Analysis of the Dutch Mission-oriented Innovation System (MIS) for a natural gas-free built environment

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Student:
Kasper Baarends
5713439
k.baarends@students.uu.nl

Supervisor Utrecht University (UU):
Dr. Joeri Wesseling
j.h.wesseling@uu.nl

Supervisor Netherlands Enterprise Agency (RVO):
Dr. Jacques T.N. Kimman
jacques.kimman@rvo.nl

Supervisor Ministry of Economic Affairs & Climate Policy (EZK):
Pim van Leeuwen
p.vanleeuwen@minezk.nl

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Utrecht University

Netherlands Enterprise Agency

Ministry of Economic Affairs and Climate Policy

Abstract

This thesis applied the Mission-oriented Innovation System (MIS) framework on a case study in the Dutch built environment. It studies the mission "*disconnecting 1.5 million existing homes from natural gas by 2030*", which finds it origin in the Dutch Climate Agreement and the Integral Knowledge and Innovation Agenda (IKIA). This mission falls under the overarching mission for the built environment, known as Mission B: A carbon-neutral built environment in 2050 (Taakgroep Innovatie, 2019; Klimaatakkoord, 2019).

By following the five analytical steps of the MIS framework, (1) problem-solution diagnosis, (2) structural analysis, (3) functional analysis, (4) systemic barrier analysis, and (5) reflection (planned) mission governance actions, and by giving specific focus in these steps on the mission governance structure and its influences, the following research questions was answered: "*To what extent are the mission governance actions and mission governance structure adequately targeted on resolving the systemic barriers present in the Dutch Mission-oriented Innovation System of the built environment?*". A qualitative research approach was chosen, and data was collected through 30 interviews with various stakeholders involved in the studied mission, desk research of policy documents, academic literature, reports, and relevant websites, and by consulting experts within the internship organisation.

Based on the data analysis, a total of six systemic barriers and their interrelatedness with weak system functions were identified: (i) municipalities experience difficulties in fulfilling their governing role in the district-oriented approach, (ii) missing central steering on the execution of the mission, (iii) bias for technological development and innovation, (iv) fragmented character built environment sector, (v) innovations experience difficulties in scaling up, (vi) difficulty in mobilising homeowners to take sustainable measures. The assessment of the adequateness of the (planned) mission governance actions targeting the these identified barriers showed that although some barriers are addressed by mission governance actions, its effectiveness remains questionable. To improve the adequateness and effectiveness of the mission governance actions, recommendations and focus point have been proposed which should be incorporated or address in (re)designing policy. Furthermore, to minimise the effects the governance structure has on the progress of the mission, it is crucial to improve the coordination, interplay, and feedback mechanisms between the different levels (local, regional, national).

Keywords: Mission-oriented Innovation Policy (MIP), Mission-oriented Innovation System (MIS), built environment, natural gas-free, mission governance, systemic barriers, policy evaluation

Table of Contents

List of tables

List of figures

1. Introduction

Modern society is increasingly dealing with the questions on how to respond to major social, environmental, and economic challenges, also referred to as 'grand challenges', to mitigate its threats. As pointed out by Mazzucato (2018) these challenges are "*wicked in the sense that they are complex, systemic, interconnected, and urgent, requiring insights from many perspective*" (p. 803). In the last decade, governments have recognized the need to better align innovation with social and environmental challenges giving rise to a 'third generation' of innovation policy aimed at overcoming societal challenges (Schot & Steinmueller, 2018; Mazzucato, 2018; Wanzenböck, et al., 2020). Scholars have labelled this third generation as 'transformative innovation policy' (TIP) (Schot & Steinmueller, 2018) or 'challenge-led, Mission-oriented Innovation Policy' (MIP) (Wanzenböck, et al., 2020).

In the policy domain, MIP has rapidly gained interest and has distinguished itself from TIP by its explicit focus on providing directionality through ambitious, actionable, measurable, and time-bound goals (Mazzucato, 2018; Wesseling & Meijerhof, 2021). The aim of MIP is "*to accelerate progress in solving societal challenges, by shaping the direction and supporting the diffusion and embedding of innovations in society*" (Wanzenböck, et al., 2020, p. 481). Missions are increasingly being adopted and translated into policy strategies, due to its capability of driving transformations in various ways. Transformative missions have "*the promise of engendering dynamics of mobilisation (of resources, actors, and institutions) and innovation around a goal, which are otherwise unachievable, uncoordinated, or too slow*" (Janssen, et al., 2021, p. 439). Furthermore, transformative missions require socio-technical transformation ('destabilizing' of the old), substantial governance, and the involvement of multiple stakeholders besides the government (Janssen, et al., 2021; Wesseling & Meijerhof, 2021; Larrue, 2021). Theoretically, MIP has shown to be a promising way to address grand (societal) challenges, however in practice it is still understudied. A framework is needed which allows to (re)design policy and governance interventions to be more effective, by gaining a deeper understanding of the innovation dynamics that contribute to completing a societal mission (Hekkert, et al., 2020; Wesseling & Meijerhof, 2021).

In response to this, a framework called the *Mission-oriented Innovation System* (MIS) has been developed (Hekkert, et al., 2020). Wesseling & Meijerhof (2021) have defined the MIS as "*a temporary (semi-coherent) configuration of different innovation system structures that effect the development and diffusion of solutions to a mission that is defined and governed by a mission arena of different stakeholders*" (p. 3). The MIS approach consists of a problem-solution diagnosis, a structural, functional, and systemic barriers analysis which shed light on the innovation system dynamics of a mission (Wesseling & Meijerhof, 2021). The identified barriers are contrasted with the mission governance actions to evaluate if the mission governance actions, which are measures aimed at achieving a mission's goal, are adequately targeted at removing the systemic barriers. This allows for recommendations on how to design more effective mission governance actions. However, this approach has until now only been applied once in a working paper about the Dutch Green Deal mission on sustainable maritime transportation (Wesseling & Meijerhof, 2021). Furthermore, the MIP literatures points out that each mission is unique and can vary along different dimensions (Mazzucato, 2018; Janssen, et al., 2021). Therefore, to build theory on how different missions impact the MIS dynamics and to test the applicability of the MIS framework, the framework should be applied on different types of missions (Wesseling & Meijerhof, 2021).

As can be seen from the MIS definition, Wesseling & Meijerhof (2021) make use of a concept called the *mission arena* and define it as "*those actors that are engaged in the highly political, and often heavily contested process of mission governance, which we describe as mobilizing, directing and aligning existing innovation system structures into a semi-coherent ensemble that aims to pursue the mission*" (p. 7). This concept is the most distinguishing feature of the MIS compared to other Innovation System frameworks, since it conceptualises a governance body/arrangement that gives direction to the wider IS and tries to mobilise it. The governance structure strongly influences the directionality and coordination provided to the MIS and how different actors are mobilized, thereby making it a key element in the success of achieving the mission (Janssen, et al., 2021; Wesseling, et al., 2020). However, little is known about how to set up this governance structure. To address this gap, this research extends the mission arena concept, in particular the mission governance task '*setting up the arena'*, with insights from the governance literature. Based on the governance theories found in the literature, a selection of relevant governance structures, their attributes, strengths, and weaknesses has been made. These insights were used to assess if the chosen governance structure suits the mission and to provide recommendations on how it could be improved.

In addition, by analysing a case study in the Dutch built environment domain, this research has added to the understanding on how different dimensions can influence mission dynamics. Making the built environment sustainable is relatively wicked due to two important factors. Firstly, the built environment sector consists of a broad array of actors operating in different domains (e.g., electricity, heat, construction, urban planning). Secondly, the built environment consists of millions of homeowners which each have the right to decide for themselves what happens to their house and have their own rationales in making these decisions. Therefore, the process of making the built environment more sustainable is strongly influenced by individual behaviour and local context. Furthermore, the energy consumption of the built environment sector accounts for approximately 34% of the total national energy consumption, making it the sector with the largest energy consumption (Regionale Klimaatmonitor, 2022), and was in 2020 responsible for 13% (21,6 Mt) of total national CO_2-emissions (Rijkswaterstaat, 2022; RVO, 2020; CBS, 2021; Topsector Energie, 2015). Most of this energy consumption is used for heat supply in the built environment, of which 76% is generated by natural gas (in 2019) (RVO, 2020a; Regionale Klimaatmonitor, 2022). To give substance to the Paris Climate Agreement, the Netherlands has set up the Climate Agreement. This is an agreement between many organisations and companies in the Netherlands to combat the mission of greenhouse gases.

The Integral Knowledge and Innovation Agenda (IKIA), which have been drawn up parallel with the Climate Agreement, has translated the commitments into overarching missions for 2050 and sub-missions for 2030 (Taakgroep Innovatie, 2019). In this research the mission "*disconnecting 1.5 million existing homes from natural gas by 2030*" is central, which is a part of the overarching mission of a carbon-neutral built environment in 2050 (Klimaatakkoord, 2019; Topsector Energie, 2020). Since this mission was established in 2019 (Ministerie van Economische Zaken en Klimaat, 2019) and the related policy has been implemented for some time, the MIS can be used to evaluate, ex-durante, the adequateness of it. To learn new empirical lessons about applying MIS and the influences of the mission governance structure, the following research questions has been formulated:

"*To what extent are the mission governance actions and mission governance structure adequately targeted on resolving the systemic barriers present in the Dutch Mission-oriented Innovation System of the built environment?"*

As a guide to answering this research question, several sub-questions based on the analytical steps of the MIS have been formulated (Wesseling & Meijerhof, 2021). These sub-questions can be found in the methods section. By answering the research question and the sub-questions, this research adds relevant scientific knowledge to the growing body of MIS literature on two aspects. First, it tests the applicability of the MIS framework by applying it to a new case, which is also the first case study in the built environment sector. Second, a first step is taken to extend the mission arena concept using literature on governance theories and gaining insights in the dynamics of the mission governance structure. Furthermore, MIS offers a method to identify systemic barriers and assess and improve the mission governance actions, making the results useful for policy makers to accelerate the sustainability in the built environment.

This thesis is structured as followed. First, the theoretical foundation of the MIS framework and its theoretical context is explained. Second, the methodology section described the research approach. Third, the results section describes the relevant societal problems and technological and social solutions to the mission, the structure of the innovation system, the performance of the innovation system, the identified systemic barriers, and the adequateness of the mission governance actions. Lastly, the results and method will be discussed after which this thesis will be concluded by answering the research questions.

2. Theory

2.1 Innovation systems

The innovation system literature provides frameworks that can be used to analyse innovation dynamics. The concept of Innovation Systems (IS) was first introduced by Lundvall (1985) and can be defined as "*all important economic, social, political, organisational, institutional, and other factors that influence the development, diffusion, and use of innovations*" (Edquist, 2006, p. 1). A system consists of *components, relationships*, and *attributes* (Carlsson, et al., 2002). The components are the operating parts of a system consisting of *actors or organisations* (e.g., individuals, firms, universities, etc.), *physical or technological artifacts* (e.g., transmission lines, etc.), and *institutions* (e.g., laws, social norms and values, etc.) (Carlsson, et al., 2002). The interactions between the components are the *relationships* and determine how dynamic the system is. Highly dynamic systems are characterised by a great number of interactions, however, even highly dynamic systems need to evolve in the right direction to be able to survive. The *attributes* are the properties of the components and the relationships between them, which characterises the system (Carlsson, et al., 2002). The features critical for understanding the system are related to the function or purpose served by that same system (Carlsson, et al., 2002). Taking the innovation systems perspective, the function of the system is "*to generate, diffuse, and utilize technology*" (p. 235) and therefore its main features are "*the capabilities of the actors to generate, diffuse, and utilize technologies (physical artifacts as well as technical know-how) that have economic value*" (Carlsson, et al., 2002, p. 235).

Over the last decades, several innovation system theories were developed each having a different type of delineation. The National Innovation System (NIS) and the Regional Innovation System (RIS) are both geographically delineated by, respectively, the borders of a country or a region (Lundvall, et al., 1988; Asheim, et al., 2011). The Sectoral System of Innovation (SSI) is delineated by a specific sector (Malerba, 2002), and the Technological Innovation System (TIS) by a certain technology (Hekkert, et al., 2007). The characteristics of the TIS can be considered unique since its delineation can both gross geographical areas as well as sectors. However, none of these IS frameworks are sufficiently equipped to comprehend innovation dynamics related to societal challenges (Hekkert, Janssen, Wesseling, & Negro, 2020; Ghazinoory, et al., 2020).

2.2 Mission-oriented Innovation Policy (MIP)

Wanzenböck et al. (2020) define MIP as "*a directional policy that starts from the perspective of a societal problem and focuses on the formulation and implementation of a goal-oriented strategy by acknowledging the degree of wickedness of the underlying challenges, and the active role of policy in ensuring coordinated action and legitimacy of both problems and innovative solutions across multiple actors*" (p. 476). As mentioned earlier, MIP has gained interest in the policy arena and has been considered promising. However, to understand and systematically assess the impact of MIP, a systems perspective is needed to achieve a comprehensive level of understanding of the innovation dynamics that missions and supportive governance actions bring about (Ghazinoory, et al., 2020; Haddad & Bergek, 2020; Hekkert, et al., 2020). In response to this, Hekkert et al. (2020) have called for a new perspective, named the *Mission-oriented Innovation System* (MIS).

Wesseling & Meijerhof (2021) have laid out several challenges when studying missions from a systems perspective: the *wickedness and transformative nature of mission*, the *temporality and embeddedness of missions*, and the *directionality of missions*. The societal problems tackled by a mission and the solutions to these problems tend both to be wicked, meaning they are contested, highly complex and involve uncertainty (Wanzenböck, et al., 2020). Furthermore, the technologically and socially innovative solutions required for a MIS do not only include the development and implementation of the 'new', but also the destabilization of existing 'old' problematic practices and technologies (Wesseling & Meijerhof, 2021; Kivimaa & Kern, 2016). In contrary to other IS frameworks, a MIS is characterised by its temporarily due to the time-bound nature of missions' goals (Mazzucato, 2018). Meaning a MIS emerges once the mission is formulated and ends when the mission is completed, or when time has run out. Missions are embedded within and aim to build on problems and solutions that have already been legitimized and framed in other existing innovation structures (regional, sectoral, national, and technological) by mobilizing available system resources (Frenken, 2017). Hence, the functioning of a MIS is strongly dependent on the structural components (i.e., the actors, institutions, networks, and materiality) on which it builds (Wesseling & Meijerhof, 2021). The directionality provided by MIP influences and shapes the sets of technological and social solutions, or solution pathways that emerge. To safeguard the directionality and to prevent the exclusion of potentially valuable (sets of) solutions or solution pathways, critical and timely reflexivity and coordination are needed (Wesseling & Meijerhof, 2021).

2.3 Mission-oriented Innovation System (MIS)

In line with the abovementioned challenges, Wesseling & Meijerhof (2021) have defined the MIS as "*a temporary (semi-coherent) configuration of different innovation system structures that effect the development and diffusion of solutions to a mission that is defined and governed by a mission arena of different stakeholders*" (p. 3). The mission arena is consisted of "*those actors that are engaged in the highly political, and often heavily contested process of mission governance*" (p. 3) and aims to mobilise, direct, and align the existing innovation systems into a well-functioning MIS which pursues the mission (Wesseling & Meijerhof, 2021).

Wesseling & Meijerhof (2021) have developed an initial approach to studying MIS, by building on the structural-functional approach of the TIS and including the transitions, governance, and MIP literature. The approach consists of five analytical steps and aims to identify the systemic barriers that hamper the functioning of the MIS, assess the adequateness of the mission governance actions on tackling these systemic barriers, and ultimately to provide recommendations for more effective mission governance (Wesseling & Meijerhof, 2021).

2.3.1 Problem-solution diagnosis

The focus of a mission is typically on a single societal problem (Mazzucato, 2018; Wanzenböck, et al., 2020) (i.e., CO_2-emission reduction), however also other societal problems are involved via framework conditions which influence the inclusion of certain solutions (Wesseling & Meijerhof, 2021). Therefore, it is of importance to get a clear understanding of the societal problems and solutions involved in the mission. Hence, first the full scope and complexity of the mission needs to be mapped out (Wesseling & Meijerhof, 2021). Two types of directionalities are of relevance, namely the *problem-directionality* and *solution-directionality*. Wesseling & Meijerhof (2021) defines these as "*the way the different societal problems are included and prioritized in the mission formulation*" (p. 6) and "*those factors that determine how stakeholders search for and invest in the solutions they deem promising for fulfilling the mission*" (p. 6), respectively. The solution-directionality is strongly influenced by the problem-directionality, since the prioritisation and inclusion of certain societal problems affects what solutions are relevant for the mission. After having identified the different societal problems involved in the mission, an overview of both technological and social innovations relevant for achieving the mission can be compiled.

2.3.2 Structural analysis

As mentioned earlier, the functioning of a MIS strongly depends on its structural components. Wesseling & Meijerhof (2021) use the concepts of *mission arena* and *overall MIS* to make a delineation between what is part of the MIS and what is not. The overall MIS consists of "*those actors, networks, institutions, and materiality that effect the rate and direction of both technologically and socially innovative solutions to the mission, including both supportive and opposing forces of change*" (Wesseling & Meijerhof, 2021, p. 9). The effect of these structural components on the innovative mission solutions can be directly or indirectly, purposefully or inadvertently, for the purpose of mission's progress or other purposes.

2.3.2.1 Mission Arena

Wesseling & Meijerhof (2021) define the mission arena as "*those actors that are engaged in the highly political, and often heavily contested process of mission governance*" (p. 7) and mission governance as "*the process of providing directionality and mobilizing and aligning existing innovation system structures into a semi-coherent ensemble that aims to pursue the mission*" (p. 7). The mission arena actors play a central directing and system building role in the MIS and aim to activate or mobilize the actors in the overall MIS. When successful, the MIS become more structured meaning that institutions become more institutionalized, actors from the overall MIS become more dedicated to the mission, and solutions are being better developed and diffused. There are four main tasks to mission governance in which the mission arena actors can be involved: (1) *setting up the mission arena*, (2) *mission formulation*, (3) *mobilization of MIS components via mission governance actions*, and (4) *continued reflexive mission governance* (Wesseling & Meijerhof, 2021). A description of the mission governance tasks is presented in table 1.

Table 1. Description of the main mission governance tasks. Adapted from Wesseling & Meijerhof (2021).

Mission governance tasks	Description
Setting up the mission arena	The process in which the mission governance structure is decided. Relevant governance structures/arrangements and theories are mentioned in table 2 and 3, respectively.
Mission formulation	The prioritization of societal problem(s) and translating them into an ambitious and actionable mission that will provide direction to the overall MIS. The mission goals will typically oppose the expectations and visions of regime actors, leading to conflict with powerful vested interests who stand to lose.
Mobilization of MIS components via mission governance actions	Creating an overall mission agenda or action plan of not only the activities that existing innovation system structures need to pursue, but also of governance actions that incentivize and enable these structures to undertake such activities.
Continued reflexive mission governance	Making sure the progress of the mission is monitored and evaluated; reflecting on how the translation of different interacting solutions into solution pathways is coordinated; reformulation and redirection of the MIS if it no longer captures the most relevant societal problem(s); mission governance actions are adapted, or existing institutions changed, if the solution pathways developed are evaluated as inadequate in relation to the mission goal.

2.3.2.2 Extending the Mission Arena concept with governance literature

Although the *mission arena* concept is useful in delineating the actors engaged in mission governance, little is known about how to set up the mission governance structure in the context of a mission (Wesseling & Meijerhof, 2021; Janssen, et al., 2021). Specifically, this corresponds to the mission governance task '*setting up the mission arena*' in which the governance structure is decided. The chosen governance structure strongly influences the directionality and coordination provided to the MIS and how different actors are mobilized (Janssen, et al., 2021; Wesseling, et al., 2020). MIPO's ongoing mission work[1] have identified several coordination problems that may arise when working with missions, such as power relations between partners; coordination and prioritization between

[1] The Mission-oriented Innovation Policy Observatory (MIPO) is an initiative by the Copernicus Institute for Sustainable Development and engages in various events, webinars, workshops, and studies to enhance the understanding, monitoring, and effective use of challenge-based innovation missions (Copernicus Institute of Sustainable Development, 2022).

missions; vertical coordination problems (municipal, regional, national); stakeholder involvement and commitment issues; committing ministries beyond their individual agendas to prevent fragmented policies (Wesseling, et al., 2020). It is therefore of importance to have the right governance structure that minimises coordination problems and contributes to the mission's success.

In the last decades, the use of the concept of governance has increased and gained much interest in the field of political and social science. However, there is no uniform definition and no such thing as one commonly agreed upon and clearly delineated theory of governance (Arnouts, et al., 2012; Qiao, et al., 2018). To clarify the concept of governance, scholars have defined various governance modes, which "*refers to a certain logic and form through which governance can be realized*" (Pahl-Wostl, 2019, p. 6; Treib, et al., 2007). Traditionally, governance has mainly been carried out by governmental actors in a hierarchical way. However, nowadays also non-governmental and private actors are being involved in the governance process. Based on the work of Kooiman (2003), Arnouts, et al. (2012) made a classification between four types of governance modes each differing in the extent to which governmental and non-governmental actors are involved. They further operationalised these modes in terms of *power* and *rules of the game*, resulting in four ideal-type of governance arrangements as presented in table 2 (Arnouts, et al., 2012).

Underlying this typology are the various governance theories that have emerged from different movements within the governance literature (e.g., public governance, environmental governance, corporate governance, etc.). As the governance literature is extremely broad, only the most common modern approaches to governance are discussed. This has resulted in three main governance theories, which are described based on their attributes, strengths, and weaknesses in table 3. These theories each conceptualise in different ways on how the governance structures should be set up regarding (a) the interactions between the actors, jurisdictions, different levels, (b) how it is designed, organised, and orchestrated, (c) the role of public, private, and civil society actors played in the governing processes, and (d) the dispersion of power (Ansell & Torfing, 2016). In this research, the theoretical insights of the governance literature (table 2 and 3) will be used to identify the mission governance structure and to provide recommendations on how it could be improved to enhance mission governance.

Table 2. Four ideal-type of governance arrangements. Adapted from Arnouts, et al. (2012), except of the italic part.

	Governance arrangement type			
	Hierarchical	**Closed co-governance**	**Open co-governance**	**Self-governance**
Actors	Mainly governmental actors	Select mixed group of actors	Large mixed group of actors	Mainly non-governmental actors
Power	With government	Pooled	Diffused	With non-government
Rules of the game	Governmental coercion	Restricted cooperation	Flexible collaboration	Non-governmental forerunning
Governance theory	*Monocentric*	*Multi-level (Type 1)*	*Multi-level (Type 2)*	*Network and collaborative governance*
		Polycentric		

Table 3. Overview governance theories, their attributes, strengths, and weaknesses.

