Have the signatories of the agreement worked together in the years after signing it?
   c. If yes, go to specific questions about NGS. If not, asked about what happened.

8- Are you participating in any other Networks for Circularity in the Built Environment?

If yes, proceed with the questions below. If not, ask "Why you are not participating in any network?" and explore further: Do you see value in participating in a Network? Do you see explicit reasons not to participate? Have you been invited to participate in any? What was your response?

Network Governance Strategies

Based on the networks identified above:

Arranging

9- Has this network organized ad-hoc work groups to work around specific topics or issues?
   a. Have been public actors involved?
   b. Have been private actors involved?
   c. NGOs/NFPs?
   d. Educational/research institutions?

Process Agreement

10- Since you participate in this Network, have you seen stakeholders making agreements regarding how this Network will function?
   e. Are there rules to define how to enter or exit the organization?
   f. And to solve conflicts?
   g. Do the agreements made allow for flexibility when there is a need to deviate from the original plan?
   h. Do those agreements allow parties to withdraw to protect their interests if necessary?

Exploring content

11- When working on this network, how has the process of clarifying everyone's perceptions and looking for solutions developed?

i. Do you think that there's been enough attention to make different opinions visible a and included?
j. Has been enough attention to exchange different viewpoints?
k. And to establish common points?
l. Do you think there has been enough attention to involve other relevant parties to bring in new ideas?
m. Have new parties been sought at different/new stages?

Connecting

12- Can you tell me more about the process through which new parties were involved in the Network?
  n. Do you think there has been enough effort in bringing new parties to enrich this network?
  o. Has it been enough time devoted to these parties to communicate?
  p. Has the project leader considered pre-existing relationships between parties and persons? And how they are developed and are developing?
  q. Has the Network Manager helped to bring opposite interests together?
  r. Has there been enough consultation to different parties at times of decision-making?

Circularity and Energy Efficiency in the Built Environment

Circularity and Energy Efficiency are normally approached as different things. However, in the different stages of a building (like designing, constructing, using and demolishing) these two aspects will come together when looking to reduce CO2 emissions.

13- Do you think these two areas have to be approached together? Or that they should remain separate domains?
14- If yes, what are the ways in which you think that could be integrated?
15- Has your participation in a Network influenced how you approach this topic in practice? How?
16- Do you have an example in which circularity and energy efficiency are designed together?
17- These are some of the examples found in the literature through which Circularity and Energy Efficiency can be integrated. Please mention if they have been part of the Projects you've been involved in:
  s. Passive Design Strategies
  t. Natural/Biobased materials for insulation
  u. Reused/reusable materials for energy efficiency (Thermal storage/ Insulation)
18- Do you think that the solutions are durable solutions for the future?
19- Do you think that benefits exceeded the cost of the cooperation process?
20- What challenges do you see in integrating circularity and energy efficiency in the Built Environment? And what opportunities?
21- Do you think that participating in a Network helps to make progress in these topics?
22- Do you measure or estimate the reduction in GHG emissions produced by the implementation of circularity and energy efficiency?

Closing

Thanks for participating in this interview. Once the research is finished the results will be shared with participants. I appreciate your time and collaboration! Before finishing,

23- Is there anything you would like to add?

Appendix 3: Information on Plagiarism

(From the Examination Regulations 2022-2023 document, Annex 8: Fraud and plagiarism procedure.)

The purpose of this document is to briefly explain the fraud/plagiarism procedure at the Institute for Housing and Urban Development Studies (IHS), Erasmus University Rotterdam. It provides the definition of fraud and plagiarism and defines the steps that are followed if student is suspected of fraud or plagiarism.

Definition of fraud and plagiarism

Fraud and plagiarism involve acts as the result of which the assessment of student's performance, knowledge or skill is partially or totally hindered.

Fraud might be in many different forms such as ghost-writing, cheating during an exam, plagiarism, etc. The following acts are considered to be fraud:

1. Obtaining knowledge concerning the questions or tasks in an examination in advance;
2. Assuming another person's identity or having another person assume one's identity during a test;
3. Consulting sources of information or having them at hand (such as books, syllabi, notes written on paper or the student's skin or clothing, programmable calculators, mobile telephones, smartphones, and all other electronic devices that might contain information), the use of which is not explicitly permitted. Mobile telephones, smartphones, etc. Must be switched off and remain off during tests;
4. Copying other students' answers or exchanging any information whatsoever with them inside or outside the examination room during the test. Providing other students with the opportunity to commit fraud is also deemed to be fraud;
5. Changing the issued question forms and/or examination papers or exchanging them with other students and/or taking question forms and/or examination papers away with them and/or copying them without permission;
6. Making any changes to previously submitted examination answers during a subsequent inspection;
7. Committing plagiarism, which means the copying of a passage containing more than one or a few words from one's own or someone else's work, either literally or in translation, for an individual or group assignment, project, thesis or any other type of text that is part of an examination, without indicating this by quotation marks or similar unequivocal typographical means, even if a bibliographically traceable and correct source reference is included. Providing other students with the opportunity to commit plagiarism is also deemed to be fraud;
8. Making it partially or completely impossible to form an accurate opinion of the student's acquired knowledge, insight and skills by actions or omissions in any other way;
9. Assuming a different identity during compulsory educational meetings;
10. Being represented by a third party during compulsory educational meetings;
11. Collaborating on the report for an individual assignment without permission;
12. All other forms of misconduct.
13. The following are likewise prohibited:
14. Taking part in a test without being entitled to do so;
15. Making it partially or completely impossible in any other way to form an accurate opinion of the student's knowledge, insight and skills through deceitful actions or omissions.

Plagiarism is a specific form of fraud and involves the use of other's work with no proper referencing and acknowledgement.

For detailed information on steps to follow regarding cases of fraud/plagiarism, sanctions and fraud involved in online examination please refer to the Examination regulations 2021-2022, Annex 8.

Appendix 4: Privacy regulations: addressing the GDPR

It is important that students ensure they are using GDPR-safe options for their research:

1) When collecting data using a survey, avoid asking for personal data if that is not directly relevant for your research.
2) If you need to include the name and personal information from the interviewee, inform him/her about the inclusion of their name in the thesis and make sure they give their consent. This can be done with, e.g., a separate tick-box to consent to this (‘yes, my name can be included in the thesis’).
3) Inform the interviewee what will happen with their personal information.
4) We recommend using the Qualtrics software for surveys as it is GDPR compliant. Further, Qualtrics is covered by a campus-license and free for students.

Appendix 5: IHS copyright form

In order to allow the IHS Research Committee to select and publish the best UMD theses, students need to sign and hand in this copyright form to the course bureau together with their final thesis.

By signing this form, you agree that you are the sole author(s) of the work and that you have the right to transfer copyright to IHS, except for those items clearly cited or quoted in your work.

Criteria for publishing:

1. A summary of 400 words must be included in the thesis.
2. The number of pages for the thesis does not exceed the maximum word count.
3. The thesis is edited for English.

Please consider the length restrictions for the thesis. The Research Committee may elect not to publish very long and/or poorly written theses.

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