Governance theories	Attributes	Strengths	Weaknesses
Polycentric governance: a governance structure in which there are *multiple centres of decision making* that are formally *independent* of each other and coordinated by an overarching system of rules (Pahl-Wostl & Knieper, 2014; Ostrom, et al., 1961) .	• Existence of multiple centres of decision making which are formally independent of each other (Van Zeben, 2019; Ostrom, et al., 1961) • The presence of continued competition, cooperation, and conflict resolution between the centres of decision making (Van Zeben, 2019) • Coordinated by an overarching system of rules (Pahl-Wostl & Knieper, 2014)	• Provides opportunities for experimentation and learning to improve policies over time (Monkelbaan, 2019) • Enables broader levels of participation (multilevel, multipurpose, multisectoral, and multifunctional) which helps to capitalize on scale-specific knowledge and enhances knowledge sharing (Schoon, et al. 2015; Olsson, et al. 2004) • Enhanced adaptive capacity[2] if decision-making centres consider the successes and failures of others and learn from them (Pahl-Wostl & Knieper, 2014; Carlisle & Gruby, 2019) • Builds redundancy that can minimize and correct errors in governance (Partelow, et al., 2020; Schoon, et al., 2015) • Creates modularity, which allows governance bodies to reduce exposure to failures and losses of collaborators through a degree of independence (Schoon, et al. 2015) • Tends to enhance innovation, learning, adaptation, trustworthiness, levels of cooperation of participants, and the achievement of more effective equitable, and sustainable outcomes at multiple scales (Ostrom E. , 2010)	• Need to balance redundancy and experimentation with inefficiencies resulting from both overlapping authority and increasing transaction costs (Schoon, et al., 2015) • Degradation of the governance system when certain actors can externalize trade-offs from their area of interest (Schoon, et al., 2015) • Polycentric governance structures tend to be more complex, leading to increased transaction costs • Lack of accountability (Monkelbaan, 2019) • Possibility to free ride on the efforts of others (Pahl-Wostl & Knieper, 2014)
Multi-level governance: a governance structures in which the power is distributed *vertically* between *many levels of government* and *horizontally* between governmental, quasi-	• Vertical and horizontal dispersion of power (Cairney, et al., 2019) • Governance across multiple jurisdictions	• Multi-level governance can capture the variations in the territorial reach of policy externalities which can be internalized in decision-making to increase efficiency (Hooghe & Marks, 2003; Marks & Hooghe, 2004)	• *Coordination needed*: since one jurisdiction can have spill overs (i.e., negative, or positive) to other jurisdictions, coordination is needed to avoid unwanted outcomes (Hooghe & Marks, 2003)

[2] Pahl-Wostl (2009) defines adaptive capacity as "*the ability of a resource governance system to first alter processes and if required convert structural elements as response to experienced or expected changes in the societal or natural environment*" (p. 355).

governmental, and non-governmental actors (Cairney, et al., 2019)	• Two types of multi-level governance (Hooghe & Marks, 2003; Marks & Hooghe, 2004): o *Type 1*: dispersion of authority is limited to a limited number of non-overlapping jurisdictional boundaries at a limited number of levels resulting in a relatively stable authority, and o *Type II*: a complex, fluid, patchwork of innumerable, overlapping jurisdictions, which tend to be flexible as demand for governance change	• *Scale flexibility*: jurisdictions can be custom designed in response to externalities, economies of scale, niches, and preferences (Hooghe & Marks, 2003; Marks & Hooghe, 2004) • Multi-level jurisdictions can better reflect heterogeneity of preferences among citizens (Hooghe & Marks, 2003; Marks & Hooghe, 2004) • Multiple jurisdictions can facilitate credible policy commitments (Marks & Hooghe, 2004) • Multiple jurisdictions allow for jurisdictional competition, meaning they can economically compete which other by adopting more favourable policies (Marks & Hooghe, 2004)	• The more jurisdictions, the higher the costs are to coordinate these jurisdictions (Hooghe & Marks, 2001) • The more jurisdictions, the lower the scale-economies of policy making. Similar policies are repeated across multiple jurisdictions, making them inefficient to organise • The central state is still an important shaper of post-decisional politics and a powerful post-decisional gate keeper (Fairbrass & Jordan, 2004)
Network and collaborative governance: *self-organizing* interorganizational networks characterised by: independencies between organisations; continuing interactions among members caused by the need to exchange resources and negotiate shared objectives; game-like interactions rooted in trust and regulated by rules negotiated and agreed by network participants; and a significant degree of *autonomy from the state* (Ojo & Mellouli, 2018, p. 107).	• Horizontally organized • Diverse variety of actors from different sectors which are interdependent but autonomous. They are interdependent on each other's resources and capacity to solve problems, but are autonomous in the sense that they are not subject to a hierarchical structure (Torfing, 2005; Monkelbaan, 2019; Ojo & Mellouli, 2018) • Collaboration marks all aspects of decision-making and implementation (Ansell & Gash, 2008; Gerlak & Heikkila, 2006)	• The diverse variety of actors bring a wide array of different resources to the table, which can be aggregated towards a solution (Ojo & Mellouli, 2018; Sørensen & Torfing, 2007) • Enhanced flexibility, adaptability, and efficiency due to the inclusion of different perspectives and thinkers (Monkelbaan, 2019; Bogason & Musso, 2006) • Connections in governance processes between involved actors (Partelow, et al., 2020) • Allows to govern when a clear mandate or political support to govern is absent, which makes it independent from the (possible) fickleness of the political arena	• Extensive networking is needed to achieve satisfactory outcomes, which requires a considerable investment of time, effort, and costs (Keast, 2016; Church, et al., 2003) • Networks consists of a wide variety of actors which have divergent interests and perspective resulting in complex interactions (Klijn & Koppenjan, 2012) • Stagnation can occur when both pioneers and incumbents are part of the network and cannot overcome their fundamentally different interests and views (Janssen, et al., 2021) • Transparency and accountability issues could arise when decision-making and actions are not made public or visible (Keast, 2016)

2.3.3 Functional analysis
The performance of an innovation system can be determined based on system functions or '*key innovation activities'* as defined by Hekkert al. al (2007). Although these system functions are mainly used to study a technological innovation system (TIS), other research has shown that the system functions are generic enough to also apply to innovation systems with other characteristics (Wesseling & Van der Vooren, 2017; Haddad & Bergek, 2020; Ghazinoory, et al., 2020). However, to be able to apply the system functions approach in the context of a MIS, several MIP-specific challenges should be accounted for.

The mission arena plays a central directing and system building role in the MIS and hence it influences the directionality (SF4) in which existing innovation system structures develop and diffuse innovations. This directionality needs to capture both the *problem* side (SF4a) and the *solution* side (S4b). Furthermore, the directionality is also influence through the monitoring and evaluation of the mission's progress, which could readjust the problem- and solution-directionality. Therefore, *reflexive* governance (SF4c) needs to be included. In addition, the mission solutions do not only consist of implementing the 'new', but also of phasing-out the 'old' practices and technologies. To capture both these process, the destabilizing counterpart of the system functions market formation, resource allocation, and creation of legitimacy needs to be included. Resulting in the adjusted system functions: *market formation and destabilisation* (SF5), *resource (re)allocation* (SF6), and *creation and withdrawal of legitimacy* (SF7). An overview of the MIS system functions can be found in table 4.

Table 4. Description of the system functions for the MIS. Adapted from Wesseling and Meijerhof (2021).

System function		**MIS interpretation**
SF1: Entrepreneurial activities		Experiments with (clusters of) solutions to enable learning; entering markets for new solutions; engaging in business model innovations to foster the diffusion of solutions
SF2: Knowledge development		Learning by searching and by 'doing', resulting in development and better understanding of new technical and social knowledge on problems and solutions, through R&D, social and behavioural science research
SF3: Knowledge diffusion		Stakeholder meetings, conferences, governance structures, public consultations, mission progress reports and other forms of disseminating technical and social knowledge for the mission's solutions and societal problems
SF4: Providing directionality	SF4a: Problem directionality	The direction provided to stakeholders' societal problem conceptions and the level of priority they give it
	SF4b: Solution directionality	The direction provided, both by existing system structures and the mission arena, to the search for new and further development of existing technological and social solutions, as well as the coordination effects needed to identify, select, and exploit synergetic sets of solutions to the mission
	SF4c: Reflexive governance	Reflexive deliberation, monitoring, anticipation, evaluation, and impact assessment procedures, which provides the analytical and forward-looking basis for redirecting the system's problem framing and search for solutions based on lessons learned and changing context. It can be seen as second order directionality. Reflexive governance can be initiated by the mission arena or by critical outsiders

SF5: Market formation and destabilisation	Creating niche market and upscaling support for technical and social solutions; phasing out or destabilizing markets for practices and technologies harmful to the mission
SF6: Resources (re)allocation	Mobilization of human, financial, and material resources to enable all other system functions
SF7: Creation and withdrawal of legitimacy	Creating legitimacy for prioritizing (a) the problem and (b) the development and diffusion of its solutions, at the costs of harmful practices and technologies

2.3.4 Systemic barrier analysis

The functioning and development of an innovation system is hampered by so called systemic barriers, which are "*structural components (actors, networks, institutions or materiality) that are missing or unable to support the system functions*" (Wesseling & Meijerhof, 2021, p. 14; Wieczorek & Hekkert, 2012). As innovation systems mature, the interactions between the system's structural components increases, causing them to become more aligned and interdependent. The interdependence of the structural components leads to different, interrelated systemic barriers, which in turn may result in systemic lock-in (Wesseling & Van der Vooren, 2017).

2.3.5 Reflection mission arena's (planned) mission governance actions

To address the systemic barriers that hinder the development of the innovation system, policy or governance actions that target the most root causes of the barriers are needed (Wesseling & Van der Vooren, 2017). The innovation systems literature refers to those actions as *systemic instruments* (Smits & Kuhlmann, 2004). In the context of the MIS, the *mission governance actions* committed by the mission arena actors in support of the mission's pursuit are considered the systemic instruments (Wesseling & Meijerhof, 2021). The mission governance actions will be assessed to see if they are adequately targeted on resolving all of the MIS barriers to effectively increase the performance of the MIS. This assessment allows to provide recommendations for more effective mission governance.

3. Methods

3.1 Research design

This research has employed a qualitative case study approach (Bryman, 2012). The five analytical steps as described in the theory section have been followed to answer the research question.

3.1.1 Case description

In 2019, the Dutch Climate Agreement (in Dutch: *Klimaatakkoord*) has been established and signed by 76 parties, in which the signatories have agreed on reducing the CO_2-emissions by 49% in 2030 and by 95% in 2050[3] (Klimaatakkoord, 2020). In total, over 600 agreements across five different sectors[4] have been made. In accordance with the Climate Agreement, an Integral Knowledge and Innovation Agenda (IKIA) has been drawn up. This agenda has translated the objectives of the climate agreement into an overarching mission for each of the sectors for 2050 and several sub-missions for 2030. For the built environment, this resulted in the overarching mission '*a carbon-neutral built environment in 2050*', and the several sub-missions for 2030 (a) achieve a pace of disconnecting 200,00 existing homes from natural gas annually, (b) disconnecting 1.5 million existing homes and 15 percent of utility buildings and social real estate from natural gas, and (c) at least 20 percent of the local energy use (including electric transport) is generated sustainably (Taakgroep Innovatie, 2019). As mentioned earlier, to reduce the complexity and keep the research manageable, this research will focus on the sub-mission: "*disconnecting 1.5 million existing homes from fossil natural gas by 2030*".

3.1.2 Analytical steps

The five analytical steps as described in the theory section will be followed to answer the research questions. An overview of the operationalisation of these steps and formulated sub-questions is presented in table 5.

3.2 Data collection

Data has been collected through desk research, expert consultations, and interviews. For the desk research, academic literature, documents, repots, and publications were the main sources of date used. This data has been obtained from sources such as Google Scholar, Web of Science (WoS), Scopus, the Ministry of Economic Affairs and Climate Policy, the Ministry of the Interior and Kingdom Relations, the Netherlands Enterprise Agency, the Topsector Energy and TKI Urban energy, and other relevant actors active in the Dutch built environment sector. The interview data has been collected through diagnostic questions which have been used to operationalise and guide the concepts of the five analyses of the MIS. Furthermore, experts within the internship organisation, the Netherlands Enterprise Agency, have been consulted to gain a deeper understanding of certain topics and reflect on the gathered insights.

3.2.1 Sampling strategy interviews

The sample for the interviews has been constructed by purposive sampling. This sampling strategy is a non-probability form of sampling in which particular settings, persons, or events are deliberately selected to ensure those sampled are relevant for the opposed research questions (Bryman, 2012; Maxwell, 2012). In addition, the sample will be strength via a snowball sampling strategy to ensure overlooked relevant actors are also included (Bryman, 2012). The purposive sample has been drawn based on the structural elements of an innovation system (see table 6), to be able to draw a representative sample of the actors in the innovation system.

[3] Compared to 1990 values.

[4] These five sectors are: electricity, industry, built environment, mobility, and agriculture and land use.

Table 5. Operationalisation of the analytical steps and formulated sub-questions (Wesseling & Meijerhof, 2021; Bergek, et al., 2015; Bergek, et al., 2008).

Analytical step	Concept	Indicators	Sub-questions
1. Problem-solution diagnosis	Problem-directionality	Societal problems and 'wants' related to the mission.	How do different societal problems and 'wants' relate to the mission?
	Solution-directionality	Technological and social solutions relevant to the mission.	What technological and social solutions are relevant to the mission?
2. Structural analysis	Mission arena actors	Actors involved in one of the four mission governance tasks (as mentioned in table 1).	What actors are part of the mission arena and contribute to (a) the mission formulation, (b) setting up the mission arena, (c) mobilising other MIS components in pursuit of the mission, and (d) the continued governance of the mission?
	Overall MIS actors	Actors that affect the rate and direction of innovative solutions to the mission, including both supportive and opposing forces of change.	What actors, networks, institutions, and materiality support the development and diffusion of the mission's solutions, including the phase-out of harmful goods and practices?
	Institutions	*Hard*: rules, laws, regulations, instructions *Soft*: customs, common habits, routines, established practices, traditions, ways of conduct, norms and values, expectations, etc	
	Networks	Informal and formal networks; standardization networks, technology platform consortia, public-private partnerships, buyer-seller relationships, university-industry links, social communities, professional networks, etc.	
	Materiality	Artefacts, instruments, machines, roads, buildings, bridges, harbours, etc.	
	Mission governance structure	The governance structure will be identified based on the characteristics described in table 2 and the theories described in table 3.	What kind of mission governance structure can be identified?

3. Functional analysis	The system functions as described in table 4 will be used to operationalise this analysis. Based on diagnostic questions, the performance of the system functions will be assessed to identify weaknesses in the system's performance.	What are weak performing system functions hampering the mission?
4. Systemic barrier analysis	Structural components (actors, networks, institutions, or materiality) that are missing or unable to support the system functions in relation to the system functions they influence.	What are the systemic barriers underlying the weak system functions thereby inhibiting mission success? How do the systemic barrier interrelate?
5. Reflection mission governance actions and mission governance structure	To assess whether all MIS barriers are adequately targeted, there are compared with the current and planned mission governance actions. The mission governance structure is assessed whether it provides sufficient directionality and coordination to the MIS.	Which current and planned mission governance actions can be identified? Do the mission governance actions adequately target the systemic barriers? What are possible recommendations to improve the mission governance actions? What are possible recommendations to improve the mission governance structure?

Table 6. Description and examples of the structural elements of an innovation system (Kuhlmann & Arnold, 2001).

Structural element	Description
Government	Political and policy actors that influence innovation through laws regulations, voluntary agreements, mission statements, etc.
Supply side	Actors from the whole supply chain of products and services (e.g., manufactures, installers, maintenance, etc.)
Demand side	Final consumers (e.g., private homeowners, housing corporations, commercial building owners, etc.)
Intermediaries	Organisations that bring different actors together (e.g., brokers, consultants, lobbying organisations, etc.)
Research	Actors that are involved in the process of knowledge creation and diffusion (e.g., research institutes, universities, knowledge institutes)
Knowledge and investment infrastructure	Organisations that contribute to the innovation system by coordinating activities, providing guidance, building networks, or financing activities (e.g., banks, associations, standards and norms, etc.)

3.2.2 Interviews

The interview data has been collected through 30 semi-structured interviews, which are interviews in which the interviewer has a series of questions that are in the general form of an interview schedule but is more flexible and able to vary the sequence of the questions (Bryman, 2012). This allows the interviewer to ask follow-up questions in response to the given answers, to gain more in-depth or unexpected insights from the interviewees. Table 7 gives an overview of the types of interviewed stakeholders. The interview guide was constructed based on the analytical steps mentioned in the theory section and the diagnostics questions laid out by Wesseling & Meijerhof (2021). The answers to these diagnostic questions provided the basis for the evaluation of the performance of the system functions and the identification of the systemic barriers (Wieczorek & Hekkert, 2012; Wesseling & Meijerhof, 2021). A complete overview of the interview guide can be found in Appendix A (English) and Appendix B (Dutch). The interviews have been conducted via Microsoft Teams or in person when possible and each lasted between 45-60 minutes. All the interviews have been conducted in Dutch and, as agreed upon by the interviewees, recorded and transcribed. The gathered data has been handled and presented in an anonymous and aggregated format to ensure confidentiality.

Table 7. Overview type of interviewed stakeholders.

Structural element	Type of stakeholders	Number of interviewees
Government	National government	2
	Local government	1
	Governmental agency	1
Supply side	Energy company	4
	Network/grid operator	4
Demand side	Branch association	1
	Housing corporation	1
Intermediaries	Innovation / knowledge alliances	2

	Industry association	2
	Entrepreneurs' association	1
	NGO	2
	Consultancy and engineering firm	2
Research	University	1
	Research institute	1
Knowledge and investment infrastructure	Information organisation	1
	Knowledge platform	2
	Financial organisation	1
	Social enterprise / foundation	1
	Total	30

3.3 Data analysis

To be able to analyse the interview data, the transcripts have been coded using NVivo. This process consisted of two rounds of coding. In the first round, the data has been coded in an open manner, meaning that it has been first broken down, examined, compared, conceptualised, and categorised according to the operationalisation of the first three analytical steps (see table 5) (Bryman, 2012). In the second round of coding, axial coding has been applied to re-examinate and re-define the themes formed during the first round to identify overarching themes and connections between them (Bryman, 2012). These connections have been made by '*linking codes to contexts, to consequences, to patterns of interaction, and to causes*' (Bryman, 2012, p. 569).

The performance of the system functions will be based on the rating the interviewees give it. In line with Wiezcorek & Hekkert (2012) the rating of the system functions will be done using a five-point Likert scale (0 = absent, 1 = weak, 2 = very weak, 3 = moderate, 4 = strong, 5 = very strong). There has been chosen to ask for this rating to better conceptualise to what extent its performance is weak or strong. Furthermore, it helps the interviewee to answer the question from a broader perspective and to substantiate the answer.

3.4 Reliability and validity

To ensure the quality of the research, some form of reliability and validity needs to be guaranteed (Bryman, 2012; Morse, et al., 2002). According to Bryman (2012), reliability for qualitative research can be divided into internal and external reliability, which corresponds to the degree different researchers would come to similar judgements when analysing the same data and "*the degree to which a study can be replicated*" (p. 390), respectively. To assure the internal reliability of the coding process and to minimise personal bias, an intercoder reliability check has been performed by calculating the Krippendorff's Alpha. Three independent researchers with experience in the innovation science domain have recoded a sample of 30 statements to determine if they would have coded it in a similar manner. The score of the Krippendorff's Alpha was 0.824 and the coding is therefore deemed reliable, as the Krippendorff's Alpha is higher than 0.8 (De Swert, 2012). To assure the external reliability, each of the analytical steps have been rigorously and as detailed as possible described to increase the replicability of the research.

Validity can also be divided into two categories, namely internal and external validity. According to Bryman (2016), internal validity is "*whether there is a good match between researchers' observations and the theoretical ideas they develop*" (p. 390) and external validity is "*the degree to which findings can be generalized across social settings*" (p. 390). To ensure the internal validity, the results have been cross-checked to assure internal coherence between the findings (Riege, 2003). Achieving external validity for this research is difficult, since each mission is unique and therefore it is hard to generalize the findings of the case study (Wesseling & Meijerhof, 2021).

4. Results

4.1 Problem-solution diagnosis

The mission studied in this research finds its origin in the Dutch Climate Agreement, in which over 100 parties have made agreements to reduce the greenhouse gas emission to achieve the carbon reduction target in 2030 (Klimaatakkoord, 2019). This target, which is formally stated in the Climate Act (*in Dutch: Klimaatwet*), is that the Netherlands needs to reduce its greenhouse gas emission by 49% in 2030 and by 95% in 2050, compared to 1990 levels (Rijksoverheid, n.d.-c). The agreements in the Climate Agreement are made over five sectors each with a specific reduction target and contributing to the overarching reduction goal. The sectors and their reduction targets are *electricity* (20.2 Mt), *industry* (14.3 Mt), *mobility* (7.3 Mt), *agriculture and land use* (3.5 Mt), and *built environment* (3.4 Mt) (Klimaatakkoord, 2019). For each of the sectors there was a sector table at which the agreements were made to limit the greenhouse gas emissions in the Netherlands. The sector tables were attended by governments, companies, and organisations that can make a concrete contribution to the changes needed in achieving the climate targets. During this process, all involved stakeholders had the problem of sustainability high on the agenda and there was a consensus that a sustainability transition is necessary to reduce our climate impact.

The built environment is a sector in which many societal problems converge, but the prioritisation of these problems within the sector varies greatly. As in the Climate Agreement, the societal problem of reducing CO_2-emissions has been prioritised and since this is largely linked to energy usage, most attention goes to this. This is also reflected in the formulation of the mission studied in which CO_2-emission reductions will be achieved when making the transition to gas-free. This has led to less attention on other aspects such as circularity and, climate-inclusive and climate-adaptive (re)construction (Rijksoverheid, n.d.-d; Rijksoverheid, 2016; Agenda Natuurinclusief, n.d.). This has also been confirmed by the interviewees, which have pointed out that these aspects are, currently, only partially included in the natural gas-free transition in the built environment. Although the mission to become natural gas-free in the built environment may not be affected by this, it is still of importance to take these aspects into account to come to solution which have the least possible climate impact. Another societal problem that is currently high on the agenda in the construction sector is the shortage of housing. To combat this, the national government has set a target of building an additional 75,000 homes (new construction and transformation) per year and plans to increase this to 100,000 per year (Rijksoverheid, 2021b; Rijksoverheid, 2021e). Due to the scale of this tasks and the more direct impact it has on society, it receives a lot of attention within the built environment. Furthermore, the rising tensions between Europe and Russia, due to the invasion of Ukraine, has brought the importance to become independent of Russian natural gas to the forefront. However, the tensions have also resulted in a decreasing availability of natural gas since the majority it imported from Russia, leading to a sharp increase of energy prices, and in particular natural gas. Thereby negatively affecting the affordability of energy, which has resulted in problems on energy poverty (Rijksoverheid, 2021a).

In the solution-analysis, several technological and social solutions have been identified of which a detailed overview and description can be found in Appendix D. The technological solutions can be categorised into three groups, namely (1) *individual heat solutions*, (2) *collective heat solutions*, and (3) *energy savings solutions*. The main technological solutions from these groups include heat pumps (all-electric or hybrid); heat networks (low, medium, high-temperature); insulation (high-efficiency glass and roof, solid wall, cavity wall, floor insulation). However, these solutions do not stand alone as strong interactions exist between the insulation measures and some individual and collective heat solutions. To elaborate, to be able to have a heat pump (all-electric) or a connection to the heat network (low temperature heating, 35 - 55°C), a sufficient insulation level is required. The supply temperature of these heating systems is lower than combustion system such as the conventional condensing boiler and a hybrid heat pump (70 - 80°C). To be able to heat a home to a comfortable temperature with low temperature heating it is important that as little heat as possible is lost, and therefore sufficient insulation is needed (Ecofys & Greenvis, 2016). Furthermore, several alternative energy sources and carriers were identified, including aquathermia, geothermal, soil energy, thermal storage, solar thermal, hydrogen, biogases, and residual heat.

Lastly, an important social solution identified are citizen initiatives, which is "*a form of self-organisation in which citizens mobilise energy and resources to collectively define and carry out projects aimed at providing public goods and services for their community*" (Igalla, et al, 2019, p. 1176). The most common form of a citizen initiative is a cooperative, which is "*an autonomous association of persons united voluntarily to meet their common economic, social, and cultural needs and aspirations through a jointly owned and democratically controlled enterprise*" (International Co-operative Alliance, 2017, p. 1). In the energy sector, this has resulted in the formation of energy cooperatives, which are groups of citizens that want to decide for themselves where their energy come from and to be independent from a (commercial) supplier. These bottom-up initiatives contribute to the energy transition by realising project that contribute to the local energy objectives, and making residents more involved directly and indirectly, which can lead to more participation and support for the energy transition (HIER, Wat is een energie-initiatief of energiecoöperatie?, n.d.-c). In the last years, the number of energy cooperatives has more than doubled, from 242 in 2015 to 676 in 2021, reflecting the growing movement of bottom-up initiatives and the need for new forms of governance (HIER & RVO, 2022).

4.2 Structural analysis

In this section the identified structural components (i.e., actors, institutions, networks, and materiality), which make up the structure of the innovation system, are discussed. A distinction is made between the *mission arena* and the *overall MIS*. First, the respective roles of the actors in the mission arena are explained. Followed by a brief explanation of the actors forming the overall MIS. Finally, the most relevant institutions of the MIS are discussed.

4.2.1 Mission arena

The respective roles of the actors involved in one of the four mission governance tasks[5], thereby forming the mission arena, are discussed. To summarise, an overview of the mission governance tasks, and their corresponding actors is presented at the end of this section (table 8).

4.2.1.1 Setting up the mission arena

At the end of 2018, after nine months of intensive preparation by more than one hundred organisations at five sector tables, three task forces and dozens of working groups, the Draft Climate Agreement was in place. In June 2019, the draft was presented to the parliament which agreed to this in July 2019 (Klimaatakkoord, n.d.). The Climate Agreement contains commitments made to reduce CO_2-emissions in the Netherlands, but it also contains agreements made on the measures and instruments needed to achieve the missions, such as drawing up roadmaps, removing obstacles, adapting legislation and regulations, creating scope for financing, creating a market for solutions through pricing, setting, standards, tendering, or subsidies (Klimaatakkoord, 2019). Each of the parties that negotiated the Climate Agreement was asked to express their commitment by confirming that they (a) recognise the urgency of the climate problem and are prepared to propagate this urgency, (b) will work together with their own supports towards the central goal of the Agreement, i.e., 49% reduction of greenhouse gases in 2030 compared to 1990, and (c) will commit itself to the implementation of agreements in which it is directly involved (Nijpels, 2020). Not all parties have expressed their commitments and only those that did are considered to be part of the mission arena.

[5] The mission governance actions as described in table 1; (i) setting up the mission arena, (ii) mission formulation, (iii) mobilisation of MIS components via mission governance actions, and (iv) continued reflexive mission governance) (Wesseling & Meijerhof, 2021).

For the built environment this resulted in a total of 32 actors[6], the Ministry of the Interior and Kingdom Relations, and the Ministry of Economic Affairs & Climate Policy (Nijpels, 2020). The Ministry of the Interior and Kingdom Relations is responsible for the execution of the agreements.

For the mission of the built environment, the governance structure identified corresponds with a multi-level governance structure in which the power is distributed vertically between three levels of government (local, regional, national) and horizontally between (non-)governmental actors (i.e., municipalities, energy regions) (Cairney, et al., 2019). On the national level, the Mission-oriented Topsector and Innovation Policy (MTIB) forms the nationwide policy focussed on tackling societal challenges by strongly focussing on innovation, research, and (technological) development (Ministerie van Economische Zaken en Klimaat, n.d.). The Ministry of Economic Affairs & Climate Policy (EZK) is responsible for this policy. In addition, the Ministry of the Interior and Kingdom Relations (BZK) is responsible for built environment specific policy, such as building regulations, sustainable building and renovation, and energy labels (Ministerie van Financiën, 2020). On the regional level, thirty energy regions have been formed which work together with other parties, such as governments, residents, business, grid operators, energy cooperatives, and civil society organisation, on forming Regional Energy Strategies (RES). These strategies indicate where and how sustainable electricity can best be generated on land (wind and solar) and which heat sources can be used to make the transition in the built environment to gas-free (Nationaal Programma RES, n.d.-b). The projects and plans from the RES are used by governments in setting up policies for the living environment. Therefore, cooperation within regions, but also between regions and between regions and the national government, is required (Nationaal Programma RES, n.d.-b).

On the local level, the 344 municipalities in the Netherlands are responsible for the district-oriented approach. In the Climate Agreements there was agreed that the Netherlands would become gas-free through a district-oriented approach in which the municipalities are taking the lead (Klimaatakkoord, 2019). In short, this approach means that municipalities have to make a plan for each neighbourhood, stating how homes and buildings will become natural gas-free. The municipalities have therefore been asked to draw up a Vision on Heat (*in Dutch: Transitievisie Warmte (TVW)*) and a District Implementation Plan (*in Dutch: Wijkuitvoeringsplan (WUP)*) (PAW, n.d.-b). This approach was chosen to be able to achieve the desired pace of sustainability improvement, since building owners often require additional incentives to begin sustainability improvements (Klimaatakkoord, 2019). It is a collective approach in which a process will have to be completed, alongside residents and building owners, to determine the best solution for each district. Since this governing role is new for municipalities and it requires new knowledge, expertise, and competences, agreements on supportive tools were made. These agreements have been made around issues such as financing, legislation, guidelines, knowledge, and learning (Klimaatakkoord, 2019).

4.2.1.2 Mission formulation

In April 2019, the Ministry of Economic Affairs and Climate Policy presented the missions which have been drawn up with the framework of the Mission-oriented Topsector and Innovation Policy. A total of 25 missions have been formed around four themes, (1) *energy transition and sustainability*, (2) *agriculture, water, and food*, (3) *health and care*, and (4) *security* (Ministerie van Economische Zaken en Klimaat, 2019). These missions provided the basis for the Knowledge and Innovation Agendas (KIA) which have been drawn up by the Topsectors for each theme (Topsectoren, n.d.). For the theme energy transition and sustainability, an Integral Knowledge and Innovation Agenda (IKIA) was drawn

[6] Aedes, Bouwend Nederland, Coteq, Enduris Netbeheer, Eneco, Enexis Netbeheer, Gasunie Transport Services, Institutionele Beleggers in Vastgoed Nederland (IVBN), Inter Provinciaal Overleg (IPO), Juva Energy Support, Klimaatenergiekoepel (KEK), Koninklijke NLingenieurs, Liander, Natuur en Milieu, Natuur en Milieufederaties, Nederlandse Vereniging Duurzame Energie (NVDE), Netbeheer Nederland, Platform Geothermie, PO Raad, Rendo Netwerken, Stedin Netbeheer, Stimuleringsfonds Volkshuisvesting, Stroomversnelling, Techniek Nederland, TKI Urban Energy, Unie van Waterschappen (UvW), Vattenfall, Vereniging Nederlandse Gemeenten (VNG), Vereniging Samenwerkende Nederlandse Universiteiten (currently: Universiteiten van Nederland), VNO-NCW, VO-raad, and Woonbond (Nijpels, 2020).

up as part of the Climate Agreement. This agenda articulates the knowledge and innovation required for the societal challenges of the Climate Agreement and has translated the commitments into five overarching missions for 2050 and intermediate sub-missions for 2030. For the built environment, this resulted in the overarching mission "*a carbon-neutral built environment in 2050*", which formed the basis for the development of the built environment related MMIPs (Taakgroep Innovatie, 2019). In addition, several intermediate goals, or sub-missions, have been formulated, including the mission studied in this research: "*disconnecting 1.5 million existing homes from natural gas by 2030*". The Topsector Energy (TSE) and the Top Consortia for Knowledge and Innovation Urban Energy (TKI UE) were responsible for the formulation.

4.2.1.3 Mobilisation of MIS components via mission governance actions

Besides the agreements in the Climate Agreement, there are several other mission governance actions which mobilise the MIS components. For the overarching missions as formulated in the Integral Knowledge and Innovation Agenda (IKIA), the Topsector Energy has developed a total of thirteen Multiyear Mission-driven Innovation Programmes (MMIPs). For the built environment this resulted in four MMIPs: (a) MMIP 2: Renewable electricity generation on land and in the built environment, (b) MMIP 3: Acceleration of energy renovations in the built environment, (c) MMIP 4: Sustainable heat and cold in the built environment, and (d) MMIP 5: electrification of the energy system in the built environment (Topsector Energie, n.d.-a). The TKI Urban Energy is responsible for the execution of the mentioned MMIPs (TKI Urban Energy, n.d.-a). In addition, the Building and Technology Innovation Centre (BTIC) have developed six Multiyear Knowledge and Innovation Programmes which contribute to the realisation of an innovative construction sector, of which the Knowledge and Innovation Programme Energy Transition Existing Buildings (IEBB) is relevant for the studied mission (BTIC, 2020).

The Ministry of Economic Affairs & Climate Policy provides generic innovation instruments through the Mission-oriented Top Sector and Innovation Policy. The implementation of these generic innovation instruments lies with the Netherlands Enterprise Agency (RVO) which have set up several subsidy schemes to stimulate innovation (RVO, 2022a). The Ministry of the Interior and Kingdom Relations is responsible for the programmes that help municipalities or regions to make the transition to natural gas-free, which are (a) the *National Programme Regional Energy Strategy (NP RES)*, (b) the *Natural Gas Free Neighbourhood Programme (PAW)*, and (c) the *Expertise Centre Heat (ECW)* (Klimaatakkoord, 2019). In addition, recently (1st of June 2022) the ministry has presented the policy programme '*accelerating the sustainability of the built environment*' which describes how the process of making homes (and schools, shops, and offices) more sustainable will be accelerated (Volkshuisvesting en Ruimtelijke Ordening, 2022). The Visions on Heat (TVWs) and the District Implementation Plans (WUPs) of all the 344 municipalities in the Netherlands provide directionality to the MIS and thereby mobilising its components. This is also the case for the Regional Energy Strategies (RESs) of the thirty energy regions. Lastly, by committing to the agreements of the Climate Agreement on the built environment sector theme, these 32 actors contribute to the mobilisation and alignments of the MIS components (Nijpels, 2020).

The above mentioned mission governance actions will be further elaborated on in the last part of the results section, which includes an overview of the identified mission governance actions and a reflection on the current and planned mission governance actions (section 4.5).

4.2.1.4 Continued reflexive mission governance

The overall progress of the mission is monitored and evaluated by the Ministry of Economic Affairs & Climate Policy and the Ministry of the Interior and Kingdom Relations. The Ministry of Economic Affairs & Climate Policy is mostly responsible for monitoring the national climate policy and the Ministry of the Interior and Kingdom Relations for the policy related to the built environment. This is done through the Regional Climate Monitor (*in Dutch: Regionale Klimaatmonitor*) (Regionale Klimaatmonitor, Regionale klimaatmonitor, n.d.), the Dashboard Climate Policy (*in Dutch: Dashboard Klimaatbeleid*) (Dashboard Klimaatbeleid, 2022), and the annual Climate and Energy Outlook (*in Dutch: Klimaat- en Energieverkenning*) (PBL, 2021a). The Netherlands Enterprise Agency monitors and evaluates the energy innovation policy instruments (RVO, 2021b), but also supports in the monitoring of programmes such as the National Programme Regional Energy Strategies (NP RES) and the Natural Gas Free Neighbourhood Programme (PAW) (Nationaal Programma RES, n.d.-a; PAW, 2020). The progress and achievements of the MMIPs and their related projects are monitored and analysed by the TKI Urban Energy.

Table 8. Overview mission governance tasks and their corresponding actors.

Mission governance task	Mission arena actor
Setting up the mission arena	• *Ministry of the Interior and Kingdom Relations (BZK)* • *Ministry of Economic Affairs & Climate Policy (EZK)* • The *30 energy regions* in the Netherlands • The *344 municipalities* in the Netherlands • The *32 actors that have committed to the Climate Agreement* on the built environment sector theme
Mission formulation	• *Topsector Energy (TSE) and TKI Urban Energy (TKI UE)*, formulation of the Integral Knowledge and Innovation Agenda (KIA) and the overarching missions and sub-missions for the built environment, including the mission studied
Mobilisation of MIS components via mission governance actions	• *Ministry of Economic Affairs & Climate (EZK)*, providing generic innovation instruments and finances the Netherlands Enterprise Agency (RVO) and Topsectors, and has final responsibility for the implementation of the agreements of the Climate Agreement • *Ministry of the Interior and Kingdom Relations (BZK)*, responsible for the implementation of the agreements in the Climate Agreement made around the built environment sector and for the programmes National Programme Regional Energy Strategies (NP RES), Natural Gas Free Neighbourhood Programme (PAW), and the Expertise Centre Heat (ECW) • *TKI Urban Energy (TKI UE)*, responsible for the Multiyear Mission-driven Innovation Programmes (MMIP's) of the built environment (MMIP 2, 3, 4, 5) • *Building and Technology Innovation Centre (BTIC)*, develops Multiyear Knowledge- and Innovation Programmes • *Netherlands Enterprise Agency (RVO)*, implementation of energy innovation instruments (i.e., subsidy schemes) • The *30 energy regions,* which each draft Regional Energy Strategies (RES) • The *344 municipalities* in the Netherlands, which each draft Visions on Heat (TVWs) and District Implementation Plans (WUPs) • The *32 actors that have committed to the Climate Agreement* on the built environment sector theme

Continued reflexive mission governance	• *Ministry of Economic Affairs & Climate (EZK)*, monitoring overall climate policy and innovation instruments • *Ministry of the Interior and Kingdom Relations (BZK)*, monitoring built environment policy and national policy in collaboration with EZK, and monitoring the progress of the PAW programme • *TKI Urban Energy*, monitoring and analysing the progress and achievements of the MMIPs and related projects • *Netherlands Enterprise Agency (RVO)*, monitoring and evaluation of the energy innovation policy instruments and supporting the monitoring of the National Programme Regional Energy Strategies (NP RES) and the Natural Gas Free Neighbourhood Programme (PAW)

4.2.2 Overall MIS

The actors that form the overall MIS are discussed followed by a description of the most relevant institutions. As the number of actors in the overall MIS is numerous, not all actors can be discussed and therefore more focus is given a description of the industry structure / value chain.

4.2.2.1 Actors overall MIS

The most relevant actors involved in the process of making homes natural gas-free, can be divided into five overarching categories (Hürlimann, et al., 2022; Provincie Noord-Holland, 2018). The first category is property owners and renter and reflecting the demand side, consisting of house owners, homeowner associations (VvEs), housing corporations, private owners of rental houses, and tenants. The size of this category is enormous, as it reflects millions of citizens. The second category are the construction and installation companies and their industry associations. In 2020, there were a total of 193,000 construction and installation companies in the Netherlands, of which 84% are 1-person companies (Aeternus, 2020). The third category are actors involved in energy generation and supply, which are the grid operators, energy suppliers, residual heat supplies, and energy cooperatives. The fourth category are the manufacturers and suppliers of energy technologies and energy saving solutions. The fifth and last category consists of the remaining actors which cannot be subdivided into an overarching category but are still of importance. These include project develops, investors, financial institutions, knowledge institutions, NGOs, energy service companies (ESCOs), (engineering) consultants, and initiatives such as Coalition Cooperative Heat (Coalitie coöperatieve warmte, n.d.), innovative sustainable heat collective WarmingUP (WarmingUP, n.d.), and the online platform SlimmeBuur where neighbours advise each other on energy saving measures (HIER, n.d.-a).

4.2.2.2 Institutions

An important formal institution in the heat transition is the Heat Act (in Dutch: Warmtewet) which regulates the supply of heat to consumers and small and medium-sized enterprises (SMEs) for connections up to 100 kW. The Heat Act is active since 2014 and the Netherlands Authority for the Financial Markets (ACM) supervises the implementation of it (RVO, 2020b). The Heat Act has been revised in 2018 to better comply with the current climate objectives. The aim of the revision was to increase the support for the product of heat, increase the confidence in the market, and increase the willingness to invest in sustainable collective heat (Overheid.nl, 2020). This resulted in the Collective Heat Supply Act (*in Dutch: Wet collective warmtevoorziening*), also known as the Heat Act 2.0, which was submitted for consultation in June 2020. It aims to achieve the following: (a) growth of collective heat systems through new rules (market regulation), (b) transparency in pricing, (c) tightening of the requirements for security of supply, and (d) securing sustainability (Overheid.nl, 2020; Wiebes, 2019). It was planned that the revised Heat Act would be active form the 1st of January 2022 onwards, however it has been postponed to 2024 due to the failure to reach agreements with local governments on choices in the legislative proposal. The Association of Netherlands Municipalities (VNG), representing the municipalities, and the Interprovincial Consultation (IPO), representing the provinces, did not agree with the draft bill for the revised Heat Act. They argue that the new Heat Act does not sufficiently offer municipalities the possibility of fulfilling their governing role as agreed in the Climate Agreement. This includes the ability to steer the type of heat company that is considered appropriate in the local situation and steering the development of a public heat infrastructure (VNG, 2021; Stichting Warmtenetwerk, 2020). The design and implementation of the new Heat Act will be decisive for the scale up of sustainable collective heat solutions (i.e., heat networks) and sources (i.e., aquathermia, geothermal).

Another important formal institution is the Gas Act which contains rules on the transport and delivery of gas. The act stipulates aspects such as the organisation of the market, transport, and distribution, including the legal tasks network operators have. The Gas Act states that the realisation of gas connections is a statutory task that must be carried out by the network operator upon request, also known as the gas connection obligation (RVO, 2018). As of 1 July 2018, this gas connection obligation has changed for new building which will no longer receive a gas connection to reduce CO_2-emissions (RVO, 2018). In addition, the future Act on Municipal Instruments for the Heat Transition (*in Dutch: Wet Gemeentelijke Instrumenten Warmtetransitie (WgiW*)) will provide municipalities with the authority to set local rules to implement the transition in the built environment to sustainable alternatives (i.e., disconnecting gas in a neighbourhood) (Rijksoverheid, 2021f). This act will be an important instrument for the municipalities in fulfilling the district-oriented approach. The Act was for consultation from December 2021 until January 2022, and it is expected to come into force on the 1st of January 2024 (Jetten, 2022).

Another further institution which is of importance is the Environment and Planning Act (*in Dutch: Omgevingswet*) which combines and simplifies the regulations for spatial project. It is expected that on the 1st of January 2023, the Environment and Planning Act will come into force. The new Act consists of 26 existing acts around built environment, housing, infrastructure, environment, nature, and water, and its advantages are (a) faster and cheaper decision-making, (b) better solutions to social challenges, (c) more transparent decision-making for initiators and beneficiaries, (d) simplification of the rules, and (e) more flexibility and a better fit to the actual situation (Business.gov.nl, n.d.; Rijksoverheid, n.d.-f). Due to the strong interaction between heat supply and the physical living environment, it is expected that the Environmental Planning Act will have an impact on the heat transition. Furthermore, under this Act participation is mandatory in the form of an obligation for municipalities to substantiate their decisions when drawing up an environmental vision, program, and plan (Over Morgen, 2020). This is an important part for the heat transitions since the gas-free transition will have a major impact on house owners and therefore participation is needed to accelerate.

4.3 System function analysis

In this section, the strengths and weaknesses of the system function are discussed after which an overview is presented (table 9).

<u>SF1: Entrepreneurial activities</u>

According to interviewees (18), a lot of entrepreneurial activity in the form of technological start-ups and pilot projects can be found within the MIS. The entrepreneurial climate in the Netherlands is considered very positive and is supported by several subsidy schemes[7] and by programs as the Natural Gas Free Neighbourhood Programme (PAW) and the Expertise Centre Heat (ECW) which supports municipalities and other parties involved in the transition of making neighbourhoods gas-free or gas-free-ready (PAW, n.d.-a; ECW, n.d.-b). This has led to a wide array of entrepreneurs involved in the

[7] Subsidy schemes such as the Mission Drive, Research, and Innovation (MOOI), the Demonstration Energy and Climate Innovation (DEI+), the Renewable Energy Subsidy (HER+), and the Stimulation of Sustainable Energy Production and Climate Transition (SDE++) (RVO, 2022a).

realisation of technological innovations. Most of the entrepreneurial activity comes from small and medium-sized enterprises (SMEs), which is also reflect in the number of SMEs that received funding through various subsidy schemes (RVO, 2021b). However, despite the many entrepreneurial activities by SMEs, they have difficulty in scaling-up their innovations (further elaborated in SF5) due to resource availability and support (SF6). In addition, interviewees involved in social entrepreneurship indicate that the number of social (bottom-up) initiatives (i.e., energy cooperatives, residents' initiatives) to accelerate the energy transition is growing. However, the amount of social entrepreneurial activity is still considered to be limited in comparison to technological entrepreneurship, due to the limited (financial) support for social initiatives (SF6), low legitimacy for social initiatives (SF7), and the fact that achieving societal change is often considered to be less tangible than the process of technological development (SF1 & 2).

Despites the high number of entrepreneurial activities within the MIS, interviewees (14) have indicated that there is a lacking entrepreneurial activity regarding integral solutions. The supply of integral solutions, which are solutions that both incorporate energy savings (i.e., insulation) and sustainable energy solutions (i.e., heat pump, heat networks) as well as ventilation, and their interactions, in its infancy. Currently the solutions are individually implemented and interactions between the different solutions are hardly taken into consideration, while this could significantly influence the overall performance. Four interviewees mentioned the importance of developing new service concepts or packages which incorporate integral gas-free solutions and limit the inconvenience causes for the customers when implementing the solutions in the house. Two important causes have been indicated by the interviewees for this. Firstly, due to the broad and fragmented character of the built environment sector and the overall MIS, collaborations are limited domain transcending and thereby hampering the development of innovations that incorporate the (entire) supply chain. Secondly, the actors in the built sector are generally conservative and therefore sticking to current structures. In combination with the current high workload, there is a limited incentive for these actors to engage in entrepreneurial activities. This is further reinforced by the limited business case for entrepreneurial activity focused on individual households. Alternative business models need to be developed to intervene in the current structures.

<u>SF2: Knowledge development</u>

In general, interviewees (14) indicate that there is a strong fundamental knowledge development to understand what is needed, both technologically and socially, for making the transition to a gas-free built environment. Many different research institutes and universities (e.g., Netherlands Organisation for Applied Scientific Research (TNO), Technical University Delft (TU Delft), Technical University Eindhoven (TU/e)) are involved in the knowledge development process. Furthermore, different consortia (e.g., WarmingUp[8]) are formed in which more practical/applicable knowledge is developed. The research done by the different organisations and consortia contribute to the (complex) understanding of what is needed and should be targeted to reach the mission goals.

Although knowledge development is generally considered sufficient, interviewees (11) point out that there is a lagging development of social knowledge, and the developed social knowledge is not adequately merged with technical knowledge. They emphasise the importance of the societal side of the transition which is a key aspect in mobilising the millions of homeowners to take sustainable measures for their houses. Some indicate that the societal change process is as important, or even more, as the technological change process and therefore should require sufficient attention. The need for more practical social oriented knowledge development in the context of the end user (homeowners) is expressed by the interviewees. However, the more tangible character of

[8] The innovative sustainable heat collective WarmingUp is a collaboration of a broad group of companies, governments, and research organisations that develop applicable knowledge so that collective heat systems are reliable, sustainable, and affordable for the heat transition (WarmingUP, n.d.).

technological knowledge leads to a bias for technological knowledge development over social knowledge development. The Natural Gas Free Neighbourhood Programme (PAW) tries to stimulate the practical knowledge development through a Knowledge and Learning Program (KLP) and large-scale living labs in which bottlenecks are identified based on practical experience and resolved where possible. This programme also initially had a bias towards technological knowledge development, however, this is changing and more social aspects (i.e., citizen participation, affordability, feasibility) are taken into account (Overlegorgaan Fysieke Leefomgeving , 2022).

Furthermore, insufficient knowledge is being developed at the municipal level regarding the issues around the gas-free transition. In the Netherlands, the municipalities are responsible for improving the sustainability of the built environment and must draw up a plan (at district level) in which they indicate how they are going to make the built environment more sustainable, also known as the Vision on Heat (TVW) and the District Implementation Plan (WUP). However, due to the complexity of the heat transition, considerable knowledge is required to constructs such plans and implement it. This complexity mainly stems from the fact that each neighbourhood, or even house, slightly differs from another, thereby making the development of specific knowledge needed. According to interviewees (13) this knowledge is currently insufficiently developed and embedded at the municipal level, with exception of the big four (Amsterdam, Rotterdam, The Hague, and Utrecht) and some others. Most municipalities have consulted external parties to help them draw up the Vision on Heat (TVW), which has limited the knowledge development and led to insufficient knowledge assurance within the municipalities. Furthermore, many municipalities do not have sufficient human capital and/or financial resources (SF6) for the execution of the tasks in the gas-free transition. The lack of support from the national government in both the diffusion of the knowledge required (SF3) and the mobilisation of resources (further elaborated in SF6) are indicated as causes for this system function weakness. As agreed in the Climate Agreement, the Expertise Centre Heat (ECW) has been set up to help municipalities make their Visions on Heat, however, opinions are divided on its functioning and contributions.

SF3: Knowledge diffusion

According to interviewees (8), the stakeholders within the MIS are actively diffusing knowledge through networks, programmes, congresses, webinars, scientific publications, media, etcetera. Collaborations are established between local governments, research institutes, universities, branch associations, market parties (i.e., energy companies, grid operations), and social enterprises. In addition, three interviewees indicate that there is in general a high willingness to diffuse knowledge within the system. Both in the public as the commercial domain actors are getting more and more open to share their knowledge. The quantity of the knowledge diffused within the MIS was assesses to be good, however it often remains superficial due to the limited domain transcending knowledge diffusion. The process of knowledge creation (SF2) and diffusion (SF3) tends to be more valuable when domain transcending since it allows to include more complex and multidisciplinary aspects. An important cause for this weakness lies in the fragmented and heterogenous character of the built environment. Due to this, the knowledge created at the different domains and levels (local, regional, national) is often not aggregated or connected with each other. Furthermore, most companies in the construction sector are small businesses which have very few resources for research and development and are sticking to conventional approaches, which makes them hard to reach.

Although the overall knowledge diffusion between organisations active in the MIS is considered to function good, interviewees (15) mentioned that there is an inadequate diffusion of knowledge towards society. The link between the business world and what measures an individual households can take is currently very poor. There are numerous measures that can be taken by individuals, however, due to the heterogenous characters of the houses and the variety of choices, homeowners find it difficult and complex to find out which measures to take. Smart tools and services are needed to meet the demands of the homeowners. As pointed out in SF1, this development is currently lagging due to lacking entrepreneurial activity within this field. In addition, because the urgency for the transition to become gas-free and the awareness regarding climate problems has so far not always been prominent in society, there is insufficient knowledge diffusion towards society. However, this is currently changing due to the war in Ukraine which have raised awareness about energy dependence and the urgency to become gas-free (further elaborated in SF7). This has further been strengthened by a recently initiated national campaign aimed at informing homeowners about ways to save energy (www.zetookdeknopom.nl). The interviewees emphasise the need to develop new innovative ways or structures to diffuse knowledge to overcome the above-mentioned weaknesses. Examples given are developing smart digital tools, mobilising local contractors and brokers to actively engage in sustainable activities, and energy cooperatives advising and helping the residents in the district.

SF4a: Problem directionality

In the Climate Agreement the societal problem of climate change and the ambition to reduce CO_2-emissions was captured, thereby contributing to the problem directionality provided to the MIS. Interviewees (5) have indicated that the transition to gas-free is highly prioritised within the built environment. Furthermore, many stakeholders within the built environment feel connect to the mission and aim to contribute to it. This is also reflected in the high response and participation rate for the interviews. In total 34 of the 45 invited stakeholders accepted the invitation (75%) for an interview, of which most indicated that they are very keen on contributing to this research. However, it should be discussed that the high prioritisation of natural gas-free may create a blind sport for other aspects that are relevant in the built environment, such as circularity, climate adaptation, and nature inclusiveness. Currently, these aspects are too loose connected with each other and often not considered in the development of gas-free solutions. Besides the fact that it is of importance to include these aspects to be able to achieve a climate neutral built environment, an integral approach has synergy benefits and could contribute to a better business case.

Furthermore, since the invasion of Russia in Ukraine (February 2022), the Dutch and European have expressed the need and urgency to become independent of Russian natural gas. The rising tensions between Europe and Russia have led to an increase in the natural gas prices and decreasing availability of natural gas due to import limitations, resulting in problems on energy security and poverty. These problems are increasingly being prioritised due to the urgency and direct impact it has on society. In response, the national government has taken several measures to reduce its impacts, both positively as negatively contributing the solution directionality (SF4b) of the MIS. On the positive note, the national government has launched a national campaign to create awareness and stimulate households and businesses with practical tips on how to save energy in the short term (www.zetookdeknopom.nl) (SF3 & SF7). In addition, the Netherlands and Europe have announced that they will, at an accelerated pace, reduce their energy consumption and make it more sustainable (Rijksoverheid, n.d.-g). However, also measures have been taken, such as the removal of coal-fired power plant production limitation and increasing the imports of liquefied natural gas (LNG), which enhance the usage of fossil sources and CO_2-emissions (Rijksoverheid, 2022c). Despite the criticism of the lack of attention for sustainable alternatives and some measures, the interviewees are positive about the momentum around the gas-free theme and the decisiveness in taking action.

SF4b: Solution directionality

Interviewees (15) indicate that there is a consensus on which set of technological solutions is needed to reach the mission goals, namely *insulation*, *heat pumps* (all-electric or hybrid), *heat networks* (low, medium, and high-temperature), and *renewable gases* (hydrogen, renewable natural gas). Several analyses and programs have contributed to the solution directionality, such as the '*Startanalyse aardgasvrije buurten*' of PBL (Planbureau voor de Leefomgeving), the Expertise Centre Heat (ECW), and the Natural Gas Free Neighbourhood Programme (PAW). Although there is a broadly supported vision of the needed technological solutions, discussion remain about which (set of) solutions should be implemented where, when, and how. This also includes discissions about the legitimacy of certain solutions (SF7). For example, many do not consider hydrogen as a suitable solution for the built environment, at least not for the coming ten years, and of which some argue that it is a means, by regime actors, to hamper the transition. While others indicate that hydrogen will be necessary to provide heat to houses in old city centres for which a heat pump or heat network connection is not suitable. According to interviewees (12), this is further strengthened by the weak solution directionality provided by the national government.

This lack of directionality stems from the fact that many tasks are passed on to the municipalities, each of which makes its own considerations and decisions and often limited by the available resources (SF6) and knowledge (SF2), leading to different perspectives and vision on the needed solutions. Therefore, interviewees (13) express the need for a more dominant role of the national government in providing directionality. More strategic directionality at the national level on which solutions to pursue and how to do this is desired. This must be complemented by the provision of the needed instruments to support the implementation capacity at the local level. Furthermore, if well executed, the solution directionality provided on national level would have a positive effect on entrepreneurial activities (SF1) and the formation of markets for solutions (SF5).

In line with this, interviewees (14) mentioned the insufficient directionality provided regarding the execution of the mission and the implementation of the solutions. It is clear what the aim is that must be achieved, namely making 1.5 million existing homes gas-free by 2030, however a vision is currently missing on how to achieve this. This involves aspects such as which solutions will be implemented where, when, and how, how residents will be included and mobilised, which local heat sources are available and how can they be optimally used, etcetera. The Regional Energy Strategies (RES), drawn up by the 30 energy regions, and the Visions on Heat (TVW) and District Implementation Plans (WUP) are aimed at contributing to the creating of a vision. However, these plans are still too loosely interlinked to be able to collectively formulate a vision providing solution directionality to the overall MIS. Two causes are mentioned for the insufficient directionality provided. Firstly, the solution directionality is often based on voluntariness, meaning that the directionality is formed based on who wants to participate instead of being reasoned from the task. Secondly, the solution directionality is often criticised as being too technocratic focussed.

Lastly, the Visions on Heat (TVW) drawn up by the municipalities in the Netherlands are considered to be insufficient in providing and contributing to the solution directionality. Interviewees (7) emphasised that in most of the TVWs limited choices have been made about which solutions will be implemented in where and when, leading to unclarities. Causes mentioned for this are the lack of knowledgeable personnel and financial resources at the local level (SF6), hampering their ability to deal with the complexity of the topic. The expectation is that his be improved when drafting the District Implementation Plans (WUPs), however, it will still take some time before these plans are completed.

<u>SF4c: Reflexive governance</u>

In general, interviewees (8) describe that there are several monitoring mechanisms in place which are sufficient for the monitoring of the overall mission progress. For example, there is the Regional Climate Monitor which monitors the decentralised energy transition (Regionale Klimaatmonitor, n.d.), the Dashboard Climate Policy which provides information on the progress of national climate policy and the development of greenhouse gas emission in the Netherlands (Dashboard Klimaatbeleid, 2022), and monitoring reports in which, for example, the progress of the mission (Climate and Energy Outlook) (PBL, 2021a) or innovation schemes are discussed (RVO, 2021b). At the same time, interviewees (6) indicate that the monitoring of the mission progress is insufficient. According to them, a monitoring dashboard is missing which provides up-to-date information on how much houses are gas-free or gas-free ready. Furthermore, monitoring of the individual route (i.e., when homeowners take individually sustainable measures) is currently lacking. Although Statistics Netherlands (*in Dutch: Centraal Bureau voor de Statistiek, CBS*) is measuring the amount of heat pumps installed in the Netherlands (CBS, 2022), little is known how many of these are an all-electric or a hybrid heat pump (PBL, 2021a). This distinction is of importance since hybrid heat pumps still use natural gas.

Besides the current monitoring, interviewees (7) mentioned the inadequate evaluation of the entire breadth of the policy. This refers to extensive evaluation of both the effectiveness of the overall policy and of each policy instrument. As mentioned earlier, there are several monitoring mechanisms in place which are there to support the evaluation of the policy. However, to evaluate the effectiveness of policy instruments a more in-depth level of monitoring is needed. Closely monitoring of the contributions of the policy instruments on the mission goals allows to identify readjustments needed. However, to evaluate the role of the policy instruments within the system a connecting is needed with more abstract indicators, such as the development of the innovation system.

SF5: Market formation and destabilisation

According to interviewees (7), the potential of the market for gas-free solutions is big, resulting in a strong incentive for actors to engage in market formation activities. This is further stimulated by the problem directionality (SF4a), which, as mentioned earlier, has recently been further strengthened due to exogenous factors (Ukraine war). This, in combination with new measures such as the National Insulation Program (*in Dutch: Nationaal Isolatieprogramma*) and the increase in the subsidy for insulation measures and (hybrid) heat pumps via the Investment Subsidy for Sustainable Energy and Energy Savings (ISDE) (SF6) (Volkshuisvesting en Ruimtelijke Ordening, 2022; RVO, 2022h), has increased the demand for gas-free solutions and thereby positively contributing to the market formation for gas-free solutions. However, it is still a developing market which is currently not (yet) competitive enough to lead to the destabilisation of markets for unsustainable solutions, as indicated by interviewees (11). This lack of competitiveness mostly stems from the insufficient price-performance ratio of gas-free solutions, hampering the development of a large-scale demand from customers for these solutions. In addition, interviewees (6) mentioned that the supply side and the demand side of gas-free solutions are currently not yet properly aligned. The gas-free solutions are often not demand-driven, and consumers' wishes (i.e., limited disturbance caused during implementation, unburdening service concepts) are not sufficiently incorporated. However, to stimulate market formation, it is deemed crucial to make supply more responsive to demand due to the impact the implementation of solutions has on the personal environment of homeowners.

As pointed out earlier in the context of entrepreneurial activity (SF1), SMEs are experiencing difficulties in scaling-up their innovations limiting market formation. Interviewees (14) mentioned several causes for this. Firstly, the (policy) support for scaling-up, except within the PAW program, is insufficient and mostly focussed on the pilot or start-up phase of innovations. The availability of financial resources (SF6) for developing technological innovations is much more numerous than those for scaling-up. Secondly, the large-scale roll-out of a standardised approach is considered difficult due to the fragmented and heterogenous character of the built environment. Although many homes can be categorised into certain type of houses, in practice it often turns out that they slightly differ from one another, thereby making customisation necessary. Thirdly, there is limited entrepreneurial activity (SF1) in the field of digitalisation and industrialisation, which are important pillars for scaling up the innovations. Lastly, the implementation of gas-free solutions, in particular heat networks, into the existing built environment is highly complex due to existing rights, spatial impact, and fitting it into the existing infrastructure (electricity, water, sewage, etc.). As a result, most of the current heat networks are constructed in new building project where everything could be designed from scratch resulting in a relatively low costs price per connection. This has hampered the development and scaling up of heat network in the existing built environment.

In the context of market destabilisation, interviewees (5) describe that the implementation of destabilising policy is limited but in development. In the last decade, the government has taken several de-stimulating measures such as the gradually increasing energy tax (Rijksoverheid, n.d.-b), the surcharge for sustainable energy (in Dutch: *Opslag Duurzame Energie (ODE))* of which the revenues are used to stimulate the production of sustainable energy via the subsidy scheme SDE++ (Rijksoverheid, n.d.-b), and the abolition of the gas connection obligation for new buildings (RVO, 2018). However, according to interviewees (10) these measures are insufficient to significantly reduce the use of fossil fuels and to stimulate sustainable energy. They further emphasised that the national government engages in limited market destabilisation activities and are reluctant to do this. It is criticised that the policy steps taken to destabilise current harmful practices is very marginal and not decisive enough. For example, to compensate the sharp rise in energy bills, due to rising prices on the gas and electricity market because of the Ukraine-Russia war, the government has increased the energy refund tax and lowered the VAT on energy from 21% to 9%. For vulnerable, low- and medium-income households, it is very important that they are compensated for the high energy bills as they also have less money available to take sustainable measures (i.e., insulation or heat pump), however this does not apply for higher-income households which are able to do this. Since the measures apply to every household in the Netherlands (low-, medium- and high-income), they are widely criticised as it reduces the incentive for higher-income households to become more sustainable and minimises the destabilising effect caused by the high energy prices. It is therefore seen as an indirect support for the usage of fossil energy. More tailored measures are needed to maximise the support for low-income households and the minimise the compensation for the higher incomes.

Although there is criticism on the destabilising policy, very recently (17^{th} of May 2022) the Dutch government announced that from 2026 hybrid heat pumps will become the standard for heating homes. This means that when central heating systems are replaced, house owners will have to switch to a more sustainable alternative (e.g., hybrid heat pump, all-electric heat pump, or connection to a heat network) (Rijksoverheid, 2022b). This standardisation is a critical step in the destabilisation of current harmful practices and will positively contribute to the development of the market for the sustainable alternatives.

SF6: Resources (re)allocation

Interviewees (11) describe the availability of financial resources for the energy transition to be good. In the coalition agreement of the new government (December 2021), agreements regarding the funding for the climate transition have been made. A total funding of €35 billion for the next 10 years is made available to help build the necessary energy infrastructure (electricity, heat, hydrogen, and CO_2), to release green industrial policy and to make mobility and the built environment more sustainable (Rijksoverheid, 2021d). Although this funding is intended for all sectors (electricity, mobility, industry, built environment, and agriculture and land use), the available budget for the transition in the built environment has increased significantly and has not been so high before. This is further strengthened by the already available subsidy schemes such as the Sustainable Energy Subsidy Scheme (SDE++), the Demonstration of Energy and Climate Innovation (DEI+), the Mission Driven Research, Development, and Innovation (MOOI), and the Investment subsidy for renewable energy and energy savings (ISDE) (RVO, 2022a). However, these subsidy schemes are mainly focussed on the development of technological innovations and limited on the development of social innovation and are often criticised for their (dis)continuity. Several weaknesses regarding resources (re)allocation have been mentioned.

Firstly, interviewees (11) mentioned that the financial resource available for the gas-free transition are insufficiently mobilised within the built environment. The mobilisation of financial resources to low and middle-income household, which have limited or no money to take sustainable measures, is currently lagging. For example, homeowners can receive a subsidy up to 30% via the ISDE when taking an insulation measure and/or making an investment in a heat pump, solar boil, or heat network connection. However, it is still necessary that they are financial capable to convert the remaining investments costs. To mobilise, stimulate, and help the low- and middle-income households in their transition to gas-free, interviewees (4) point out the need for new subsidy schemes, funds, or (social) loans specially focused on this group. Furthermore, residents' initiatives and energy cooperatives experience a difficulty in gaining structural support and funding from governments in both the orientation as implementation phase.

Secondly, the availability of resources to support municipalities in fulfilling the governing role in the district-oriented approach is described by interviewees (14) to be insufficient. The allocation of financial resources, i.e., (partial) reimbursement of the implementation costs made for the transition by the municipalities, and human resources (i.e., available FTEs) is currently lacking. This mostly applies for the small to medium-sized municipalities, and not the large-sized municipalities which have often sufficient resources available. Due to this limited allocation of resources in combination with the complexity of the transition, has hampered the process of disconnecting existing houses from natural gas. Although there is a consensus that the municipality is the best candidate for the governing role, it has been criticised that the burden has been shifted to the municipalities and that the national government has provided insufficient support until now. Furthermore, it is deemed crucial to overcome this weakness to accelerate the transition on local level.

Lastly, in the built sector there is currently a significant shortage of human resources needed to reach the mission goals. This mostly concerns human capital that installs and implements the sustainable solutions into the existing built environment (e.g., the installation of heat pumps, implementing insulation measures, and construction of heat networks) (Mensen Maken de Transitie, n.d.). The shortage of human resources is not specific for the built sector but is a nationwide problem which affects also other sectors. In combination with the declining valuation of the technical profession and the enrolment in related educations, it is not expected that this shortage will be filled in the course of time (van der Molen, et al., 2019). Therefore, the importance of reducing the labour intensity of current processes has been emphasised. Means to do this are by developing easy to install (plug & play) products and by improving the efficiency in the supply chain by stimulating innovations that are focused on achieving this (SF1).

<u>SF7: Creation and withdrawal of legitimacy</u>

Although the Climate Agreement emphasises the need to reduce the CO_2-emissions by making the transition to a gas-free built environment, the legitimacy of the societal problem has not also been high. However, interviewees (6) describe that the legitimacy for the societal problem is growing, and it is reaching its high level. This is reflected in the new coalition agreement in which the climate transition has been further emphasised and the newly published policy program on accelerating the sustainability in the built environment (Rijksoverheid, 2021d; Rijksoverheid, 2022a). Furthermore, the Ukraine-Russia war has brought the importance of becoming independent of Russian natural gas to the forefront. Although this is not primarily focussed on reducing CO_2-emission, the need to accelerate the phasing-out of natural gas still has increased the legitimacy of the problem.

Interviewees (4) pointed out that there is a positive movement towards growing legitimacy for bottom-up initiatives, such as energy cooperatives, residents' initiatives, and citizen participation. These initiatives have received significantly more attention and recognition in the recent years. However, it is still developing and according to interviewees (5) the legitimacy for residents' initiatives and energy cooperatives is currently still low. These bottom-up initiatives are often not seen as a valuable partner in the gas-free transition by the municipalities and the national government, because they are often labelled as unprofessional and inexperienced. However, as mentioned, this is changing as people realise that these initiatives can contribute positively to the support for this transition and thereby mobilising house owners in a neighbourhood (Beers, et al., 2019).

An important limitation indicated by interviewees (9) is the low legitimacy among residents for making the transition to gas-free. Three important causes have been mentioned. Firstly, the measures needed in achieving a gas-free house have a significant impact on both the personal environment as well as the financial situation of the residents. For example, in the case of taking insulation measures, the walls must be striped and different workmen are needed to deliver it neatly, which can cause inconvenience to the residents. Secondly, the higher purchase price of sustainable solutions in comparison to conventional solutions make homeowners reluctant to invest in it. Lastly, the urgency of the transition is not always been felt by the residents. Mentioned reasons for this are; the transition has a voluntary character and has not been imposed on people, thereby reducing the urgency; some people experience other problems in life thereby reducing the important or focus on this; and there because there is not always a direct benefit from taking sustainable measures for some homeowners (i.e., comfort wise), apart from the currently high energy prices, making them reluctant to take gas-free measures.

Although there is indicated that there is an overall legitimacy to the set of needed solutions, discussions about the legitimacy of certain solutions, in particular heat networks and hydrogen, remain. In the case of heat networks its legitimacy is hampered by their monopolistic character and thereby opposition comes from those seeing this as a limitation of their freedom of choice. In addition, the price of heat delivered through a heat network is coupled with the gas price, meaning that when the price of gas is rising, which is currently the case, the heat price will also go up. The new Heat Act (as discussed in 4.2.3) is expected to address these problems, however this process has been considerably delayed and the law will be presented to the parliament at earliest in 2023. It is expressed by interviewees (11) that the design and the speed of introduction of the new heat law will be decisive for the development of sustainable collective heat solutions. In the case of hydrogen, the discussion mostly originates from the lack of available green hydrogen now and in the coming ten years, and when available it is seen more as a solution for greening the industry then the built environment.

Table 9. Summary of the mentioned strengths and weaknesses of each respective system function.

System function	Strengths	Weaknesses
SF1: Entrepreneurial activities	(+) many entrepreneurial activities regarding (technological) solutions (+) good entrepreneurial climate for technological entrepreneurship	(-) lacking entrepreneurial activity regarding integral solutions and process innovation (-) lagging entrepreneurial activity in the field of digitalisation and industrialisation (-) social entrepreneurial activity limited in comparison to technological entrepreneurship (-) limited entrepreneurial activity focussed on (supply) chain cooperation
SF2: Knowledge creation	(+) strong fundamental knowledge development (+) strong technological knowledge development	(-) lagging development of social knowledge (-) insufficient knowledge development at municipal level (-) knowledge insufficiently embedded within municipal level
SF3: Knowledge diffusion	(-) stakeholders actively diffuse knowledge (+) high willingness to diffuse knowledge	(-) insufficient knowledge diffusion towards society, especially homeowners (-) knowledge diffusion often superficial and limited domain transcending (-) insufficient knowledge diffusion towards and among SME's
SF4a: Problem directionality	(+) high prioritisation transition natural gas-free (+) many stakeholders feel connected to the mission (+) growing prioritisation on phasing out natural gas due to Ukraine-Russia war	(-) prioritisation on energy independence could lead to sub-optimal solutions
SF4b: Solution directionality	(+) broadly supported vision of needed technological solutions	(-) insufficient directionality provided regarding the execution of the mission and the implementation of the solutions (-) insufficient directionality provided by the Visions on Heat (TVW) (-) weak solution directionality provided by national government
SF4c: Reflexive governance	(+) sufficient monitoring overall mission progress	(-) inadequate evaluation of the effectiveness of the various policy instruments (-) insufficient monitoring mission progress

SF5: Market formation and destabilisation	(+) strong incentive to engage in market formation activities due to potential of the market (+) developing markets for natural gas-free solutions (+) destabilising policy in development	(-) gas-free solutions often not demand driven, limiting market formation (-) current markets for natural gas-free solutions underdeveloped (-) national government engages in limited destabilisation activities
SF6: Resources (re)allocation	(+) large availability financial resources for energy transition (+) many resources available for technological innovations	(-) financial resources insufficiently mobilised within the built environment (-) insufficient mobilisation of resources to support municipalities in the district-oriented approach (-) insufficient mobilisation of financial resources to low- and middle-income households (-) lack of human resources within the built environment sector
SF7: Creation and withdrawal of legitimacy	(+) growing legitimacy natural gas-free transition (+) Ukraine-Russia war has brought the importance of phasing out natural gas to the forefront, thereby increasing the legitimacy of the natural gas-free transition (+) positive movement towards growing legitimacy for bottom-up initiatives (+) growing legitimacy natural gas-free solutions	(-) legitimacy natural gas-free transition among residents limited due to the impact it has (i.e., financial, personal environment) (-) legitimacy bottom-up initiatives still considered low (-) low legitimacy for some technological solutions (i.e., heat networks and hydrogen)

4.4 System barrier analysis

In this section, the systemic barriers in the MIS are described and their interrelatedness with other system functions. The systemic barriers reflect structural components that are missing or unable to support the system functions in relation to the system functions they influence. The systemic barriers are identified based on the previous analyses and the gathered (interview) data. A distinction is made between the *mission arena* and the *overall MIS*. At the end of this section, an overview (table 10) and a visualisation (figure 1) of the systemic barriers and interrelated SF(s) is presented.

4.4.1 Systemic barriers in the Mission arena

<u>Systemic barrier 1: Municipalities have difficulties in fulfilling their governing role in the district-oriented approach</u>

The first systemic barrier identified in the mission arena relates to the governance structure, specifically the governing role of the municipalities in the district-oriented approach. The municipalities experience difficulties in fulfilling this role which is the result of structural problems located around human capital, financial resources, and knowledge development and diffusion. In the last decade, considerable number of tasks haven been decentralised to municipalities and broader social tasks and developments have also led to more responsibilities at the municipal level, such as the district-oriented approach. This has led to municipalities increasingly reaching the limits of their human capacity and expertise, organisation processes and management, and financial resources (VNG, 2020). The problems arise particularly in small and medium-sized municipalities. Currently there is insufficient human capacity (FTEs) at the municipal level to take on their governing role and learn the new skills required for this transition (SF6), hampering the development and assurance of knowledge within the municipalities (SF2). This has resulted in a lack of educated/knowledgeable personnel (SF6) at municipal level needed to tailor the solutions for the heterogeneous neighbourhoods. Furthermore, the limited financial resources available at the municipal level and the insufficient mobilisation of financial resources towards them, have resulted in the municipalities being unable to cover the costs associated with the district-oriented approach (SF6), thereby hampering the execution of the mission. In addition, due to discussion between the national government and the municipalities about the instruments needed and provided, the process of adjusting policy instruments is hampered (SF4c). These discussions originate around issues such as affordability for citizens, support in the implementation of the district-oriented approach (especially for small municipalities), and the human capacity needed.

This systemic barrier in turn has an implication on the solution directionality (SF4b) provided to the overall MIS. As a result of the difficulties municipalities experience in fulfilling their governing role, many struggled to draft a sound and well-developed vision on how to make the transition to gas-free in their districts. Limited choices have been made and residents have been left in the dark with questions about which measures to take and when. Due to the lack of clarity of the Visions on Heat (TVWs), they have insufficiently contributed to providing solutions directionality to the overall MIS.

<u>Systemic barrier 2: Missing central steering on the execution of the mission</u>

The second systemic barrier also touched upon the governance structure and in particular the role of the national government in the execution of the mission. As pointed out earlier (section 4.2), the Mission-oriented Top Sector and Innovation Policy is the nationwide policy focussed on tackling societal challenges by strongly focussing on innovation, research, and (technological) development. In addition to stimulating innovation, the national government is responsible for setting up the legislative framework and the provision of policy instruments to lower levels of governments. However, as in line with the district-oriented approach, the execution of the mission lies in the hands of the 344 municipalities which each have different perspectives and rationales resulting in large variance in the choices made. Although the complexity and the local character of the heat transition require that room is given at the municipal level to make choices about the needed solutions, providing too less directionality can lead to a lack of choices or their absence. This is reflected in the level of abstraction of the Visions on Heat (TVWs) which differ considerably. In particular, the concreteness differs on (a) whether or not concrete starting districts are named, (b) whether or not a step-by-step approach has been developed, and (c) whether or not an end date for natural gas has been set (Stroomversnelling, n.d.-a). Furthermore, the TVWs are full of ifs, buts and disclaimers due to uncertainty among municipalities regarding the available capacity and financing for the district-oriented approach (Stroomversnelling, n.d.-b). In addition, the lack of guidance provided by the national government has led to the inadequate tackling of bottlenecks such as *limitations of the current legal framework*, *lack of instruments provided for acceleration*, *capacity problems, financing,* and *a lack of a broadly supported and overarching story* (PBL, 2021b). To better coordinate the execution of the mission and to accelerate the roll-out of the district-oriented approach central steering is needed, which is currently missing.

This systemic barrier is further strengthened by a weak reflexive governance to evaluate or redirect the mission, which is a result of (a) the lack of extensive evaluations of both the effectiveness of the overall policy and policy instruments, (b) inadequate feedback mechanisms between national government and governmental organisations (e.g., between EZK and RVO) and between national government and lower levels of governments, and (c) the limited consequences attached to not achieving mission objectives. Due to the weak reflexive governance, ineffective policy or policy instruments are often adjusted too slow and hampers the adequateness of the national solution directionality provided.

The lack of central steering on the execution of the mission has implications on three other system functions. First, the reluctance of the national government to make choices about which solutions to pursue but leaving it open for the municipalities to decide, has resulted in a lack of national solution directionality (SF4b). A certain degree of national solution directionality should be provided to help the municipalities with the complexity of choosing the most suitable solution. Second, since choices about the solutions and their implementation are being made sparsely, room is given for the emergence of legitimacy discussions (SF7). These discussions, in turn, hinder the development of markets for the respective solutions. Thirdly, the missing steering on the execution of the mission leads to a lack of long-term certainty about the solution pathways, thereby hampering the development of markets for innovative sustainable solutions (SF5). Furthermore, this systemic barrier strongly influences the first systemic barrier since the difficulty in fulfilling the governing role for municipalities partly stems from the insufficient directionality and steering.

<u>Systemic barrier 3: Bias for technological development and innovation</u>

The third systemic barrier identified is a bias for technological development and innovation over social development and innovation. As discussed earlier (section 4.3), this is mainly due to the more tangible character of technological knowledge and innovations. Furthermore, technological innovations fit the typical innovation policy paradigm of making investments to (a) solve societal problems without require behavioural changes and inconvenient government interactions, (b) while at the same time creating economic competitiveness in an industry that can export the solutions. Two implications arise from this bias. First, resources are insufficiently mobilised to support the development of social innovations, making it difficult for them to receive structural support. The lack of resource mobilisation and supportive structure for social innovations hampers the social entrepreneurial activity (SF1) and the development of social knowledge (SF2) within the MIS. However, these aspects are deemed important to find ways to mobilise homeowners to take sustainable measures thus influencing systemic barrier 6 (elaborated in respective section). Second, the bias hampers the creation of legitimacy for bottom-up (social) initiatives. As pointed out earlier, these initiatives are often seen as unprofessional and inferior to other solutions, therefore struggling to gain legitimacy.

Furthermore, the low legitimacy makes governments and organisations reluctant to release funds for these types of initiatives.

4.4.2 Systemic barriers overall MIS

Systemic barrier 4: Fragmented built environment sector

The fourth systemic barrier identified is the fragmented character of the built environment sector. The sector is characterised by numerous SMEs each operating within a specific domain (e.g., construction, installation, heat generation, heat supply, insulation, etc.). These actors often have a limited incentive to engage in collaborations that are domain transcending or that cover the entire supply chain. However, such collaborations are needed to increase the efficiency in the supply chain and to come to integral solutions and synergies between solutions. Due to the limitedness of these kind of collaborations, there is a lacking entrepreneurial activity regarding the development of integral solutions. This has further implications on the development of markets for gas-free solutions (SF5) since integral solutions are considered important to increase demand and accelerate the adoption by homeowners. In addition, the fragmentation of the system and the limited collaboration also results in a limited domain transcending diffusion of knowledge (SF3). This forms a hurdle for the mission arena to diffuse the mission's problems and solution to all relevant stakeholders in the MIS. Furthermore, it also affects the development of knowledge at the municipal level (SF2).

Systemic barrier 5: Innovations experience difficulties in scaling-up

The fifth systemic barrier relates to the difficulties innovations experience in scaling up, which has implications on the development of the market for gas-free solutions (SF5). In turn, due to the underdeveloped markets, the development of a large-scale demand is lagging which has further implications on the scaling up of innovation. The creation of a large-scale demand is needed to make the business case (i.e., for the investor, customer, etc.) more competitive and for economies of scale. Both the systemic barrier and the weak system function reinforce each other, thereby forming a positive feedback loop.

There are several system function weaknesses, originating from other systemic barriers, which are influencing the development of markets for gas-free solutions (SF5). First, there is a lacking entrepreneurial activity regarding the development of integral solutions, smart tools and services (digitalisation), and easy to install solutions (i.e., plug & play) (industrialisation) (SF1), which are important pillars to better match supply and demand. Furthermore, currently there isn't really any standardised way of making homes gas-free. Although this isn't easy due to the heterogenous character of the buildings, some degree of standardisation is needed to increase the pace and scale thereby lowering the costs involved. Second, legitimacy discussions about the solutions and their implementation hamper the development of the markets for those solutions (SF7). Third, because there is a difficulty in mobilising homeowners to take sustainable measures due to the lack of clarity about what to do, they are reluctant to invest in sustainable measures (SF6). This reluctance hampers the creation of a large-scale demand and thereby the formation of markets for these solutions. Fourth and last, resources are insufficiently made available to support innovations in the scaling up phase (SF6). The resources available for the pilot or start-up phase are overall considered to be sufficient, however, after this phase the structural support is missing. Providing support in the scaling up phase is important since the business case is often not yet competitive, making it difficult to attract investors.

Systemic barrier 6: Difficulty in mobilising homeowners to take sustainable measures

The sixth and last systemic barrier relates to the difficulties in mobilising homeowners to take sustainable measures. This systemic barrier is influenced by a lack of national solution directionality and solution directionality provided by the Visions on Heat (TVWs), which are in turn caused by a missing central steering on the execution of the mission (systemic barrier 2) and the difficulties municipalities have in fulfilling their governing role in the district-oriented approach (systemic barrier

1), respectively. The lack of solution directionality leads to a lack of clarity for homeowners about which solutions they can take, which are the best for their situation, and when they should take sustainable measures. Because homeowners are left with questions and uncertainty about what to do, they are reluctant to invest in sustainable measures (SF6). The creating of a large-scale demand from homeowners for gas-free solutions is thereby lagging which has further implications on the development of markets for gas-free solutions. In addition, as discussed earlier, the bias for technological development and innovation (systemic barrier 3) results in a lack of resource mobilisation to support social development and innovation (SF6), which in turn hampers social entrepreneurial activities (SF1) and the development of social knowledge (SF2). Due to the fact this is lagging, insufficient tools and instruments are developed that incorporate social aspects and factors, which are deemed important to mobilise homeowners to take sustainable measures.

Table 10. Overview systemic barriers and interrelated SFs.

Systemic barrier	**Implications on SF(s)**
(1a) Limited financial resources and human capital at municipal level	• **SF2**: Limited development and assurance of knowledge at municipal level • **SF6**: insufficient mobilisation of financial resources & lack of educated/knowledgeable personnel at municipal level
(1b) Municipalities have difficulties in fulfilling their governing role in the district-oriented approach	• **SF4b**: Visions on Heat insufficiently contribute to providing solution directionality to the overall MIS
(2) Missing central steering on the execution of the mission	• **SF4b**: lack of national solution directionality • **SF5**: underdeveloped markets for gas-free solutions • **SF6**: insufficient mobilisation of resources to innovations in the scaling up phase • **SF7**: legitimacy discussion about solutions and their implementation (how, when, where)
(3) Bias for technological development and innovation	• **SF6**: lack of resource mobilisation to support social development and innovation • **SF7**: low legitimacy for bottom-up (social) initiatives • **SF1 & 2**: lagging social entrepreneurial activities and development of social knowledge
(4) Fragmented character built environment sector	• **SF1**: lacking entrepreneurial activity regarding the development of integral solutions • **SF3**: limited domain transcending diffusion of knowledge
(5) Innovations experience difficulties in scaling up	• **SF5**: underdeveloped market for gas-free solutions
(6) Difficulty in mobilising homeowners to take sustainable measures	• **SF6**: reluctant to invest

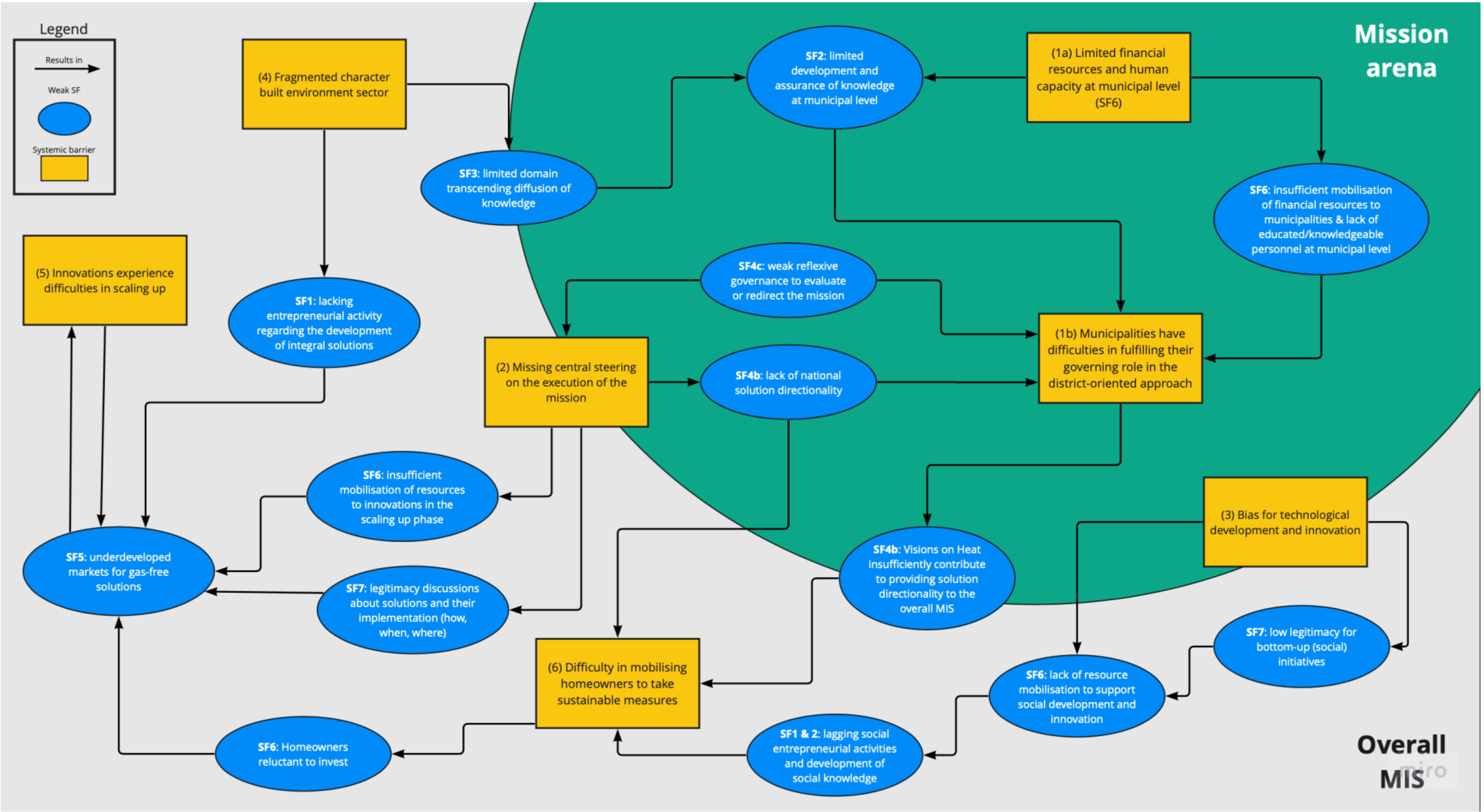

Figure 1. Visualisation systemic barriers and their interrelatedness.

4.5 Reflection (planned) mission governance actions and governance structure

In this section, the current and planned mission governance actions (MGAs) targeting the identified systemic barriers are discussed.

4.5.1 Identified current and planned mission governance actions (MGAs)

At the built environment sector table of the Climate Agreement, a total of 137 agreement were made to achieve the objectives of the Climate Agreement (Klimaatakkoord, 2019). These agreements vary from agreements on needed policy instruments, government actions, and commitments by market parties to engage in sustainable practices. The commitments by market parties are considered to be less profound than the government actions, due to its voluntary character. Therefore, the government actions are considered further. Based on this, a total of 11 mission governance actions were identified that originated from the Climate Agreement. Next to this, the Integral Knowledge and Innovation Agenda (IKIA) and the Mission-oriented Topsector and Innovation Policy (MTIB) have also led to several MGAs which are relevant for the studied mission. Important of these are the MMIPs and the MOOI (Mission-driven Research, Development, and Innovation) which are interrelated and are at the heart of the Mission-oriented Innovation and Top Sector Policy. The MMIPs outline the knowledge and innovation challenges to be tackled in the short term for research, development, demonstration, and implementation. The MOOI is interrelated with the MMIPs as it follows their themes, and its budget is tied to it. The MOOI differs from other innovation subsidy schemes since it is intended for multidisciplinary consortia working on integral solutions rather than individual technologies (Janssen, 2020).

In addition to the current mission governance actions, the Ministry of the Interior and Kingdom Relations has presented on 1 June 2022 a new policy programme titled '*accelerating the sustainability of the built environment*', which aims to speed up the transition to a climate neutral built environment. This programme is developed in reaction to the current too slow pace of making the built environment more sustainable and the development of the fit-for-55 package in the European context. Once finalised, expected in 2023, the guidelines of the fit-for-55 package must be transposed by the Dutch government into national legislation and climate policy. Therefore, the main points of the fit-for-55 packages[9] have been used as a guideline for the development of the programme accelerating the sustainability of the built environment (Volkshuisvesting en Ruimtelijke Ordening, 2022). The aim of the new policy programme is to bring a sustainable home within reach for everyone, with a special attention to household with a small budget. To achieve this, various measures will be taken targeted on (a) *energy savings and sustainable heat supply*, (b) *affordability for everyone*, (c) *new standards for making the built environment more sustainable*, and (d) *increasing the implementation capacity of municipalities and the market* (Rijksoverheid, 2022a; Klimaatakkoord, 2022).

An overview of the identified (planned) MGAs originating from the Climate Agreement, the Mission-oriented Topsector and Innovation Policy (MTIB) and Integral Knowledge and Innovation Agenda (IKIA), and the new policy programme '*accelerating the sustainability of the built environment*' can be found in table 11.

[9] The main points of the package are: (1) introduction of an emission trading system for the built environment, (2) increase of the ambition for energy efficiency and renewable energy, (3) acceleration of the renovation rate and phasing out of bad energy labels, and (4) revision of the European Energy Taxation Directive (ETD) (Volkshuisvesting en Ruimtelijke Ordening, 2022).

Table 11. Overview identified current and planned Mission Governance Actions (MGAs).

Mission Governance Actions (MGAs)		Description
Climate Agreement	Programma Aardgasvrije Wijken (*Natural Gas Free Neighbourhood Programme*) (PAW)	In this inter-governmental programme various ministries and umbrella organisations work to provide municipalities and parties involved with the best possible support in the natural gas-free tasks. The involved organisations look at practical problems and resolve them wherever possible to better design and scale up the district-oriented approach. This is done through a Knowledge and Learning Programme (KLP) and large-scale pilots, which provide a flywheel so that municipalities, together with parties involved, are able to start with the district-oriented approach on an increasingly larger scale (PAW, n.d.-a).
	Expertise Centrum Warmte (*Expertise Centre Heat*) (ECW)	An expert knowledge centre that supports municipalities in the heat transition by dealing with issues in the field of technology, finance, market organisation, and sustainability (ECW, n.d.-b).
	Nationaal Programma Regionale Energiestrategie (*National Programme Regional Energy Strategy*) (NP RES)	One of the agreements of the Climate Agreement is that 30 energy regions investigate where and how sustainable electricity can best be generated on land (wind and sun) and which heat sources can be used to make the transition in the built environment to gas-free. Each energy region describes its own choices in the Regional Energy Strategy (RES). The NP RES supports the regions in making their RESs. This includes developing and sharing knowledge, process support (for decision-making, participation, etc.), data support (analyses, calculation methods, etc.), a learning community, an expert pool and account managers (Nationaal Programma RES, n.d.-b).
	Demonstratie Energie- en Klimaatinnovatie: Innovaties aardgasloze woningen, wijken en gebouwen (Demonstration Energy and Climate Innovation) (DEI+)	This subsidy scheme supports projects in which one or more innovative products and services are developed that contribute to the transition to natural-gas free or gas-free-ready homes, buildings, and/or neighbourhoods (RVO, 2022c; TKI Urban Energy, n.d.-b).
	Investeringsubsidie duurzame energie en energiebesparing (*Investment Subsidy for Sustainable Energy and Energy Savings*) (ISDE)	• *House owners* can make use of the ISDE with an investment in a solar boiler, heat pump, a connection to a heat network, and with 5 types of insulation measures. Different subsidy amount applies to each investment (RVO, 2022i). From 2022 onwards the subsidy amount for solar boilers, (hybrid) heat pumps, and insulation measures have been increased (RVO, 2022h); • *Business users*[10] can make use of the ISDE when doing an investment in a (hybrid) heat pump and a solar boiler. For Homeowner Associations (VvEs) the ISDE applies, in addition to a heat pump and solar boiler, also to a central connection to a heat network of an apartment building. Different subsidy amount applies to each investment (RVO, 2022j).
	Stimuleringsregeling aardgasvrije huurwoningen (*Incentive Scheme for Natural Gas-free Rental Properties*) (SAH)	Landlords can receive a subsidy for existing houses that are to be phased out of natural gas within 5 years and that are or will be connected to a heat network. The subsidy is available for adaptations in the homes (internal housing costs) and for the connection costs to the external heat network. As of 1 October 2021, mixed VvEs may also apply for the SAH (RVO, 2022n).

[10] Companies, housing corporations, associations, homeowner associations (*in Dutch: Vereniging van Eigenaars, VvEs*), and private landlords (RVO, 2022j).

	Subsidieregeling Energiebesparing Eigen Huis (*Home Energy Savings Subsidy Scheme)* (SEEH)	This subsidy scheme is intended for (mixed) Homeowner Associations (VvEs), housing associations, and housing cooperatives that want to save energy in their buildings (insulations measures, energy advice, etc.) (RVO, 2022o).
	Regeling Vermindering Verhuurderheffing (*Landlord Levy Reduction Scheme*) (RVV)	Landlords with more than 50 social housing units can apply for the RVV and thereby receive a tax benefit in order to make their housing stock more sustainable (RVO, 2022l). Recently, the coalition agreement announced that the RVV would be abolished on 1 January 2023. The government will present a bill on this subject to the parliament in 2022 (Rijksoverheid, 2021d).
	Nationaal Warmtefonds (*National Heat Fund*)	The National Heat Fund offers homeowners and VvEs loans (Energy Savings Loan) at favourable rates for financing energy-saving measures, such as insulation measures, (hybrid) heat pump, heat network connection, energy savings advice, guidance, and management tools (Nationaal Warmtefonds, n.d.).
	Renovatieversneller (*Renovation Accelerator*)	This national multi-year support and learning programme offers subsidies, sharing of knowledge, and experience and guidance to applicant and provides who together want to make the process of making rental houses more sustainable faster, better, and more affordable. It contributes to the mission goals by stimulating accelerated upscaling of energy renovations at lower integral costs and aims to achieve more innovation and higher productivity in the construction sector (de Renovatie Versneller, n.d.). The Renovation Accelerator is an important part of the 'Starter Motor for the Rental Sector'[11] in the Climate Agreement (Klimaatakkoord, 2019).
	Verbeterjehuis.nl (*Improveyourhome.nl*)	This (online) platform provides homeowners advice on energy-saving measures and the savings, costs, financing, and implementation of those measures. The aim of the platform is to bring information and advice on energy-saving measures in the home together in one place, making it easier for homeowners to take sustainable steps in their homes (Verbeterjehuis, n.d.-a).
IKIA/MTIB	MMIP 2: Renewable electricity generation on land and in the built environment	This MMIP has as main objective to make innovative solutions available that combine the large-scale generation of electricity from renewable sources on land with preserving or even strengthening other values and functions such as the quality of the living environment, nature and recreation, agriculture and horticulture, and transport and mobility. The focus of the MMIP is on the development of the innovations needed to enable strong growth of renewable electricity generation on land, considering technical, economic, social and environmental factors and its integration into the energy system (TKI Urban Energy, 2021c).
	MMIP 3: Acceleration of energy renovations in the built environment	This MMIP has as main objective to develop innovation that prepare homes and utility buildings for a natural gas-free heating supply and that accelerate the scaling up of energy renovations. It focuses on the realisation of integral solutions, whereby at least the following three aspects are addressed: (1) *development of integral renovation concepts for homes and non-residential buildings*, (2) *industrialisation and digitalisation of the renovation process*, and (3) *putting building owners and users at the heart of energy renovations* (TKI Urban Energy, 2021d).
	MMIP 4: Sustainable heat and cold in the built environment	This MMIP has as main objective to develop a range of competitive and attractive natural gas-free options for end users in residential construction, non-residential construction, and greenhouse horticulture. It focuses on the development of

[11] The Stater Motor for the Rental Sector is a part of the Climate Agreement on which agreements are made to accelerate the process of making rental houses more sustainable. The aim is to make 100,000 rental houses gas-free or gas-free ready between 2019 and 2023 (Klimaatakkoord, 2019).

		individual heat production and storage systems and on large-scale collective heat networks in combination with sustainable sources and large-scale heat storage. The MMIP consists of seven sub-programmes: (1) *heat pumps*, (2) *distribution, ventilation, and tap water systems*, (3) *small-scale heat storage systems*, (4) *sustainable heat and cold networks*, (5) *large-scale thermal storage*, (6) *geothermal energy*, and (7) *low-temperature heat sources (ground source heat, aquathermia, solar thermal energy and low-temperature residual heat* (TKI Urban Energy, 2021b).
	MMIP 5: Electrification of the energy system in the built environment	This MMIP focuses on the electricity supply in the built environment and works towards three main objectives: (1) *scalable solutions for the facilitation of a reliable, efficient, smart, integral, and socially supported system of electricity generations, storage, conversion, transport, and use in the built environment, with attention for the local context, other energy carriers in the built environment, and the connection with the (inter)national energy system*, (2) *solutions which enable end-users to shape and intervene in the way they sustainably meet their own energy requirements, taking into account the context of the (local) energy system*, and (3) *realising the flexible electricity capacity of and for the built environment that will be needed in 2030 (including electricity demand for transport in the built environment*) (TKI Urban Energy, 2021a).
	Missiegedreven Onderzoek, Ontwikkeling en Innovatie (*Mission Driven Research, Development, and Innovation*) (MOOI: Gebouwde Omgeving)	The MOOI scheme is for multidisciplinary consortia that work together on innovative solutions with a multidisciplinary approach to develop integral solutions that contribute to the climate goals. The consortia need to take technical, social, and other factors that increase the chances of success into account in their projects. The MOOI stimulates research and development projects that help in the transition to affordable, reliable, clean, sustainable, energy-efficient, and safe housing and heating. The themes of the MOOI correspond to those of the MMIPs (RVO, 2022k; TKI Urban Energy, n.d.-b).
	Stimulering duurzame energieproductie en klimaattransitie (*Stimulation of Sustainable Energy Production and Climate Transition*) (SDE++)	This subsidy scheme focuses on the large-scale rollout of technologies that produce renewable energy and other technologies that reduce carbon dioxide (CO_2). It is an exploitation subsidy, meaning that organisations can receive it during the exploitation period of their project. The SDE++ compensates for the difference between the costs price of the renewable energy or the CO_2 emissions to be reduced and the (possible) returns (unprofitable top). The scheme consists of five main categories, each having various techniques: (1) *renewable electricity*, (2) *renewable heat (CHP)*, (3) *renewable gases*, (4) *low CO_2 heat*, and (5) *low CO_2 production* (RVO, 2022m; RVO, 2022b).
	Subsidie Hernieuwbare Energie (*Renewable Energy Subsidy*) (HER+)	The HER+ has as aim to achieve energy targets at less costs through innovative projects. The projects should lead to savings on future expenditures on subsidies for the SDE++ or to costs benefits that are greater than the subsidy requested for. The HER+ projects must focus primarily on the development and demonstration of technologies with a technology readiness level (TRL) of 6 to 8 (RVO, 2022f; RVO, 2022g).
	TSE Gebouwde Omgeving (*TSE Built Environment*)	The TSE Built Environment subsidy has as objective to develop (parts of) new or substantially improved (1) *(renovation)arrangements for homes and non-residential buildings*, (2) *solutions for making collective heating and cooling more sustainable*, or (3) *smart solutions for the reliability, affordability, and fairness of the electricity supply*. The scheme subsidises industrial research and experimental development (RVO, 2021c).

	Kennis- en Innovatieprogramma Integrale Energietransitie Bestaande Bouw (*Knowledge and Innovation Programme Integral Energy Transition Existing Buildings*) (IEBB)	This innovation programme has as main objective to carry out the (scientific and applied) research and innovation in the field of construction, design, and technology that is needed to realise the objectives of the Climate Agreement. It focuses on those developments that will not get off the ground, or will be significantly delayed, without a high degree of cooperation between the various stakeholders. Close cooperation between partners (consortia) from the business community, knowledge institutes, and the government are encouraged. The programme has been developed in parallel and in consultation with the relevant MMIPs for the built environment and outlines activities in the areas of (1) *innovation in the renovation chain*, (2) *innovation for heat pumps and heat batteries*, (3) *innovations for collective heat supply*, and (4) *electrification and system integration (digitalisation and smart buildings)* (BTIC, 2020).
	Uptempo!	In the Uptempo! programme, which is an initiative from the TKI Urban Energy and TKI CLICKNL, promising energy innovations and solutions developed in the Urban Energy innovation programmes are linked to requesting parties (e.g., municipalities, housing corporations, building owners, and homeowners) to accelerate and scale up the energy transition in the built environment. The goal of the programme is to contribute to a situation (around 2025) in which properly functioning, affordable, and supported climate-neutral energy systems are available for practically all situation in the built environment (TKI Urban Energy, n.d.-c).
	Nationaal Isolatieprogramma (*National Insulation Programme*)	This programme has as aim to insulate 2.5 million homes in the period up to and including 2030, with the emphasis on poorly insulated homes (label E, F, and G). The programme has four lines of action: (1) *local approach to insulation of 750,000 homes in collaboration with municipalities*, (2) *insulation of 1 million rental homes*, (3) *accelerated insulation of 750,000 homes on own initiative*, and (4) *low-threshold measures for saving energy*. With this programme a total of 4 billion euros is available until 2030 (Volkshuisvesting en Ruimtelijke Ordening, 2022).
Policy programme: accelerating the	Programma Hybride Warmtepompen (*Programme Hybrid Heat Pumps*)	This programme has as aim to install 1 million hybrid heat pumps by 2030. To achieve this, the following actions will be taken in conjunction and in close consultation with the sector (Volkshuisvesting en Ruimtelijke Ordening, 2022): • *Subsidies*: hybrid heat pumps will be made affordable for increasing numbers of residents and building owners with subsidies. The government has reserved 150 million euros per year for the period 2025 to 2030 for this. • *Standardisation of heating installations*: the government is developing standards to set higher efficiency requirements for heating systems from 2026 onwards when central heating boilers are replaced, leading to hybrid heat pumps or other sustainable techniques to be the logic solution. Setting this standard offers suppliers, installers, and home and building owners a clear perspective. • *Action plan for hybrid heat pumps*: a plan that contains agreements with various stakeholders in the sector that are required to increase the number of installed hybrid heat pumps in the coming years (2022 – 2024). These agreements include uniform communication, unambiguous monitoring of numbers, monitoring the impact on network capacity, scaling up products, and training installers.

	Nationaal Programma Lokale Warmtetransitie (*National Programme Local Heat Transition*) (NPLW)	The NPLW supports municipalities in the local heat transition with two types of activities (1) *acquiring knowledge about what works in practice, developing knowledge and products and tools, and exchanging knowledge and experience in learning circles and network meeting*, and (2) *monitoring the implementation of the Visions on Heat (TVW) and the WUP by using data and surveys to provide an annual overview of the current situation*. In addition, a regional support structure is in place to support cooperation between municipalities by making expertise and project capacity available for directly relevant regional dossiers. The learning and development activities form the PAW, and from the ECW will be integrated into this new programme, which is aimed at all municipalities (Volkshuisvesting en Ruimtelijke Ordening, 2022).
	Programma Groen Gas (*Green Gas Programme*)	The government has the ambition to upscale the production of green gas to 2.0 BCM by 2030, which will be facilitated in the form of a Green Gas Programme. Two main aspects of this program are: (1) *the mandatory blending of natural gas which has as purpose to create a stable sales market by obliging suppliers to green their gas supply using green gas*, and (2) *supporting and flanking policy will be provided, such as supporting innovative techniques, improving access to organic residual flows, and supporting the spatial integration of green gas production* (Volkshuisvesting en Ruimtelijke Ordening, 2022).
	Abolition of the Landlord Levy	The abolition of the landlord levy will create more investment capacity for housing corporations, which then have the financial room to take on the sustainability challenges more effectively. The bill regulating the abolition is currently in consultation and is expected to be effective from 2023 onwards (Rijksoverheid, 2022d).

4.5.2 Systemic barriers, related (planned) MGAs, and proposed interventions

The current and planned MGAs are set out against the identified systemic barriers to assess to what extent these are addressed. Recommendations and focus points are formulated to indicate how the system barriers can be better addressed. This section concludes with an overview of the systemic barriers, current and planned MGAs, and the proposed recommendations and focus points.

4.5.2.1 Municipalities have difficulties in fulfilling their governing role in the district-oriented approach

Currently there are two MGAs targeted at supporting municipalities in the district-oriented approach, which are the Natural Gas Free Neighbourhood Programme (PAW) and the Expertise Centre Heat (ECW). The PAW helps municipalities by identifying and resolving practical problems through a Knowledge and Learning Programme (KLP) and large-scale living labs to scale up the district-oriented approach. The ECW supports municipalities in the heat transition by dealing with issues in the field of technology, finance, market organisation, and sustainability.

The knowledge and findings gained in the PAW are made available for all municipalities so that they can make use of it. However, most municipalities face difficulties in using or applying it into practice due to structural problems related to the available human capital and financial resources at the municipal level. These problems hamper the process of knowledge development and embedding this within the municipalities, which is of importance to deal with the complexity of the transition. The municipalities that have a living lab that is part of the PAW are supported with sufficient guidance and financial resources to help them find ways to rollout solutions and scale up the district-oriented approach. From the 344 municipalities in the Netherlands, only 56 have one or more of such living labs (Rijksoverheid, n.d.-a). It has been pointed out by interviewees (5) that the municipalities that do not have a living lab find it difficult to develop the needed knowledge and receive sufficient financial resources to scale up. Therefore, more attention should be given that sufficient support and financial resources are provided to all municipalities, and not just to the ones that have a living lab. Furthermore, the PAW municipalities tend also to experience scale up problems and attention must be given to create the necessary preconditions for scaling up the district-oriented approach (PAW, 2022). These are important features in helping municipalities to overcome the difficulties in fulfilling their governing role.

The ECW support municipalities in the heat transition through several instruments, of which the '*Leidraad*' (Guideline) is the main one (ECW, n.d.-a). The guideline consists of two parts, the Start Analysis, which was developed by the Netherlands Environmental Assessment Agency (PBL), and the Guide to Local Analysis of the ECW. The Start Analysis provides a first picture of the techno-economic consequences (e.g., national costs, energy demand, CO_2 reduction) for five CO_2-neutral heat strategies at neighbourhood level (ECW, n.d.-a). The municipalities need to further enrich this analysis with local data to tailor it to their local situation, for which tips and guidelines are given by the Guide to Local Analysis. Interviewees (7) have criticised the effectiveness of these instruments due to (a) the top-down approach in defining which insulation level is needed in combination with a technology for a certain package to succeed, (b) the limited inclusion of factors that are important for house owners (i.e., motives, financial aspects, wishes, etc.), and (c) the conservative assumptions regarding energy consumption and costs of energy-saving measures.

Although both the PAW and ECW started in 2019, the interviewed stakeholders pointed out that the difficulty for municipalities in fulfilling their governing role in the district-oriented approach remains a critical barrier. Despite the complexity and time intensity of the natural gas-free transition in the built environment, the effectiveness of these MGAs can be questioned. Opinions differ widely on this as some indicate that the contribution of the PAW and ECW is limited and not a great success, and others indicate that many important and valuable lessons have been learned for scaling up. Nevertheless, for sure it can be concluded that its contribution to the acceleration of the gas-free transition in the built environment has not been as expected. To increase the effectiveness of the programmes, several recommendations are proposed. Firstly, the programmes need to be structured in such a way that they provide sufficient instruments to all municipalities, both in the form of financial resources as structural support in the development and assurance of knowledge within the municipalities. Secondly, it must be ensured that the knowledge developed in the programmes is not solely disseminated to the municipal officials, but that they are also guided in determining what information they need and how they can best make use of it. Lastly, the knowledge developed needs to be structured in such a way that it is know what works under which preconditions. These are crucial features in preparing the municipalities, with the capacity they have, to be able to deal with the complexity of the heat transition and come to sound and well-developed plans.

The national government has announced that a new programme, named National Programme Local Heat Transition (NPLW), will be set up to support municipalities in the local heat transition. The learning and development activities form the PAW and ECW will be integrated into this new programme, whereby a central support structure is created. Furthermore, there will come a regional support structure to support cooperation between municipalities by making expertise and project capacity available for directly relevant regional dossiers. Although these changes seem to be a first step in the right direction, much is still unclear how the programme will be executed and to what extent the discussed points will be incorporated. Focus must be given that the new programme allows for sufficient interplay and feedback between the different levels (i.e., national, regional, local) to adequately tackle bottlenecks arising at the different levels.

4.5.2.2 Missing central steering on the execution of the mission

The current MGAs that are aimed at giving direction and steering to the mission are the Multiyear Mission-driven Innovation Programmes (MMIP 2, 3, 4, and 5). The MMIPs are the main instruments for giving directionality on which knowledge and innovation tasks need to be tackled in the short term for research, development, demonstration, and implementation (Topsector Energie, n.d.-b). Thereby helping companies, knowledge institutions, and other parties in offering the prospect of investing in the development of innovation. Furthermore, the MMIP themes are also reflected in various subsidy schemes, such as the MOOI and TSE Built Environment (RVO, 2022k; RVO, 2021c). Although the MMIPs have positively contributed to the development of innovations, it seems that the overall directionality provided on the execution of the mission has been less profound. Interviewees (14) have indicated that an integral vision is missing on how to implement the innovations into practice. In general, it is known where to end up, namely that 1.5 million existing homes have to be made natural gas-free, however there is no real consensus on how to execute the mission and questions regarding this remain unanswered. The Regional Energy Strategies made by the energy regions and the Visions on Heat, and later District Implementation Plans, made by the municipalities can be used as a basis for the development of this vision.

In addition, it has been criticised by the interviewees (7) that the current thinking is mostly based on solutions and less on the (bottom-up) characteristics of the built environment. This means to look first, for example, to aspects such as what counts to the built environment and of which parts does it consist, what are the characteristics of those parts, and what are the requirements and wishes of the involved actors. To shape an integral vision on how to achieve the mission, both solutions and bottom-up thinking should be considered. This is also reflected in the Strat Analysis, which was initially aimed at helping municipalities in the district-oriented approach by providing directionality on the various solution pathways but felt short in doing this due to the limited incorporation of bottom-up aspects.

With the planned introduction of the programmes on insulation and hybrid heat pump the national government aims to give more guidance to the district-oriented approach and the individual approach.

The main objectives for 2030 of these programmes are (1) *insulate 2.5 million homes with an emphasis on phasing out bad labels (E, F, and G), of which 1.5 million owner-occupied homes and 1 million rented homes*, (2) *1 million hybrid heat pumps installed in existing buildings*, and (3) *500,000 new connections to a heat network in the existing building stock*. As can be seen, the objectives have been made more specific and are directly related to a certain solution. Although this might positively contribute to the solution directionality provided to the overall MIS, care must be taken to not draw attention away from the overarching mission and other solution directions. Sub-optimal solutions could hinder achieving the long term goals. Since it are planned MGAs, it is too early to conclude which effect the new programmes will have on the overall solution directionality.

Besides the observed weak solution directionality provided by the national government, this systemic barrier is also influenced by a weak reflexive governance to evaluate or redirect the mission. There are currently three overall monitoring instruments[12] which are not specific for the mission studied but are more focussed on monitoring the overall climate policy. According to interviewees (7) these instruments are too abstract and do not sufficiently incorporate the local character of the built environment. In addition, the feedback loops tend to be too long or slow thereby hampering the reflexive governance. Monitoring on the local level is mostly done via the PAW which monitors the progress and the learning processes of the program and the living labs. Furthermore, as pointed out by interviewees (6), it is of importance to gather the information centrally to evaluate policy instruments and adjust it. It seems that this current limitation will be addressed in the new programme to support the local heat transition (NPLW) in which the implementation of the Visions on Heat (TVWs) and the District Implementation Plans (WUPs) will be monitored to provide an annual overview of the current situation. This will thus go beyond the monitoring within a certain programme and instead includes all the TVWs and WUPs of the municipalities. Although promising, it is of importance that the monitoring is done in a sufficiently thorough way so that clear conclusions can be drawn from it and ineffective policy instruments can be adjusted.

4.5.2.3 Bias for technological development and innovation

As can been seen from the MGAs mentioned in table 11, they are mostly focussed on themes as technological development and innovation. The MMIPs are focussed on the development of innovation to accelerate the scaling up of energy renovations (MMIP 3), the development of individual heat production and large-scale collective heat networks (MMIP 4), and development of the electricity supply (MMIP 5). This also applies for the Knowledge and Innovation Programme Integral Energy Transition Existing Buildings (IEBB) which is mainly focused on the same themes as the MMIPs. In addition, some of the subsidy schemes are only available to parties engaged in technological development and innovation, for example related to the large-scale rollout of technologies that produce renewable energy or reduce CO_2-emissions (SDE++), and to innovations targeted at achieving energy targets at lower costs (HER+). However, there are two subsidy schemes which have a requirement that, in addition to technological aspects, social aspects must be included in the projects to quality for it. These are the Mission Driven Research, Development, and Innovation (MOOI) scheme and the Demonstration Energy and Climate Innovation (DEI+) scheme.

The MOOI schemes encourages the formation of multidisciplinary consortia working on innovative solutions with a multidisciplinary approach including technological, social, and other relevant aspects, to develop integral solutions. An important facet of this scheme is to combine technological innovation with non-technological aspects to focus on a system level rather than a product or component level (RVO, 2022e). The Demonstration Energy and Climate Innovation (DEI+) scheme supports project in which one or more innovation products and service are developed that contribute to the gas-free transition. Although the social component in this scheme is less pronounced than in MOOI, the

[12] These monitoring instruments are (i) Climate Monitor, (ii) Dashboard Climate Policy, and (iii) the annual Climate and Energy Outlook.

applicant should demonstrate in their project plan an understanding of the main non-technological aspects of the relevant societal and market factors involved in the production and application of the envisaged final products and services and translate these aspects into design requirements of these product and process (RVO, 2022d). Both these schemes are aimed at successfully embedding technological innovations through addition institutional changes, which are often tied to societal aspects. The focus within these schemes on the development of social innovation is rather limited. This is further emphasised by interviewees (3) which indicate that there remains a lack of social entrepreneurial activities and of resource mobilisation to social development and innovation. Furthermore, more focus should be given on the integration of social knowledge with technical knowledge.

Another MGA that gives room for the development of social innovations is the PAW. These social innovations are mainly in the form of cooperation between municipalities and residents' initiatives and energy cooperatives. Cooperating with citizens in the development of energy systems is new for municipalities and therefore attention is given on learning how to deal with this (PAW, 2022). In response, the PAW has recently started a learning group aimed at experimental projects in which resident's initiatives are central. One of the themes of the Knowledge and Learning Programme is about participation and communication which seeks to find answers on the questions (i) how to develop an inclusive participation approach that contributes to broad support and trust?, (ii) how can citizens be empowered in the neighbourhood process?, (iii) how can the satisfaction of residents be promoted and what factors influence this?, and (iv) how can a successful personal, community, and district-oriented approach be organised in a scalable way? (PAW, n.d.-c). Although there seems much focus on the learning and developing from residents' initiatives and energy cooperatives, the legitimacy is low for these bottom-up initiatives, and they are not sufficiently involved by governments in the transition. To better support bottom-up (social) initiatives and acknowledge the contributions they can have, it is important that they receive sufficient support and financial resources in the design and implementation phase. A way to do this is by setting up a knowledge and innovation programme focussed on bottom-up (social) initiatives. Furthermore, supporting laws and regulations need to be formed to give the initiatives a larger playing field.

4.5.2.4 Fragmented character built environment sector

There are currently two MGAs aimed at stimulating and encouraging multidisciplinary consortia to work together on innovative solutions thereby contributing to reduce the fragmentation of the built environment sector. These are the Mission Driven, Research, Development and Innovation (MOOI) scheme and the Knowledge and Innovation Programme Integral Energy Transition Existing Buildings (IEBB).

The MOOI scheme is for multidisciplinary consortia that work together on innovative solutions with a multidisciplinary approach to develop integral solutions. The consortium needs to be diverse in composition and should contain at least three companies that are not linked to each other in a group (RVO, 2022e). The applications for the MOOI scheme are assessed and ranked by independent external consultant using 5 criteria, of which the quality of the partnership is one and has a weighting of 25%. Partnerships including the following score higher on the quality criteria and thereby positively influences its raking: (a) partnerships that include all necessary parties for the proposal (involvement of the value chain) and of which the (end) user is the future owner or operator of the intended product, process, or service, and (b) partnerships that better involve the direct stakeholders in the proposed solutions, such as the problem owner and parties for (local) support, and the (end) user of the intended products, processes and service is more actively involved in the innovation process (RVO, 2022e).

The Knowledge and Innovation Programme Integral Energy Transition Existing Buildings (IEBB) from the Building and Technology Innovation Centre (BTIC) focuses on those development that will not get off the ground, or will be significantly delayed, without a high degree of cooperation between the various stakeholders (BTIC, 2020). The BTIC has initiated a consortium of over 125 participating parties from knowledge institutions, the construction industry, the engineering and design sector, governments, homeowners, and residents to work on the program. Hereby, it is aimed to convert the fragmentation in the sector into long-term broad cooperation by encouraging collaborations between requesting parties, offering parties, and knowledge institutions to develop knowledge and innovative solutions based on a joint development agenda (BTIC, n.d.).

Although both MGAs aimed at encouraging multidisciplinary cooperation and developing integral solutions, interviewees (8) point out that currently the built environment sector is still fragmented. This is complemented by the soft criticism that the formed consortia often consist of existing (closed) network and thereby are more relationship-oriented than solution-oriented, hampering the development of integral concepts. Furthermore, very few consider the home as a whole and therefore the process of making a home natural gas-free is often cut up into parts. The different professions do their part and overlook the fact that everything is connected which each other. However, it must be said, that the formation and maintenance of multidisciplinary consortia takes time. This is also reflected, for example, in the duration of the MOOI projects, which can be up to four years in total. It is therefore still too early to draw conclusion about the impact of the MGAs, however there is an initial indication that more scheme and programmes need to incorporate multidisciplinary and supply chain wide cooperation to tackle the fragmented character of the built environment sector.

4.5.2.5 Innovation experience difficulties in scaling up

There are several MGAs that are focussed on supporting innovations that are in the upscaling and market launch phase and there are others that are focussed on stimulating the demand of sustainable solutions. The SDE++ schemes and the programs Renovation Accelerator and Uptempo! are focussed on the scaling up and implementation of new solutions. The SDE++ scheme focuses on the large-scale rollout of technologies that produce renewable energy and other technologies that reduce carbon dioxide emissions. Organisations can receive this subsidy during the exploitation period of their project (RVO, 2022b). The Renovation Accelerator programmes stimulates the upscaling of energy renovations at lower integral costs and aims to achieve more innovation and higher productivity in the construction sector. This program is aimed at linking the innovation domain and the built environment ecosystem and therefore is designed to spread knowledge and findings developed in other innovation programs (de Renovatie Versneller, n.d.; Janssen, 2020). The Uptempo! programme launched by TKI Urban Energy and the Topsector Creative Industries (TKI ClickNL) is aimed at accelerating the energy transition by connecting developed solutions in Urban Energy innovation programmes to requesting parties such as municipalities, housing corporations, and homeowners (TKI Urban Energy, n.d.-c). This program has its own website (www.uptempo.nu) on which an overview of innovative energy solutions for the renovation of residential and commercial buildings is presented and currently features 150+ different energy innovations (Uptempo, n.d.). This website forms the link between parties looking for sustainable solutions and organisations which offer those.

The MGAs focussed on stimulating the demand of sustainable solutions by subsidising the implementation of sustainable solutions or by giving a fiscal advantage, are the Investment Subsidy for Sustainable Energy and Energy Savings (ISDE), Incentive Scheme for Natural Gas-free Rental Properties (SAH), Home Energy Savings Subsidy Scheme (SEEH), National Heat Fund, and the reduction, and planned abolition, of the landlord levy. Via the ISDE homeowners can receive a subsidy when making an investment in a solar boiler, heat pump, a connection to a heat network, and with five types of insulation measures, and business users can receive a subsidy with an investment in a (hybrid) heat pump or a solar boiler, and for Homeowner Associations (VvEs) also for a central connection to a heat network (RVO, 2022i). Via the SAH landlord can receive a subsidy for existing houses that are to be phased out of natural gas within 5 years and that are or will be connected to a heat network (RVO, 2022n). Via the SEEH (mixed) VvEs, housing association, and housing cooperatives can receive subsidy for energy saving measures (RVO, 2022o). The National Heat Fund offers homeowners and VvEs loans at favourable rates for financing energy-saving measures (Nationaal Warmtefonds, n.d.). Currently, the Landlord Levy Reduction Scheme (RVV) offers an incentive for landlord to make their housing stock more sustainable through a tax benefit. It is planned to abolish the landlord levy from 2023 onwards to create more investment capacity for housing corporations to tackle sustainability challenges (RVO, 2022l; Rijksoverheid, 2022d).

Although it seems that there are sufficient MGAs targeted on support the scaling up and implementation of innovations, as pointed about by interviewees (12) it remains difficult for innovations to scale up and to link supply and demand to create a large-scale demand for gas-free solutions. Various solutions have been proposed by the interviewees. Six interviewees pointed out that, to increase economies of scale, it is important that the current scattered demand is bundled. The contingent approach[13] developed by the Netherlands Organisation for Applied Scientific Research (TNO) is considered a promising way in achieving this. Other interviewees (5) indicate that the national government can play an important role in developing demand for sustainable solutions and reducing investment risks by, for example, making all government buildings more sustainable and thereby creating a certain market for these solutions. Furthermore, according to interviewees (20) more attention should be given to stimulate the formation of markets for natural gas-free solutions by directing it with policy on standardisation to enhance certainty about the direction of development. Lastly, the mobilisation and support of intermediaries (e.g., energy desks, pop-up advice centres) could help to better match the supply side with the demand side to enhance scaling up.

The planned MGAs of the policy program Acceleration the sustainability in the built environment (National Insulation Program, Hybrid Heat Pumps Program, and Green Gas Program) are expected to partially meet these points. There will come standardisation in the sense that from 2026 onwards a (hybrid) heat pump (or connection to a heat network) will be the standard when replacing a condensing boiler and the phase out of the worst energy labels. Furthermore, the policy program aims to support individual homeowners, homeowners' associations, social and private landlords with increased investment opportunities and attractive financing and subsidies. A special attention is given to household with a low and middle income to further improve the conditions for participation by lowering the threshold for financing and making subsidies more accessible (Volkshuisvesting en Ruimtelijke Ordening, 2022). As these are planned MGAs it is not possible to assess the impact of it, however in the execution attention should be given that factors that are important for homeowners (i.e., motives, financial aspects, wishes, etc.) are not lost out of sight, since they are crucial factor in the success of solutions.

4.5.2.6 Difficulty in mobilising homeowners

The MGAs that are focussed on mobilising homeowners are either aimed at creating (price) incentives or providing information about which measures that could be taken. There are two subsidy schemes where homeowners can make us of when investing in sustainable measures. First, the Investment Subsidy for Sustainable Energy and Energy Savings (ISDE), as mentioned earlier, offers homeowners a subsidy when making an investment in a sustainable heat technology (e.g., solar boiler, heat pump, heat network connection) and/or in five types of insulation measures. This subsidy can go up to 30% when combining an insulation measure with a second insulation measure or an investment in a heat pump, solar boiler, or heat network connection. Second, via the Home Energy Savings Subsidy Scheme

[13] The contingent approach, which is based on groups of buildings with similar characteristics to which similar sustainable solutions can be applied, leads, through smart matching and bundling of demand, to a more uniform renovation approach that makes it possible to increase the efficiency of the implementation of sustainable renovation solutions (TNO, 2021b).

(SEEH), homeowners, together with the Homeowner Association (VvE), can apply for a subsidy which can be used for energy saving measures. In addition to these schemes, there is a National Heat Fund which offers homeowners the possible to take a loan for financing energy-saving measures, such as insulation measures, (hybrid) heat pump, heat network connection, energy saving advice and guidance. Next to creating (price) incentives, the (online) platform Verbeterjehuis.nl provides homeowners information and advice on energy-saving measures and the savings, costs, financing, and implementation of those measures. This platform has been developed by the independent information organisation Milieu Centraal, in collaboration with the Netherlands Enterprise Agency (RVO) and the Ministry of the Interior and Kingdom Relations, and is aimed at making it easier for homeowners to take sustainable by bringing information and advice on energy-saving measures together in one place (Verbeterjehuis, n.d.-a).

Although there are several MGAs focussed on mobilising homeowners to take sustainable measures, interviewees (6) have indicated that these falls short in doing that. The subsidies are partially compensating for the higher purchase price of sustainable heat technologies, however the majority of the costs are still borne by the homeowner. In most cases, these costs are still much higher than those of conventional (unsustainable) technologies. The homeowners must therefore have their own capital to make these investments at all, which is a problem for low- and middle-income households. These households could make use of the loan offered by the National Heat Fund, however they tend to be relucted to engage in this due their financial situation and different priorities and wishes. Interviewees (2) also point out that loaning money to take sustainable measures is mostly only for the 'green types', which are highly motivated to improve sustainability. There is a need for subsidy schemes or funds that are tailored to the low- and middle-income households by accounting for the investment abilities they have and by taking away burdens to invest. Furthermore, it is important to keep encourage high-income households to take sustainable measures with several incentives, but it must be ensured that most of the available financial resources are mobilised to the low- and middle-income households. In the new policy programme (accelerating the sustainability in the built environment), the government outlined the aim that everyone must be able to participate in the transition. To achieve this, they will improve the conditions for participation through attractive energy-saving loans and mortgages via the National Heat Fund, and they increased the subsidy amounts (Rijksoverheid, 2022a). Although there will be more focus on the low- and middle income households, it is still questionable whether the proposed improvements will help to mobilise this group. Several preconditions (i.e., lower purchase costs sustainable technologies, standardisation) still have to be met to have the desired effect.

Lastly, the MGA focussed on providing homeowners with information and advice on taking sustainable measures (verbeterjehuis.nl) has been indicated by interviewees (4) as insufficient. There are three main reasons given for this. First, the homeowners that are not actively engaged in making their homes more sustainable are limited reached. Second, due to the heterogenous character of the houses slight customisation is needed for each homeowner, which makes it sometimes difficult to place the generic information provided. Third, due to the broad variety of the measures that can be taken homeowners get stuck in the process due to the difficulty in choosing which measures to take. The process of diffusion of information and giving advice to homeowners could be improved by providing support at all the different stages of the customer journey, from creating awareness for sustainable measures to purchasing and implementing them. This could be complemented by helping homeowners to draft a long-term plan on how to make their house more sustainable and when to take which steps.

Table 12. Overview systemic barrier, current and planned MGAs, and proposed recommendations and focus points.

	Current MGAs	**Planned MGAs**	**Recommendations**	**Focus points**
Systemic barrier 1: Municipalities experience difficulties in fulfilling their governing role in the district-oriented approach	• Natural Gas Free Neighbourhood Programme (PAW) • Expertise Centre Heat (ECW)	• National Programme Local Heat Transition (NPLW)	• Structure the programmes in such a way that they provide sufficient instruments to all municipalities in the Netherlands and not just to the ones that have living lab • Improve knowledge assurance within the municipalities • Do not only diffuse knowledge, but guide municipal officials in how to absorb and use this knowledge • Developed knowledge needs to be structure in such a way that it is know what works under which preconditions	• Focus must be given that there is sufficient interplay and feedback mechanisms between the different levels (national, regional, local)
Systemic barrier 2: Missing central steering on the execution of the mission	• Multiyear Mission-driven Innovation Programmes (MMIPs) ○ MMIP 2 ○ MMIP 3 ○ MMIP 4 ○ MMIP 5	• National Insulation Programme • Programme Hybrid Heat pumps • Green Gas Programme	• Middle-out approach, combinations of top-down and bottom-up • Create an integral vision on how to execute the mission • Integrate the Regional Energy Strategies, Visions on Heat, and District Implementation Plans to a national roadmap	• Care must be taken that the new programmes are not drawing attention away from the overarching mission • Sub-optimal solutions could hinder achieving the long-term goals (i.e., hybrid heat pumps)
Systemic barrier 3: Bias for technological development and innovation	• Mission Driven Research, Development, and Innovation (MOOI) • Demonstration Energy and Climate Innovation (DEI+) • Natural Gas Free Neighbourhood Programme (PAW)		• More focus on the integration of social knowledge with technical knowledge • More support and subsidy for bottom-up initiatives • Establish a knowledge and innovation programme for energy communities • Acknowledge the contributions that bottom-up initiatives can have and ensure supporting laws and regulations (i.e., Heat Act 2.0)	

Systemic barrier 4: Fragmented character built environment sector	• Mission Driven, Research, Development, and Innovation (MOOI) • Knowledge and Innovation Programme Integral Energy Transition Existing Buildings (IEBB)		• Extent the number of subsidy schemes and programmes that incorporate multidisciplinary and supply chain wide cooperation	
Systemic barrier 5: Innovations experience difficulties in scaling up	Scaling up/implementation: • Stimulation of Sustainable Energy Production and Climate Transition (SDE++) • Renovation Accelerator • Uptempo! Stimulating demand: • Investment Subsidy for Sustainable Energy and Energy Savings (ISDE) • Incentive Scheme for Natural Gas-free Rental Properties (SAH) • Home Energy Savings Subsidy Scheme (SEEH) • National Heat Fund • Reduction (abolition) landlord levy		• Direct market formation by standardisation, increasing economies of scale by bundling demand or creation of a certain demand • Mobilise financial resources that create a large-scale demand • More support for the scale up phase • More focus on incorporating factors that are important for homeowners in offered solutions → integral solutions	
Systemic barrier 6: Difficulty in mobilising homeowners to take sustainable measures	• Investment Subsidy for Sustainable Energy and Energy Savings (ISDE) • Home Energy Savings Subsidy Scheme (SEEH) • National Heat Fund • Verbeterjehuis.nl	• Conditions for participation will be improved through attractive energy-saving loans and mortgages via the National Heat Fund and increased subsidy via the ISDE	• Support at all different stages of the customer journey • Support homeowners in drafting a long-term plan	• Tailored subsidy schemes for low- and middle-income households

4.5.3 Reflection mission governance structure

The interviewees deem the multi-level governance structure the most suitable. The heat transition has an enormous impact on citizens, as it reaches beyond the front door, their living environment, and energy consumption. Therefore, it has been emphasised that it is important the governing role of this transition is entrusted to the government with the highest proximity to the citizens, i.e., the municipalities. However, some issues (e.g., legal issue, energy poverty, energy security, etc.) extent beyond the reach of the local level and must be addressed by higher levels of government, i.e., regional, or national. The multi-level governance structure allows for this, as local problems can be addressed locally, and wider problems can be tackled at a higher level. Multi-level jurisdictions can better reflect the heterogeneity of preferences among citizens, which is a key aspect to reduce resistance among citizens to mobilise them in contributing to the mission (Hooghe & Marks, 2003; Marks & Hooghe, 2004).

Although, theoretically, the multi-level governance structure is deemed a good food, in practice it appears to be at the root of various problems within the MIS. This is mainly due to how the governance structure is currently executed. There is a lack of interplay and interaction between the different levels (national, regional, local) influencing the quality of the feedback mechanisms, and there is a lack of coordination within the governance structure. Coordination is an important part in the execution of the multi-level governance to avoid unwanted outcomes, as one jurisdiction can have spill overs to other jurisdictions (Hooghe & Marks, 2003). Furthermore, it is needed to give direction to the different levels so that it is clear which tasks need to be performed and which issues should be handled at each level. Sufficient interaction, interplay, and coordination between the different levels is needed to adequately tackle bottlenecks that arise at the different levels and extent beyond the reach of a certain level.

In case of the governance structure of the studied mission, there is currently a flaw regarding its execution. The provinces, which are located at the regional level, do not have a clearly formulated steering and facilitating role in the natural gas-free transition. In some promising cases, all over Europe, the Energy Agencies support this intermediate governance level using their (international) knowledge, instruments, and networks (European Energy Network, 2021). However, instead of giving the provinces a clearly formulated steering and facilitating role, energy regions have been formed which have been given this role to a greater extent. In this energy regions, municipalities, provinces, and other stakeholders work together on drafting Regional Energy Strategies (RESs) which contains the plans for the generation of renewable energy on land and the usage of heat sources (Nationaal Programma RES, n.d.-b). Although these parties are working together towards a collective solution, in their daily practice they work in their old and less collective settings. In addition, the energy regions do not have the mandate to implement decisions made, which is in the hands of the municipalities and provinces. In a well-executed multi-level governance structure, the regional level (i.e., provinces) is a key link between the local and national level. They could support and assist municipalities with knowledge exchange and financial resources and, in some cases, solve the issues they encounter. When these issues extent beyond their authority, they could escalate the problems to the national level to be addressed. This interaction and interplay are crucial for the optimal functioning of the multi-level governance structure. Furthermore, by clearly defining the tasks and steering role of each level, coordination problems are minimised. However, in practice it seems difficult to get this done.

Next to the multi-level governance structure, an alternative governance structure could also be considered that would suit the studied mission. This is the polycentric governance structure, which is a governance structure in which there are multiple centres of decision making that are formally independent of each other and coordinated by an overarching system of rules (Pahl-Wostl & Knieper, 2014). It enables broader levels of participation (multilevel, multipurpose, multisectoral, and multifunctional) (Schoon, et al., 2015; Olsson, et al., 2004), and tends to enhance innovation, learning, adaptation, trustworthiness, levels of cooperation of participants, and the achievement of more effective equitable, and sustainable outcomes at multiple scales (Ostrom E. , 2010). Therefore, this structure would be able to meet the complexity and heterogeneity of the built environment and its actors. Furthermore, the interaction and feedback mechanisms tend to be more embedded in this structure, since multiple governing bodies interact to make and enforce rules in accordance with the overarching set of rules (Stephan, et al., 2019). The structure of the energy regions has similarities with a polycentric structure, however, these governing bodies lack the mandate to steer and implement decisions. When equipped with the appropriate authorities and decision-making power, this structure could be a fruitful basis for a polycentric governance structure.

5. Discussion

In this section, the general insights for policy makers are discussed. After this, the theoretical contributions are discussed followed by the limitations of the study.

5.1 General insights for policy makers

In addition to the recommendations and focus points discussed in the previous section, some general insights for policy makers can be formulated. These insights are from a higher abstraction level and could be kept in mind when designing new policies or policy instruments for the natural gas-free transition in the built environment.

The first, and most important insight is to reconsider the role of the national government with the multi-level governance structure and the interplay between the different levels. Although the national government is at the highest level of the governance structure and thereby should have a central directing role, this role is currently not sufficiently fulfilled. For example, the Visions on Heat (TVW) made by the municipalities and the Regional Energy Strategies (RES) of the energy regions have not (yet) been brought together and converted to a higher abstraction, i.e., national level. However, this could help the national government to get a comprehensive picture of what is needed at the different levels (i.e., local, regional, national) to better coordinate the execution of the mission. Furthermore, discussions arise between the levels about bottlenecks located on the different levels on how to tackle or address these. Better interplay and feedback mechanisms between the levels is needed to be able to address the challenges adequately. This should be further strengthened with frequent and extensive monitoring. In this way the national government could coordinate the lower levels and to steer the stakeholders of the MIS into the right direction to accelerate the transition, and that is why it should take a more dominant role in coordinating the execution of the mission and the interplay and interactions between the different levels.

Secondly, a combination of current top-down policy with more bottom-up perspectives and thinking is needed to deal with the complexity and local character of this transition. Currently, most policy instruments are formed based on science, technological development, and technological innovation. This mainly stems from the thinking that societal problems can be best tackled by supporting the development of technological innovations. However, transitions move beyond just technological innovation, but also asks for change in social practices and perspectives. To better accommodate for the societal change processes of transitions and its importance in succeeding, social development and innovation should be given a greater role in policy instruments and the facilitation of bottom-up (social) aspects should be considered when designing or adapting policy.

The third and last insight is to better support the development and implementation of integral solutions. To become natural gas-free in the built environment, issues around energy supply, heat supply, comfort, financial, impact on (living) environment, need to be addressed. For solutions or solutions packages to be successful, an integral perspective is needed to take sufficiently account of the synergies of these issues. Currently, there are some mission governance actions focused on stimulating multidisciplinary consortia to develop integral solutions (e.g., the MOOI). However, as pointed out in the previous analyses, stakeholders emphasised that the number of integral solutions and collaborations developed is rather limited. The formation of multidisciplinary consortia and the development of integral solutions should get a more dominant role in policy or policy instruments to address this shortcoming. In addition, there needs to be sufficient stimulation and support for chain wide collaborations, especially for developed solutions, to encourage stakeholders in the value chain to better align their processes and products. Furthermore, the inclusion of stakeholders of the quadruple helix (public authorities, industry, academia, and citizens) is of importance to better include the citizen/end-user perspectives in the innovation processes (Värmland County Administrative Board, 2019; Schütz, et al., 2019).

5.2 Theoretical contributions

In this research, by applying the Mission-oriented Innovation System (MIS) framework to study a case in the built environment domain, several contributions have been made. This research has empirically tested and contributed to the body of MIS literature by showing the applicability of the MIS framework and how MIS dynamics differ along different dimensions. Furthermore, it has shown the potential of the MIS to be used as a policy evaluation tool. The dynamics of the MIS change over time, as well as the systemic barriers, and to be able to adequately react to changes in the system and assess the impact and effectiveness of mission governance actions, performing a MIS analysis on a yearly or two-yearly basis as monitoring tool would be fruitful. Additionally, it would give useful insights for policy makers in which direction the mission is developing to redirect the mission when needed.

This research has made a first step in highlighting the importance of the mission governance structure and its influence on the structural components and functioning of the innovation system. A specific focus has been given on the identification of the governance structure and the implications it has on the mission progress. Questions have actively been asked whether the current mission governance structure contains obstacles to the mission progress. It has been proved useful to shed some light on this to identify systemic barriers resulting from the governance structure and its execution. As shown by the case study, the governance structure forms an important barrier to accelerate the transition within the built environment and is at the root of other systemic problems and weaknesses. However, further research is needed on how to best incorporate the mission governance structure and its dynamics in the MIS framework.

Lastly, in comparison to previous case studies, this case study allowed to assess ex-durante the impact of previously implemented mission governance actions on the development of the MIS (Wesseling & Meijerhof, 2021). This because several of the existing mission governance actions have been implemented 2 till 3 years ago. Over the course of time, these mission governance actions have affected the MIS and therefore its impact could be evaluated. Previous MIS analyses have mostly been performed on case studies which had only planned or very recently implemented mission governance actions, which only allows for an ex-ante evaluation whether the mission governance actions effectively target the systemic barriers. However, the assessment is limited since this is the first MIS analysis in the built environment domain and therefore there is no information on the systemic barriers that existed at the time of implementation. These barriers could differ from the current ones and might have been (partly) removed by the mission governance actions over time. This research forms a first benchmark structural-functional assessment which can be used to analyse the resolution of and changes in systemic barriers over time.

5.3 Limitations

There are several limitations of this research that should be discussed. Firstly, due to the qualitative nature of this research some form of subjectivity bias needs to be expected. To minimise this bias, triangulation has been used between different stakeholders and data sources to increase the credibility and validity of the findings. In addition, to further limit interpretations biases, an interview guide and coding scheme based on the MIS framework has been used and an intercoder reliability check has been performed to assure the reliability of the coding process (which was sufficient).

Secondly, although the response rate on the interviewees was high due to time limitations and availability of stakeholders, not all type of stakeholders within the system could be interviewed. Thereby resulting in a situation that some stakeholders were not presented, or others not sufficiently. This concerns, for example, stakeholders such as municipalities and bottom-up (social) initiatives. However, this limitation can most likely be considered rather limited, as the data saturation was achieved since no new insights emerged in the last interviews conducted. Therefore, including more stakeholders and conducting more interviewees would not necessarily lead to the identification of other system weaknesses or systemic barriers, but would only contribute to the completeness of the case study.

Thirdly, the generalisability of the case study over other social settings is rather limited. This is mainly due to the unique character of missions, which makes it difficult to generalise findings of one case study to another (Janssen, et al., 2021). However, the goal of this research was also not to generalise, but to provide a detailed understanding of the system dynamics. Fourthly, some of the new mission governance actions were implemented a relatively short period before the interviews were held, making it sometimes difficult to distinguish between the current and possible future effects of the mission governance actions. This could have limited the formative assessment of the mission governance actions.

Lastly, the visualisation of the systemic barriers and interrelated system function weaknesses (figure 1) gives an overall impression of the complexity of the system and the interactions between the identified systemic barriers and weak system functions. However, to truly unravel the underlying causes and the dynamics between the problems in the system, a more in-dept analysis is needed. Therefore, the identified system barriers mainly serve as attention points to further analyse. To accommodate for this limitation, useful aspect of the Logical Framework Approach (LFA) could be used in further analysing the identified barriers. The LFA is an analytical process and set of tools used to support project planning and management (European Commission, n.d.-b). It consists of several analytical steps, of which the problem analysis could be a useful way to gain a deeper understanding of the identified barriers. In this step, the problem tree method is used which helps to establish cause and effect relationships to ensure that root problems are identified and addressed on three different governance levels (strategical, tactical, and operational) (European Commission, n.d.-b). The problem tree gives a visualisation of the problems on the three governance levels in the form of a diagram, which helps to understand the cause / effect relationship between the problems (Barbera, 2018; European Commission, n.d.-b). To ensure the validity of the problem tree and to verify the relationships, it should be drawn up in a participatory exercise with relevant stakeholders.

6. Conclusion

In this research, the Mission-oriented Innovation System (MIS) of the mission for a sustainable built environment by disconnecting houses from natural gas was analysed. By following the five analytical steps of the MIS theory, insights into the system dynamics, strengths and weaknesses, systemic barriers, and adequateness of the mission governance actions, were obtained. Thereby aiming to answer the research questions "*to what extent are the mission governance actions and mission governance structure adequately targeted on resolving the systemic barriers present in the Dutch Mission-oriented Innovation System (MIS) for a natural gas free built environment*?" and the formulated sub-research questions for each analytical step. Before answering the research question, the sub-research questions will be answered first.

In the problem-solution diagnosis, it has been described that the built environment is a sector in which many societal problems converge. This are societal problems such as climate change, biodiversity loss, energy security and poverty, and clean energy. Next to the societal problems, there are several technological and social solutions identified that are relevant to the mission. The solutions can be categorised in: (i) *individual solutions*, (ii) *collective solutions*, (iii) *energy saving solutions*, (iv) *alternative energy sources & carriers*, and (v) *bottom-up (social) initiatives*. These solutions do not stand alone and are in some cases strongly interacting each other. For example, to be able to implement certain heat supply technologies (i.e., heat pump or heat network), a certain level of insulation is required to be effective. The dynamics between the different solutions and their interrelatedness are important factors to determine the most suitable solutions (package) to become natural gas-free.

In the structural analysis, the respective roles of the actors that are involved in one of the four mission governance tasks, thereby forming the mission arena, have been described. These actors are the Ministry of the Interior and Kingdom Relations (BZK); the Ministry of Economic Affairs & Climate Policy (EZK); the 30 energy regions; the 344 municipalities; the Topsector Energy (TSE) and TKI Urban Energy (TKI UE); the Building and Technology Innovation Centre (BTIC); the Netherlands Enterprise Agency (RVO); and the 32 actors that have committed to the Climate Agreement on the built environment sector theme. The mission governance structure identified for the mission of the built environment is a multi-level governance structure. On the national level, the Ministry of Economic Affairs & Climate Policy is responsible for the nationwide policy focussed on innovation, research, and (technological) development, and the Ministry of the Interior and Kingdom Relations is responsible for built environment specific policy. On the regional level, the 30 energy regions are responsible for making Regional Energy Strategies (RES) regarding the production of sustainable electricity and the usage of heat sources. On the local level, the 344 municipalities are responsible for the district-oriented approach, which is a collective approach in which a process will have to be completed, alongside residents and building owners, to determine the best solutions for each district. Furthermore, three important formal institutions described are the Heat Act which regulates the supply of heat, the Gas Act which dictates the rules on transport and delivery of natural gas, and the Environment and Planning act which includes laws and regulation on building, environment, water, spatial planning, and nature.

In the functional analysis, the strengths and weaknesses of the system functions have been identified and described. This has led to many insights regarding the performance of the innovation system and its weaknesses. In the systemic barrier analysis, the systemic barriers underlying these weak system functions have been described.

In total, six systemic barriers and their interrelatedness with weak system function have been identified. First, municipalities experience difficulties in fulfilling their governing role in the district-oriented approach due to limit financial resources and human capital at the municipal level. Thereby limiting the development and assurance of knowledge within municipalities, the attraction and development of knowledgeable personnel, and the mobilisation of financial resources. Having further implications on the quality/clarity of the Visions on Heat (TVW) drafted, which have insufficiently contributed to providing solution directionality to the overall MIS. Second, there is a missing central steering on the execution of the mission leading to a lack of national solution directionality, insufficient mobilisation of resources to innovation in the scaling up phase, gave room to legitimacy discussion about solutions and their implementation. The latter two have further implications on the development of markets for gas-free solutions and hampering it. Third, there is a bias for technological development and innovation over social development and innovation due to the more tangible character of technology. Leading to a lack of resource mobilisation to support social development and innovation and a low legitimacy for bottom-up (social) initiatives, which both in turn hamper social entrepreneurial activities and the development of social knowledge. Fourth, the fragmentated character of the built environment sector hampers domain transcending diffusion of knowledge and collaborations, thereby limiting the entrepreneurial activity within the system regarding integral solutions. Fifth, innovations experience difficulties in scaling-up due to a lacking large-scale demand and insufficient financial resources available for this phase, resulting in an underdeveloped market for gas-free solution. Sixth and last, there is a difficulty in mobilising homeowners to take sustainable measures which makes them reluctant to invest. This difficulty mostly stems from the lack of solution directionality provided by both the national government as the Visions on Heat, there failing to provide clarity to homeowners about which solutions they can take, which are the best for their situation, and when they should take sustainable measures.

In the last analytical step, the adequateness of the current and planned mission governance actions targeting the identified system barriers was assessed. Although some of the current mission governance actions have been active for some time (2-3 years) and have been aimed at similar problems to those of the identified systemic barriers, they have not been effective in solving those since they still occur in the system. For the current mission governance actions, recommendation have been proposed which should be adapted to increase the effectiveness of those mission governance actions. Furthermore, for the planned mission governance actions, which originate from the recently published policy program on accelerating the sustainability in the built environment, focus points are given which should be considered in the set-up and execution of these mission governance actions.

To conclude and answer the research questions, to improve the adequateness and effectiveness of the mission governance actions the proposed recommendations and focus points, as discussed in section 4.5.2, should be incorporated or addressed. This would help to better target the current systemic barriers and to accelerate the transition to a natural-gas free built environment. Although the current mission governance structure, i.e., multi-level governance, is deemed the most suitable for the natural-gas free transition, better coordination and interplay between the various levels is needed to have the desired effect. This could help the actors at the different levels to better complement each other and respond more adequately to arising problems.

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Appendix A: Interview guide (English)

Introduction

First of all, thank you for freeing up some time to share your knowledge and expertise with me. This is highly appreciated and valuable for my research. This interview contributes to the analysis of the Mission-oriented Innovation system around the mission: '*disconnecting 1.5 million existing homes from fossil natural gas by 2030*'. In short, I am interested in the performance of the innovation system and the barriers hampering this performance. The interview will take approximately 45-60 minutes in which we cover the innovation system functions. Each of these system functions represent key innovation activities based on which the performance of the innovation system can be determined. During this interview I will ask you to rate the system functions on a scale from 1 to 5 (0 = absent, 1 = weak, 2 = very weak, 3 = moderate, 4 = strong, 5 = very strong).

Let me first shortly introduce myself, I am Kasper Baarends a master's student Innovation Sciences at Utrecht University. The research I am conducting is regarding my master thesis and for the Netherlands Enterprise Agency (RVO) and the Ministry of Economic Affairs and Climate (EZK). For my research I will make use of the Mission-oriented Innovation Systems (MIS) framework developed by Marko Hekkert and Joeri Wesseling (and other research at the Copernicus Institute for Sustainable Development). The MIS approach aims to identify the systemic barriers that hamper the functioning of the MIS, assess the adequateness of the mission governance actions on tackling these systemic barriers, and ultimately to provide recommendations for more effective mission governance.

With your approval, I would like to record the interview to be able to create a transcript. This allows me to analyse the interview data precisely and thoroughly. The data will be handled in a confidential manner and completely anonymised processed in my thesis. Do you give approval to this?

Before we start, do you have any questions or remarks?

Interview questions

Table 13. Overview interview questions in English.

Questions		Possible follow-up questions
General		
1.	What is your organisation's relationship to the mission?	
2.	How does your organisation contribute to the mission?	
3.	How is the governance structure executed and which influence does it has on the progress of the mission?	
System functions		
4.	SF1: On a scale of 1-5, to what extent is there enough **entrepreneurial activity** (start-ups, new business models, experiments with new solutions) towards sustainable solutions to achieve the mission?	• What is the reason for this score? and (when score is 3 or lower) what is the underlying problem? • What could be a potential solution to this problem(s)?

		• How is this influenced by the formulated mission?
5.	SF2: On a scale of 1-5, to what extent is there sufficient **knowledge developed** to facilitate the mission's goal?	• What is the reason for this score? and (when score is 3 or lower) what is the underlying problem? • What could be a potential solution to this problem(s)? • Is sufficient knowledge developed regarding the phase-out of unsustainable practices?
6.	SF3: On a scale of 1-5, to what extent is **knowledge** sufficiently **diffused** between stakeholders within the built environment?	• What is the reason for this score? and (when score is 3 or lower) what is the underlying problem? • What could be a potential solution to this problem(s)? • Is knowledge diffused sufficiently rapidly among the stakeholders?
7.	SF4A: On a scale of 1-5, to what extent are the mission's societal problem(s) and framework conditions **prioritised** by stakeholders in relation to other societal problems and wants?	• What is the reason for this score? and (when score is 3 or lower) what is the underlying problem? • What could be a potential solution to this problem(s)? • Are stakeholders sufficiently involved in the mission?
8.	SF4B: On a scale of 1-5, to what extent is there a clear **vision** about which solutions are necessary for mission completement?	• What is the reason for this score? and (when score is 3 or lower) what is the underlying problem? • What could be a potential solution to this problem(s)? • Do the involved stakeholders agree on the necessary solutions? • What solution directions are currently being prioritized?
9.	SF4C: On a scale of 1-5, to what extent is the progress of the mission **measured** and **evaluated**?	• What is the reason for this score? and (when score is 3 or lower) what is the underlying problem? • What could be a potential solution to this problem(s)?

		• Is the MIS on track to meet the mission? If not, are sufficient measures taken to catch-up? • Are ineffective mission governance actions redesigned?
10A.	SF5: On a scale of 1-5, to what extent is there a **market** for the solutions relevant to the mission?	• What is the reason for this score? and (when score is 3 or lower) what is the underlying problem? • What could be a potential solution to this problem(s)? • Are new solutions quickly adopted by stakeholders? • Are harmful practices and technologies quickly abandoned by stakeholders?
10B.	SF5: On a scale of 1-5, to what extent are markets for practices and technologies harmful to the mission **destabilised**?	
11A.	SF6: On a scale of 1-5, to what extent are **resources** (human, financial, and material) **mobilised** within the built environment sector to support mission' solutions?	• What is the reason for this score? and (when score is 3 or lower) what is the underlying problem? • What could be a potential solution to this problem(s)?
11B.	SF6: On a scale of 1-5, to what extent are **resources withdrawn** from harmful practices and technologies to stop their continuation?	
12A.	SF7: On a scale of 1-5, to what extent is their sufficient **legitimacy** for the mission's societal problem and solutions?	• What is the reason for this score? and (when score is 3 or lower) what is the underlying problem? • What could be a potential solution to this problem(s)? • Are you involved in practices (e.g., lobbying) to generate more support by the public or by other actors for mission support?
12B.	SF7: On a scale of 1-5, to what extent is **legitimacy withdrawn** from harmful practices and technologies?	
Concluding		
13.	Are there any other weaknesses in the system related to the mission that need to be discussed?	
14.	In your opinion, what is needed to reduce or resolve the discussed barriers?	
15.	In your opinion, which policies/regulations should be changed to support the mission?	

Appendix B: Interview guide (Dutch)

Introductie

In de eerste plaats dank ik u dat u tijd hebt vrijgemaakt om uw kennis en deskundigheid met mij te delen. Dit wordt zeer gewaardeerd en is waardevol voor mijn onderzoek. Dit interview draagt bij aan de analyse van het Missiegerichte Innovatiesysteem rondom de missie: '1,5 miljoen bestaande woningen loskoppelen van fossiel aardgas in 2030'. Kortom, ik ben geïnteresseerd in de prestaties van het innovatiesysteem en de belemmeringen die deze prestaties in de weg staan. Het interview zal ongeveer 45-60 minuten duren waarin we de innovatiesysteemfuncties behandelen. Elk van deze systeemfuncties vertegenwoordigt belangrijke innovatieactiviteiten op basis waarvan de prestaties van het innovatiesysteem kunnen worden bepaald. Tijdens dit interview zal ik u vragen de systeemfuncties te beoordelen op een schaal van 1 tot 5 (0 = afwezig, 1 = zwak, 2 = zeer zwak, 3 = matig, 4 = sterk, 5 = zeer sterk).

Laat ik me eerst kort voorstellen, ik ben Kasper Baarends een masterstudent Innovatiewetenschappen aan de Universiteit Utrecht. Het onderzoek dat ik doe is in het kader van mijn masterscriptie en in opdracht van de Rijksdienst voor Ondernemend Nederland (RVO) en het Ministerie van Economische Zaken en Klimaat (EZK). Voor mijn onderzoek maak ik gebruik van het Missiegerichte Innovatie Systemen (MIS) raamwerk ontwikkeld door Marko Hekkert en Joeri Wesseling (en ander onderzoek van het Copernicus Instituut voor Duurzame Ontwikkeling). De MIS-benadering is erop gericht de systemische barrières die het functioneren van de MIS belemmeren in kaart te brengen, te beoordelen in hoeverre de maatregelen van het missiebestuur om deze systemische barrières aan te pakken toereikend zijn, en uiteindelijk aanbevelingen te doen voor een effectiever missiebestuur.

Met uw toestemming zou ik het interview willen opnemen om een transcriptie te kunnen maken. Dit stelt mij in staat de interviewgegevens nauwkeurig en grondig te analyseren. De gegevens zullen vertrouwelijk worden behandeld en volledig geanonimiseerd worden verwerkt in mijn scriptie. Geeft u hier toestemming voor?

Voordat we beginnen, heeft u nog vragen of opmerkingen?

Interview vragen

Table 14. Overview interview questions in Dutch.

Vragen		**Mogelijke vervolgvragen**
Algemeen		
1.	Wat is de relatie van uw organisatie met de missie?	
2.	Hoe draagt uw organisatie bij aan de missie?	
3.	Welke technologische en sociale oplossingen krijgen de meeste aandacht en ondersteuning?	Naar uw mening, welke oplossingen zouden de meeste aandacht en ondersteuning moeten hebben?
4.	Hoe wordt de bestuursstructuur uitgevoerd en welke invloed heeft het op de voortgang van de missie?	
Systeemfuncties		

5.	SF1: Op een schaal van 1-5, in welke mate is er voldoende **ondernemersactiviteit** (startups, nieuwe bedrijfsmodellen, experimenten met nieuwe oplossingen) in de richting van duurzame oplossing voor het bereiken van de missie?	• Wat is de reden voor deze score? En (bij een score van 3 of lager) wat is het onderliggende probleem? • Wat zou een mogelijke oplossing voor dit probleem (of problemen) kunnen zijn? • Hoe wordt dit beïnvloed door de missie?
6.	SF2: Op een schaal van 1-5, in welke mate wordt er voldoende **kennis gecreëerd/ontwikkeld** die bijdraagt aan het bereiken van de missie?	• Wat is de reden voor deze score? En (bij een score van 3 of lager) wat is het onderliggende probleem? • Wat zou een mogelijke oplossing voor dit probleem (of problemen) kunnen zijn? • Is er voldoende kennis ontwikkeld over het geleidelijk stopzetten van niet-duurzame praktijken?
7.	SF3: Op een schaal van 1-5, in welke mate wordt **kennis** voldoende **verspreid** tussen belanghebbenden binnen de gebouwde omgeving?	• Wat is de reden voor deze score? En (bij een score van 3 of lager) wat is het onderliggende probleem? • Wat zou een mogelijke oplossing voor dit probleem (of problemen) kunnen zijn? • Wordt kennis voldoende snel verspreid/gedeeld onder de belanghebbenden?
8.	SF4A: Op een schaal van 1-5, in welke mate worden de maatschappelijke problemen en randvoorwaarden van de missie door stakeholders **geprioriteerd** ten opzichte van andere maatschappelijke problemen en wensen?	• Wat is de reden voor deze score? En (bij een score van 3 of lager) wat is het onderliggende probleem? • Wat zou een mogelijke oplossing voor dit probleem (of problemen) kunnen zijn? • Worden de belanghebbende voldoende betrokken bij de missie?
9.	SF4B: Op een schaal van 1-5, in welke mate is er een duidelijke **visie** over welke oplossingen nodig zijn voor het bereiken van de missie?	• Wat is de reden voor deze score? En (bij een score van 3 of lager) wat is het onderliggende probleem? • Wat zou een mogelijke oplossing voor dit probleem (of problemen) kunnen zijn? • Zijn de betrokken partijen het eens over de benodigde oplossingen? • Aan welke oplossingsrichtingen wordt momenteel prioriteit gegeven?
10.	SF4C: Op een schaal van 1-5, in welke mate wordt de voortgang van de missie **gemeten en geëvalueerd**?	• Wat is de reden voor deze score? En (bij een score van 3 of lager) wat is het onderliggende probleem?

		• Wat zou een mogelijke oplossing voor dit probleem (of problemen) kunnen zijn? • Ligt het MIS op koers om de missie te halen? Zo niet, worden er voldoende maatregelen genomen om de achterstand in te lopen? • Worden ineffectieve bestuursmaatregelen herontwerpen/aangepast?
11A.	SF5: Op een schaal van 1-5, in welke mate zijn is er een **markt** voor de oplossingen die relevant zijn voor de missie?	• Wat is de reden voor deze score? En (bij een score van 3 of lager) wat is het onderliggende probleem? • Wat zou een mogelijke oplossing voor dit probleem (of problemen) kunnen zijn? • Worden nieuwe oplossingen snel door de belanghebbende partijen overgenomen? • Worden schadelijke praktijken en technologieën snel opgegeven door de belanghebbenden?
11B.	SF5: Op een schaal van 1-5, in welke mate worden de markten voor praktijken en technologieën die schadelijk zijn voor de missie **gedestabiliseerd**?	
12A.	SF6: Op een schaal van 1-5, in welke mate worden **middelen** (menselijke, financiële, en materiële) binnen de gebouwde omgeving **gemobiliseerd** ten behoeve van de oplossingen voor de missie?	• Wat is de reden voor deze score? En (bij een score van 3 of lager) wat is het onderliggende probleem? • Wat zou een mogelijke oplossing voor dit probleem (of problemen) kunnen zijn?
12B.	SF6: Op een schaal van1-5, in welke mate worden **middelen onttrokken** aan schadelijke praktijken en technologieën om de voortzetting hiervan terug te dringen/stoppen?	
13A.	SF7: Op een schaal van 1-5, in welke mate is er voldoende **legitimiteit** voor het maatschappelijk probleem en de oplossingen van de missie?	• Wat is de reden voor deze score? En (bij een score van 3 of lager) wat is het onderliggende probleem? • Wat zou een mogelijke oplossing voor dit probleem (of problemen) kunnen zijn? • Bent u betrokken bij praktijken (bijv. lobbyen) om meer steun van het publiek of andere actoren te krijgen ten behoeve van de missie?

Appendix C: Calculation of Krippendorff's Alpha

The table below shows how the fragments were coded by the thesis research and three other researchers for the calculation of the Krippendorff's Alpha. The numbers corresponded with the system functions as described in table 15. The calculation was performed in RStudio and is presented below the table. The score of the Krippendorff's Alpha is 0.824 which is sufficient.

Table 15. Coded fragments.

Fragment	Thesis researcher	Coder 1	Coder 2	Coder 3
1.	5	5	5	5
2.	4	4	4	4
3.	2	2	2	2
4.	4	4	4	4
5.	6	5	6	4
6.	4	4	4	4
7.	4	4	4	4
8.	1	4	1	1
9.	2	2	3	2
10.	3	3	3	3
11.	4	4	4	4
12.	4	4	4	4
13.	1	4	1	1
14.	5	5	5	5
15.	6	6	6	6
16.	6	6	6	6
17.	7	7	7	7
18.	7	4	7	4
19.	3	3	3	3
20.	1	1	1	1
21.	4	4	4	4
22.	2	2	2	2
23.	7	4	7	7
24.	6	5	1	6
25.	5	5	5	5
26.	3	3	3	3
27.	6	6	6	6
28.	1	1	1	1
29.	5	5	5	5
30.	4	4	4	4

```
> data <- read.csv("krippendorffsalpha.csv", sep=";", head=TRUE)
> data2 <- as.matrix(data)
> data3 <- t(data2)
> library(DescTools)
> KrippAlpha(data3, method="nominal")
$method
[1] "Krippendorff's alpha"
```

```
$subjects
[1] 30

$raters
[1] 4

$irr.name
[1] "alpha"

$value
[1] 0.82392

$stat.name
[1] "nil"

$statistic
NULL

$cm
     [,1] [,2] [,3] [,4] [,5] [,6] [,7]
[1,]   36    0    0    6    1    2    0
[2,]    0   30    3    0    0    0    0
[3,]    0    3   36    0    0    0    0
[4,]    6    0    0   98    1    2    7
[5,]    1    0    0    1   48    4    0
[6,]    2    0    0    2    4   40    0
[7,]    0    0    0    7    0    0   20

$data.values
[1] "1" "2" "3" "4" "5" "6" "7"

$nmatchval
[1] 360

$data.level
[1] "nominal"

attr(,"class")
[1] "irrlist"
```

Appendix D: Overview technological and social solutions.

Table 16. Overview technological and social solutions.

Solutions		Advantages	Disadvantages
Individual solutions for houses and buildings			
Boilers	**Biomass boiler** (*bio-ketel)*: works in a similar way as a condensing boiler, but instead of natural gas it uses biomass (i.e., wood) to produce heat. The biomass is stored in a storage tank and is automatically fed to the boiler when it switches on (ECW, 2021b; Verbeterjehuis, n.d.-b).	• Biomass is a renewable source of energy • The total CO_2-emission of a biomass boiler depends on the origin of the biomass used, but is in most cases lower than for fossil fuel technologies • High efficiency (90%-105% for space heating and up to 90% for domestic hot water) • Can be connected to existing or new heating systems (both radiators and underfloor heating) • Both for space heating as well as domestic hot water (DHW)	• Requires more space than a condensing boiler, since a biomass boiler also requires a heat buffer and storage for the biomass product • Particulate matter is released during combustion of biomass which can cause health problems and nuisance to residents or neighbours. Especially a problem in densely populated areas. • The sustainability of the biomass boiler is strongly dependent on the origin of the biomass • Sustainability criteria and control needed to ensure the biomass is extracted and produced in a sustainable manner (forest management, land use, etc.)
	Electric boiler (*Elektrische ketel)*: works similar as a condensing boiler but uses only electricity to produce heat. The boiler converts 1 kWh electricity into 1 kWh heat (1:1 ratio) (ECW, 2021d).	• No adjustments needed to the existing heating system (radiators, underfloor heating, etc.)	• High electricity usage and heavily loads the power grid • Low efficiency (1:1 ratio) • To be considered sustainable, the energy needed must be produced by renewable energy sources • In most cases not suitable as alternative to natural gas in houses, neighbourhoods, and districts
	Solar boiler (*Zonneboiler*): heats water with the energy obtained from the sun. A liquid is heated via a solar collector on the roof. The heated liquid transfers the heat to the water	• Solar energy is a renewable source of energy • A solar boiler can be combined with existing heat systems (condensing boiler and heat pumps)	• It is not possible to cover the entire heat demand with a solar boiler (and therefore needs to be combined with another heating system, e.g., condensing boiler or heat pump)

	in a storage tank (boiler) (Milieucentraal, n.d.-g; CE Delft, n.d.-f).	• Reduced gas or electricity usage to produce domestic hot water (up to 50%), or in case of a solar boiler combination also for space heating • A solar boiler combination (solar boiler + condensing boiler or heat pump) can both be used for domestic hot water and low temperature space heating	• A standard solar boiler can only be used for domestic hot water • Affected by fluctuation in temperature (low) and sunshine (none/minimal)
Heat pumps	**Electric air source heat pump** (*Elektrische luchtwarmtepomp*): extracts available heat from the outside air and upgrades it with the help of electricity to a usable temperature for space heating and domestic hot water (Milieucentraal, n.d.-e; ECW, 2021e; CE Delft, n.d.-e). **Electric ground source heat pump** (*Elektrische bodemwarmtepomp*): extracts available heat from the ground and upgrades it with the help of electricity to a usable temperature for space heating and domestic hot water (CE Delft, n.d.-a)	• Zero emission depending on energy source used • High efficiency (coverts 1 kWh electricity into 2-6 kWh of heat) • Energy-efficient since, in addition to electricity, it mainly uses energy extracted from the outside air or the ground • A ground source heat pump has a higher annual efficiency, compared to an air source heat pump, because the temperature of the ground is higher than the outside air in the winter • Possibility to be used for cooling • Electric heat pumps supplied with renewable electricity fit in a net-zero energy system	• Currently mostly used with 'grey' electricity and therefore not yet zero emission • The heat pump is not able to quickly supply a lot of warm water and needs therefore be combined with a DHW cylinder when used for domestic hot water. • To work sufficient, the house needs to have a RC-value[14] of 2.5 or higher (otherwise too much heat gets lost which cannot be compensated by the heat pump) • Potential grid reinforcement needed due to the increased electricity usage • Efficiency drops with low outside temperatures • A ground source heat pump is dependent on the availability of space for the ground pipe system (especially in horizontal systems) • The air source heat pump has an outside unit (ventilator) which makes noise when in operation and could therefore cause some form of nuisance

[14] The RC-value is the thermal resistance of the total construction and indicates the insulating capacity of the entire building structure. The higher the number, the more heat stays inside (PBL, 2020).

	Hybrid heat pump (*Hybride warmtepomp*): combination of an electric air source heat pump with a gas-fired condensing boiler. The heat pump provides the heating for most of the year and the gas boiler only assists at very cold moments (outside temperature below 2 °C) and to produce the hot tap water (Milieucentraal, n.d.-a; ECW, 2020a; CE Delft, n.d.-c).	• Lower investment costs (compared to an electric heat pump) • Reduced gas usage • No immediate need for insulation improvements. This gives consumers the ability to spread out investments in home insulation, while maintaining comfort levels • No (immediate) grind reinforcement needed (in contrast to an electric heat pump), because the integration of electricity and gas reduces peak power demand • Increased system resilience and flexibility due to the ability to switch between gas and electricity • Hybrid heat pumps supplied with renewable electricity and green gas fit in a net-zero energy system	• Currently mostly used with natural gas and 'grey' electricity and therefore not yet zero emission • Additional space needed for the heat pump (next to the condensing boiler) • The heat pump has an outside unit (ventilator) which makes noise when in operation and could cause some form of nuisance
	Ventilation heat pump (*Ventilatiewarmtepomp*): a small heat pump for houses/buildings that have a mechanical ventilation. The heat pump extracts energy from the warm ventilation air which is used for heating (Milieucentraal, n.d.-d).	• Ensures a healthy income climate because it sufficiently ventilates the house so that polluted air is quickly replaced by fresh air • Because it uses warm ventilation air, it also has a high efficiency with (very) low outside temperatures	• The amount of ventilation air is limed and therefore the capacity is not very large and can't cover the entire heat demand (especially during peak moments). Hence, it needs to be combined with another heating system • Can only be applied in houses with a mechanical ventilation system • To work sufficient, the house needs to have a RC-value of 2.5 or higher • Can't cover the entire heat demand and needs assistance during peak moments
	Booster heat pump (B*oosterwarmtepomp*): heats up low-temperature heat (30-40 °C) for domestic hot water (Duurzaam verwarmen, n.d.)	• Efficiency is considerably higher than that of a conventional heat pump • No energy loss through transporting hot water over long distances • Particularly suitable for use in multi-storey buildings (e.g., apartment complexes)	• Only suitable in combination with a low-temperature district heating network
Infrared heating panels (*Infraroodpanelen*): convert electricity into (infrared) radiation heat which provides local (targeted) heating. The panels do not heat the entire		• An infrared panel as additional heating can reduce the energy consumption of the main heating system	• Currently mostly used with 'grey' electricity and therefore not yet zero emission • Outside of the reach of the panel it remains cold

room, but the objects and people that are in the range. (ECW, 2021h; Milieucentraal, n.d.-b).	• Suitable alternative for rooms where heat is only required for a limited part of the time (and thereby reducing energy usage for heating) • Low investment costs • Infrared heating panels supplied with renewable electricity fit in a net-zero energy system • The radiation heat can be felt immediately	• To work sufficient and to reduce energy usage, the house needs to have a RC-value of 2.5 or higher • Cannot be used for domestic hot water • Less suitable as main heating, unless the house is very well insulated and renewable electricity is used
Energy savings solutions		
Insulation (*Isoleren)*: insulating and air sealing a house or building leads to a lower heat demand, and therefore less energy is needed and used. Concerns (a) façade insulation, (b) floor insulation, (c) roof insulation, and (d) glass insulation (ECW, 2022c; Milieucentraal, n.d.-c).	• Reduced heat demand and thus also the energy usage for heating • Reduced energy production • Comfort improves • Reduced energy costs • Improves thermal quality of the house shell • Lower heat demand prevents a (too) heavy load on the electricity grid or the district heating network	• High investment costs • Not always possible, for example in the case of monumental buildings
Collective solutions for houses and buildings		
High-temperature district heating (*Hogetemperatuur warmtenet*): a network that transports heat at a high-temperature level (>75 °C) from a collective heat source (e.g., geothermal, waste heat from industry, waste incineration and power plants, biomass-fired heating plants) to houses connected to the network (Milieucentraal, n.d.-f; TKI Urban Energy, 2020b; Regionaal energieloket, n.d.; CE Delft, n.d.-b).	• Direct supply of high-temperature heat for both space heating and domestic hot water	• High heat loss during conversion and transportation (15-40%)

Medium temperature district heating (*Middentemperatuur warmtenet*): a network that transports heat at a medium temperature level (55-75 °C) from a collective heat source (e.g., geothermal, waste heat from industry, waste incineration and power plants, solar thermal) to houses connected to the network (Milieucentraal, n.d.-f; TKI Urban Energy, 2020b; Regionaal energieloket, n.d.).	• Direct supply of medium-temperature heat for both space heating and domestic hot water	• Higher heat loss during conversion and transportation than a low-temperature network, but lower than a high-temperature network
Low temperature district heating (*Lagetemperatuur warmtenet*): a network that transports heat at a low-temperature level (30-55 °C) from a collective heat source (e.g., solar thermal, large heat pumps, low-temperature waste heat, shallow geothermal) to houses connected to the network (Milieucentraal, n.d.-f; TKI Urban Energy, 2020b; Regionaal energieloket, n.d.; CE Delft, n.d.-d; TKI Urban Energy, 2020c).	• Direct supply of low-temperature heat for space heating • Reduced heat loss compared to medium and high temperature district heating	• Booster heat pump needed for domestic hot water • To work sufficient the house needs to have a RC-value of 2.5 or higher
Alternative energy sources and carriers		
Aquathermia (*Aquathermie)*: is heating and cooling buildings sustainably using heat and cold from water. There are three different types: (1) thermal energy from surface water such as a river, canal, or lake (TEO in Dutch), (2) thermal energy from wastewater (TEA), and (3) thermal energy from drinking water (TED) (Netwerk AquaThermie, n.d.; ECW, 2021a; Stichting Warmtenetwerk, 2021).	• Renewable energy source • Extracting heat from surface water (TEO) can have a positive effect on the water quality and ecology, and reduces heat stress in urban areas • Reliable heat source, since the source owners are stable (government and semi-government)	• The temperature of the extracted heat varies throughout the year • Potential need for grid reinforcement • Currently only available on a small scale and many parties have to be involved for project realisation • Needs to be used in combination with a district heating network

Biomass/energy (*Biomass/energie*): organic matter from which heat is extracted by direct incineration in a biomass power plant in solid or liquid form, or by conversion into biogas or syngas through fermentation or gasification (ECW, 2022a; Stichting Warmtenetwerk, 2021).	• Short carbon cycle • CO_2-neutral depending on the how it is produced and obtained • Independent of seasonal and weather conditions • Suitable as a base load, peak, or back-up source • Little adaptation to existing homes is required	• Societal discussion about the sustainability of different types of biomasses • Availability of biomass is limited in the long term • Sustainability criteria and control needed to ensure the biomass is extracted and produced in a sustainable manner (forest management, land use, etc.)
Soil energy (*Bodemenergie*): the use of the soil to extract and store heat and cold up to 500 metres deep. The heat extracted from the soil is upgraded to a usable temperature by a heat pump (ECW, 2021c; Bodemenergie Nederland, n.d.; Stichting Warmtenetwerk, 2021).	• Renewable energy source • Zero emission depending on the fuel mix for electricity generation • Heating with high efficiency through seasonal energy storage • The soil in the Netherlands is in most places very suitable	• Small risk of undesirable mixing of different groundwater layers • Leakage risk of harmful coolant in closed systems • Potential need for grid reinforcement
Geothermal (*Geothermie*): the extraction of heat from water that originates in deep earth layers (from 500 metres and deeper) (Geothermie Nederland, n.d.; ECW, 2021f; Stichting Warmtenetwerk, 2021).	• Renewable energy source • Enough energy available in the Dutch underground to cover the entire heat demand • Independent of seasonal and weather conditions • Can be applied on a large-scale (approximately 30.000 houses per geothermal plant) • Hardly any impact on the environment	• Not applicable in every area • Not suitable for individual heat demand • Requires a district heat network and therefore major investments are needed to realise sufficient (medium temperature) heat networks • High investment costs • (Small) risk of leakages • (Small) risk of seismicity
Green gas (*Groengas*): renewable gas, which can be generated from the anaerobic digestion of organic biomass and residues produced in agriculture, food production, and waste processing and can be upgraded to natural gas quality (IEA Bioenergy, 2018; ECW, 2021g).	• CO_2-neutral • Has the same quality as natural gas and can therefore make use of the current gas infrastructure • No adjustments needed for the consumer • Effective alternative for neighbourhoods where alternative heat supply systems are too expensive or technically unfeasible	• Limited availability, hence large-scale usage and switch not possible • Green gas certification needed to prove the source of the gas (since it is for the consumer not possible to distinguish the difference between natural and green gas)
Residual heat (*Restwarmte*): unavoidable thermal energy generated as a by-product in industrial or commercial, which cannot be reused in the process. When captured,	• CO_2-neutral, since it is an unavoidable by-product • Avoids losses caused by waste heat escaping through the air or water	• Dependent on the availability of sources and the temperature and the distance to an (existing) heat network

this heat can be used to heat buildings (ECW, 2022d; Rijksoverheid, n.d.-e).		• The amount of residual heat and the temperature decreases with energy saving and electrification of industrial processes
Hydrogen (*Waterstof*): is an energy carrier and not an energy source, just like electricity (ECW, 2020b; TNO, 2020).	• Hydrogen in its gaseous from can directly substitute natural gas and can make use of the current gas infrastructure with some limited modifications • Limited costs and adjustments needed in and around the house for hydrogen usage	• Currently mostly produced from natural gas and therefore not yet zero emission • Climate neutral hydrogen is currently hardly available • The process of producing hydrogen is currently energy-intensive and therefore not yet an efficient alternative • New protocols and standards are needed for the safe use of hydrogen
Solar thermal (*Zonthermie*): generating heat by capturing solar energy through thermal solar panels (ECW, 2022e; Stichting Warmtenetwerk, 2021).	• Energy yield per m^2 is higher than solar panels and wind energy • Technology has been successfully proven in practice • Complementary to and easy to fit into existing heat networks.	• Energy yield is dependent on seasonal and weather conditions
Heat storage (*Warmteopslag*): the storage of heat for later use. Heat can be stored for a short period (hours), a day, a week, or a season. The most common method is heat storage in water and can be done in above ground or underground tanks or in the ground using thermal energy storage (Aquifer Thermal Energy Storage, ATES) (TKI Urban Energy, 2020a; ECW, 2022b).	• Increases the use of renewable energy sources • Heat from energy sources can be used more efficient, which in turn makes the energy sources more profitable • Reduces the use of boilers for peak moments and serves as a back-up when the renewable energy source fails • Could eliminate or reduce the need for expensive network reinforcement	• Heat storage in water in above-ground tanks takes up a lot of space. The spatial impact is however smaller for underground storage • Heat loss during storage
Social solutions		
Energy cooperative (Energie coöperatie): an initiative by citizens that want to decide for themselves where their energy comes from and be independent form a (commercial) supplier. They join forces to work on sustainable local energy and start an energy cooperative (HIER, n.d.-c; HIER, n.d.-b; DRIFT, 2017)	• Independent from energy suppliers • Local ownership • Make use of locally produced energy • Have the ability to mobilise the involvement and commitment of local residents	• Dependence on voluntary engagement of persons • Lack of financial resources and power • Lack of technical expertise

Energy Community (Energie gemeenschap): an association that produces and shares renewable energy, generating, and managing cost-effective green energy autonomously, reducing CO_2 emissions and energy waste. The community may consists of local citizens, businesses, public administrations, small and medium-sized enterprises, etc. (Enel Greenpower, n.d.; European Commission, n.d.-a; Roberts, et al., 2019; European Commission, 2022)	• Contribute to increasing public acceptance of renewable energy projects • Its primary purpose is to provide environmental, economic, or social community benefits to its members or shareholders or the local areas where it operates, rather than to generate financial profits • Potential to provide direct benefits to citizens by increasing energy efficiency, lowering their electricity bills, and creating local job opportunities • By supporting citizen participation, energy communities can help providing flexibility to the electricity system through demand-response and storage	